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PEDIRKA AND EROMANGA BASINS THERMAL AND TECTONIC HISTORY PROJECT

REPORTS FOR THE PERIOD JANUARY 1995 TO DECEMBER 1996

Submitted by

Mines and Energy South Australia and National Centre for Petroleum Geology and Geophysics
1996

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MINES and ENERGY RESOURCES SOUTH AUSTRALIA

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PALYNOLOGY OF NINE CARBONIFEROUS TO CRETACEOUS SAMPLES FROM THE ERINGA TROUGH, ONSHORE SOUTH AUSTRALIA

BY

ROGER MORGAN

for **SA DEPT OF MINERALS & ENERGY**

February 1995

REF:OTW.RPERINGA

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FIGURE 1 : ZONATION FRAMEWORK

FIGURE 2 : AUSTRALIAN PALYNOSTRATIGRAPHIC SCHEMES

I SUMMARY

EOB 2, 113-115m cutts : *operculata* Dinoflagellate Zone of Helby, Morgan and Partridge (1987) = part PK3 Spore-Pollen unit of Price et al (1985) : Aptian : nearshore marine : usually lower Bulldog Shale

CUR 3 (Afmeco), 252.4m, 293.5m(cores) : *florida* Spore-Pollen Zone of HMP = PJ5 Spore-Pollen unit of Price et al : Kimmeridgian-Callovian (Late to Middle Jurassic) : non-marine : usually Birkhead Formation

Mt Hammersley-1, 3380-90ft, 3700-10ft, 3930-40ft, 4100-10ft, 4360-70ft, 4500-10ft (all cuttings) : apparently all Stage 2 (= PP1 of Price et al) Latest Carboniferous to earliest Permian : with caved Stage 3 (= PP2 of Price et al) early Permian, *florida* Zone (= PJ5 of Price et al) Late Jurassic and *davidii* Dinoflagellate Zone Early Cretaceous : environments unreliable due to cavings with *spinose* acritarchs and dinoflagellates probably entirely caved : Leiospheres particularly common 3390ft, 4100ft, 4360ft and 4500ft and probably in place.

II INTRODUCTION

Elinor Alexander from the Oil, Gas and Coal Section of the SA Department of Minerals and Energy submitted nine samples for palynology. These were primarily for age control as the samples were originally studied for acritarch biostratigraphy by Dr Wen Long Zang.

Palynostratigraphic subdivision of Late Carboniferous and Permian sequences relies on the identification of a series of interval-zones as defined by Kemp and others, (1977) and later refined by Price and others, (1985). An outline of the biostratigraphic zonation schemes for the Late Carboniferous and Early Permian is shown on Figure 2. Zonal assignment of assemblages is based on the first consistent occurrence of an index taxon. Definition of such zones from cuttings samples is usually difficult due to the presence of uphole cavings contamination masking the true first appearance of key species and assignment to a range of zones is often only possible.

In the Mesozoic, the most recent zonal summaries are those of Helby et al (1987) for all of Australia, and Price et al (1985) for central Australia. The scheme of Helby et al is shown as Figure 1, but clear equivalents exist in the Price Scheme. Table 1 summaries individual sample results for the Mt Hammersley-1 section, while raw data are presented in Appendix 1.

WELL NAME: MOUNT HAMMERSLEY NO.1
CLIENT : MESA

SAMPLE	DEPTH FT	AGE	PALYNOSTRATIGRAPHIC UNIT	REMARKS
CUTTINGS	3380-3390	LATE CARBONIFEROUS TO EARLY PERMIAN, ?LATE CARBONIFEROUS	STAGE 2 TO STAGE 3B, ?STAGE 2. (PP1.2-PP2.2, ?PP1.2)	Mesozoic cavings contaminants common. Monosaccate pollen relatively abundant, cavate/zonate spores common, striate bisaccate pollen prominent. *M. tentula, P. pseudoreticulata and G. trisinus* present.
CUTTINGS	3700-3710	LATE CARBONIFEROUS TO EARLY PERMIAN, ?LATE CARBONIFEROUS	STAGE 2 TO STAGE 3A, ?STAGE 2 (PP1.2-PP2.1, ?PP1.2)	Mesozoic contaminants prominent. Monosaccate pollen abundant, *M. tentula* rare. *G. confluens* and *P. pseudoreticulata* present.
CUTTINGS	3930-3940	?LATE CARBONIFEROUS	?STAGE 2 (PP1)	Assemblage predominantly Cretaceous cavings contaminants. Leiosphaerids common. Monosaccate pollen are a prominent minor element. *V. andersonii* present.
CUTTINGS	4100-4110	LATE CARBONIFEROUS TO EARLY PERMIAN, ?LATE CARBONIFEROUS	STAGE 2 TO STAGE 3B, ?STAGE 2 (PP1.2-PP2.2, ?PP1.2)	Mixed assemblage. Mesozoic forms and Leiosphaerids prominent. Monosaccate pollen common, cryptogams rare. *G. confluens, P. pseudoreticulata, G. trisinus* present.
CUTTINGS	4360-4370	LATE CARBONIFEROUS TO EARLY PERMIAN, ?LATE CARBONIFEROUS	STAGE 2 TO STAGE 3A, ?STAGE 2 (PP1.2-PP2.1, ?PP1.2)	Leiosphaerids abundant, monosaccate pollen and *M. triradiatus* common. *M. tentula, P. pseudoreticulata, G. confluens* present.
CUTTINGS	4500-4510	LATE CARBONIFEROUS TO EARLY PERMIAN	STAGE 2 TO STAGE 3B (PP1-PP2.2)	Mixed assemblage. Monosaccate pollen less prominent, cryptogams more common. Leiosphaerids prominent, *M. triradiatus common,* striate bisaccates and cavate/zonate spores frequent. *P. pseudoreticulata, D. townrowii, V. andersonii, G. trisinus* present.

Table 1

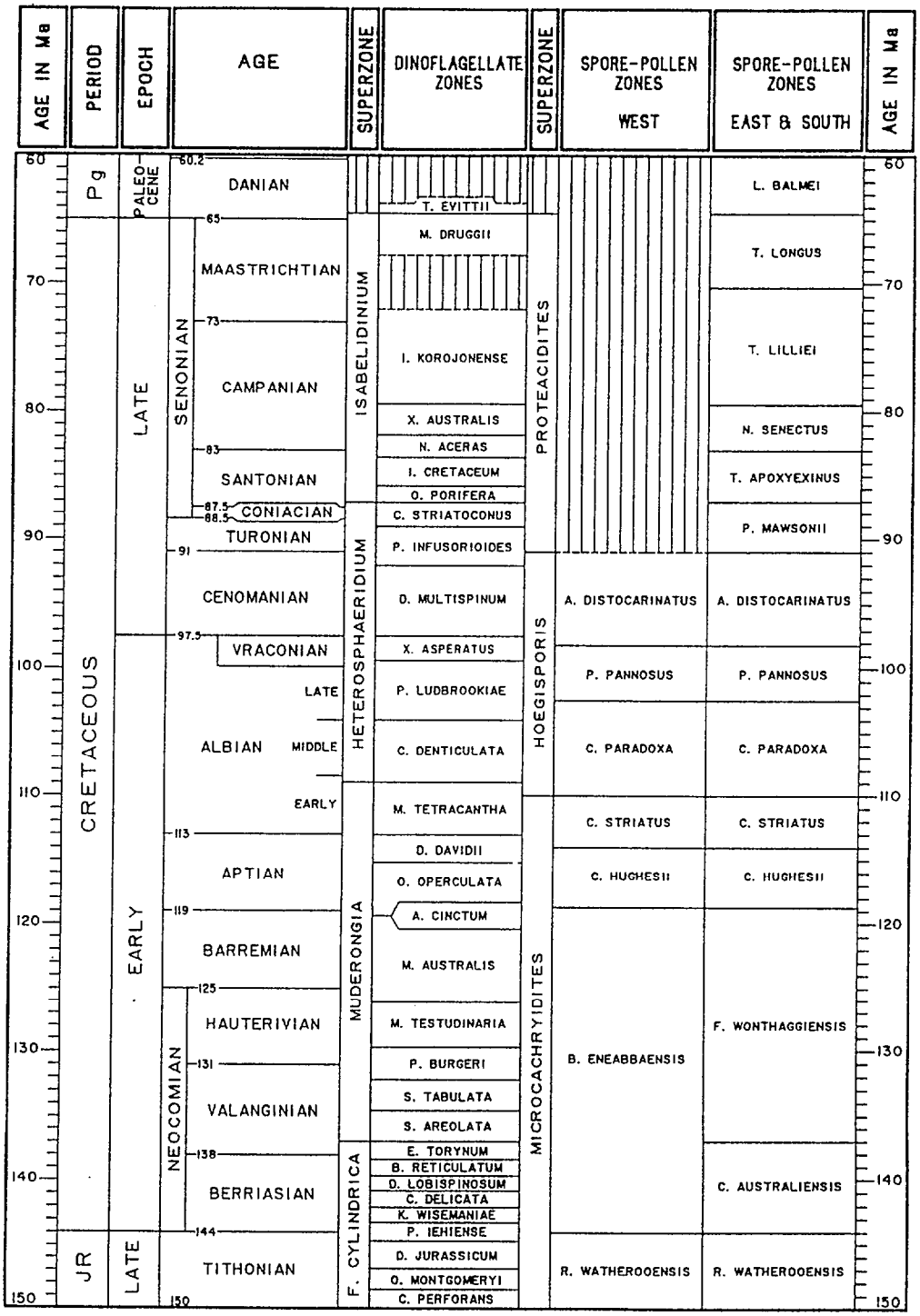

Figure 1a ZONATION FRAMEWORK - LATEST JURASSIC TO PALEOCENE (from Helby et al, 1987)

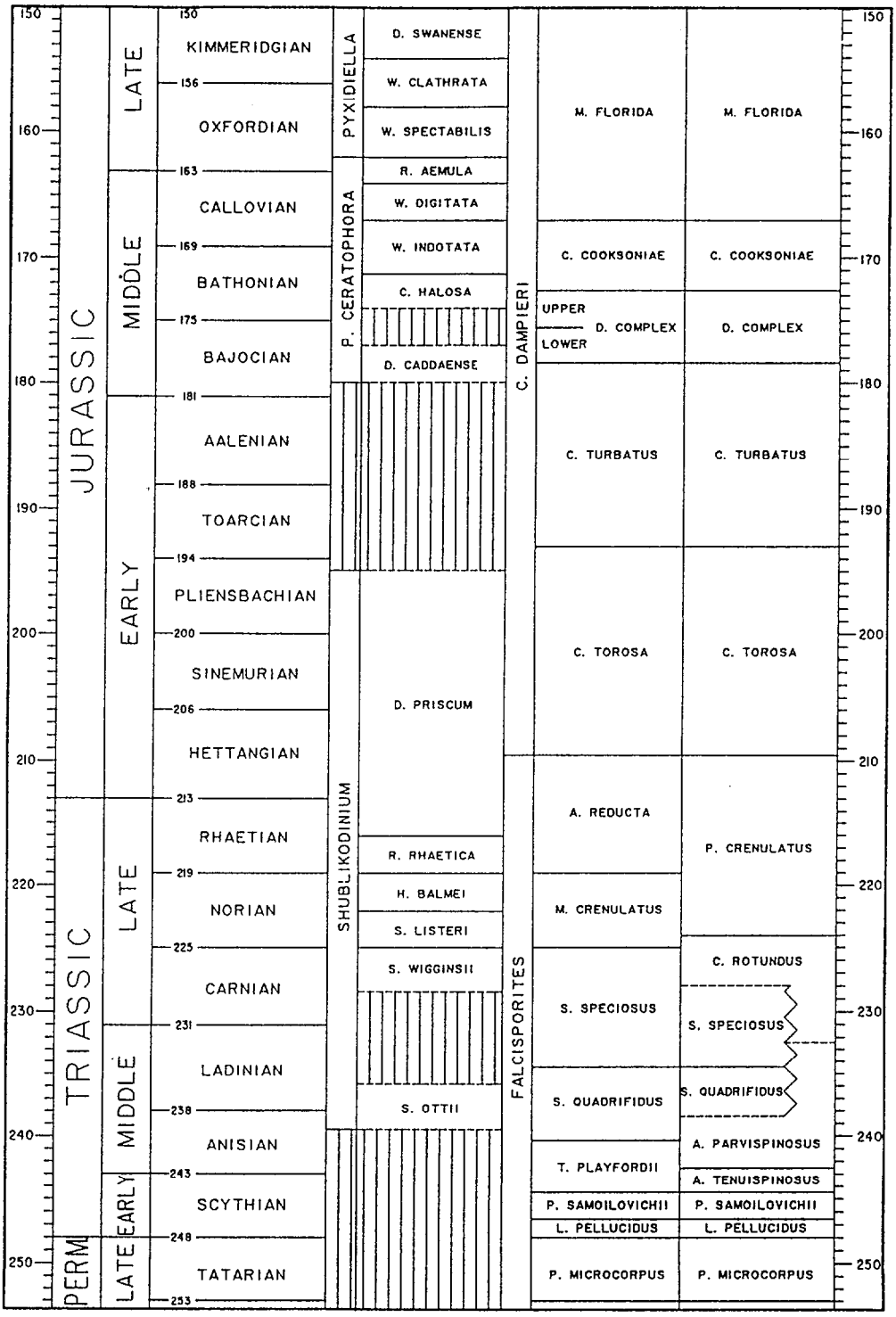

Figure 1b ZONATION FRAMEWORK - LATE PERMIAN TO LATE JURASSIC (from Helby et al, 1987)

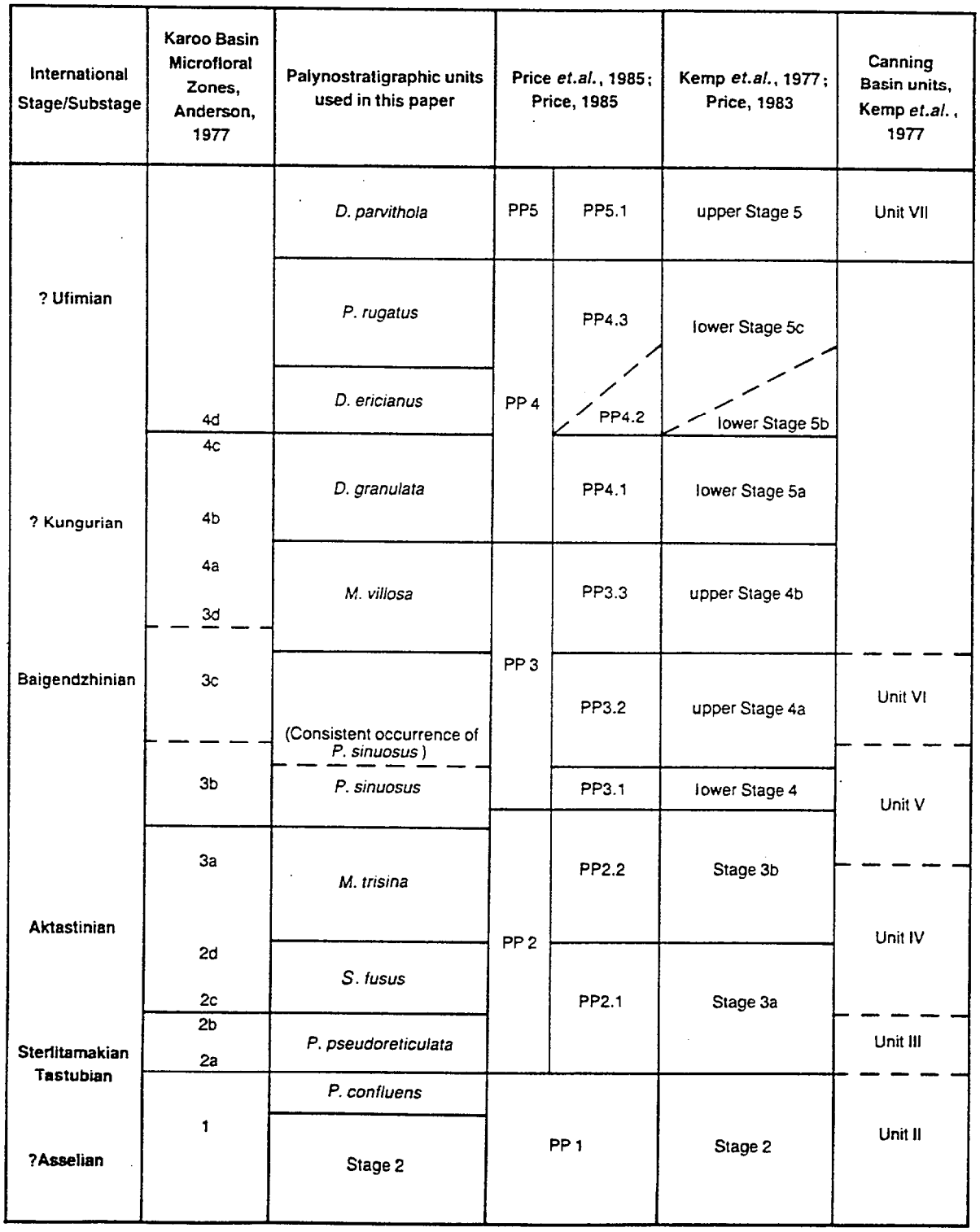

Figure 2 AUSTRALIAN PALYNOSTRATIGRAPHIC SCHEMES
(Backhouse 1991)

III PALYNOSTRATIGRAPHY

A EOB 2, 113-115m(cutts) : *operculata* Dinoflagellate Zone

Assignment to the *Odontochitina operculata* Dinoflagellate Zone of Helby, Morgan and Partridge (1987) of Aptian age is indicated by the presence of *Muderongia mcwhaei*, *Dingodinium cerviculum* and *Diconodinium pusillum* without other markers. The assemblage is very lean but includes frequent *Spiniferites ramosus*.

Spores and pollen are quite common but lack diversity due to the very lean yield. *Cyathidites* and *Falcisporites* are frequent and *Cicatricosisporites australiensis* was noted. Spore-pollen zonal assignment is thus not possible.

Nearshore marine environments are indicated by the dominant spores and pollen and subordinate dinoflagellates.

This zone is usually seen in the lower Bulldog Shale.

B CUR 3 (Afmeco) 252.4m, 293.5m(cores) : *florida* Zone

Assignment to the *Murospora florida* Zone of Helby et al (= PJ5 of Price et al) is indicated clearly at 293.5m by frequent *M. florida* without younger markers. *Contignisporites cooksoniae*, *Coronatispora perforata* and *Sestrosporites pseudoalveolatus* are notably present, with *Cyathidites australis* common, and *Cyathidites minor* and *M. florida* frequent. Cuticle is abundant.

At 252.4m, the assignment is less certain due to abundant amorphous organic matter (AOM) diluting the assemblage, but on general similarity (frequent *C. australis*, *C. minor* and *Retitriletes austroclavatidites* with consistent *Callialasporites dampieri*, *C. perforata* and *S. pseudoalveolatus*), the absence of younger markers, and the sample beneath, this sample probably also belongs to the *florida* Zone.

Non-marine environments are indicated, as saline indicators are totally missing from these core samples.

This zone is usually seen in the Birkhead Formation or equivalents.

C Mt Hammersley-1, 3380-90ft, 3700-10ft, 3930-40ft, 4100-10ft, 4360-70ft, 4500-10ft (all cuttings) : apparently all Stage 2 (= PP1)

Individual sample details are given in Table 1.

Early Cretaceous dinoflagellates and spore-pollen cavings contaminants are common in all samples and are particularly prominent in samples from 3380 and 3930ft. Key forms identified indicate that sediments assignable to the *Foraminisporis wonthaggiensis* to *Crybelosporites striatus* spore-pollen Zones and *Diconodinium davidii* Dinoflagellate Zone are present higher in the section.

Rare superbly preserved *Murospora florida* are also seen and suggest a Late Jurassic *florida* Zone interval (= PJ5) also caving.

The relatively high proportion of monosaccate pollen and the general paucity of cheilocardioid spores in the cuttings samples suggests assignment to the Late Carboniferous to earliest Early Permian Stage 2 (= PP1, Price & others, 1985). This assignment is supported by the common occurrence of *Jayantisporites pseudozonatus* and *Verrucosisporites andersonii*. Younger index forms such as *Granulatisporites trisinus*, *Pseudoreticulatispora pseudoreticulata* and *Granulatisporites confluens* are only very rare in most samples and are probably cavings derived from overlying early Permian sequences.

Leiosphaerids are particularly common in samples from 3930, 4100, 4360 and 4500ft. *Micrhystridium* and *Veryhachium spp* are minor elements in most samples, particularly those with prominent Early Cretaceous cavings contaminants, and are thus considered to be derived also from the Early Cretaceous marine sequence.

Environments are uncertain as many of the acritarchs and all of the dinoflagellates are considered caved.

V REFERENCES

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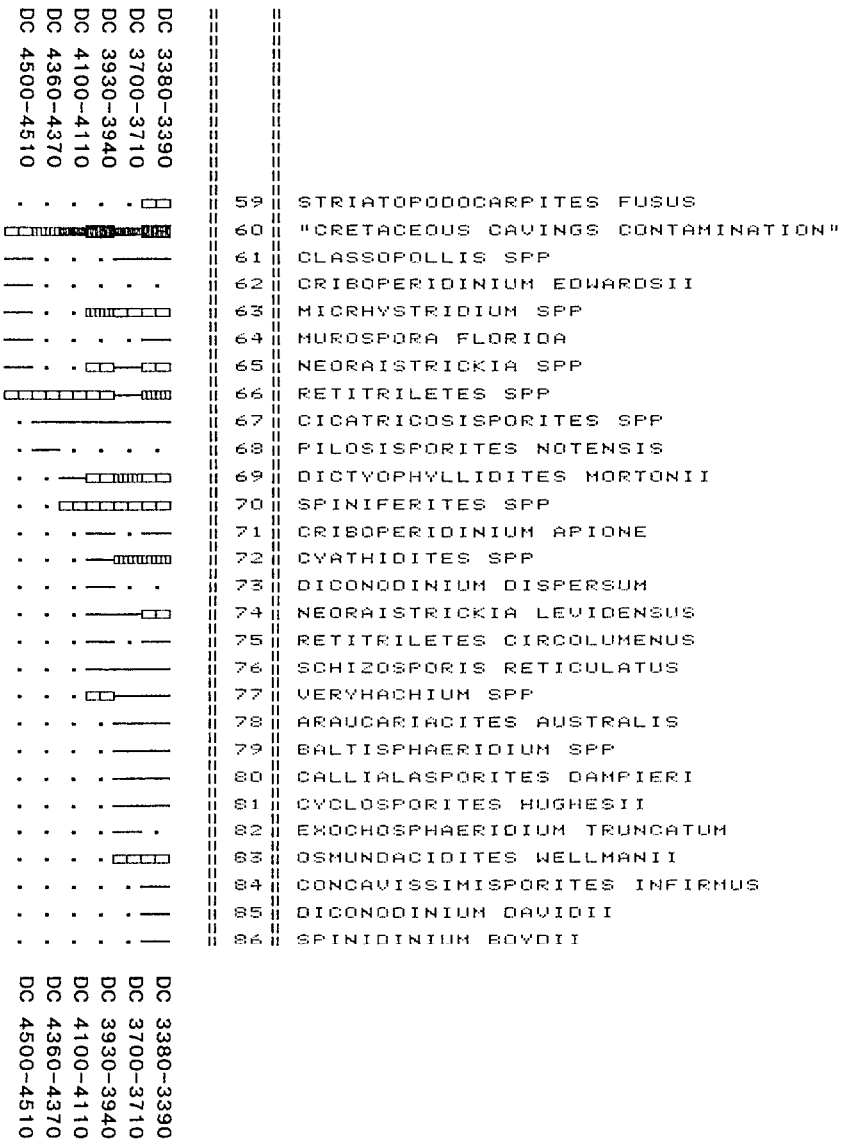
MOUNT HAMMERSLEY NO.1 CUTTINGS REVIEW (MESA)

RANGE CHART OF GRAPHIC ABUNDANCES BY LOWEST APPEARANCE

Key to Symbols

= Very Rare
= Rare
= Few
= Common
= Abundant
? = Questionably Present
. = Not Present

		DC 3380-3390	DC 3700-3710	DC 3930-3940	DC 4100-4110	DC 4360-4370	DC 4500-4510
1	ALISPORITES SPP						
2	APICULATISPORIS PSEUDOHELES						
3	BREVITRILETES "CLARUS"						
4	BREVITRILETES CORNUTUS						
5	BREVITRILETES SUPERBUS						
6	CALAMOSPORA SPP						
7	CANNANOROPOLLIS SPP						
8	COLUMNISPORITES CF PEPPERSII						
9	CONVERRUCOSISPORITES NAUMOVAE						
10	CYCADOPITES FOLLICULARIS						
11	DENSOSPORITES ROTUNDIDENTATUS						
12	GRANULATISPORITES CF TRISINUS (SEGROVES)						
13	GRANULATISPORITES TRISINUS						
14	HORRIDITRILETES TERETEANGULATUS						
15	INDOTRIRADITES ENORMIS						
16	INDOTRIRADITES REIDII						
17	INDOTRIRADITES SPLENDENS						
18	JAVANTISPORITES "SIMPLEXUS"						
19	JAVANTISPORITES PSEUDOZONATUS						
20	JAVANTISPORITES SP A (BACKHOUSE)						
21	JAVANTISPORITES VARIABILIS						
22	LAEVIGATOSPORITES VULGARIS						
23	LEIOSPHAERIDIA SPP						
24	LEIOTRILETES DIRECTUS						
25	LEIOTRILETES VIRKII						
26	LIMITISPORITES RECTUS						
27	LOPHOTRILETES SCOTINUS						
28	MARSUPIPOLLENITES STRIATUS						
29	MARSUPIPOLLENITES TRIRADIATUS						
30	MICROBACULISPORA MICRONODOSUS						
31	MICROBACULISPORA TENTULA						
32	OSMUNDACIDITES SPP						
33	PHASELISPORITES HAMATUS						
34	PLICATIPOLLENITES DENSUS						
35	PLICATIPOLLENITES MALABARENSIS						
36	POTONIEISPORITES NOVICUS						
37	PROTOHAPLOXYPINUS AMPLUS						
38	PROTOHAPLOXYPINUS LIMPIDUS						
39	PSEUDORETICULATISPORA PSEUDORETICULATA						
40	PUNCTATISPORITES SPP						
41	RETUSOTRILETES NIGRITELLUS						
42	SCHEURINGIPOLLENITES SPP						
43	SIRIATUABIEITES MULTISTRIATUS						
44	VERRUCOSISPORITES "POLYGONALIS"						
45	VERRUCOSISPORITES ANDERSONII						
46	GRANULATISPORITES CONFLUENS						
47	PROTOHAPLOXYPINUS GORAIENSIS						
48	VERRUCOSISPORITES BASILISCUTIS						
49	GONDISPORITES RANIGANJENSIS						
50	QUADRISPORITES HORRIDUS						
51	TETRAPORINA SPP						
52	CAHENIASACCITES SPP						
53	HORRIDITRILETES RAMOSUS						
54	INDOTRIRADITES NIGER						
55	POTONIEISPORITES BALMEI						
56	CONVERRUCOSISPORITES PUSTULATUS						
57	GRANDISPORA SP A (FOSTER & GILBY)						
58	PROCORONASPORA SPINOSA						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66 RETITRILETES SPP
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77 VERYHACHIUM SPP
78 ARAUCARIACITES AUSTRALIS
79 BALTISPHAERIDIUM SPP
80 CALLIALASPORITES DAMPIERI
81 CYCLOSPORITES HUGHESII
82 EXOCHOSPHAERIDIUM TRUNCATUM
83 OSMUNDACIDITES WELLMANII
84 CONCAVISSIMISPORITES INFIRMUS
85 DICONODINIUM DAVIDII
86 SPINIDINIUM BOYDII
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4	BREVITRILETES CORNUTUS
5	BREVITRILETES SUPERBUS
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6	CALAMOSPORA SPP
80	CALLIALASPORITES DAMPIERI
7	CANNANOROPOLLIS SPP
67	CICATRICOSISPORITES SPP
61	CLASSOPOLLIS SPP
8	COLUMNISPORITES CF PEPPERSII
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3	CHLAMYDOPHORELLA NYEI
12	CICATRICOSISPORITES AUSTRALIENSIS
13	CINGUTRILETES CLAVUS
4	CIRCULODINIUM DEFLANDREI
36	CONTIGNISPORITES COOKSONIAE
14	CONTIGNISPORITES GLEBULENTUS
37	COROLLINA TOROSUS
28	CORONATISPORA PERFORATA
5	CRIBROPERIDINIUM EDWARDSII
15	CYATHIDITES AUSTRALIS
29	CYATHIDITES MINOR
6	DICONODINIUM PUSILLUM
7	DINGODINIUM CERVICULUM
8	EXOCHOSPHAERIDIUM PHRAGMITES
16	FALCISPORITES GRANDIS
17	FALCISPORITES SIMILIS
18	FOVEOTRILETES PARVIRETUS
19	GLEICHENIIDITES
30	ISCHYOSPORITES PUNCTATUS
38	KLUKISPORITES SCABERIS
20	KUYLISPORITES LUNARIS
39	LEPTOLEPIDITES MAJOR
31	LYCOPODIACIDITES ASPERATUS
21	MICROCACHRYIDITES ANTARCTICUS
9	MUDERONGIA MCWHAEI
22	MUROSPORA FLORIDA
10	OLIGOSPHAERIDIUM COMPLEX
32	OSMUNDACIDITES WELLMANII
23	RETITRILETES AUSTROCLAVATIDITES
33	SESTROSPORITES PSEUDOALVEOLATUS
11	SPINIFERITES FURCATUS/RAMOSUS
34	STAPLINISPORITES CAMINUS
24	STEREISPORITES ANTIQUASPORITES
35	VITREISPORITES PALLIDUS

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C L I E N T: SOUTH AUSTRALIAN DEPARTMENT OF MINES AND ENERGY

W E L L: VARIOUS

F I E L D / A R E A: ERINGA TROUGH, SOUTH AUSTRALIA

A N A L Y S T: Roger Morgan D A T E : February '95

N O T E S: all depths are in metres
"C"=common (11-30%) "F"=frequent (4-10%) "X"=present (<4%)

RANGE CHART OF OCCURRENCES BY HIGHEST APPEARANCE: grouped

	1 APTEODINIUM GRANULATUM	2 BATIOLADINIUM MICROPODUM	3 CHLAMYDOPHORELLA NYEI	4 CIRCULODINIUM DEFLANDREI	5 CRIBROPERIDINIUM EDWARDSII	6 DICONODINIUM PUSILLUM	7 DINGODINIUM CERVICULUM	8 EXOCHOSPHAERIDIUM PHRAGMITES	9 MUDERONGIA MCWHAEI	10 OLIGOSPHAERIDIUM COMPLEX	11 SPINIFERITES FURCATUS/RAMOSUS	12 CICATRICOSISPORITES AUSTRALIENSIS	13 CINGUTRILETES CLAVUS	14 CONTIGNISPORITES GLEBULENTUS	15 CYATHIDITES AUSTRALIS	16 FALCISPORITES GRANDIS	17 FALCISPORITES SIMILIS	18 FOVEOTRILETES PARVIRETUS	19 GLEICHENIIDITES	20 KUYLISPORITES LUNARIS	21 MICROCACHRYIDITES ANTARCTICUS	22 MUROSPORA FLORIDA	23 RETITRILETES AUSTROCLAVATIDITES	24 STEREISPORITES ANTIQUASPORITES	25 ARAUCARIACITES AUSTRALIS	26 CALLIALASPORITES DAMPIERI	27 CALLIALASPORITES TURBATUS	28 CORONATISPORA PERFORATA	29 CYATHIDITES MINOR	30 ISCHYOSPORITES PUNCTATUS	31 LYCOPODIACIDITES ASPERATUS	32 OSMUNDACIDITES WELLMANII	33 SESTROSPORITES PSEUDOALVEOLATUS	34 STAPLINISPORITES CAMINUS	35 VITREISPORITES PALLIDUS	36 CONTIGNISPORITES COOKSONIAE	37 COROLLINA TOROSUS	38 KLUKISPORITES SCABERIS	39 LEPTOLEPIDITES MAJOR	
EOB #2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	EOB #2
0115 CUTTS CUR #3	X	X	X	X	X	X	X	X	X	X	X	F	X	X	X	F	X	F	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0115 CUTTS CUR #3
0252.4 CORE	.	.	.	.	.	.	.	.	.	.	.	.	X	X	F	X	X	.	X	.	.	.	F	.	X	X	X	X	F	X	X	X	X	X	X	.	.	.	.	0252.4 CORE
0293.5 CORE	.	.	.	.	.	.	.	.	.	.	.	.	C	X	X	.	X	.	.	F	1	1	X	X	X	X	F	X	X	X	X	.	.	X	X	X	X	0293.5 CORE		

GEOTRACK

0018

APATITE FISSION TRACK ANALYSIS OF SAMPLES FROM ERINGA TROUGH AND WESTERN EROMANGA BASIN, AUSTRALIA

GEOTRACK REPORT #550

Data Report Only

A report prepared for Mines and Energy South Australia

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APATITE FISSION TRACK ANALYSIS OF SAMPLES FROM ERINGA TROUGH AND WESTERN EROMANGA BASIN, AUSTRALIA

Data Report Only

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1. Introduction

This report comprises the Apatite Fission Track Analysis (AFTA™) data obtained for samples from five wells from the **Eringa Trough and Western Eromanga** region, supplied by Mines and Energy South Australia. Chlorine contents were measured in all grains in which AFTA parameters were determined. At the request of the client, no interpretation is provided in this report.

2. Report structure

Sample details are discussed in Appendix A, together with the yields of detrital apatite obtained after mineral separation. Sample preparation and analytical details are described in Appendix B, followed by presentation of all AFTA data, including raw track counts and fission track ages for individual grains. The presentation of data in the form of Tables and Figures throughout the report is discussed in detail in Appendix B.

APPENDIX A

Sample Details

A.1 Apatite yields and quality

Samples from five wells from the **Eringa Trough and Western Eromanga Basin** region were submitted for Apatite Fission Track Analysis (AFTA™) by Mines and Energy South Australia. The yield of detrital apatite obtained after mineral separation from the samples varied from poor to excellent, with one sample not yielding, while the quality of apatite grains was good, as summarised in Table A.1. All data are considered to be reliable and should form the basis of a solid thermal history interpretation. The overall quality of the data is very good.

A.2 Stratigraphic details

Stratigraphic ages of each sample are summarised in Table A.1. Chronostratigraphic and chronometric (numerical) age information was supplied by Mines and Energy South Australia.

A.3 Present temperatures

In the application of any technique involving estimation of paleotemperatures, it is critical to control the present temperature, since estimation of maximum paleotemperatures proceeds from determining how much of the observed effect can be explained by the magnitude of present temperatures.

Corrected BHT temperature data and geothermal gradients were provided by Mines and Energy South Australia, as summarised in Table A.2. An estimate of 21°C for the present surface temperature was assumed. A regional geothermal gradient of 40°C/km was assumed for the two AFMECO wells.

A.4 Grain morphologies

Although grain morphologies were variable, good quality euhedral and rounded apatite grains were prominent.

A.5 Apatite compositions

The annealing kinetics of fission tracks in apatite are affected be chemical composition, specifically the Cl content.

For this study, chlorine compositions were determined for all individual apatite grains in which fission track ages were determined. Chlorine contents were measured using a semi-automated Jeol JXA-5A electron microprobe equipped with three wavelength dispersive crystal spectrometers, with an accelerating voltage of 15KV and beam current of 25nA. The beam was defocussed to 20 μm to avoid the problems associated with apatite decomposition, which occur under a fully focussed 1μm - 2μm beam. The X-Y co-ordinates of apatite grains within the grain mount were transferred from the Autoscan Fission Track Stage to a file suitable for direct input into the electron microprobe. Pure rock salt (NaCl) was used as a standard for chlorine, which was the only element determined in each apatite grain. Count rates were converted to wt% Cl using an empirically determined correction factor. This allows for atomic number absorption and fluorescence matrix effects, which are normally calculated explicitly when analysing for all elements. Durango apatite (Melbourne University Standard APT151) was analysed at regular intervals throughout the analysis to monitor microprobe performance.

Using this approach, lower limits of detection for chlorine content have been calculated for typical analytical conditions (beam current, counting time, etc.) and are listed in Table A.2. Errors in wt% composition are given as a percentage and quoted at 1σ for chlorine determinations. A generalised summary of error values for various values of wt% chlorine is presented in Table A.3.

The measured range of chlorine content of apatites (both age and length grains) within each sample is shown in histogram format in Figure A.1. Plots of single grain age versus weight % chlorine are shown in Figure B.5. Chlorine contents appear in the fission track age summary sheets in Appendix B.

Table A.1: Details of AFTA samples and apatite yields - well samples from the Eringa Trough and Western Eromanga (Geotrack Report #550)

Sample number	Depth (m)	Sample type	Stratigraphic subdivision	Stratigraphic age (Ma)	Present temperature *1 (°C)	Raw weight (g)	Washed weight (g)	Apatite yield *2
AFMECO CUR-5								
GC550-1	209-209 *(685-687')*	core	Algebuckina Sst	186-138	29	1420	846	Poor
GC550-2	328-328 *(1075-1077')*	core	Basement	1090-1080	34	1091	791	Good
AFMECO CUR-3								
GC550-3	377-377 *(1236-1237')*	core	Crown Pt Fm	283-277	36	252	165	Very Good
Mt Hammersley-1								
GC550-4	351-381 *(1150-1250')*	cuttings	Algebuckina Sst	186-138	36	1053	821	Poor
GC550-5	555-582 *(1820-1910')*	cuttings	Algebuckina Sst	186-138	44	1027	780	Poor
GC550-6	900-901 *(2954-2956')*	core	Permian Undifferentiated	286-277	57	863	Not	Irradiated
GC550-7	1309-1311 *(4296-4301')*	core	Crown Pt Fm	286-283	73	997	800	Excellent
GC550-8	1527-1551 *(5010-5090')*	cuttings	Crown Pt Fm	286-283	82	954	791	Excellent
GC550-9	1835-1865 *(6020-6120')*	cuttings	Mereenie Sst	430-415	94	1230	663	Very Good
Purni-1								
GC550-10	140-162 *(460-530')*	cuttings	Winton Fm	97.5-90	27	530	349	Good
GC550-11	1392-1393 *(4566-4569')*	core	Poolowanna Fm	193-186	75	1070	37	Poor
Mt Crispe-1								
GC550-12	219-235 *(720-770')*	cuttings	Algebuckina Sst	186-138	29	890	735	Poor
GC550-13	868-869 *(2848-2851')*	core	Mt Crispe Beds	510-505	53	810	462	Poor
GC550-14	1026-1027 *(3367-3370')*	core	Mt Crispe Beds	510-505	58	930	575	Poor
GC550-15	1333-1335 *(4374-4379')*	core	Mt Crispe Beds	510-505	70	1030	196	Fair
GC550-16	1534-1535 *(5033-5036')*	core	Mt Crispe Beds	510-505	77	990	187	Poor
GC550-17	1699-1717 *(5575-5635')*	cuttings	Mt Crispe Beds	510-505	83	1260	375	Good

*1 See Appendix A for discussion of present temperature data.

*2 Yield based on quantity of mineral suitable for age determination. Excellent: >20 grains; Very Good: ~20 grains; Good: 15-20 grains; Fair: 10-15 grains; Poor: 5-10 grains; Very Poor: <5 grains.

Note: All depths quoted are TVD with respect to KB.

Table A.2: Summary of present temperature measurements - Eringa Trough and Western Eromanga wells (Geotrack Report #550)

Well	Ground surface (ft)	Ground surface (m)	Depth (log) (ft)	Depth (m)	Corrected temperature (°C)	Geothermal gradient (°C/km)
AFMECO CUR-5						
	0	0				40*2
AFMECO CUR-3						
	0	0				40*2
Mt Hammersley-1						
	0	0	6120	1865	95*1	39.7
Purni-1						
	0	0				38.8*1
Mt Crispe-1						
	0	0				36.4*1

A surface temperature of 21°C has been assumed.
All depths quoted are with respect to KB, except where otherwise stated.
*1 Data supplied by client
*2 Regional gradient assumed.

Table A.3: Lower Limits of Detection for Apatite Analyses (Geotrack Report #550)

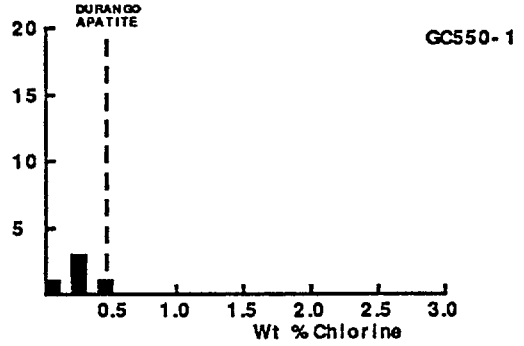
Element	LLD (95% c.l.)		LLD (99% c.l.)	
	(wt%)	(ppm)	(wt%)	(ppm)
Cl	0.01	126	0.02	182

Table A.4: Per cent errors in chlorine content (Geotrack Report #550)

Chlorine content (wt%)	Error (%)
0.01	9.3
0.02	8.7
0.05	7.3
0.10	6.1
0.20	4.7
0.50	3.2
1.00	2.3
1.50	1.9
2.00	1.7
2.50	1.5
3.00	1.4

Errors quoted are at 1σ. See Appendix A for more details.

GC550-1



GC550-2

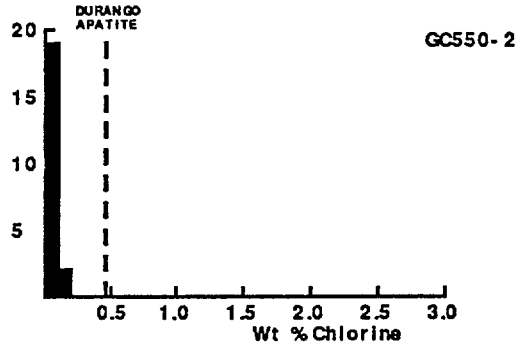


Figure A.1a: Distributions of chlorine content in samples from well **AFMECO CUR-5, Eringa Trough and Western Eromanga.**

GC550-3

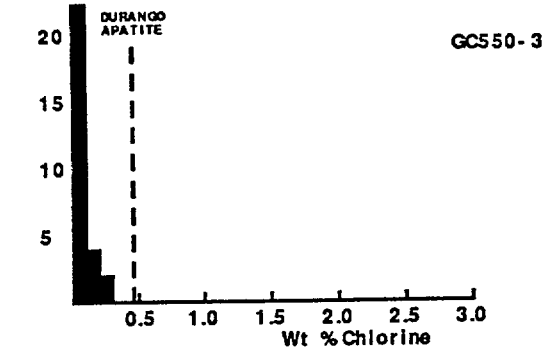
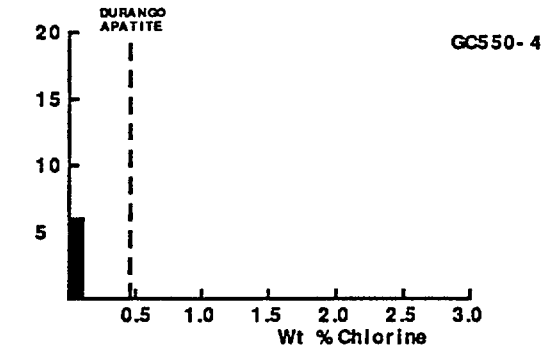
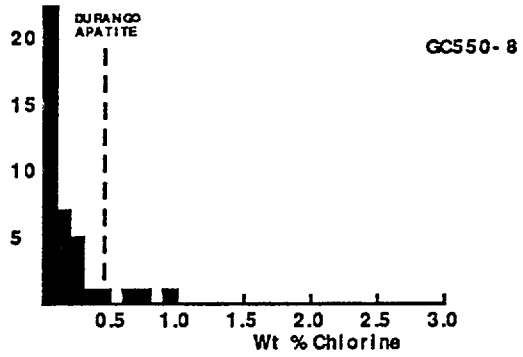


Figure A.1b: Distributions of chlorine content in samples from well AFMECO CUR-3, Eringa Trough and Western Eromanga.

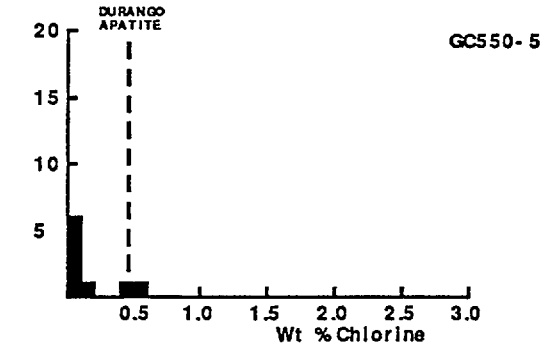
GC550-4



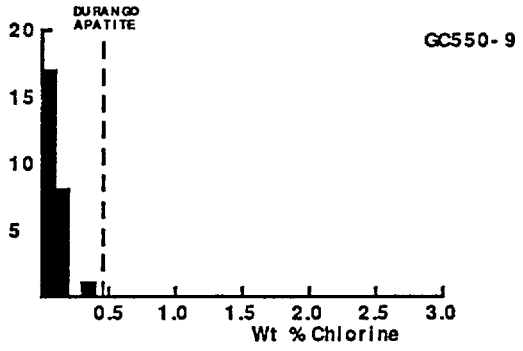
GC550-8



GC550-5



GC550-9



GC550-6

No Apatite

GC550-7

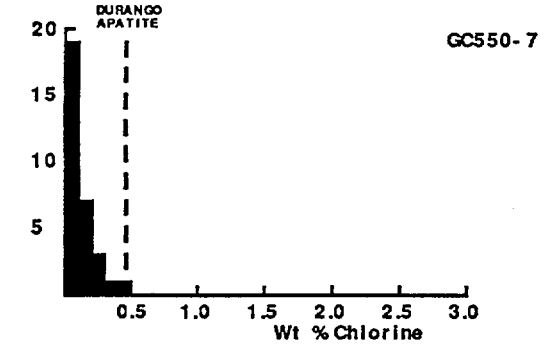
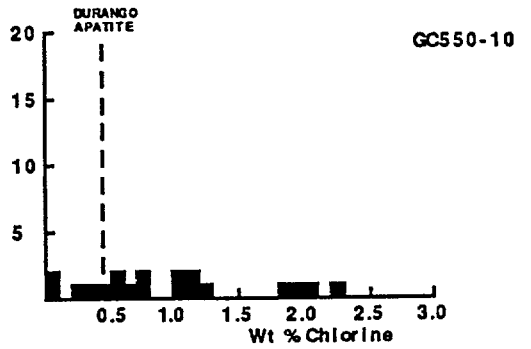


Figure A.1c: Distributions of chlorine content in samples from well Mt Hammersley-1, Eringa Trough and Western Eromanga.

GC550-10



GC550-11

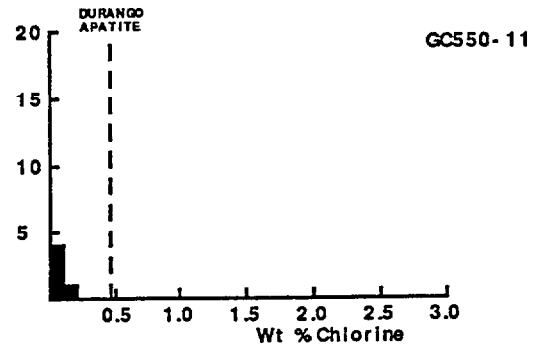
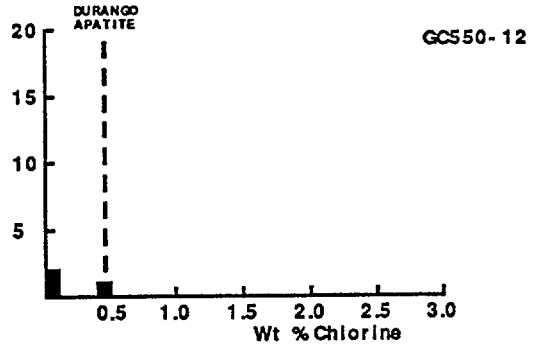
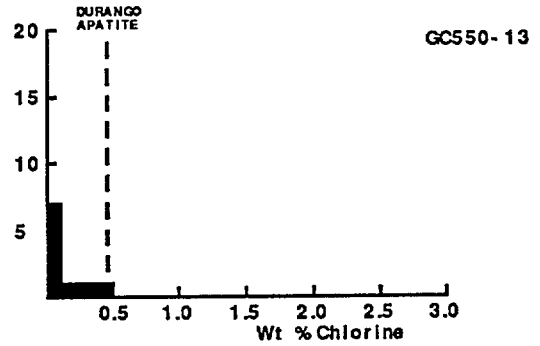


Figure A.1d: Distributions of chlorine content in samples from well **Purni-1, Eringa Trough and Western Eromanga.**

GC550-12



GC550-13



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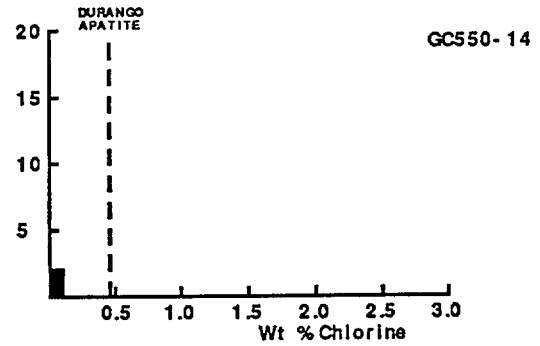

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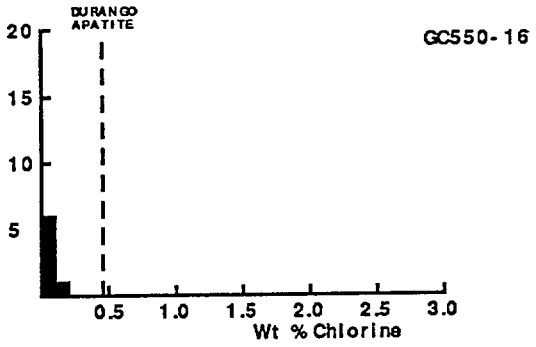

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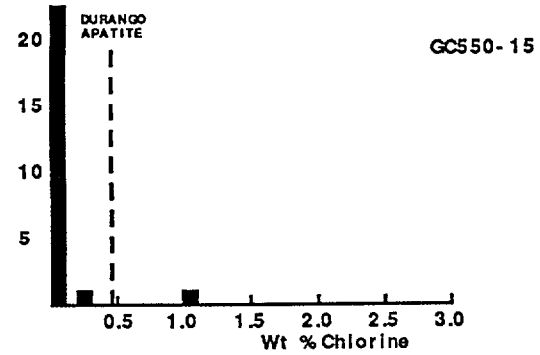

GC550-17

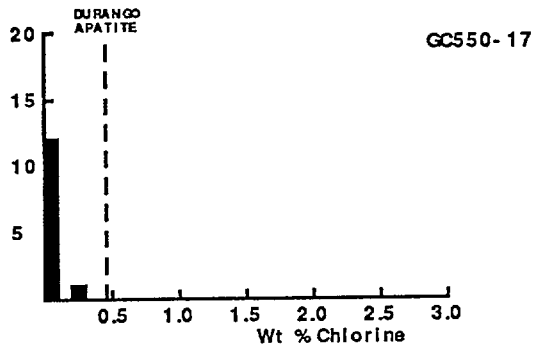

Figure A.1e: Distributions of chlorine content in samples from well Mt Crispe-1, Eringa Trough and Western Eromanga.

APPENDIX B

Sample Preparation, Analytical Details and Data Presentation

B.1 Sample Preparation

Core and outcrop samples are crushed in a jaw crusher and then ground to sand grade in a rotary disc mill. Cuttings samples are washed and dried before grinding to sand grade. The ground material is then washed to remove dust, dried and processed by conventional heavy liquid and magnetic separation techniques to recover heavy minerals. Apatite grains are mounted in epoxy resin on glass slides, polished and etched for 20 sec in 5M HNO_3 at 20°C to reveal the fossil fission tracks.

After etching, all mounts are cut down to 1.5 X 1 cm, and cleaned in detergent, alcohol and distilled water. The mounts are then sealed in intimate contact with low-uranium muscovite detectors within heat shrink plastic film. Each batch of mounts is stacked between two pieces of uranium standard glass which has been prepared in similar fashion. The stack is then inserted into an aluminium can for irradiation.

B.2 Experimental Details

Fission track ages

Fission track ages are calculated using the standard fission track age equation using the zeta calibration method (equation 5 of Hurford and Green, 1983), viz:

$$\text{F.T. AGE} = \frac{1}{\lambda_D} \ln \left[1 + \left(\frac{\zeta \lambda_D \rho_s g \rho_D}{\rho_i} \right) \right] \qquad \text{B.1}$$

where:
- λ_D = total decay constant of ^{238}U (= 1.55125 x 10^{-10})
- ζ = Zeta calibration factor
- ρ_s = Spontaneous track density
- ρ_i = Induced track density
- ρ_D = Track density from uranium standard glass
- g = A geometry factor (= 0.5)

Fission track ages are determined by the external detector method or EDM (Gleadow, 1981). The EDM has the advantage of allowing fission track ages to be determined on single grains. In apatite, tracks are counted in 20 grains from each mount wherever

possible. In those samples where the desired number is not present, all available grains are counted, the actual number depending on the availability of suitably etched and oriented grains. Only grains oriented with surfaces parallel to the crystallographic c-axis are analysed. Such grains can be identified on the basis of the etching characteristics, as well as from morphological evidence in euhedral grains. The grain mount is scanned sequentially, and the first 20 suitably oriented grains identified are analysed.

Tracks are counted within an eyepiece graticule divided into 100 grid squares. In each grain, the number of spontaneous tracks, N_s, within a certain number of grid squares, N_a, is recorded. The number of induced tracks, N_i, in the corresponding location within the mica external detector is then counted. Spontaneous and induced track densities, ρ_s and ρ_i, respectively, are calculated by dividing the track counts by the total area counted, given by the product of Na and the area or each grid square (determined by calibration against a ruled stage graticule or diffraction grating). Fission track ages may be calculated by substituting track counts, N_s and N_i, for track densities ρ_s and ρ_i in equation B.1, since the areas cancel in the ratio.

Translation between apatite grains in the grain mount and external detector locations corresponding to each grain is carried out using Autoscan™ microcomputer-controlled automatic stages (Smith and Leigh Jones, 1985). This system allows repeated movement between grain and detector, and all grain locations are stored for later reference if required.

Neutron irradiations are carried out in a well thermalised flux (X-7 facility; Cd ratio for Au ~98) in the Australian Atomic Energy Commission's HIFAR research reactor. Total neutron fluence is monitored by counting tracks in mica external detectors attached to two pieces of NBS standard glass SRM612 included in the irradiation canister at each end of the sample stack. In determining track densities in external detectors irradiated adjacent to uranium standard glasses, 25 fields are normally counted in each detector, and the total track count N_D is divided by the total area counted to obtain the track density ρ_D. The positions of the counted fields are arranged in a 5 X 5 grid covering the whole area of the detector. For typical track densities of between ~5 X 10^5 and 5 X 10^6 this is a convenient arrangement to sample across the detector while gathering sufficient counts to achieve a precision of ~±2% in a reasonable time.

A small flux gradient is often present in the irradiation facility over the length of the sample package (note that this developed only in late 1991, after extended refurbishment of the reactor, before which no detectable flux gradient was present). If a detectable gradient is present, the track count in the external detector adjacent to each standard glass is converted to a track density ρ_D and a value for each mount in the stack is calculated by

linear interpolation. When no detectable gradient is present, the track counts in the two external detectors are pooled to give a single value of ρ_D which is used to calculate fission track ages for each sample.

A Zeta calibration factor, ζ, has been determined empirically for each observer by analysing a set of carefully chosen age standards with independently known K-Ar ages, following the methods outlined by Hurford and Green (1983) and Green (1985).

All track counting is carried out using Zeiss(R) Axioplan microscopes, with an overall linear magnification of 1068 x using dry objectives.

For further details and background information on practical aspects of fission track age determination, see e.g. Fleischer, Price and Walker (1975), Naeser (1979) and Hurford (1986).

Track length measurements

For track length studies in apatite, the full lengths of 'confined' fission tracks are measured. Confined tracks are those which do not intersect the polished surface but have been etched from other tracks or fractures, so that the whole length of the track is etched. Confined track lengths are measured using a digitising tablet connected to a microcomputer, superimposed on the microscope field of view via a projection tube. With this system, calibrated against a stage graticule ruled in 2 μm divisions, individual tracks can be measured to a precision of ± 0.2 μm. Tracks are measured only in prismatic grains, characterised by sharp polishing scratches with well etched tracks of narrow cone angle in all orientations, because of the anisotropy of annealing of fission tracks in apatite (as discussed by Green et al., 1986). Tracks are also measured following the recommendations of Laslett et al. (1982), the most important of which is that only horizontal tracks should be measured. One hundred tracks are measured whenever possible. In apatite samples with low track density, or in those samples in which only a small number of apatite grains are obtained, fewer confined tracks may be available, and in such cases, the whole mount is scanned to measure as many confined tracks as possible.

Integrated fission track age and length measurement

Fission track age determination and length measurement are now made in a single pass of the grain mount, in an integrated approach. The location of each grain in which tracks are either counted or measured is recorded for future reference. Thus track length measurements can be tied to age determination in individual grains. As a routine procedure we do not measure the age of every grain in which lengths are determined, as

this would be much too time consuming. Likewise we do not only measure ages in grain in which lengths are measured, as this would bias the age data against low track density grains. Nevertheless, the ability to determine the fission track age of certain grains from which length data originate can be a particularly useful aid to interpretation in some cases. Grain location data are not provided in this report, but are available on request.

B.3 Data Presentation

Fission track age data

Data sheets summarising the apatite fission track age data, including full details of fission track age data for individual apatite grains in each sample, together with the primary counting results and statistical data, are given in the following pages. Individual grain fission track ages are calculated from the ratio of spontaneous to induced fission track counts for each grain using equation B.1, and errors in the single grain ages are calculated using Poissonian statistics, as explained in more detail by Galbraith (1981) and Green (1981). All errors are quoted as $\pm 1\sigma$ throughout this report, unless otherwise stated.

The variability of fission track ages between individual apatite grains within each sample can be assessed using a chi-squared (χ^2) statistic (Galbraith, 1981), the results of which are summarised for each sample in the data sheets. If all the grains counted belong to a single age population, then the probability of obtaining the observed χ^2 value, for ν degrees of freedom (where ν = number of crystals -1), is listed in the data sheets as $P(\chi^2)$ or P(chi squared).

A $P(\chi^2)$ value greater than 5% can be taken as evidence that all grains are consistent with a single population of fission track age. In this case, the best estimate of the fission track age of the sample is given by the "pooled age", calculated from the ratio of the total spontaneous and induced track counts in all grains analysed. Errors for the pooled age are calculated using the 'conventional' technique outlined by Green (1981), based on the total number of tracks counted for each track density measurement (see also Galbraith, 1981).

A $P(\chi^2)$ value of less than 5% denotes a significant spread of single grain ages, and suggests that real differences exist between the fission track ages of individual apatite grains. A significant spread in grain ages can result either from inheritance of detrital grains from mixed source areas (in sedimentary rocks), or from differential annealing in apatite grains of different composition, within a narrow range of temperature.

Calculation of the pooled age inherently assumes that only a single population of ages is present, and is thus not appropriate to samples containing a significant spread of fission track ages. In such cases Galbraith has recently devised a means of estimating the modal age of a distribution of single grain fission track ages which is referred to as the "central age". Calculation of the central age assumes that all single grain ages belong to a Normal distribution of ages with a standard deviation, σ, known as the "age dispersion". An iterative algorithm (as yet unpublished) is used to provide estimates of the central age with its associated error, and the age dispersion, which are all quoted in the data sheets. Note that this treatment replaces use of the "mean age" which has used been in the past for those samples in which $P(\chi^2)<5\%$. For samples in which $P(\chi^2)>5\%$, the central age and the pooled age should be equal, and the age dispersion should be less than ~10%.

Table B.1 summarises the fission track age data in apatite from each sample analysed.

Construction of radial plots of single grain age data

Single grain age data are best represented in the form of radial plot diagrams (Galbraith, 1988, 1990). As illustrated in Figure B.1, these plots display the variation of individual grain ages in a plot of y against x, where:

$$y = (z_j - z_o)/\sigma_i \qquad x = 1/\sigma_j \qquad \text{B.2}$$

and; z_j = fission track age of grain j

z_o = a reference age

σ_j = error in age for grain j

In this plot, all points on a straight line from the origin define a single value of fission track age, and at any point the value of x is a measure of the precision of each individual grain age. Therefore, precise individual grain ages fall to the right of the plot (small error, high x), which is useful, for example, in enabling precise, young grains to be identified. The age scale is shown radially around the perimeter of the plot (in Ma). If all grains belong to a single age population, all data should scatter between y = +2 and y = -2, equivalent to scatter within $\pm 2\sigma$. Scatter outside these boundaries shows a significant spread of individual grain ages, as also reflected in the values of $P(\chi^2)$ and age dispersion.

In detail, rather than using the fission track age for each grain as in equation B.2, we use:

$$z_j = \frac{N_{sj}}{N_{ij}} \qquad \sigma_j = \{1/N_{sj} + 1/N_{ij}\} \qquad \text{B.3}$$

as we are interested in displaying the scatter within the data from each sample in comparison with that allowed by the Poissonian uncertainty in track counts, without the additional terms which are involved in determination of the fission track age (ρ_D, ζ, etc).

Zero ages cannot be displayed in such a plot. This can be achieved using a modified plot, (Galbraith, 1990) with:

$$z_j = \arcsin\sqrt{\left\{\frac{N_{sj}+3/8}{N_{sj}+N_{ij}+3/4}\right\}} \qquad \sigma_j = \frac{1}{2}\sqrt{\left\{\frac{1}{N_{sj}+N_{ij}}\right\}} \qquad \text{B.4}$$

Note that the numerical terms in the equation for z_j are standard terms, introduced for statistical reasons. Using this arc-sin transformation, zero ages plot on a diagonal line which slopes from upper left to lower right. Note that this line does not go through the origin. Figure B.2 illustrates this difference between conventional and arc-sin radial plots, and also provides a simple guide to the structure of radial plots.

Use of arc-sin radial plots is particularly useful in assessing the relative importance of zero ages. For instance, grains with $N_s = 0$, $N_i = 1$ are compatible with ages up to ~900 Ma (at the 95% confidence level), whereas grains with $N_s = 0$, $N_i = 50$ are only compatible with ages up to ~14 Ma. The two data would readily be distinguishable on the radial plot as the 0,50 datum would plot well to the right (high x) compared to the 0,1 datum.

In this report the value of z corresponding to the fission track age of each sample is adopted as the reference value, z_o.

Note that the x axis of the radial plot is normally not labelled, as this would obscure the age scale around the plot. In general labelling is not considered necessary, as we are concerned only with relative variation within the data, rather than absolute values of precision.

Radial plots of the single grain age data in apatite from each sample analysed in this report are shown in Figure B.3.

Smoothed probability distributions

The single grain ages within each sample are also shown in Figure B.3 in histogram form and also as smoothed probability distributions (Hurford et al., 1984). In constructing these distributions, each grain is represented by a normal probability curve with mean equal to the single grain age, standard deviation given by the error on the single grain age, and the contributions from all grains analysed in each sample are summed to produce the plotted curve. These distributions are generally not as informative as the radial plot

presentation of single grain age data as they convey little assessment of the relative precision of the fission track ages of different grains. However they can be useful for portraying the general form of the distribution of ages within a sample.

Track length data

Distributions of confined track lengths in apatite from each sample are shown as simple histograms in Figure B.4. For every track length measurement the length is recorded to the nearest 0.1 μm, but the measurements have been group into 1 μm intervals in the histograms in Figure B.4. Each distribution has been normalised to 100 tracks for each sample to facilitate comparison. A summary of the length distribution in each sample is presented in Table B.2, which also shows the mean track length in each sample and its associated error, the standard deviation of each distribution, and the number of tracks (N) measured in each sample. The angle which each confined track makes with the crystallographic c-axis is also routinely recorded, as is the width of each fracture within which tracks are revealed. These data are not provided in this report, but can be supplied on request.

B.4 A note on terminology

Note that throughout this report, the term "fission track age" is understood to denote the parameter calculated from the fission track age equation, using the observed spontaneous and induced track counts (either pooled for all grains or for individual grains). The resulting number (with units of Ma) should not be taken as possessing any significance in terms of events taking place at the time indicated by the measured fission track age, but should rather be regarded as a measure of the integrated thermal history of the sample, and should be interpreted in that light. Use of the term "apparent age" is not considered to be useful in this regard, as almost every fission track age should be regarded as an apparent age, in the classic sense, and repeated use becomes cumbersome.

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Table B.1: Apatite fission track analytical results - samples from the Eringa Trough and Western Eromanga (Geotrack Report #550)

Sample number	Number of grains	Rho D x10⁶ (ND)	Rho S x10⁶ (Ns)	Rho I x10⁶ (Ni)	Uranium content (ppm)	P(chi squared) (%)	Age dispersion (%)	Fission track age (Ma)
AFMECO CUR-5								
GC550-1	4	1.256 (1975)	1.266 (145)	2.052 (235)	19	5	23	145.7 ± 15.9 *129.1 ± 22.7**
GC550-2	20	1.256 (1975)	1.964 (1634)	1.743 (1450)	16	2	15	263.7 ± 11.9 *268.4 ± 16.3**
AFMECO CUR-3								
GC550-3	19	1.256 (1975)	2.743 (1431)	2.155 (1124)	20	<1	20	297.1 ± 14.3 *286.0 ± 21.2**
Mt Hammersley-1								
GC550-4	5	1.198 (1856)	3.082 (256)	2.444 (203)	23	12	<1	290.1 ± 28.6
GC550-5	8	1.186 (1856)	2.274 (465)	1.858 (380)	18	21	<1	278.9 ± 21.0
GC550-6			No apatite					
GC550-7	20	1.174 (1856)	2.284 (1669)	2.908 (2125)	28	<1	49	178.6 ± 7.9 *204.8 ± 24.7**
GC550-8	20	1.162 (1856)	0.540 (334)	1.115 (690)	11	<1	66	109.6 ± 8.0 *101.6 ± 17.8**
GC550-9	20	1.150 (1856)	1.037 (519)	1.391 (696)	14	<1	60	166.3 ± 10.9 *158.2 ± 25.2**
Purni-1								
GC550-10	13	1.255 (1975)	0.515 (177)	0.832 (286)	8	61	<1	146.0 ± 14.5
GC550-11	3	1.306 (1958)	2.747 (242)	2.962 (261)	26	1	23	226.2 ± 21.1 *235.0 ± 37.8**
Mt Crispe-1								
GC550-12	2	1.292 (1958)	0.540 (18)	1.619 (54)	14	34	<1	81.4 ± 22.3
GC550-13	9	1.279 (1958)	3.402 (668)	3.662 (719)	33	<1	31	222.1 ± 13.4 *232.7 ± 32.6**
GC550-14	1	1.251 (1958)	3.011 (36)	8.280 (99)	75	-	-	86.0 ± 16.9
GC550-15	20	1.238 (1958)	4.020 (468)	3.513 (409)	32	63	1	263.9 ± 19.2
GC550-16	6	1.225 (1958)	5.103 (228)	5.640 (252)	53	94	<1	207.4 ± 19.8
GC550-17	12	1.197 (1958)	2.754 (565)	2.915 (598)	28	<1	31	211.6 ± 13.7 *226.6 ± 26.9**

Rho S = spontaneous track density; Rho I = induced track density; Rho D = track density in glass standard external detector.
All track densities quoted in units of 1000000 tracks per square cm. Brackets show number of tracks counted.
Rho D and Rho I measured in mica external detectors; Rho S measured in internal surfaces.
* Central age, used where sample contains a significant spread of single grain ages—P(chi squared)<5%. Errors quoted at ±1 sigma.
Ages calculated using dosimeter glass CN5, with a zeta of 380.4±5.7 (Analyst: C. O'Brien) for samples 1-3, 10-17
392.9±7.4 (Analyst: M. Moore) for samples 4-9

Table B.2: Length distribution summary data - samples from the Eringa Trough and Western Eromanga (Geotrack Report #550)

Sample number	Mean track length (μm)	Standard deviation (μm)	Number of tracks (N)	Number of Tracks in Length Intervals (μm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
AFMECO CUR-5																							
GC550-1	11.84 ± 0.68	1.81	7	-	-	-	-	-	-	-	-	1	-	-	2	2	2	-	-	-	-	-	-
GC550-2	13.02 ± 0.09	0.95	104	-	-	-	-	-	-	-	-	-	-	1	18	34	32	19	-	-	-	-	-
AFMECO CUR-3																							
GC550-3	13.20 ± 0.13	1.25	100	-	-	-	-	-	-	-	-	-	-	5	11	23	35	19	6	1	-	-	-
Mt Hammersley-1																							
GC550-4	12.07 ± 0.34	1.61	22	-	-	-	-	-	-	-	-	2	-	2	4	9	4	1	-	-	-	-	-
GC550-5	12.26 ± 0.26	1.28	25	-	-	-	-	-	-	-	-	-	1	3	7	6	6	2	-	-	-	-	-
GC550-6	No apatite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GC550-7	10.49 ± 0.16	1.59	104	-	-	-	-	-	-	-	5	15	22	25	21	10	3	1	2	-	-	-	-
GC550-8	9.65 ± 0.23	2.36	102	-	1	-	1	3	3	6	7	13	17	22	17	6	3	3	-	-	-	-	-
GC550-9	10.20 ± 0.30	2.36	62	-	-	-	-	3	-	4	1	12	5	8	14	10	4	-	1	-	-	-	-
Purni-1																							
GC550-10	14.70 ± 0.33	1.62	24	-	-	-	-	-	-	-	-	1	-	-	-	2	1	8	8	4	-	-	-
GC550-11	10.02 ± 0.20	0.94	23	-	-	-	-	-	-	-	-	2	13	4	4	-	-	-	-	-	-	-	-
Mt Crispe-1																							
GC550-12	No confined tracks		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GC550-13	11.82 ± 0.30	1.57	28	-	-	-	-	-	-	-	1	-	4	1	10	5	5	2	-	-	-	-	-
GC550-14	No confined tracks		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GC550-15	11.31 ± 0.24	1.37	32	-	-	-	-	-	-	-	-	1	2	11	8	7	2	-	1	-	-	-	-
GC550-16	10.51 ± 0.34	0.84	6	-	-	-	-	-	-	-	-	-	2	2	2	-	-	-	-	-	-	-	-
GC550-17	11.57 ± 0.24	1.54	41	-	-	-	-	-	-	-	-	3	3	9	9	9	5	3	-	-	-	-	-

Track length measurements by C. O'Brien for samples 1-3
10-17
M. Moore for samples 4-9

Table B.3: AFTA Data in Compositional Groups - (Geotrack Report #550)

Cl	Default fission track age*	Measured fission track age	Error in age	P (χ 2)	Number of grains	Default fission track length*	Mean track length	Error in length	Std deviation	Number of lengths	Number of grains	Number of tracks in length interval																	
												1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Wt %	(Ma)	(Ma)	(Ma)			(μm)	(μm)	(μm)	(μm)			(μm)																			
AFMECO CUR-5																													
†550-1	**163.1**	**129.1**	**22.4**	**5.0**	**4**	**14.2**	**11.8**	**0.7**	**1.8**	**7**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	162.8	128.4	28.8	3.0	3	14.2	11.8	0.7	1.8	7	3	0	0	0	0	0	0	0	0	1	0	0	2	2	2	0	0	0	0	0	0
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	164.0	108.6	39.6	100.0	1	14.3	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
†550-2	**1005.8**	**268.4**	**14.5**	**2.0**	**20**	**13.7**	**13.0**	**0.1**	**1.0**	**104**	**11**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**18**	**34**	**32**	**19**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	1005.2	263.3	15.7	2.0	18	13.7	13.0	0.1	1.0	78	9	0	0	0	0	0	0	0	0	0	0	1	15	26	20	16	0	0	0	0	0
0.1-0.2	1010.8	307.0	29.9	51.0	2	13.7	13.1	0.2	0.9	26	2	0	0	0	0	0	0	0	0	0	0	0	3	8	12	3	0	0	0	0	0
AFMECO CUR-3																													
†550-3	**1003.3**	**286.0**	**19.7**	**0.0**	**19**	**13.6**	**13.2**	**0.1**	**1.3**	**100**	**25**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**11**	**23**	**35**	**19**	**6**	**1**	**0**	**0**	**0**
0.0-0.1	1001.1	270.3	14.3	15.0	14	13.5	13.1	0.1	1.3	81	20	0	0	0	0	0	0	0	0	0	0	5	11	18	24	17	5	1	0	0	0
0.1-0.2	1007.1	380.3	55.4	1.0	3	13.6	13.5	0.2	0.8	18	4	0	0	0	0	0	0	0	0	0	0	0	0	5	11	1	1	0	0	0	0
0.2-0.3	1013.0	207.4	73.6	31.0	2	13.7	14.0	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Mt Hammersley-1																													
†550-4	**133.7**	**290.1**	**28.0**	**12.0**	**5**	**13.8**	**12.1**	**0.3**	**1.6**	**22**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**	**4**	**9**	**4**	**1**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	133.7	290.1	28.0	12.0	5	13.8	12.1	0.3	1.6	22	5	0	0	0	0	0	0	0	0	2	0	2	4	9	4	1	0	0	0	0	0
†550-5	**163.2**	**278.9**	**20.3**	**21.0**	**8**	**13.4**	**12.3**	**0.3**	**1.3**	**25**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**7**	**6**	**6**	**2**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	161.9	259.9	24.1	36.0	5	13.3	12.8	0.3	0.9	12	3	0	0	0	0	0	0	0	0	0	0	0	2	5	4	1	0	0	0	0	0
0.1-0.2	163.0	354.3	61.7	100.0	1	13.4	11.7	0.4	1.5	11	1	0	0	0	0	0	0	0	0	0	1	3	4	0	2	1	0	0	0	0	0
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	166.2	291.0	41.5	100.0	1	13.7	12.0	0.6	0.8	2	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
0.5-0.6	167.0	58.0	64.8	100.0	1	13.8	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
†550-7	**210.1**	**204.8**	**24.0**	**0.0**	**20**	**11.0**	**10.5**	**0.2**	**1.6**	**104**	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**15**	**22**	**25**	**21**	**10**	**3**	**1**	**2**	**0**	**0**	**0**	**0**
0.0-0.1	206.4	166.2	27.6	0.0	12	10.8	10.4	0.2	1.5	50	12	0	0	0	0	0	0	0	3	8	7	17	8	6	0	0	1	0	0	0	0
0.1-0.2	212.2	273.3	34.5	1.0	5	11.0	10.4	0.3	1.5	27	4	0	0	0	0	0	0	0	2	4	6	3	9	2	1	0	0	0	0	0	0
0.2-0.3	217.8	266.4	41.4	32.0	2	11.3	10.4	0.5	1.9	17	2	0	0	0	0	0	0	0	0	3	6	4	2	0	1	0	1	0	0	0	0
0.3-0.4	223.3	0.0	0.0	0.0	0	11.6	9.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0.4-0.5	228.0	293.7	32.0	100.0	1	11.9	11.8	0.5	1.5	9	1	0	0	0	0	0	0	0	0	0	2	1	2	2	1	1	0	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)

† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #550)

Cl	Default fission track age*	Measured fission track age	Error in age	P (χ 2)	Number of grains	Default fission track length*	Mean track length	Error in length	Std deviation	Number of lengths	Number of grains	Number of tracks in length interval																			
												1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Wt %	(Ma)	(Ma)	(Ma)			(μm)	(μm)	(μm)	(μm)			(μm)																			
†550-8	142.5	101.6	17.5	0.0	20	10.1	9.7	0.2	2.4	102	32	0	1	0	1	3	3	6	7	13	17	22	17	6	3	3	0	0	0	0	0
0.0-0.1	125.1	67.5	11.2	0.0	14	9.5	8.7	0.4	2.4	42	17	0	1	0	0	3	3	2	4	5	10	6	7	1	0	0	0	0	0	0	0
0.1-0.2	156.0	247.2	35.3	46.0	3	9.8	9.8	0.6	2.6	20	6	0	0	0	1	0	0	1	3	2	3	5	1	2	1	1	0	0	0	0	0
0.2-0.3	183.1	64.9	52.0	100.0	1	10.2	10.3	0.5	2.0	19	4	0	0	0	0	0	0	2	0	3	3	5	3	1	1	1	0	0	0	0	0
0.3-0.4	205.8	0.0	0.0	0.0	0	10.7	10.8	0.8	1.1	2	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
0.4-0.5	213.0	0.0	0.0	0.0	0	11.0	11.2	0.3	0.5	3	1	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0
0.5-0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6-0.7	221.2	208.0	41.1	100.0	1	11.4	11.0	0.8	2.0	6	1	0	0	0	0	0	0	0	0	1	1	0	2	1	1	0	0	0	0	0	0
0.7-0.8	225.1	327.2	103.1	100.0	1	11.6	10.8	0.9	2.3	7	1	0	0	0	0	0	0	1	0	0	0	3	1	1	0	1	0	0	0	0	0
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	230.2	0.0	0.0	0.0	0	11.9	9.3	0.7	1.2	3	1	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0
†550-9	158.2	158.2	24.8	0.0	20	9.2	10.2	0.3	2.4	62	18	0	0	0	0	3	0	4	1	12	5	8	14	10	4	0	1	0	0	0	0
0.0-0.1	133.5	108.1	18.4	0.0	13	9.1	9.7	0.4	2.5	34	11	0	0	0	0	2	0	4	1	7	2	7	5	3	3	0	0	0	0	0	0
0.1-0.2	190.6	332.3	34.8	7.0	6	9.4	10.9	0.4	2.1	28	7	0	0	0	0	1	0	0	0	5	3	1	9	7	1	0	1	0	0	0	0
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	284.2	303.4	141.1	100.0	1	10.3	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Purni-1																															
†550-10	90.2	146.0	14.3	61.0	13	14.6	14.7	0.3	1.6	24	13	0	0	0	0	0	0	0	0	1	0	0	0	2	1	8	8	4	0	0	0
0.0-0.1	88.4	0.0	0.0	0.0	0	14.3	13.0	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	89.0	118.2	26.1	100.0	1	14.4	8.8	0.0	0.0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0.3-0.4	89.3	188.2	126.3	100.0	1	14.5	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.4-0.5	89.6	172.7	39.8	100.0	1	14.5	14.0	0.9	1.2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0.5-0.6	89.8	47.6	30.1	18.0	2	14.6	14.7	0.5	0.7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
0.6-0.7	90.0	176.6	55.2	100.0	1	14.6	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.7-0.8	90.2	162.0	36.8	100.0	1	14.6	16.0	0.3	0.7	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	0
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0-1.1	90.6	150.1	72.7	17.0	2	14.7	14.1	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1.1-1.2	90.6	191.1	71.5	77.0	2	14.7	16.1	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1.2-1.3	90.7	0.0	0.0	0.0	0	14.7	14.9	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1.3-1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.4-1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5-1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)

† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #550)

Cl	Default fission track age*	Measured fission track age	Error in age	P (χ 2)	Number of grains	Default fission track length*	Mean track length	Error in length	Std deviation	Number of lengths	Number of grains	Number of tracks in length interval																			
												1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Wt %	(Ma)	(Ma)	(Ma)			(µm)	(µm)	(µm)	(µm)			(µm)																			
1.6-1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.7-1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.8-1.9	90.9	114.5	36.1	100.0	1	14.7	13.5	0.6	0.9	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
1.9-2.0	91.0	0.0	0.0	0.0	0	14.7	15.4	0.3	0.4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
2.0-2.1	91.0	0.0	0.0	0.0	0	14.8	15.2	0.3	0.6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0
2.1-2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.2-2.3	91.1	162.5	47.4	100.0	1	14.8	14.9	0.2	0.3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
†550-11	**140.2**	**235.0**	**37.3**	**1.0**	**3**	**11.0**	**10.0**	**0.2**	**0.9**	**23**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**13**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	139.0	278.2	33.0	27.0	2	10.9	10.0	0.3	1.1	14	3	0	0	0	0	0	0	0	0	2	7	2	3	0	0	0	0	0	0	0	0
0.1-0.2	142.6	167.4	24.0	100.0	1	11.2	10.1	0.3	0.8	9	1	0	0	0	0	0	0	0	0	0	6	2	1	0	0	0	0	0	0	0	0
Mt Crispe-1																															
†550-12	**134.9**	**81.4**	**22.2**	**34.0**	**2**	**14.3**	**10.3**	**0.0**	**0.0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	133.9	72.8	22.2	100.0	1	14.1	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	136.0	138.9	87.1	100.0	1	14.3	10.3	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
†550-13	**426.7**	**232.6**	**32.0**	**0.0**	**9**	**12.5**	**11.8**	**0.3**	**1.6**	**28**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**4**	**1**	**10**	**5**	**5**	**2**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	420.7	187.9	13.2	6.0	5	12.3	11.7	0.4	1.8	21	4	0	0	0	0	0	0	0	1	0	4	1	7	1	5	2	0	0	0	0	0
0.1-0.2	426.2	305.3	154.0	100.0	1	12.4	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.2-0.3	431.6	264.7	35.6	100.0	1	12.6	11.8	0.3	0.5	4	1	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0
0.3-0.4	437.1	382.1	75.5	100.0	1	12.7	13.0	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0.4-0.5	442.0	335.6	63.7	100.0	1	12.9	12.3	0.1	0.1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
†550-14	**417.4**	**86.0**	**16.8**	**100.0**	**1**	**12.2**	**12.0**	**0.0**	**0.0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	417.4	86.0	16.8	100.0	1	12.2	12.0	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

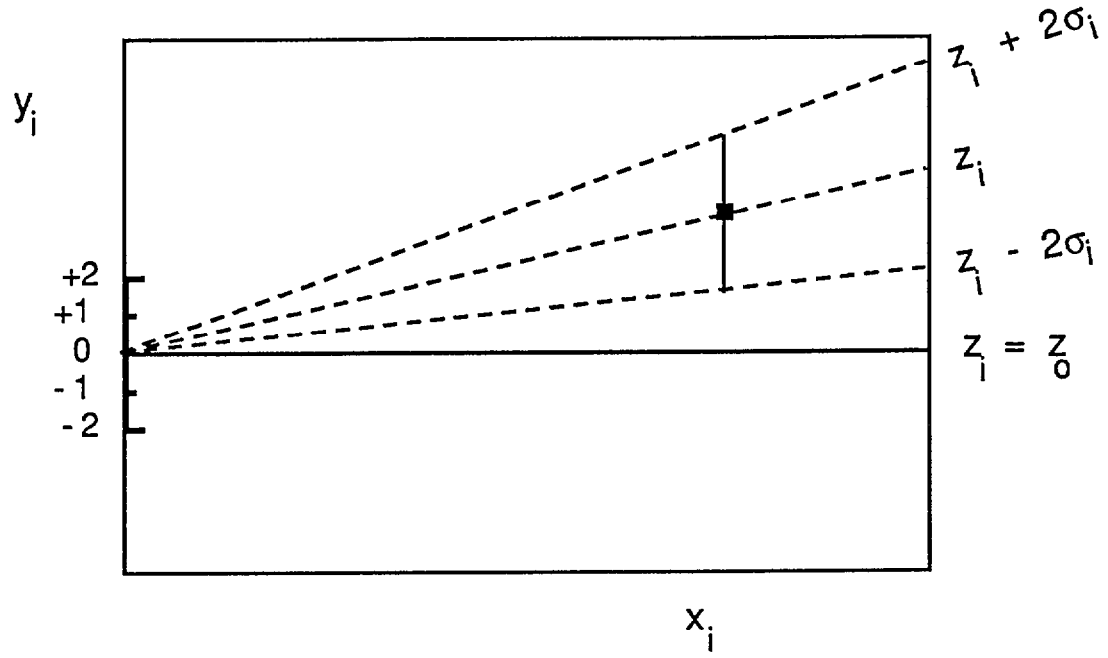
Table B.3: Continued - (Geotrack Report #550)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (μm)	Mean track length (μm)	Error in length (μm)	Std deviation (μm)	Number of lengths	Number of grains	Number of tracks in length interval 1 (μm)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
†550-15	**380.8**	**263.9**	**18.8**	**63.0**	**20**	**11.2**	**11.3**	**0.2**	**1.4**	**32**	**15**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**11**	**8**	**7**	**2**	**0**	**1**	**0**	**0**	**0**	**0**
0.0-0.1	379.9	261.1	19.1	59.0	19	11.0	11.3	0.3	1.4	29	13	0	0	0	0	0	0	0	0	1	2	9	8	7	1	0	1	0	0	0	0
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	398.2	313.3	88.2	100.0	1	11.6	12.1	1.2	1.7	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.5-0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0-1.1	436.4	0.0	0.0	0.0	0	12.7	10.4	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
†550-16	**303.7**	**207.3**	**19.5**	**94.0**	**6**	**10.1**	**10.5**	**0.3**	**0.8**	**6**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	296.6	210.6	38.9	88.0	5	9.9	10.5	0.6	1.0	3	2	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
0.1-0.2	339.0	206.2	22.2	100.0	1	10.3	10.5	0.5	0.8	3	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
†550-17	**173.6**	**226.6**	**26.2**	**0.0**	**12**	**9.2**	**11.6**	**0.2**	**1.5**	**41**	**11**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**3**	**9**	**9**	**9**	**5**	**3**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	163.1	244.5	26.5	1.0	11	9.1	11.7	0.3	1.6	35	10	0	0	0	0	0	0	0	0	3	1	7	7	9	5	3	0	0	0	0	0
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	288.8	143.3	15.5	100.0	1	9.9	10.5	0.4	0.9	6	1	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

Estimates	z_i
Standard errors	σ_i
Reference value	z_o
Standardised estimates	$y_i = (z_i - z_o) / \sigma_i$
Precision	$x_i = 1 / \sigma_i$

PLOT y_i against x_i



Slope of line from origin through data point $= y_i / x_i$

$= \{(z_i - z_o)/\sigma_i\} / \{1/\sigma_i\}$

$= z_i - z_o$

Key Points:

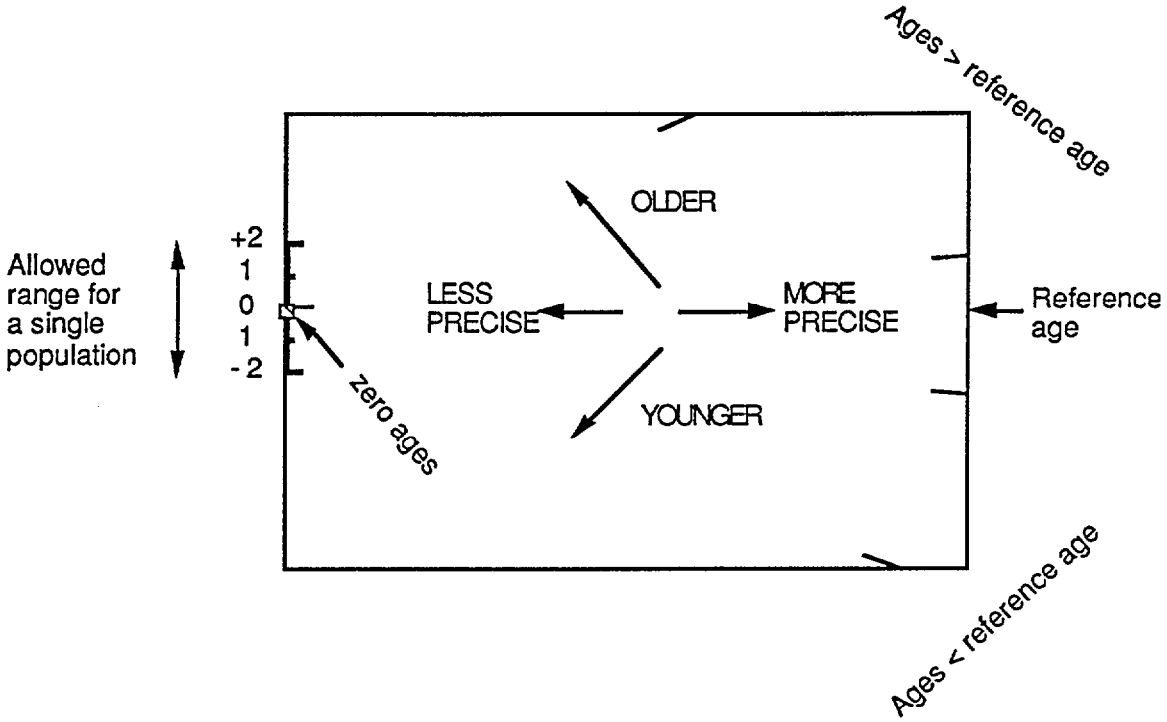
Radial lines emanating from the origin correspond to fixed values of z

Data points with higher values of x_i have greater precision.

Error bars on all points are the same size in this plot.

Figure B.1 Basic construction of a radial plot. In AFTA, the estimates z_i correspond to the fission track age values for individual apatite grains. Any convenient value of age can be chosen as the reference value corresponding to the horizontal in the radial plot. Radial lines emanating from the origin with positive slopes correspond to fission track ages greater than the reference value. Lines with negative slopes correspond to fission track ages less than the reference value.

Normal radial plot (equations B.2 and B.3)



Arc-sin radial plot (equations B.2 and B.4)

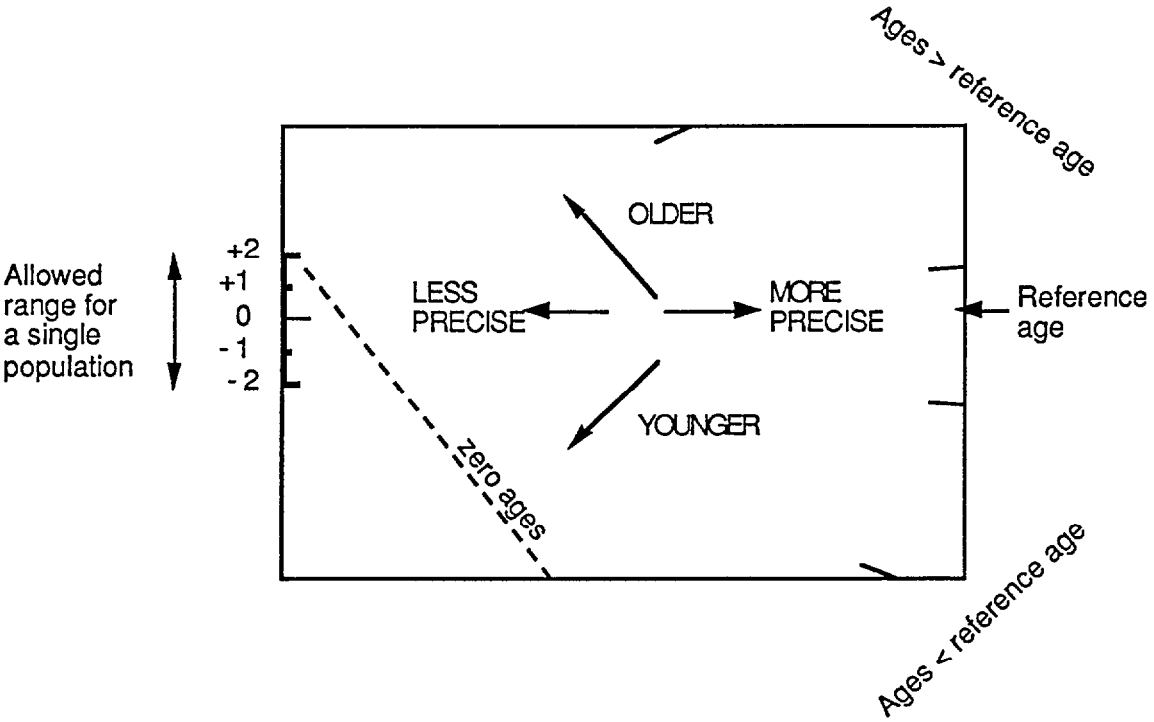
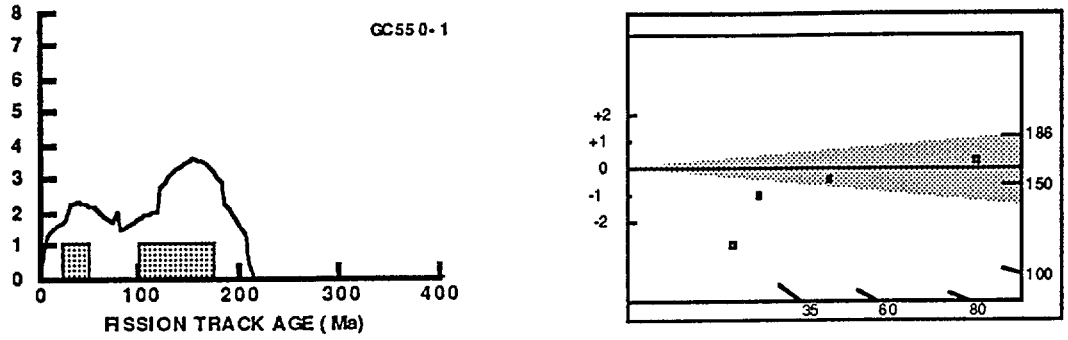


Figure B.2 Simplified structure of Normal and Arc-sin radial plots.

GC550-1



GC550-2

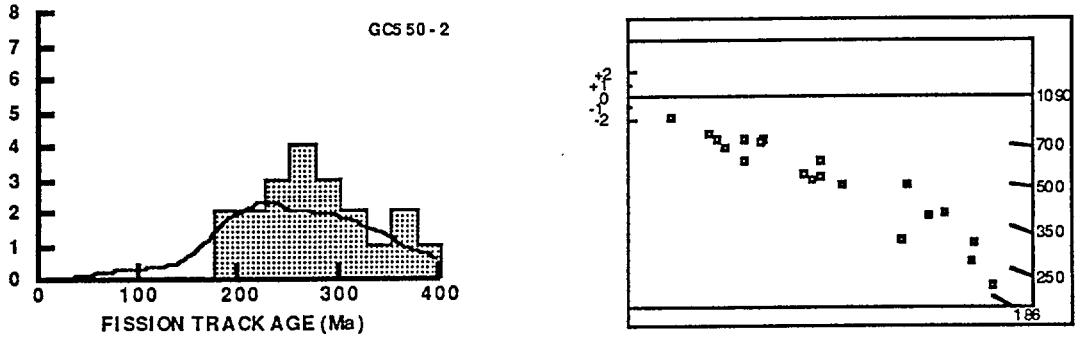


Figure B.3a: Single grain age figures for samples from **well AFMECO-CUR 5, Eringa Trough and Western Eromanga.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC550-3

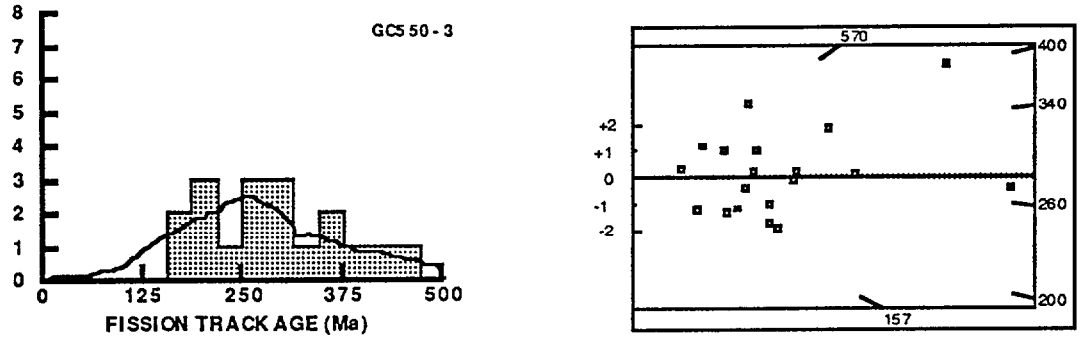
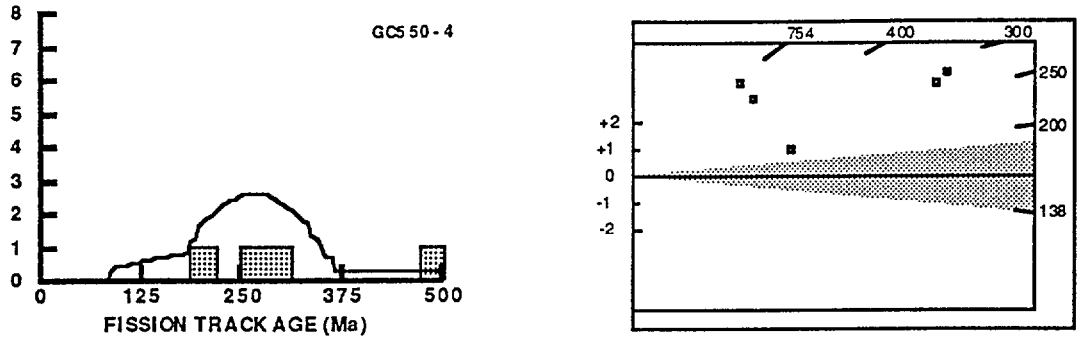
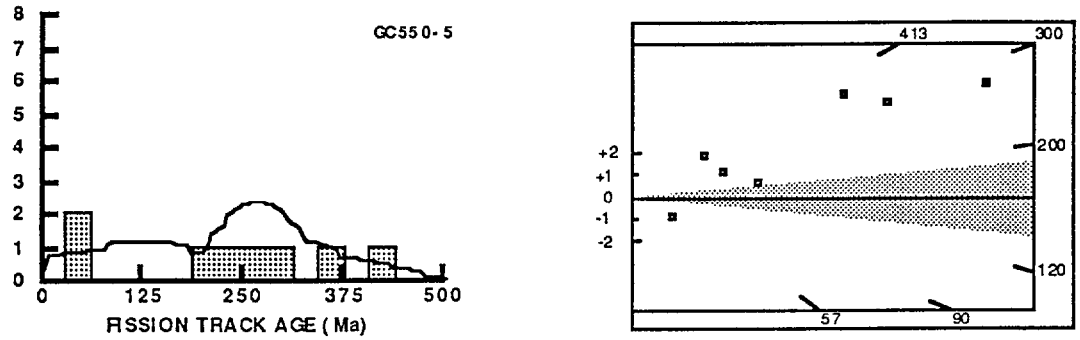


Figure B.3b: Single grain age figures for samples from **well AFMECO-CUR 3, Eringa Trough and Western Eromanga.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC550-4



GC550-5



GC550-6

No Apatite

GC550-7

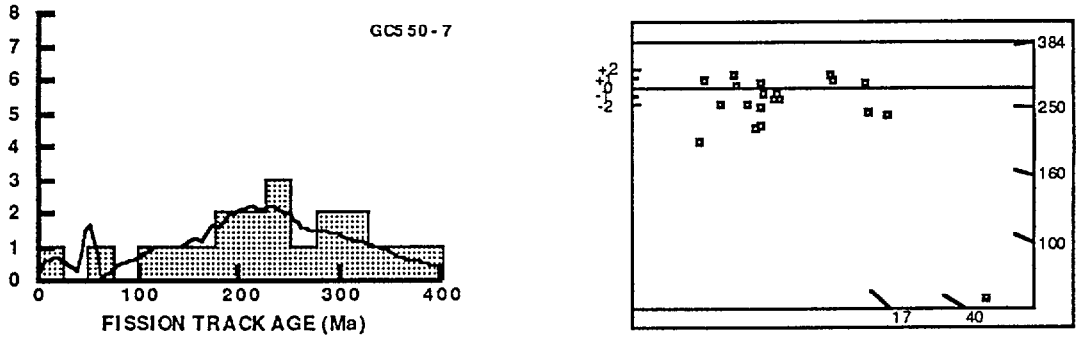
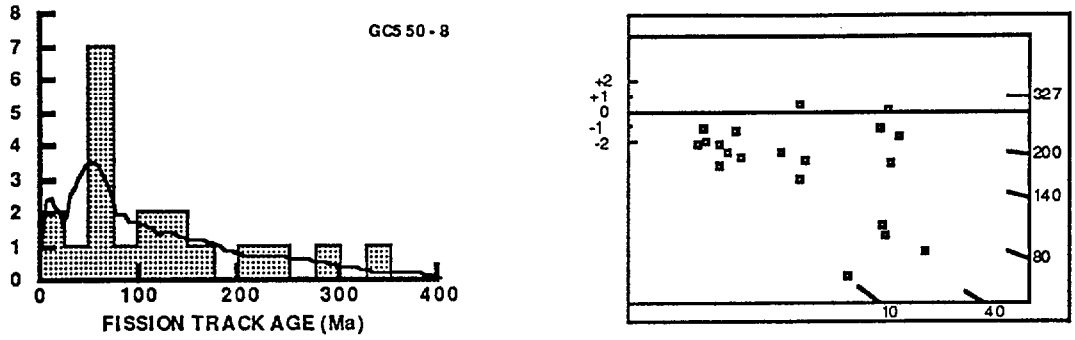


Figure B.3c: Single grain age figures for samples from **well Mt Hammersley-1, Eringa Trough and Western Eromanga.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC550-8



GC550-9

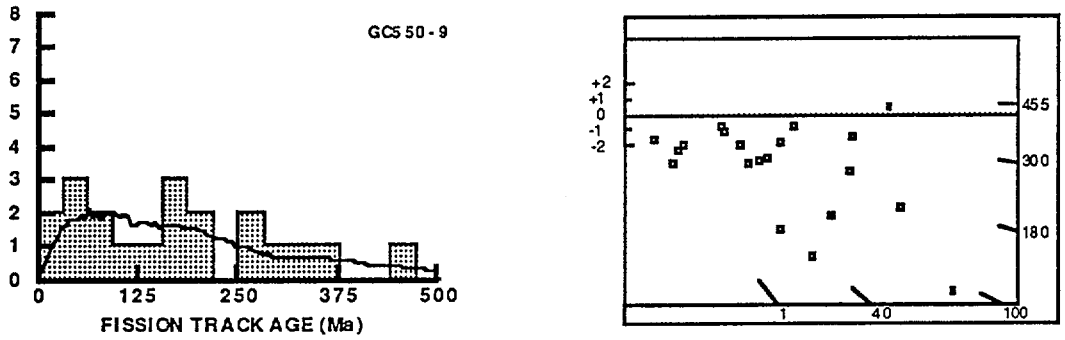
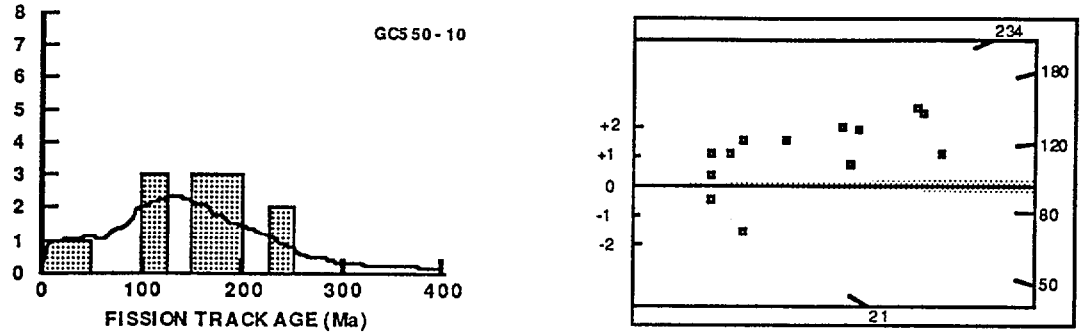


Figure B.3c: Continued

GC550-10



GC550-11

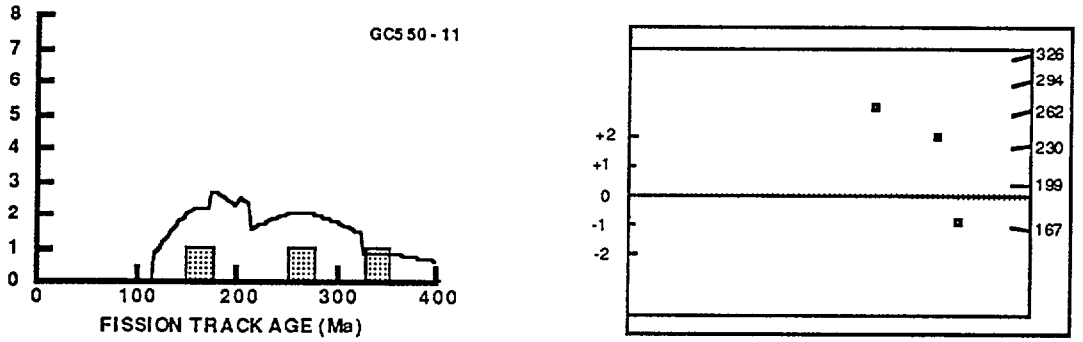
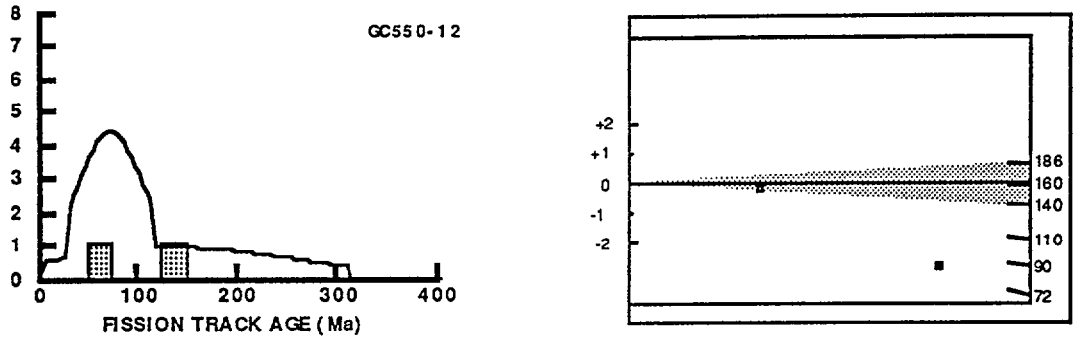
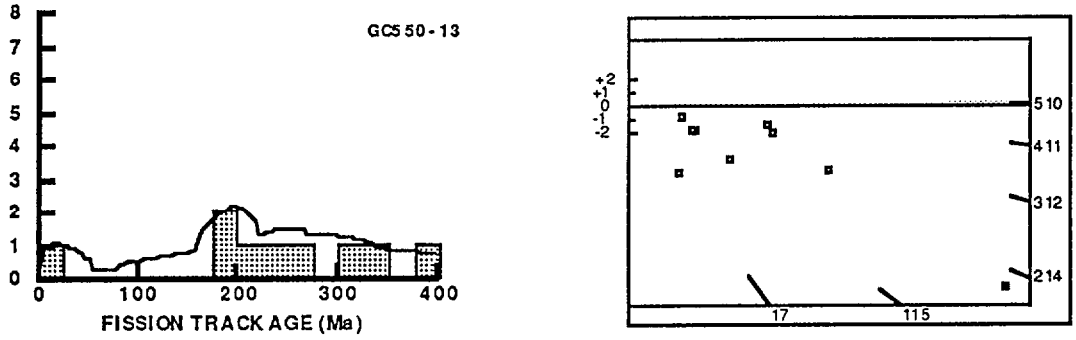


Figure B.3d: Single grain age figures for samples from **well Purni-1, Eringa Trough and Western Eromanga.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

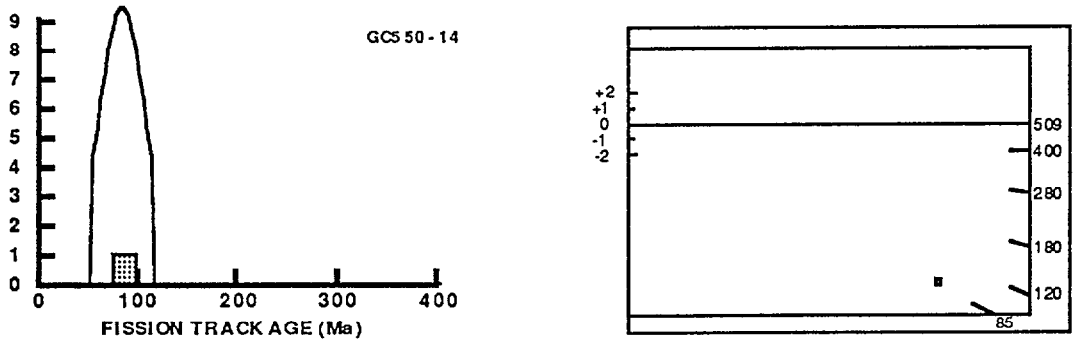
GC550-12



GC550-13



GC550-14



GC550-15

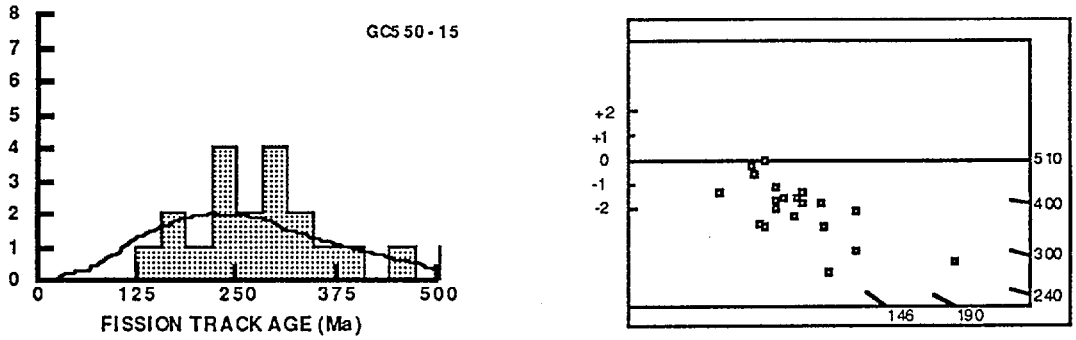
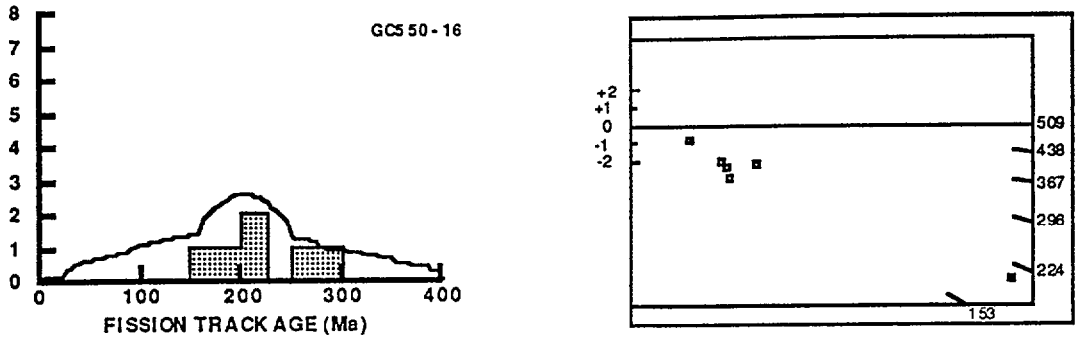


Figure B.3e: Single grain age figures for samples from **well Mt Crispe-1, Eringa Trough and Western Eromanga.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC550-16



GC550-17

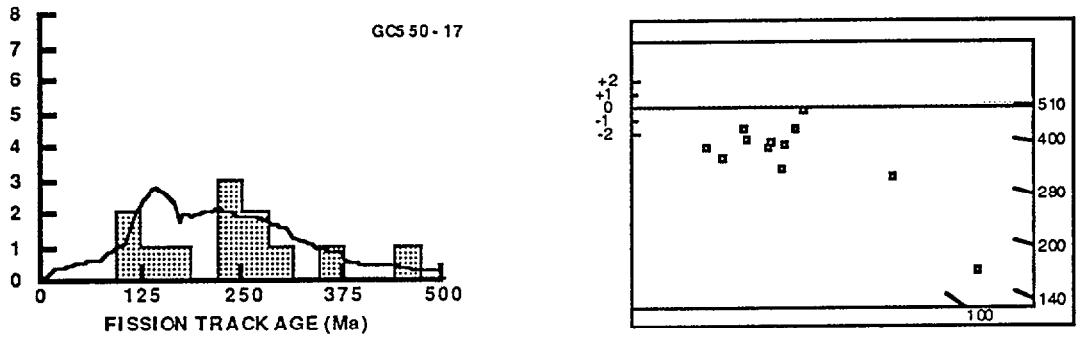
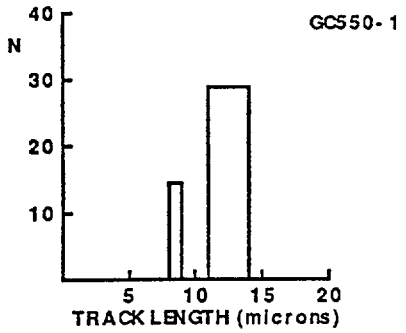


Figure B.3e: Continued.

GC550-1



GC550-2

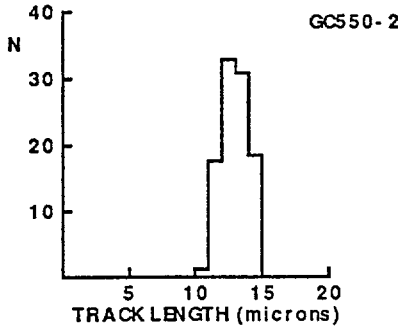


Figure B.4a: Distributions of confined track lengths in well samples from **AFMECO CUR-5, Eringa Trough and Western Eromanga.**

GC550-3

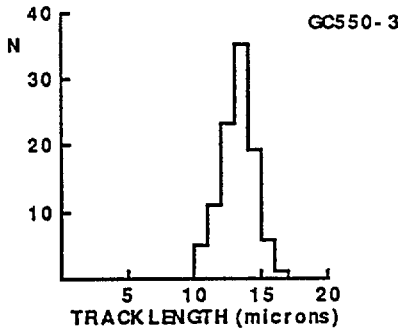
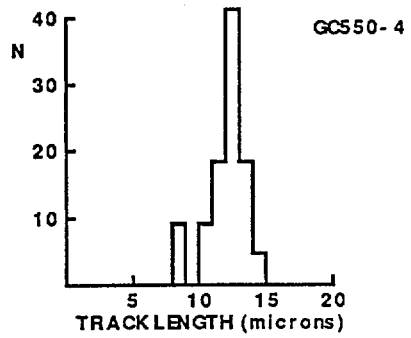
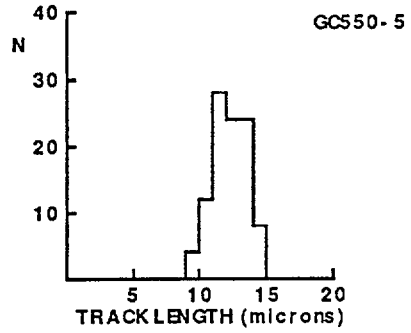


Figure B.4b: Distributions of confined track lengths in well samples from **AFMECO CUR-3, Eringa Trough and Western Eromanga.**

GC550-4



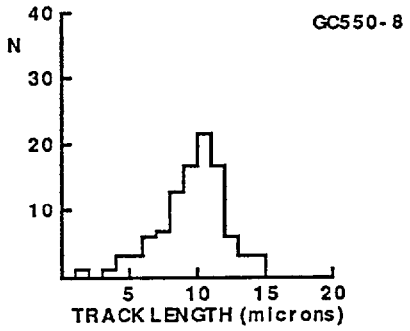
GC550-5



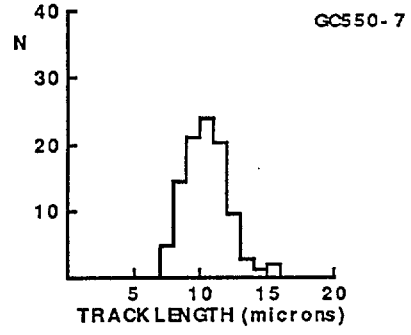
GC550-6

No Apatite

GC550-8



GC550-7



GC550-9

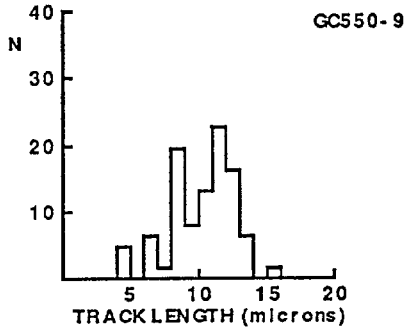
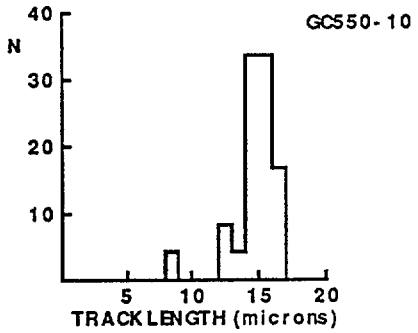


Figure B.4c: Distributions of confined track lengths in well samples from Mt Hammersley-1, Eringa Trough and Western Eromanga.

GC550-10



GC550-11

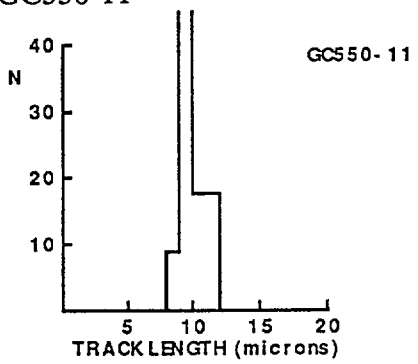
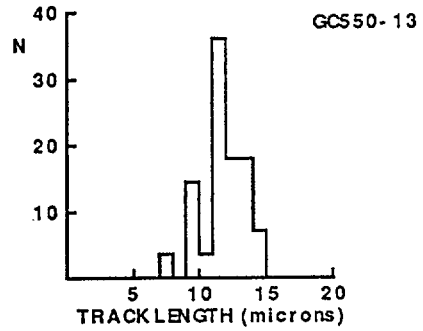


Figure B.4d: Distributions of confined track lengths in well samples from **Purni-1, Eringa Trough and Western Eromanga.**

GC550-12

No Confined Tracks

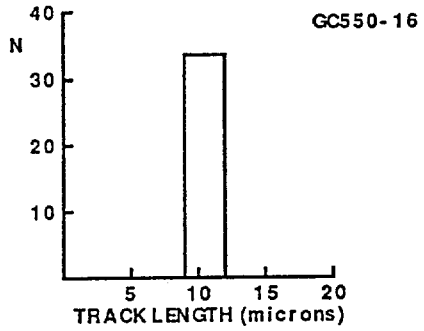
GC550-13



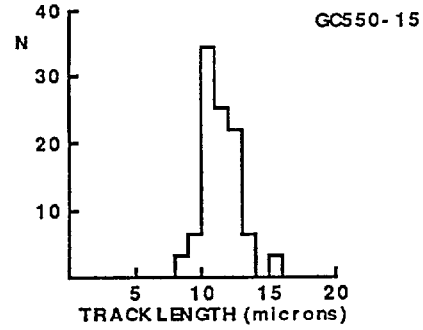
GC550-14

No Confined Tracks

GC550-16



GC550-15



GC550-17

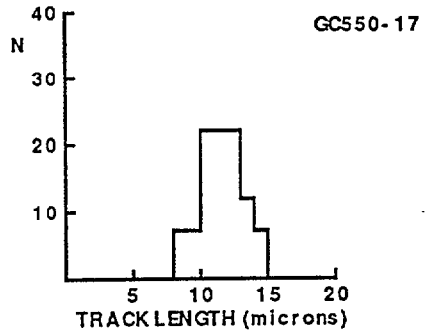
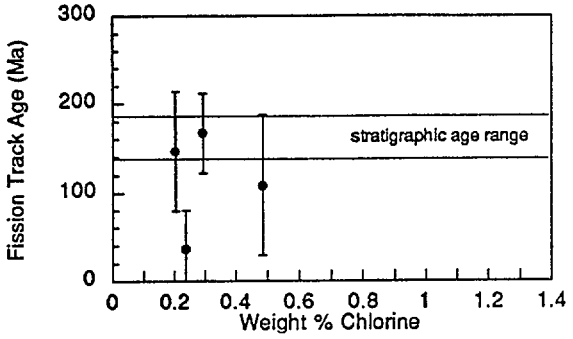


Figure B.4e: Distributions of confined track lengths in well samples from **Mt Crispe-1, Eringa Trough and Western Eromanga.**

GC550-1



GC550-2

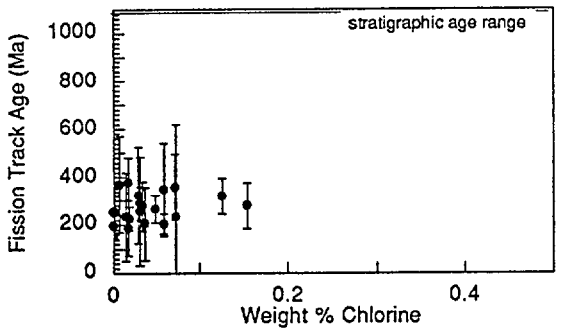


Figure B.5a: Plots of single grain age against weight percent chlorine for samples from well AFMECO CUR-5, Eringa Trough and Western Eromanga

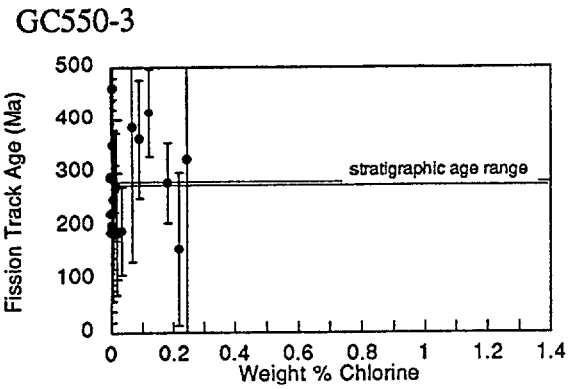
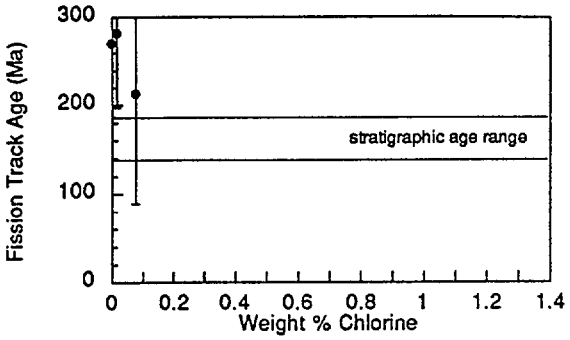
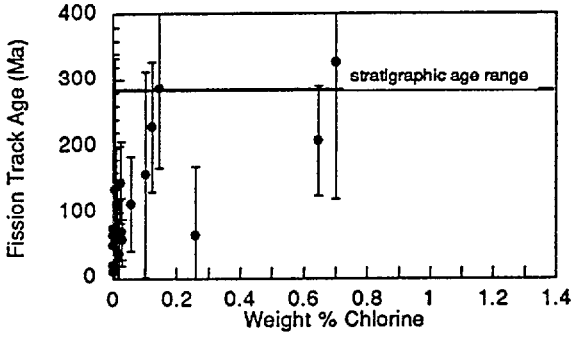


Figure B.5b: Plots of single grain age against weight percent chlorine for samples from well AFMECO CUR-3, Eringa Trough and Western Eromanga.

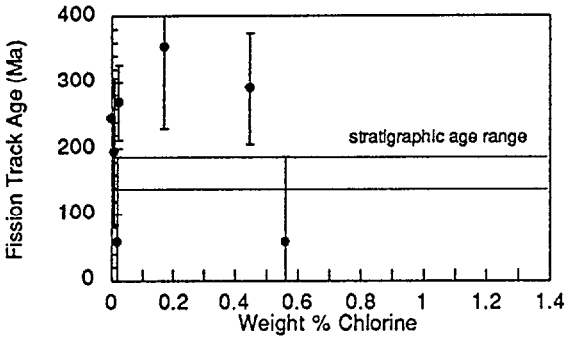
GC550-4



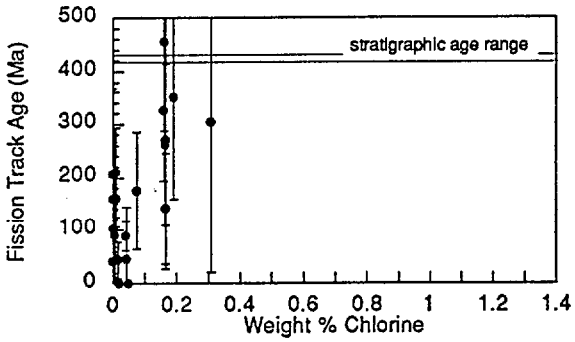
GC550-8



GC550-5



GC550-9



GC550-6

No Apatite

GC550-7

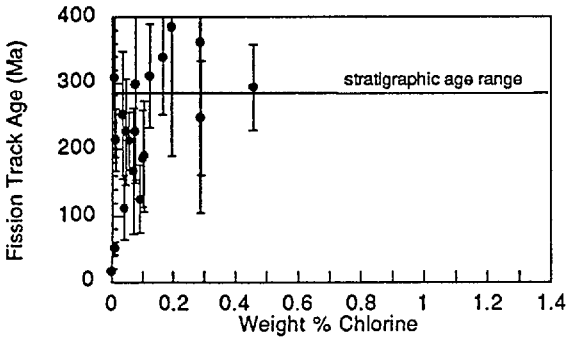
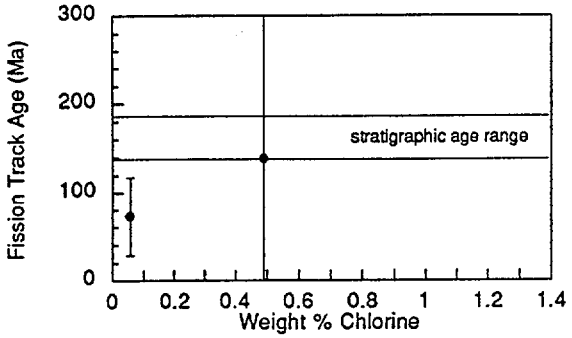
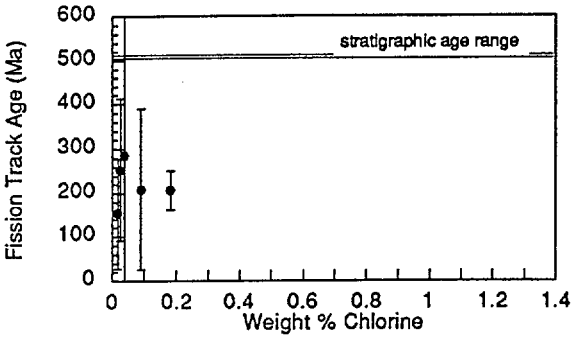


Figure B.5c: Plots of single grain age against weight percent chlorine for samples from well Mt Hammersley-1, Eringa Trough and Western Eromanga.

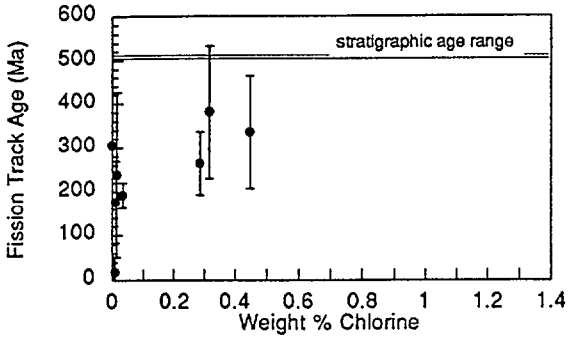
GC550-12



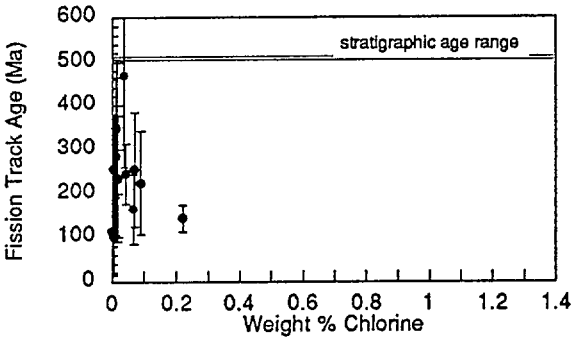
GC550-16



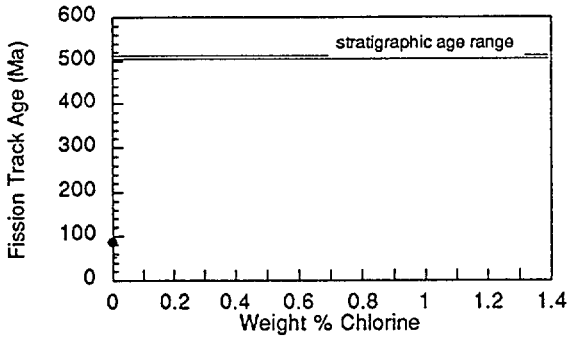
GC550-13



GC550-17



GC550-14



GC550-15

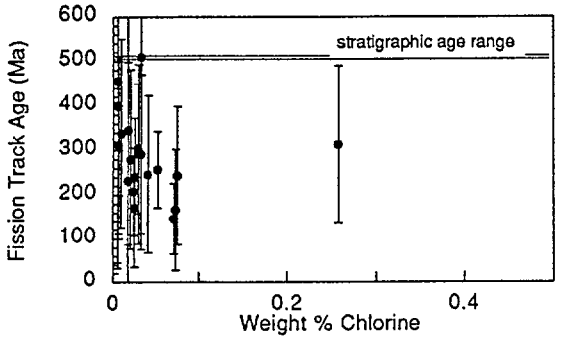
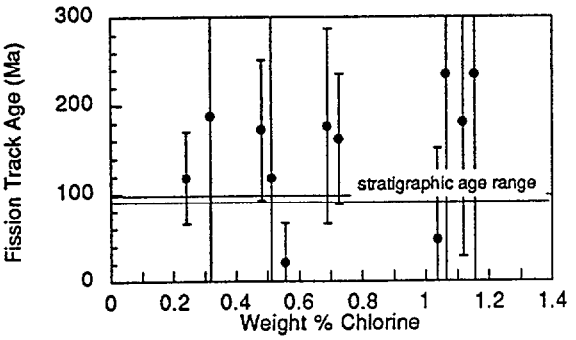


Figure B.5d: Plots of single grain age against weight percent chlorine for samples from well Purni-1, Eringa Trough and Western Eromanga.

GC550-10



GC550-11

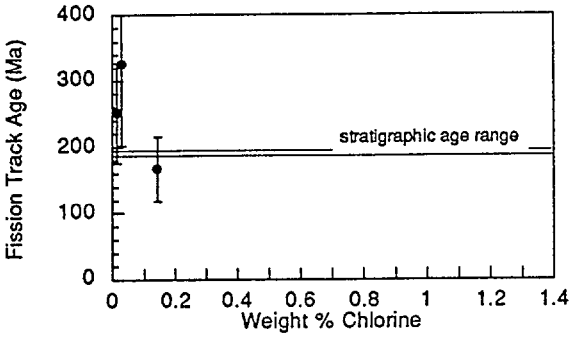


Figure B.5e: Plots of single grain age against weight percent chlorine for samples from well Mt Crispe-1, Eringa Trough and Western Eromanga.

Fission Track Age Data Sheets - Glossary

Ns	=	Number of spontaneous tracks in Na grid squares
Ni	=	Number of induced tracks in Na grid squares
Na	=	Number of grid squares counted in each grain
RATIO	=	Ns/Ni
U (ppm)	=	Uranium content of each grain (= U content of standard glass * $\rho i/\rho_D$)
Cl (wt%)	=	Weight percent chlorine content of each grain
RHOs	=	Spontaneous track density (ρs) = Ns/ (Na*area of basic unit)
RHOi	=	Induced track density (ρi) = Ni/(Na*area of basic unit)
F.T.AGE	=	Fission track age, calculated using equation B.1
Area of basic unit	=	Area of one grid square
Chi squared	=	χ^2 parameter, used to assess variation of single grain ages within the sample
P(chi squared)	=	Probability of obtaining observed χ^2 value for the relevant number of degrees of freedom, if all grains belong to a single population
Correlation coefficient	=	Correlation coefficient between Ns and Ni
Variance of SQR(Ns)	=	Variance of square root of Ns values - should be ~ 0.25 for Poisson distribution; greater if additional variation present
Variance of SQR(Ni)	=	Variance of square root of Ni values - should be ~ 0.25 for Poisson distribution; greater if additional variation present
Age Dispersion	=	% variation in single grain ages - see discussion in text re "Central age"
Ns/Ni	=	Pooled ratio, total spontaneous tracks divided by total induced tracks for all grains
Mean ratio	=	Mean of (Ns/Ni) for individual grains
Zeta	=	Calibration constant, determined empirically for each observer
RhoD	=	Track density (ρ_D) from uranium standard glass (interpolated from values at each end of stack)
ND	=	Total number of tracks counted for determining ρ_D
POOLED AGE	=	Fission track age calculated from pooled ratio Ns/Ni. Valid only when $\chi^2 > 5\%$
CENTRAL AGE	=	Alternative to pooled age when $\chi^2 < 5\%$

GC550-1 APATITE

IRRADIATION G506
SLIDE NUMBER 1
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	3	20	32	1.490E+05	9.932E+05	0.150	9.0	0.24	35.7 ± 22.1
4	31	50	20	2.463E+06	3.973E+06	0.620	36.1	0.20	146.4 ± 33.7
5	100	141	60	2.648E+06	3.734E+06	0.709	33.9	0.30	167.2 ± 22.3
6	11	24	70	2.497E+05	5.448E+05	0.458	4.9	0.48	108.6 ± 39.6
	145	235		1.266E+06	2.052E+06		18.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 7.956 with 3 degrees of freedom
P(chi squared) = 4.7 %
Correlation Coefficient = 0.999
Variance of SQR(Ns) = 12.91
Variance of SQR(Ni) = 11.51
Age Dispersion = 23.127 % (did not converge)

Ns/Ni = 0.617 ± 0.065
Mean Ratio = 0.484 ± 0.123

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.256E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 145.7 ± 15.9 Ma
CENTRAL AGE = 129.1 ± 22.7 Ma

GC550-2 APATITE

IRRADIATION G506
SLIDE NUMBER 2
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	193	223	50	6.134E+06	7.087E+06	0.865	64.3	0.06	203.5 ± 20.7
4	11	10	60	2.913E+05	2.648E+05	1.100	2.4	0.03	257.5 ± 112.7
5	150	92	60	3.973E+06	2.437E+06	1.630	22.1	0.02	378.1 ± 51.1
6	55	51	30	2.913E+06	2.701E+06	1.078	24.5	0.00	252.6 ± 49.6
7	13	13	36	5.738E+05	5.738E+05	1.000	5.2	0.01	234.5 ± 92.2
8	198	174	100	3.146E+06	2.765E+06	1.138	25.1	0.05	266.2 ± 28.6
9	35	22	80	6.952E+05	4.370E+05	1.591	4.0	0.01	369.2 ± 100.9
10	25	18	80	4.966E+05	3.575E+05	1.389	3.2	0.03	323.5 ± 100.4
11	78	65	100	1.239E+06	1.033E+06	1.200	9.4	0.15	280.4 ± 47.7
12	180	187	80	3.575E+06	3.714E+06	0.963	33.7	0.02	225.9 ± 24.4
13	3	3	50	9.534E+04	9.534E+04	1.000	0.9	0.07	234.5 ± 191.6
14	180	131	60	4.767E+06	3.469E+06	1.374	31.5	0.13	320.1 ± 37.8
15	106	127	50	3.369E+06	4.036E+06	0.835	36.6	0.00	196.3 ± 26.4
16	71	46	100	1.128E+06	7.310E+05	1.543	6.6	0.07	358.5 ± 68.5
17	156	126	70	3.541E+06	2.860E+06	1.238	26.0	0.03	289.1 ± 35.5
18	14	16	100	2.225E+05	2.542E+05	0.875	2.3	0.04	205.7 ± 75.5
19	33	22	100	5.244E+05	3.496E+05	1.500	3.2	0.06	348.7 ± 96.4
20	63	53	42	2.384E+06	2.005E+06	1.189	18.2	0.03	277.8 ± 52.3
21	51	47	24	3.377E+06	3.112E+06	1.085	28.2	0.00	254.1 ± 51.8
22	19	24	50	6.038E+05	7.628E+05	0.792	6.9	0.02	186.4 ± 57.4
	1634	1450		1.964E+06	1.743E+06		15.8		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 34.462 with 19 degrees of freedom
P(chi squared) = 1.6 %
Correlation Coefficient = 0.953
Variance of SQR(Ns) = 16.08
Variance of SQR(Ni) = 15.14
Age Dispersion = 15.063 %

Ns/Ni = 1.127 ± 0.041
Mean Ratio = 1.169 ± 0.058

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.256E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 263.7 ± 11.9 Ma
CENTRAL AGE = 268.4 ± 16.3 Ma

GC550-3 APATITE

IRRADIATION G506
SLIDE NUMBER 3
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	31	29	20	2.463E+06	2.304E+06	1.069	20.9	0.01	250.4 ± 65.0
4	39	31	24	2.582E+06	2.053E+06	1.258	18.6	0.00	293.7 ± 71.1
5	25	15	15	2.648E+06	1.589E+06	1.667	14.4	0.07	386.2 ± 126.6
6	72	58	30	3.814E+06	3.072E+06	1.241	27.9	0.00	289.8 ± 51.7
7	8	12	30	4.238E+05	6.356E+05	0.667	5.8	0.22	157.3 ± 71.9
8	129	107	60	3.416E+06	2.834E+06	1.206	25.7	0.18	281.7 ± 37.6
9	44	29	50	1.398E+06	9.217E+05	1.517	8.4	0.01	352.5 ± 84.9
10	45	56	24	2.980E+06	3.708E+06	0.804	33.7	0.00	189.1 ± 38.2
11	16	8	21	1.211E+06	6.054E+05	2.000	5.5	0.01	460.8 ± 199.9
13	361	311	70	8.195E+06	7.060E+06	1.161	64.1	0.02	271.4 ± 22.2
14	44	46	28	2.497E+06	2.611E+06	0.957	23.7	0.00	224.5 ± 47.7
16	113	72	48	3.741E+06	2.384E+06	1.569	21.6	0.09	364.3 ± 55.8
17	301	168	100	4.783E+06	2.670E+06	1.792	24.2	0.12	414.3 ± 41.4
18	19	24	100	3.019E+05	3.814E+05	0.792	3.5	0.02	186.3 ± 57.4
19	40	49	40	1.589E+06	1.947E+06	0.816	17.7	0.04	192.1 ± 41.3
20	45	18	50	1.430E+06	5.721E+05	2.500	5.2	0.12	571.0 ± 160.0
21	7	5	24	4.635E+05	3.311E+05	1.400	3.0	0.24	326.0 ± 191.1
22	67	57	50	2.129E+06	1.812E+06	1.175	16.4	0.02	274.8 ± 50.1
12	25	29	45	8.828E+05	1.024E+06	0.862	9.3	0.00	202.7 ± 55.6
	1431	1124		2.743E+06	2.155E+06		19.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 43.594 with 18 degrees of freedom
P(chi squared) = 0.1 %
Correlation Coefficient = 0.964
Variance of SQR(Ns) = 19.15
Variance of SQR(Ni) = 13.69
Age Dispersion = 20.413 %

Ns/Ni = 1.273 ± 0.051
Mean Ratio = 1.287 ± 0.108

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.256E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 297.1 ± 14.3 Ma
CENTRAL AGE = 286.0 ± 21.2 Ma

GC550-4 APATITE

IRRADIATION G506
SLIDE NUMBER 4
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	17	5	30	9.005E+05	2.648E+05	3.400	2.5	0.00	754.0 ± 384.3
4	23	25	8	4.569E+06	4.966E+06	0.920	47.3	0.08	212.9 ± 61.8
5	103	84	40	4.092E+06	3.337E+06	1.226	31.8	0.02	282.2 ± 42.3
6	19	9	36	8.387E+05	3.973E+05	2.111	3.8	0.03	478.5 ± 194.1
7	94	80	18	8.298E+06	7.063E+06	1.175	67.2	0.00	270.7 ± 42.0
	256	203		3.082E+06	2.444E+06		23.3		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 7.234 with 4 degrees of freedom
P(chi squared) = 12.4 %
Correlation Coefficient = 0.989
Variance of SQR(Ns) = 9.15
Variance of SQR(Ni) = 10.58
Age Dispersion = 0.187 % (did not converge)

Ns/Ni = 1.261 ± 0.119
Mean Ratio = 1.766 ± 0.455

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.198E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 290.1 ± 28.6 Ma
CENTRAL AGE = 290.1 ± 28.6 Ma

GC550-5 APATITE

IRRADIATION G506
SLIDE NUMBER 5
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
4	86	55	18	7.592E+06	4.855E+06	1.564	46.7	0.17	354.3 ± 62.1
5	1	4	100	1.589E+04	6.356E+04	0.250	0.6	0.02	58.0 ± 64.8
6	11	6	24	7.283E+05	3.973E+05	1.833	3.8	0.09	413.5 ± 210.2
7	214	181	54	6.297E+06	5.326E+06	1.182	51.2	0.02	269.7 ± 28.4
8	1	4	21	7.567E+04	3.027E+05	0.250	2.9	0.56	58.0 ± 64.8
9	14	13	18	1.236E+06	1.148E+06	1.077	11.0	0.00	246.1 ± 95.1
10	115	90	40	4.569E+06	3.575E+06	1.278	34.4	0.45	291.0 ± 41.9
12	23	27	50	7.310E+05	8.581E+05	0.852	8.2	0.01	195.4 ± 55.8
	465	380		2.274E+06	1.858E+06		17.9		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 9.596 with 7 degrees of freedom
P(chi squared) = 21.3 %
Correlation Coefficient = 0.993
Variance of SQR(Ns) = 24.46
Variance of SQR(Ni) = 17.14
Age Dispersion = 0.127 % (did not converge)

Ns/Ni = 1.224 ± 0.085
Mean Ratio = 1.036 ± 0.201

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.186E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 278.9 ± 21.0 Ma
CENTRAL AGE = 278.9 ± 21.0 Ma

GC550-7 APATITE

IRRADIATION G506
SLIDE NUMBER 6
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
5	59	53	48	1.953E+06	1.755E+06	1.113	17.0	0.04	251.7 ± 48.2
10	71	65	24	4.701E+06	4.304E+06	1.092	41.8	0.29	247.1 ± 43.1
11	71	71	72	1.567E+06	1.567E+06	1.000	15.2	0.08	226.6 ± 38.6
12	21	13	80	4.171E+05	2.582E+05	1.615	2.5	0.29	362.1 ± 128.3
14	41	31	70	9.307E+05	7.037E+05	1.323	6.8	0.08	298.0 ± 71.5
15	33	67	40	1.311E+06	2.662E+06	0.493	25.8	0.04	112.6 ± 24.2
16	156	113	90	2.754E+06	1.995E+06	1.381	19.4	0.12	310.7 ± 39.5
17	50	61	36	2.207E+06	2.693E+06	0.820	26.2	0.10	186.3 ± 36.0
18	40	48	35	1.816E+06	2.179E+06	0.833	21.2	0.10	189.4 ± 40.9
20	22	30	40	8.740E+05	1.192E+06	0.733	11.6	0.07	166.9 ± 47.1
21	178	189	60	4.714E+06	5.006E+06	0.942	48.6	0.01	213.6 ± 23.2
23	157	104	80	3.119E+06	2.066E+06	1.510	20.1	0.16	339.0 ± 44.0
24	150	671	90	2.648E+06	1.185E+07	0.224	115.1	0.01	51.3 ± 4.9
25	63	46	36	2.781E+06	2.030E+06	1.370	19.7	0.01	308.3 ± 60.5
26	43	25	72	9.490E+05	5.518E+05	1.720	5.4	0.19	384.9 ± 97.5
27	66	66	80	1.311E+06	1.311E+06	1.000	12.7	0.04	226.6 ± 40.0
28	205	219	80	4.072E+06	4.350E+06	0.936	42.2	0.06	212.3 ± 21.6
29	39	71	40	1.549E+06	2.821E+06	0.549	27.4	0.09	125.4 ± 25.3
30	202	155	48	6.687E+06	5.131E+06	1.303	49.8	0.46	293.7 ± 32.6
31	2	27	40	7.945E+04	1.073E+06	0.074	10.4	0.00	17.1 ± 12.5
	1669	2125		2.284E+06	2.908E+06		28.2		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 362.409 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.567
Variance of SQR(Ns) = 12.89
Variance of SQR(Ni) = 24.10
Age Dispersion = 48.750 %

Ns/Ni = 0.785 ± 0.026
Mean Ratio = 1.002 ± 0.099

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.174E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 178.6 ± 7.9 Ma
CENTRAL AGE = 204.8 ± 24.7 Ma

GC550-8 APATITE

IRRADIATION G506
SLIDE NUMBER 7
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
4	3	11	70	6.810E+04	2.497E+05	0.273	2.4	0.02	62.0 ± 40.4
5	11	22	36	4.855E+05	9.711E+05	0.500	9.5	0.01	113.1 ± 41.9
6	23	101	80	4.569E+05	2.006E+06	0.228	19.7	0.00	51.8 ± 12.1
7	7	10	30	3.708E+05	5.297E+05	0.700	5.2	0.10	157.8 ± 77.9
8	10	32	90	1.766E+05	5.650E+05	0.312	5.5	0.03	70.9 ± 25.8
9	4	14	12	5.297E+05	1.854E+06	0.286	18.2	0.00	64.9 ± 36.8
11	1	11	45	3.531E+04	3.884E+05	0.091	3.8	0.00	20.7 ± 21.6
13	15	30	32	7.449E+05	1.490E+06	0.500	14.6	0.06	113.1 ± 35.9
14	45	44	45	1.589E+06	1.554E+06	1.023	15.2	0.12	229.3 ± 49.1
15	17	77	60	4.502E+05	2.039E+06	0.221	20.0	0.00	50.2 ± 13.5
16	3	9	60	7.945E+04	2.384E+05	0.333	2.3	0.00	75.6 ± 50.5
18	3	66	80	5.959E+04	1.311E+06	0.045	12.9	0.00	10.4 ± 6.1
21	3	5	40	1.192E+05	1.986E+05	0.600	1.9	0.01	135.5 ± 99.1
22	54	42	50	1.716E+06	1.335E+06	1.286	13.1	0.15	287.0 ± 59.7
23	1	6	70	2.270E+04	1.362E+05	0.167	1.3	0.02	37.9 ± 41.0
25	38	59	42	1.438E+06	2.232E+06	0.644	21.9	0.03	145.4 ± 30.5
27	50	54	30	2.648E+06	2.860E+06	0.926	28.1	0.65	208.0 ± 41.3
28	2	7	50	6.356E+04	2.225E+05	0.286	2.2	0.26	64.9 ± 52.1
29	19	73	25	1.208E+06	4.640E+06	0.260	45.5	0.03	59.1 ± 15.3
30	25	17	36	1.104E+06	7.504E+05	1.471	7.4	0.70	327.2 ± 103.3
	334	690		5.399E+05	1.115E+06		10.9		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 124.644 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.485
Variance of SQR(Ns) = 4.35
Variance of SQR(Ni) = 5.93
Age Dispersion = 66.252 %

Ns/Ni = 0.484 ± 0.032
Mean Ratio = 0.508 ± 0.089

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.162E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 109.6 ± 8.0 Ma
CENTRAL AGE = 101.6 ± 17.8 Ma

GC550-9 APATITE

IRRADIATION G506
SLIDE NUMBER 8
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	15	21	48	4.966E+05	6.952E+05	0.714	6.9	0.00	159.4 ± 54.1
4	27	59	70	6.129E+05	1.339E+06	0.458	13.3	0.00	102.6 ± 24.0
5	0	5	25	0.000E+00	3.178E+05	0.000	3.2	0.05	0.0 ± 0.0
6	11	8	25	6.992E+05	5.085E+05	1.375	5.0	0.31	303.4 ± 141.3
7	2	5	49	6.486E+04	1.621E+05	0.400	1.6	0.01	89.7 ± 75.1
8	18	23	35	8.172E+05	1.044E+06	0.783	10.4	0.08	174.4 ± 55.1
9	35	22	42	1.324E+06	8.324E+05	1.591	8.2	0.19	349.8 ± 95.7
11	62	42	36	2.737E+06	1.854E+06	1.476	18.4	0.16	325.2 ± 65.7
13	13	14	42	4.919E+05	5.297E+05	0.929	5.2	0.00	206.5 ± 79.8
14	11	9	24	7.283E+05	5.959E+05	1.222	5.9	0.17	270.4 ± 121.8
15	61	154	50	1.939E+06	4.894E+06	0.396	48.5	0.04	88.9 ± 13.7
17	94	45	48	3.112E+06	1.490E+06	2.089	14.8	0.16	455.5 ± 83.7
19	12	19	24	7.945E+05	1.258E+06	0.632	12.5	0.17	141.1 ± 52.2
20	8	41	48	2.648E+05	1.357E+06	0.195	13.5	0.02	43.9 ± 17.0
22	63	88	25	4.004E+06	5.594E+06	0.716	55.4	0.01	159.8 ± 26.8
23	26	22	80	5.164E+05	4.370E+05	1.182	4.3	0.17	261.6 ± 76.2
25	0	2	54	0.000E+00	5.885E+04	0.000	0.6	0.02	0.0 ± 0.0
28	11	60	24	7.283E+05	3.973E+06	0.183	39.4	0.00	41.3 ± 13.6
35	1	5	18	8.828E+04	4.414E+05	0.200	4.4	0.04	45.0 ± 49.3
36	49	52	28	2.781E+06	2.951E+06	0.942	29.3	0.01	209.5 ± 42.2
	519	696		1.037E+06	1.391E+06		13.8		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 128.620 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.631
Variance of SQR(Ns) = 7.44
Variance of SQR(Ni) = 7.71
Age Dispersion = 59.510 %

Ns/Ni = 0.746 ± 0.043
Mean Ratio = 0.774 ± 0.129

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.150E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 166.3 ± 10.9 Ma
CENTRAL AGE = 158.2 ± 25.2 Ma

GC550-10 APATITE

IRRADIATION G506
SLIDE NUMBER 9
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	4	5	40	1.589E+05	1.986E+05	0.800	1.8	0.32	188.2 ± 126.3
4	3	3	18	2.648E+05	2.648E+05	1.000	2.4	1.15	234.3 ± 191.4
5	31	62	16	3.079E+06	6.158E+06	0.500	55.9	0.24	118.2 ± 26.2
6	15	31	12	1.986E+06	4.105E+06	0.484	37.3	1.84	114.5 ± 36.1
10	1	5	21	7.567E+04	3.783E+05	0.200	3.4	1.04	47.6 ± 52.1
11	2	4	20	1.589E+05	3.178E+05	0.500	2.9	0.51	118.2 ± 102.4
12	10	13	28	5.675E+05	7.378E+05	0.769	6.7	1.12	181.0 ± 76.3
13	33	48	100	5.244E+05	7.628E+05	0.688	6.9	0.73	162.0 ± 36.9
14	1	11	60	2.648E+04	2.913E+05	0.091	2.6	0.56	21.7 ± 22.6
16	18	24	80	3.575E+05	4.767E+05	0.750	4.3	0.69	176.6 ± 55.3
17	6	6	15	6.356E+05	6.356E+05	1.000	5.8	1.06	234.3 ± 135.4
18	33	45	36	1.457E+06	1.986E+06	0.733	18.0	0.48	172.7 ± 39.8
20	20	29	100	3.178E+05	4.608E+05	0.690	4.2	2.23	162.5 ± 47.4
	177	286		5.151E+05	8.324E+05		7.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 10.101 with 12 degrees of freedom
P(chi squared) = 60.7 %
Correlation Coefficient = 0.953
Variance of SQR(Ns) = 3.22
Variance of SQR(Ni) = 4.49
Age Dispersion = 0.171 % (did not converge)

Ns/Ni = 0.619 ± 0.059
Mean Ratio = 0.631 ± 0.075

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.255E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 146.0 ± 14.5 Ma
CENTRAL AGE = 146.0 ± 14.5 Ma

GC550-11 APATITE

IRRADIATION G507
SLIDE NUMBER 1
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	92	89	50	2.924E+06	2.829E+06	1.034	24.7	0.02	251.7 ± 38.0
5	66	49	48	2.185E+06	1.622E+06	1.347	14.2	0.03	326.1 ± 62.1
6	84	123	42	3.178E+06	4.654E+06	0.683	40.6	0.14	167.4 ± 24.1
	242	261		2.747E+06	2.962E+06		25.9		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 9.206 with 2 degrees of freedom
P(chi squared) = 1.0 %
Correlation Coefficient = 0.710
Variance of SQR(Ns) = 0.57
Variance of SQR(Ni) = 4.23
Age Dispersion = 22.565 %

Ns/Ni = 0.927 ± 0.083
Mean Ratio = 1.021 ± 0.192

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.306E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 226.2 ± 21.1 Ma
CENTRAL AGE = 235.0 ± 37.8 Ma

GC550-12 APATITE

IRRADIATION G507
SLIDE NUMBER 2
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	14	47	35	6.356E+05	2.134E+06	0.298	18.8	0.06	72.8 ± 22.2
4	4	7	18	3.531E+05	6.180E+05	0.571	5.5	0.49	138.9 ± 87.1
	18	54		5.397E+05	1.619E+06		14.3		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 0.894 with 1 degrees of freedom
P(chi squared) = 34.4 %
Correlation Coefficient = 1.000
Variance of SQR(Ns) = 1.52
Variance of SQR(Ni) = 8.86
Age Dispersion = 0.000 % (did not converge)

Ns/Ni = 0.333 ± 0.091
Mean Ratio = 0.435 ± 0.137

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.292E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 81.4 ± 22.3 Ma
CENTRAL AGE = 81.4 ± 22.3 Ma

GC550-13 APATITE

IRRADIATION 507
SLIDE NUMBER 3
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	13	13	70	2.951E+05	2.951E+05	1.000	2.6	0.02	238.7 ± 93.9
4	1	14	9	1.766E+05	2.472E+06	0.071	22.0	0.01	17.4 ± 18.0
5	68	42	48	2.251E+06	1.390E+06	1.619	12.4	0.32	382.2 ± 75.7
7	353	441	90	6.233E+06	7.786E+06	0.800	69.4	0.04	191.8 ± 14.6
8	120	108	28	6.810E+06	6.129E+06	1.111	54.6	0.29	264.7 ± 35.8
13	11	12	14	1.249E+06	1.362E+06	0.917	12.1	0.00	219.2 ± 91.7
14	25	34	24	1.655E+06	2.251E+06	0.735	20.1	0.01	176.4 ± 46.7
15	68	48	24	4.502E+06	3.178E+06	1.417	28.3	0.45	335.7 ± 63.9
16	9	7	5	2.860E+06	2.225E+06	1.286	19.8	0.00	305.4 ± 154.1
	668	719		3.402E+06	3.662E+06		32.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 31.078 with 8 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.988
Variance of SQR(Ns) = 29.84
Variance of SQR(Ni) = 32.83
Age Dispersion = 31.391 %

Ns/Ni = 0.929 ± 0.050
Mean Ratio = 0.995 ± 0.150

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.279E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 222.1 ± 13.4 Ma
CENTRAL AGE = 232.7 ± 32.6 Ma

GC550-14 APATITE

IRRADIATION G507
SLIDE NUMBER 5
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	36	99	19	3.011E+06	8.280E+06	0.364	75.4	0.00	86.0 ± 16.9
	36	99		3.011E+06	8.280E+06		75.4		

Area of basic unit = 6.293E-07 cm-2

Ns/Ni = 0.364 ± 0.071

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.251E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 86.0 ± 16.9 Ma

GC550-15 APATITE

IRRADIATION G507
SLIDE NUMBER 6
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	34	38	12	4.502E+06	5.032E+06	0.895	46.3	0.02	207.3 ± 49.2
4	11	15	8	2.185E+06	2.980E+06	0.733	27.4	0.02	170.4 ± 67.8
5	14	7	4	5.562E+06	2.781E+06	2.000	25.6	0.01	454.4 ± 210.7
6	19	15	6	5.032E+06	3.973E+06	1.267	36.6	0.03	291.5 ± 101.0
7	41	31	11	5.923E+06	4.478E+06	1.323	41.2	0.03	304.1 ± 72.8
8	17	14	12	2.251E+06	1.854E+06	1.214	17.1	0.02	279.7 ± 101.2
9	22	35	6	5.827E+06	9.270E+06	0.629	85.4	0.07	146.3 ± 40.0
10	16	15	7	3.632E+06	3.405E+06	1.067	31.4	0.04	246.3 ± 88.8
11	18	8	7	4.086E+06	1.816E+06	2.250	16.7	0.03	509.0 ± 216.7
12	20	19	7	4.540E+06	4.313E+06	1.053	39.7	0.08	243.2 ± 78.2
13	27	26	20	2.145E+06	2.066E+06	1.038	19.0	0.03	239.9 ± 66.2
14	14	8	5	4.449E+06	2.542E+06	1.750	23.4	0.01	399.3 ± 177.3
15	10	14	6	2.648E+06	3.708E+06	0.714	34.1	0.07	166.0 ± 68.9
16	6	6	5	1.907E+06	1.907E+06	1.000	17.6	0.02	231.2 ± 133.6
17	30	22	12	3.973E+06	2.913E+06	1.364	26.8	0.26	313.3 ± 88.3
19	18	12	6	4.767E+06	3.178E+06	1.500	29.3	0.02	343.8 ± 128.5
20	25	17	12	3.311E+06	2.251E+06	1.471	20.7	0.01	337.2 ± 106.4
21	24	19	11	3.467E+06	2.745E+06	1.263	25.3	0.03	290.7 ± 89.6
22	23	17	10	3.655E+06	2.701E+06	1.353	24.9	0.01	310.9 ± 99.8
23	79	71	18	6.974E+06	6.268E+06	1.113	57.7	0.05	256.8 ± 42.6
	468	409		4.020E+06	3.513E+06		32.4		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 16.480 with 19 degrees of freedom
P(chi squared) = 62.5 %
Correlation Coefficient = 0.927
Variance of SQR(Ns) = 1.86
Variance of SQR(Ni) = 2.00
Age Dispersion = 1.159 % (did not converge)

Ns/Ni = 1.144 ± 0.077
Mean Ratio = 1.250 ± 0.092

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.238E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 263.9 ± 19.2 Ma
CENTRAL AGE = 263.9 ± 19.3 Ma

GC550-16 APATITE

IRRADIATION 507
SLIDE NUMBER 7
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	21	19	16	2.086E+06	1.887E+06	1.105	17.6	0.03	252.4 ± 80.2
4	171	190	24	1.132E+07	1.258E+07	0.900	117.1	0.18	206.3 ± 22.4
5	10	11	7	2.270E+06	2.497E+06	0.909	23.2	0.09	208.3 ± 91.2
6	10	15	8	1.986E+06	2.980E+06	0.667	27.7	0.02	153.4 ± 62.8
13	11	13	12	1.457E+06	1.721E+06	0.846	16.0	0.05	194.1 ± 79.7
14	5	4	4	1.986E+06	1.589E+06	1.250	14.8	0.04	284.8 ± 191.2
	228	252		5.103E+06	5.640E+06		52.5		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 1.228 with 5 degrees of freedom
P(chi squared) = 94.2 %
Correlation Coefficient = 0.999
Variance of SQR(Ns) = 16.52
Variance of SQR(Ni) = 18.49
Age Dispersion = 0.000 % (did not converge)

Ns/Ni = 0.905 ± 0.083
Mean Ratio = 0.946 ± 0.084

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.225E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 207.4 ± 19.8 Ma
CENTRAL AGE = 207.4 ± 19.8 Ma

GC550-17 APATITE

IRRADIATION G507
SLIDE NUMBER 9
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	112	102	30	5.933E+06	5.403E+06	1.098	51.5	0.04	245.3 ± 34.2
4	22	21	36	9.711E+05	9.270E+05	1.048	8.8	0.02	234.2 ± 71.7
5	6	12	40	2.384E+05	4.767E+05	0.500	4.5	0.00	112.8 ± 56.5
6	30	41	20	2.384E+06	3.258E+06	0.732	31.0	0.07	164.5 ± 39.8
8	52	33	32	2.582E+06	1.639E+06	1.576	15.6	0.02	349.1 ± 78.3
9	147	231	40	5.840E+06	9.177E+06	0.636	87.4	0.22	143.3 ± 15.6
10	29	29	16	2.880E+06	2.880E+06	1.000	27.4	0.09	223.7 ± 59.1
11	8	18	24	5.297E+05	1.192E+06	0.444	11.3	0.01	100.4 ± 42.7
12	23	18	25	1.462E+06	1.144E+06	1.278	10.9	0.01	284.5 ± 89.9
13	64	30	24	4.238E+06	1.986E+06	2.133	18.9	0.04	468.3 ± 104.4
14	39	34	21	2.951E+06	2.573E+06	1.147	24.5	0.01	256.0 ± 60.5
15	33	29	18	2.913E+06	2.560E+06	1.138	24.4	0.07	254.0 ± 65.0
	565	598		2.754E+06	2.915E+06		27.8		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 43.562 with 11 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.915
Variance of SQR(Ns) = 8.14
Variance of SQR(Ni) = 10.54
Age Dispersion = 31.315 %

Ns/Ni = 0.945 ± 0.055
Mean Ratio = 1.061 ± 0.137

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.197E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 211.6 ± 13.7 Ma
CENTRAL AGE = 226.6 ± 26.9 Ma

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SOURCE ROCK AND PETROLEUM GEOCHEMISTRY OF THE ERINGA TROUGH, PEDIRKA BASIN

Report for Department of Mines and Energy South Australia

by

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INTRODUCTION

This report forms a preliminary assessment of the hydrocarbon potential of predominantly coaly sediments from the Eringa Trough, in the western Eromanga Basin/Pedirka Basin province, South Australia. Geochemical and petrographic analyses have been undertaken on targeted organic-rich intervals, comprising core samples from AFMECO Cur-3 and Cur-5 along the western edge of the Eringa Trough, and cuttings samples recovered from Dalmatia-1 and Mt Hammersley-1 exploration wells on the eastern margin (Table 1, Fig. 1). Samples from both AFMECO wells represent Algebuckina Sandstone (Middle Jurassic). All Dalmatia-1 samples are Purni Formation (Permian); the 6 uppermost Mt Hammersley-1 samples are Purni Formation, whereas the lowermost samples represent Crown Point Formation and undifferentiated Permian. To date only these relatively shallow-lying sediments on the margins of the trough have been penetrated by the drill. No exploratory drilling has taken place within the Eringa Trough proper. If oil-prone sediments can be identified on the flanks of the basin, mature hydrocarbon kitchens may have developed basinward where sediments have been more deeply buried.

SAMPLE SELECTION AND PREPARATION

In total 68 cuttings samples were collected from Dalmatia-1 and Mt Hammersley-1, and 6 quarter core samples from AFMECO Cur-3 and Cur-5. Wherever possible, the darkest (organic rich) samples were selected. Each of the 68 cuttings samples were meticulously washed and rinsed in distilled water using step-wise ultrasonification to remove drilling mud. These washed cuttings were consolidated into 13 composite samples (Table 1). The core samples were scraped and brushed clean to remove surficial contamination. In the case of the cuttings, selective picking of argillaceous/coaly lithologies as individual rock chips generally greater than 0.75 mm avoided potential contamination. Identified contaminants included iron-filings and minor paint in Dalmatia-1; and grass, abundant paint, iron filings and (?) rubber in Mt Hammersley-1.

EXPERIMENTAL

Sub-specimens of two composite samples from Dalmatia-1 (Dal 2 & Dal 5), and all eight composite samples from Mt Hammersley-1, were mounted in resin and polished for petrographic analyses. For convenience a simplified naming (I.D.) scheme was established for the Dalmatia-1 and Mt Hammersley-1 samples (Table 1). Sub-specimens of the 6 core samples were cut perpendicular to bedding and also prepared as polished blocks. Reflectance measurements were made using a Leitz Ortholux Pol BK microscope under conditions specified by Standards Association of Australia (1989). Random vitrinite (R_r %) reflectance measurements (n = 30 per sample, except AFMECO Cur-5 209.2 m where n = 10) were converted to mean maximum reflectance values (R_o %) using Kilby's (1991) formula $R_o = 1.083 \times R_r$.

Prior to geochemical analyses, the 13 picked cuttings and 6 core samples were crushed and extracted in Soxhlet apparatus using an azeotropic solvent mixture (CH_2Cl_2:CH_3OH, 93:7). The extract was fractionated by liquid column chromatography on activated silica into saturated hydrocarbons, aromatic hydrocarbons and polar compounds (resins and asphaltenes).

Gas Chromatography

A Varian 3400 gas chromatograph was used to analyse the saturate (total alkane) fraction. The instrument was fitted with a 25 m x 0.22 mm i.d. fused silica column (BP-1, 0.25 μm film thickness; SGE Australia). Samples in *n*-hexane were injected using a split/splitless injector operating in split mode. H_2 was used as the carrier gas (linear flow velocity of 30 cm s^{-1}), with injector and detector (FID) temperatures of 300°C. The oven temperature was held at 40°C for 5 minutes and then programmed from 40 to 300°C at 4°C min^{-1}, and then held at 300°C for 30 minutes.

Gas Chromatography-Mass Spectrometry

The GC-MS analyses were undertaken using a Varian 3400 gas chromatograph interfaced to a Finnigan TSQ 70 mass spectrometer. The gas chromatograph was fitted with a 60 m x 0.25 mm i.d. fused silica column (DB-1, 0.25 μm film thickness; J&W Scientific). Helium was used as the carrier gas at an inlet pressure of approximately 23.5 psi. The program of the oven was as follows: 50°C for 2 min, 50° to 120°C at 8°C min^{-1}, 120° to 300°C at 4°C min^{-1} and then held at 300°C for 35 min. The injector was held at 50°C for 3 seconds then ramped to 300°C at 180°C min^{-1}, and held at 300°C for 5 minutes. Mass spectrometer operating parameters included an ionization voltage of 70 eV and a filament current of 200 μA.

Aromatic hydrocarbons

The photomultiplier voltage was set at 1100 V. Aromatic fractions in CH_2Cl_2 were injected on-column. The mass spectrometer was programmed (multiple ion detection: MID) to monitor *m/z* 128 (naphthalene), *m/z* 141 and 142 (methylnaphthalenes), *m/z* 156 (dimethylnaphthalenes), *m/z* 170 (trimethylnaphthalenes), *m/z* 178 (phenanthrene), *m/z* 192 (methylphenanthrenes), *m/z* 206 (dimethylphenanthrenes), *m/z* 219 (retene), *m/z* 231 and 245 (monoaromatic steroids), and *m/z* 253 (triaromatic steroids).

Saturated hydrocarbons

Vitrinite reflectance, Rock-Eval pyrolysis and GC analyses all suggested that the samples to be examined by GC-MS were of low rank (*i.e.* vitrinite reflectance < 0.45%). The interpretation and structural assignment of saturated compounds resolved (or unresolved!) by GC-MS can be complicated in such cases by the presence of *unsaturated* hydrocarbons (*i.e.* alkenes), and even functionalized moieties (*e.g.* phenolics). In an attempt to overcome these problems, selective reaction monitoring (SRM) by triple-stage mass spectrometry (GC-MS-MS) was used to analyse the saturated hydrocarbon fraction. Argon was employed as the collision gas (-20 eV collision-offset voltage) to induce

dissociation (collision-activated decomposition: CAD) in the second quadrupole (Q2MS) and the photomultiplier was set to 1900 V. The first quadrupole (Q1MS) was used as a mass filter, allowing only parent ions with specific *m/z* ratios to pass into Q2MS. The third quadrupole (Q3MS) measured the molecular ions of targeted *m/z* ratios corresponding to the daughter ions produced by CAD in Q2MS. Q1MS and Q3MS were operated in tandem to provide the SRM data presented here. The ability of various GC-MS-MS techniques to deconvolute complex biomarker mixtures (*e.g.* steranes) is described in the literature (Peters and Moldowan, 1993). Saturated hydrocarbons were disolved in *n*-hexane and injected on-column. The mass spectrometer was programmed to monitor the following decomposition reactions:

Q1MS *m/z*		Q3MS *m/z*	Target compounds
Hopanes			
370, 398	→	163	25-norhopanes (10-desmethylhopanes)
398, 370, 412	→	177	Demethylated hopanes
370	→	191	C_{27} hopanes (*e.g.* T_s, T_m)
384	→	191	C_{28} hopanes (*e.g.* 28,30-BNH)
398	→	191	C_{29} hopanes (*e.g.* $C_{29}T_s$)
412	→	191	C_{30} hopanes (*e.g.* diahopane)
440, 454, 468, 482	→	191	Homohopanes
370, 384, 398, 412, 426, 440, 454	→	205	Methylhopanes
Steranes			
358	→	217	C_{26} steranes
374	→	217	C_{27} steranes
386	→	217	C_{28} steranes
400	→	217	C_{29} steranes
414	→	217	C_{30} steranes (4-desmethylsteranes)
414	→	231	C_{30} steranes (A-ring methylsteranes)

RESULTS

Analytical data are summarized and presented herein as follows:

	Table	Figure
Sample details	1	
Rock-Eval pyrolysis	2	2
Petrographic descriptions and vitrinite reflectance data	3	
Biomarker parameters	4	
Summary of geochemical data	5	
GC of saturated hydrocarbons		A1–A14
GC-MS-MS transitions for C_{27}–C_{32} hopanes		B1–B10
GC-MS-MS transitions for C_{27}–C_{29} steranes		C1–C10

DISCUSSION

Algebuckina Sandstone

Five coal samples from the Middle Jurassic Algebuckina Sandstone have good to excellent source potential based on Rock-Eval pyrolysis data (Table 2; Fig. 2). Hydrogen indices in the range 312 to 542 demonstrate that most of these samples belong to kerogen class Type II/III. One sample (AFMECO Cur-3 259.1 m) is an excellent potential source rock (Type II kerogen). Petrographic observations suggest that its oil-prone nature is attibutable to a high resinite and fluorinite (plant oil) content (Table 3). Elevated hopane/sterane ratios (10.3 to 35.8; Table 4) also suggest a significant bacterial input. [A sixth sample comprises a thin (*ca* 1 cm) *reworked* coal which is consistent with its very poor source potential (HI = 87) and anomalously high vitrinite reflectance (0.62%). However, this is inconsequential, since the reworked coal facies would only be developed locally.] Maturity estimates based on vitrinite reflectance (R_o) suggest a rank corresponding to 0.41 to 0.44% for the 5 samples of high source potential. This is in good agreement with maturities estimates derived from Rock-Eval pyrolysis which confirm a maturity in the range 0.40 to 0.45% R_o. In Cook's (1986) opinion, hydrocarbon formation from resinite can commence as early as 0.40 to 0.45% R_o. Powell (1985) also put forward an hydrocarbon generation model whereby resinite-enriched and bacterially-modified source rocks (comprising predominantly vitrinite and inertinite) can generate hydrocarbons by 0.45% R_o. Given that fluorinite is even more labile than resinite, it is conceivable that the Algebuckina coals may have just entered the oil window and are about to become effective source rocks. Extracted aromatic hydrocarbon fractions were also prepared and analysed by GC-MS to provide maturity estimates based on the methylphenanthrene index (MPI). However, the phenanthrene data, display poorly resolved peaks that preclude accurate calculation of MPI and R_c.

Purni Formation

The Purni Formation of Early Permian age was intersected by Dalmatia-1 and Mt Hammersley-1. Source quality ranges poor to good (HI = 113 to 359). The maturity of these sediments is in the range 0.43 to 0.45% R_o. Lower values (0.33 to 0.39%) from some Mt Hammersley-1 samples (MH 3, MH 4, MH 5) and one Dalmatia-1 sample (Dal 2) are unlikely to be representative of the true maturity. These reflectance levels are possibly suppressed (?bacterial reworking). Calculated vitrinite reflectances based on MPI suggest a maturity greater than 0.5% R_o. However, this value is unduly high and possibly source facies-related. Results from Rock-Eval pyrolysis support a maturity of greater than 0.40% but less than 0.45% R_o. Further, the values of several maturation-dependant biomarker parameters (*e.g.* T_s/T_m, $T_m/17\beta,21\alpha$-22,29,30-trisnorhopane: Table 3) and the predominance of steranes with biologically inherited $5\beta,14\alpha,17\alpha$-stereochemistry, confirm that the maturity is only marginally greater than 0.40% R_o but less than 0.45% R_o.

GC-MS analyses of aromatic hydrocarbons have also been undertaken. Derived methylphenanthrene indices (MPI) and R_c calculated therefrom are presented as part of Table 5. The provisional identification of retene in exceptionally high concentration in some samples from the Purni Formation

TABLE 1: Sample details

Well/depth	I.D.	Formation	Sample description (of total sample excluding contaminants)
AFMECO Cur-3			
251.60 m		Algebuckina Sst	Mottled, laminated, poorly sorted coaly siltstone.
251.90 m		Algebuckina Sst	Dark coaly shale.
259.50 m		Algebuckina Sst	Dark poorly-sorted coaly shale.
AFMECO Cur-5			
209.20 m		Algebuckina Sst	Carbonaceous, unconsolidated, poorly sorted fine/med sandstone.
210.10 m		Algebuckina Sst	Dark laminated coaly shale.
249.40 m		Algebuckina Sst	Dark brown/black coal, with alternating light and dull bands < 4 mm wide.
Dalmatia-1			
1940-1990'	Dal 5	Purni Formation	Dark shales, and minor coal.
2010-2050'	Dal 4	Purni Formation	Dark coaly shales and minor coal.
2080-2120'	Dal 3	Purni Formation	Dark shales, and minor coal.
2340-2370'	Dal 2	Purni Formation	Dark shale/siltstone, and minor coal.
2600-2660'	Dal 1	Purni Formation	Coaly shales and dark shales.
Mt Hammersley-1			
2020-2070'	MH 8	Purni Formation	Dark shales, coaly shales and coal.
2160-2210'	MH 7	Purni Formation	Dark shales, coaly shales and coal.
2310-2360	MH 6	Purni Formation	Dark coaly shales, dark shales and coal.
2500-2540'	MH 5	Purni Formation	Coals, coaly shales and dark shales.
2750-2800'	MH 4	Purni Formation	Dark coaly shales and dark shales.
2860-2910'	MH 3	Purni Formation	Very dark coaly shales and coal.
4000-4060'	MH 2	Undiff. Permian	Grey/green shale/siltstone, and minor dark shales.
4620-4670'	MH 1	Crown Point Fm	Grey/green shales/siltstone, and minor dark shales.

(Early Permian) is unexpected. This compound has only been reported in very low concentrations in pre-Jurassic sediments in the Cooper/Eromanga Basin province (Alexander *et al.*, 1988). Our finding has important implications for future oil-source rock correlations; oils containing relatively high retene contents may have been sourced from Permian source kitchens. This aspect requires greater consideration than can be afforded here. A more complete account of the aromatic hydrocarbon distributions in these rocks will be provided by Staples as part of an honours thesis (November, 1995).

Undifferentiated Permian and Crown Point Formation

Very poor source potential is displayed by one sample from the Early Permian Crown Point Formation (MH 1, 4620–4670'; HI = 34) and one undifferentiated Early Permian interval (MH 2, 4000–4060'; HI = 39) both from Mt Hammersley-1. Calculated vitrinite reflectance based on MPI suggests a maturity equivalent of 0.80% R_o for the latter.

Table 5 summarizes the most important maturity and source rock data.

SUMMARY

1. Resinite-rich coals of Middle Jurassic age (Algebuckina Sandstone) from the western margin of the Eringa Trough in AFMECO Cur-3 and Cur-5 display good to excellent oil-generative potential (HI = 312 to 542). They are marginally mature for liquid hydrocarbon generation (R_o = 0.41 to 0.44%). It should be noted that resinite and fluorinite-rich coals can generate light naphthenic oil at these low levels of organic metamorphism.

2. Coals and shaley coals from the Purni and Crown Point Formations (Permian) in Dalmatia-1 and Mt Hammersley-1 (eastern margin of the Eringa Trough), have poor to good source potential for liquid hydrocarbons (HI = 113 to 359). Their present maturity (0.40 to 0.45% R_o) is probably insufficient for oil generation. However, if the coals extend basinward, they may be effective source rocks in zones of greater maturity.

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TABLE 2: Rock-Eval pyrolysis

Well / Depth	I.D.	T_{max}	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
AFMECO Cur-3												
251.60 m		421	11.88	123.20	13.20	135.08	9.33	0.09	11.21	34.30	359	38
251.90 m		423	16.79	151.50	13.86	168.29	10.93	0.10	13.97	39.00	388	36
259.50 m		419	23.65	255.76	17.50	279.41	14.61	0.08	23.19	47.20	542	37
AFMECO Cur-5												
209.20 m		421	3.51	45.90	24.97	49.41	1.84	0.07	4.10	52.90	87	47
210.10 m		424	18.27	157.45	19.72	175.72	7.98	0.10	14.58	50.50	312	39
249.40 m		424	32.52	216.07	27.19	248.59	7.95	0.13	20.63	58.70	368	46
Dalmatia-1												
1940–1990'	DAL 5	423	5.32	150.09	11.96	155.41	12.55	0.03	12.90	49.20	305	24
2010–2050'	DAL 4	425	4.11	118.72	13.03	122.83	9.11	0.03	10.19	44.30	268	29
2080–2120'	DAL 3	426	1.85	91.11	12.87	92.96	7.08	0.02	7.72	37.70	242	34
2340–2370'	DAL 2	425	3.90	122.36	8.45	126.26	14.48	0.03	10.48	38.50	318	22
2600–2660'	DAL 1	422	4.23	125.09	11.25	129.32	11.12	0.03	10.73	39.40	317	29
Mt Hammersley-1												
2020–2070'	MH 8	424	2.12	80.18	17.96	82.30	4.46	0.03	6.83	63.10	127	28
2160–2210'	MH 7	425	1.58	71.21	17.66	72.79	4.03	0.02	6.04	62.80	113	28
2310–2360'	MH 6	425	2.77	96.20	15.74	98.97	6.11	0.03	8.21	58.70	164	27
2500–2540'	MH 5	425	6.37	172.94	9.70	179.31	17.83	0.04	14.88	59.10	293	16
2750–2800'	MH 4	427	6.34	200.38	8.17	206.72	24.53	0.03	17.16	55.80	359	15
2860–2910'	MH 3	427	5.38	139.13	9.13	144.51	15.24	0.04	11.99	52.80	264	17
4000–4060'	MH 2	nd	0.03	0.16	0.14	0.19	1.14	0.16	0.02	0.41	39	34
4620–4670'	MH 1	nd	0.07	0.12	0.12	0.19	1.00	0.37	0.02	0.35	34	34

T_{max} = temperature of maximum generation of S2 hydrocarbons

S1 = mg hydrocarbons/g rock; S2 = mg hydrocarbons/g rock; S3 = mg CO_2/g rock

PI = S1/(S1+S2); PC = pyrolysable carbon; TOC = total organic carbon

HI = S2/g TOC; OI = S3/g TOC

TABLE 3: Biomarker parameters

Well / Depth	I.D.	C_{27} hopanes		C_{29} hopanes		C_{30} hopanes		C_{31} hopanes		
		$\frac{T_S}{T_m}$	$\frac{\beta\alpha}{\beta\beta}$	$\frac{\alpha\beta}{\beta\alpha}$	$\frac{\beta\alpha}{\beta\beta}$	$\frac{\alpha\beta}{\beta\alpha}$	$\frac{\beta\alpha}{\beta\beta}$	$\frac{\alpha\beta\ 22R}{\beta\beta\ 22R}$	$\frac{\beta\alpha\ 22S+22R}{\beta\beta\ 22R}$	$\frac{\text{Hopane}}{\text{Sterane}}$
AFMECO Cur-3										
251.60 m		0.13	0.22	1.14	0.88	2.48	0.40	0.14	0.66	11.5
259.50 m		0.10	0.28	1.24	1.04	2.77	0.52	0.11	0.79	10.3
AFMECO Cur-5										
249.40 m		0.00	0.14	0.38	0.67	2.40	0.28	0.15	0.31	35.8
Dalmatia-1										
1940–1990'	DAL 5	0.45	0.46	1.07	1.29	4.50	0.67	0.39	0.55	1.2
2010–2050'	DAL 4	0.44	0.34	1.40	1.16	5.14	0.70	0.32	0.72	1.5
2340–2370'	DAL 2	0.45	0.40	1.09	1.57	4.50	0.67	0.49	0.63	1.9
Mt Hammersley-1										
2020–2070'	MH 8	0.15	0.36	0.92	0.86	6.00	0.38	0.31	0.43	1.8
2310–2360'	MH 6	0.06	0.46	0.58	0.98	5.14	0.64	0.25	0.68	2.3
2750–2800'	MH 4	0.18	0.47	0.90	1.57	4.00	1.13	0.19	1.35	2.0
4000–4060'	MH 2	0.44	3.00	3.60	2.00	9.00	4.44	0.76	0.43	3.8

Ratios based on peak heights for hopanes (*m/z* 191) and steranes (*m/z* 217).

C_{27} Hopanes

T_S	18α-22,29,30-trisnorneohopane
T_m	17α -22,29,30-trisnorhopane
βα	17β-22,29,30-trisnorhopane

C_{29} Hopanes

αβ	17α,21β-30-norhopane
βα	17β,21α-30-norhopane
ββ	17β,21β-30-norhopane

C_{30} Hopanes

αβ	17α,21β-hopane
βα	17β,21α-hopane
ββ	17β,21β-hopane

C_{31} Hopanes

αβ 20S	17α,21β-homohopane (22S)
αβ 20R	17α,21β-homohopane (22R)
βα 20S+20R	17β,21α-homohopane (22S+22R)
ββ	17β,21β-homohopane (presumably 22R)

C_{29} Steranes

βα 20S	13β,17α-diaethylcholestane (20S)
βα 20R	13β,17α-diaethylcholestane (20R)
ααα 20S	5α,14α,17α-ethylcholestane (20S)
ααα 20R	5α,14α,17α-ethylcholestane (20S)
βαα 20R	5β,14α,17α-ethylcholestane (20R)
αββ (20R+20S)	5α,14β,17β-ethylcholestane (20R+20S)

$$\frac{\text{Hopane}}{\text{Sterane}} = \frac{\Sigma(C_{27}\text{ hopanes} + C_{29}\text{ hopanes} + C_{30}\text{ hopanes})}{\Sigma C_{29}\text{ steranes}}$$

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TABLE 4: Petrographic descriptions and vitrinite reflectance data

Sample	Lithology	R_o (%)	Description
AFMECO Cur-3			
251.60 m	Coal/shaley coal	0.43	Complex maceral assemblage, poorly layered. Comprises vitrinite (texto-ulminite and corpogelinite), minor inertinite, and abundant resinite, fluorinite, sporinite and cutinite.
251.90 m	Coal	0.43	As above.
259.50 m	Coal	0.44	Similar to above but contains more resinite and fluorinite.
AFMECO Cur-5			
209.20 m	Reworked coal	0.62	Coal fragments include large phytoclasts of eu-ulminite and bogen-structured semifusinite. Some coal fragments contain abundant sporinite and ?resinite.
210.10 m	Coal	0.41	Similar to AFMECO Cur-3 samples, however, contains much larger resinite phytoclasts.
249.40 m	Coal	0.45	Comprises intimate layers of vitrinite, minor inertinite, sporinite, liptodetrinite and resinite.
Dalmatia-1			
Dal 5	Coal/shaley coal	0.44	Cutinite ≈ vitrinite ≈ sporinite. Only minor inertinite present. Bituminite abundant in association with degraded humic macerals. Minor ?exsudatinite.
Dal 2	Coal	0.34	Vitrinite>liptinite>inertinite. Vitrinite macerals in order of abundance: texto-ulminite (structured vitrinite), eu-ulminite (gelified structured vitrinite), densinite and corpogelinite. Inertinite macerals in order of abundance: semifusinite, fusinite. Liptinite macerals in order of abundance: sporinite, resinite, ?alginite. Resinite occurs as very small (1 – 2 μm) globule-like phytoclasts widely dispersed within the sample. Other resinite occurs as more conventional (larger) phytoclasts in a densinite matrix. **Possible R_o suppression.**
Mt Hammersley-1			
MH 8	Coal	0.43	Almost entirely texto-ulminite, oxidized vitrinite and semifusinite. Minor sporinite.
MH 7	Coal	0.37	Almost entirely texto-ulminite, oxidized vitrinite and semifusinite. Minor sporinite.
MH 6	Coal	0.45	Poorly layered with desiccation cracks/possibly partially reworked fragments. Densinite (partially gelified detrital virtinite) is the dominant maceral. Sporinite and resinite common. Only minor inertinite.
MH 5	Coal	0.39	Unclearly layered with desiccation cracks/possibly partially reworked fragments. Densinite (partially gelified detrital virtinite) is the dominant maceral. Sporinite and resinite common. Minor inertinite. **Possible R_o suppression.**
MH 4	Coal/shaley coal	0.33	Vitrinite is the dominant maceral group and comprises degraded densinite and corpogelinite. Only minor inertinite. Sporinite and resinite are the dominant liptinites. Bituminite present and ?exsudatinite. **Possible R_o suppression.**
MH 3	Coal	0.36	Vitrinite ≈ inertinite > liptinite. Vitrinite macerals are predominantly eu-ulminite and texto-ulminite. Inertinites are predominant semifusinite. **Possible R_o suppression.**
MH 2	Siltstone	nd	Organics very sparse. Liptodetrinite, sporinite (?dinoflagellate cysts) and inertinite/vitrinite present.
MH 1	Siltstone	nd	Organics very sparse. Liptodetrinite, sporinite (?dinoflagellate cysts) and inertinite/vitrinite present.

TABLE 5: Lithology, vitrinite reflectance and geochemical data summary.

Depth (m)	I.D.	Lithology analysed	R_o (%)	EOM mg/g TOC	MPI	R_c (%)	Pr/Ph	Hop/Ster	TOC (wt %)	T_{max} (°C)	HI	Source potential
AFMECO CUR3												
251.60		Coal/shaley coal	0.43	432				11.5	34.30	421	359	Good
251.90		Coal	0.43	178					39.00	423	388	Good
259.50		Coal	0.44	162				10.3	47.20	419	542	Excellent
AFMECO CUR5												
209.20		Reworked coal	0.62						52.90	421	87	V. poor
210.10		Coal	0.41	141					50.50	424	312	Good
249.40		Coal	0.45	137				35.8	58.70	424	368	Good
Dalmatia-1												
1940–1990'	DAL5	Shaley coal/coal	0.44	54	0.41	0.51	4.0	1.2	49.20	423	305	Good
2010–2050'	DAL4	Shaley coal		48	0.58	0.63	3.0	1.5	44.30	425	268	Fair
2080–2120'	DAL3	Shaley coal							37.70	426	242	Fair
2340–2370'	DAL2	Shaley coal	0.34	79	0.46	0.54	4.2	1.9	38.50	425	318	Good
2600–2660'	DAL1	Shaley coal							39.40	422	317	Good
Mt Hammersley-1												
2020–2070'	MH8	Coal	0.43	29	0.62	0.65	3.4	1.8	63.10	424	127	Poor
2160–2210'	MH7	Coal	0.37	27	0.46	0.54	2.3		62.80	425	113	Poor
2160–2210'	MH6	Coal	0.45	34	0.48	0.56	3.8	2.3	58.70	425	164	Poor
2310–2360'	MH5	Coal	0.39	54	0.45	0.53	3.5		59.10	425	293	Fair
2750–2800'	MH4	Coal	0.33	57	0.40	0.50	3.8	2.0	55.80	427	359	Good
2860–2910'	MH3	Coal	0.36	50	0.48	0.56	3.3		52.80	427	264	Fair
4000–4060'	MH2	Organically-lean siltstone		89	0.82	0.80		3.8	0.41	nd	39	V. poor
4620–4670'	MH1	Organically-lean siltstone							0.35	nd	34	V. poor

R_o (%)=mean of maximum vitrinite reflectance (from R_r, see Experimental Methods).

$MPI = 1.5 \times \frac{2\text{-MP} + 3\text{-MP}}{P + 1\text{-MP} + 9\text{-MP}}$ (calculated using peak areas); R_c (%) = 0.7 MPI + 0.22 after Boreham *et al.* (1988).

where; P = phenanthrene*, 1-MP = 1-methylphenanthrene, 2-MP = 2-methyphenanthrene, and so on.

* A GC-MS response factor of 0.69 was applied to the area of this peak in calculating MPI.

Pr = pristane, Ph = phytane (from GC–FID peak heights)

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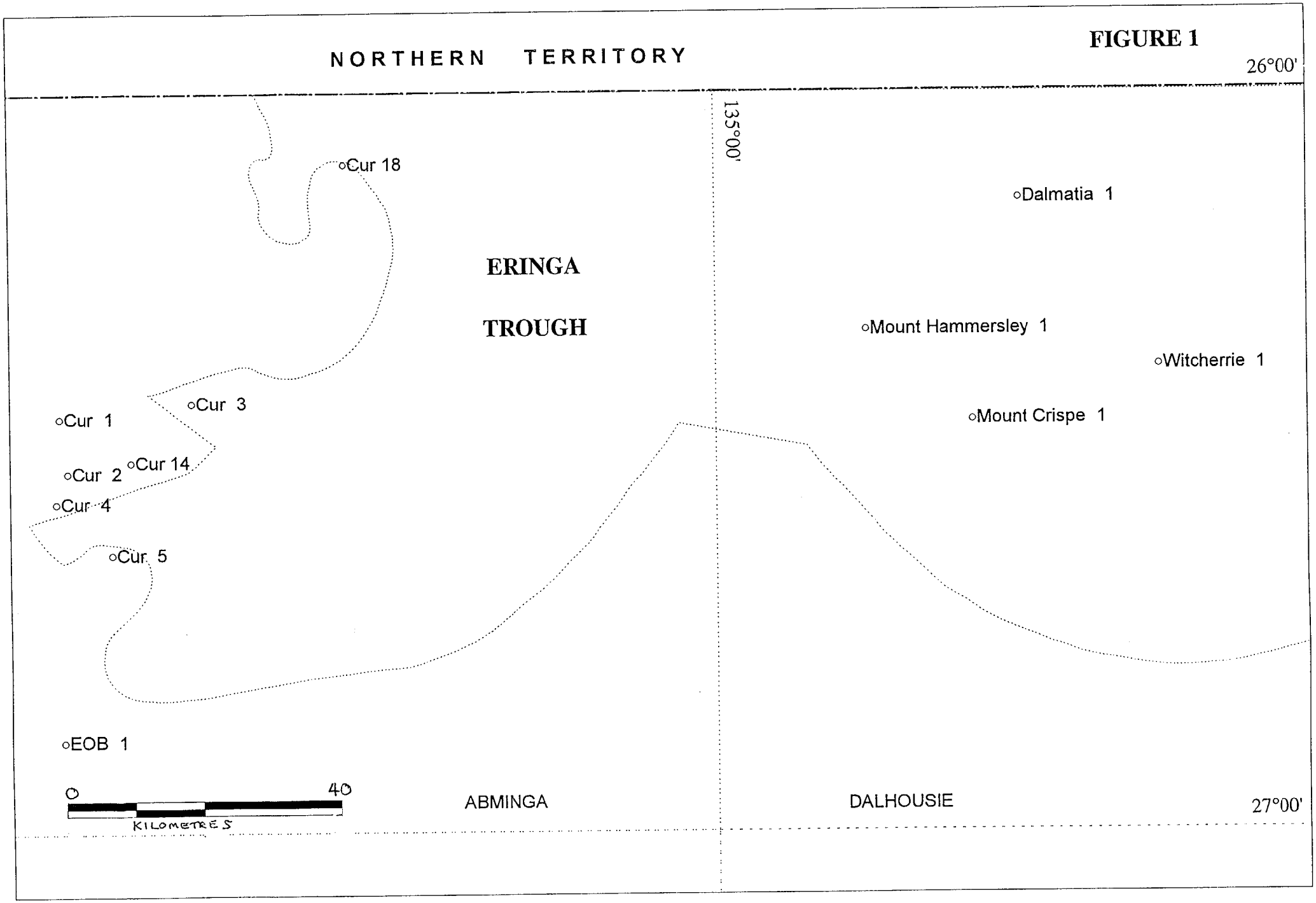
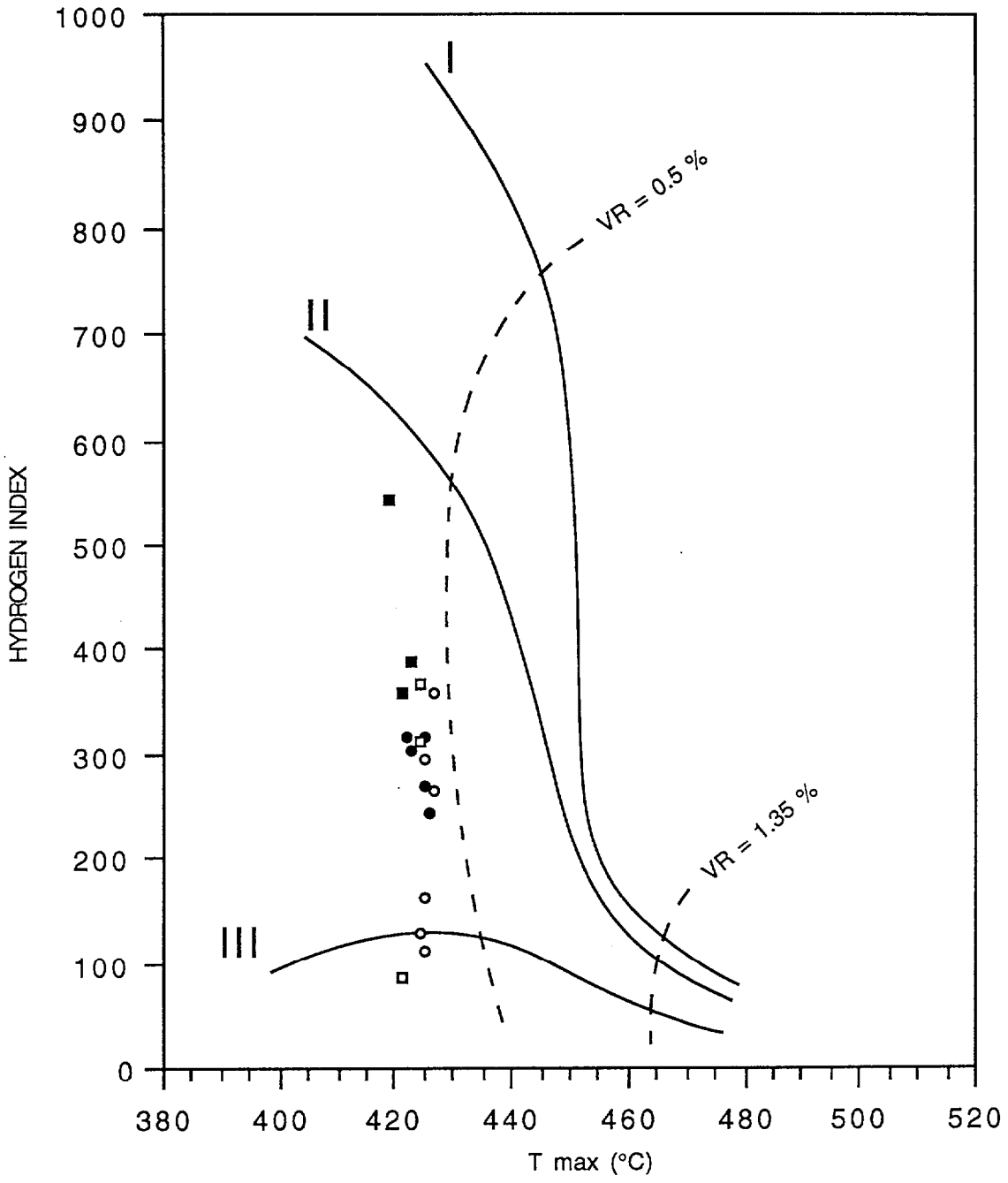

NORTHERN TERRITORY
FIGURE 1
26°00'
135°00'
Cur 18
Dalmatia 1
ERINGA
TROUGH
Mount Hammersley 1
Witcherrie 1
Cur 3
Cur 1
Mount Crispe 1
Cur 14
Cur 2
Cur 4
Cur 5
EOB 1
0
40
KILOMETRES
ABMINGA
DALHOUSIE
27°00'

00694

FIGURE 2



- AFMECO Cur-3
- AFMECO Cur-5
- Dalmatia-1
- Mt Hammersley-1

KEY TO BIOMARKER ASSIGNMENTS

Saturates GC (Figures A1 to A14)

See Figure A7 for key.

Hopanes (Figures B1 to B10)

C_{27} Hopanes

T_s	18α-22,29,30-trisnorneohopane
T_m	17α -22,29,30-trisnorhopane
βα	17β-22,29,30-trisnorhopane

C_{29} Hopanes

αβ	17α,21β-30-norhopane
βα	17β,21α-30-norhopane (*i.e.* 30-normoretane)
ββ	17β,21β-30-norhopane

C_{30} Hopanes

αβ	17α,21β-hopane
βα	17β,21α-hopane (*i.e.* moretane)
ββ	17β,21β-hopane

C_{31} Hopanes

αβ 20S	17α,21β-homohopane (22S)
αβ 20R	17α,21β-homohopane (22R)
βα 20S+20R	17β,21α-homohopane (22S+22R)
ββ	17β,21β-homohopane (presumably 22R)

Steranes (Figures C1 to C10)

C_{29} Steranes

βα 20S	13β,17α-diaethylcholestane (20S)
βα 20R	13β,17α-diaethylcholestane (20R)
ααα 20S	5α,14α,17α-ethylcholestane (20S)
ααα 20R	5α,14α,17α-ethylcholestane (20S)
βαα 20R	5β,14α,17α-ethylcholestane (20R)
αββ (20R+20S)	5α,14β,17β-ethylcholestane (20R+20S)

FIGURE A1
AFMECO Cur-3
251.60 m
Saturates GC

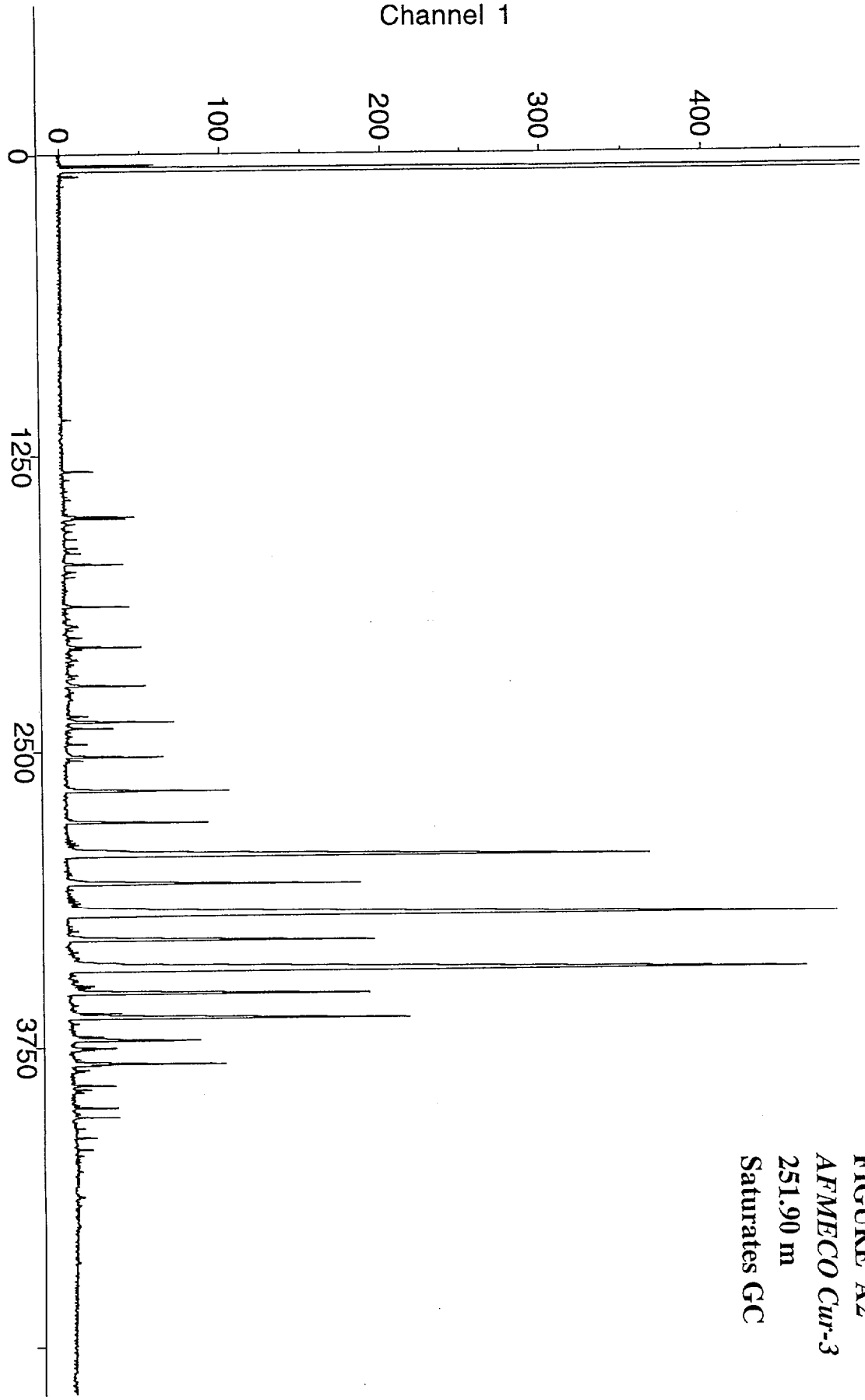


FIGURE A2
AFMECO Cur-3
251.90 m
Saturates GC

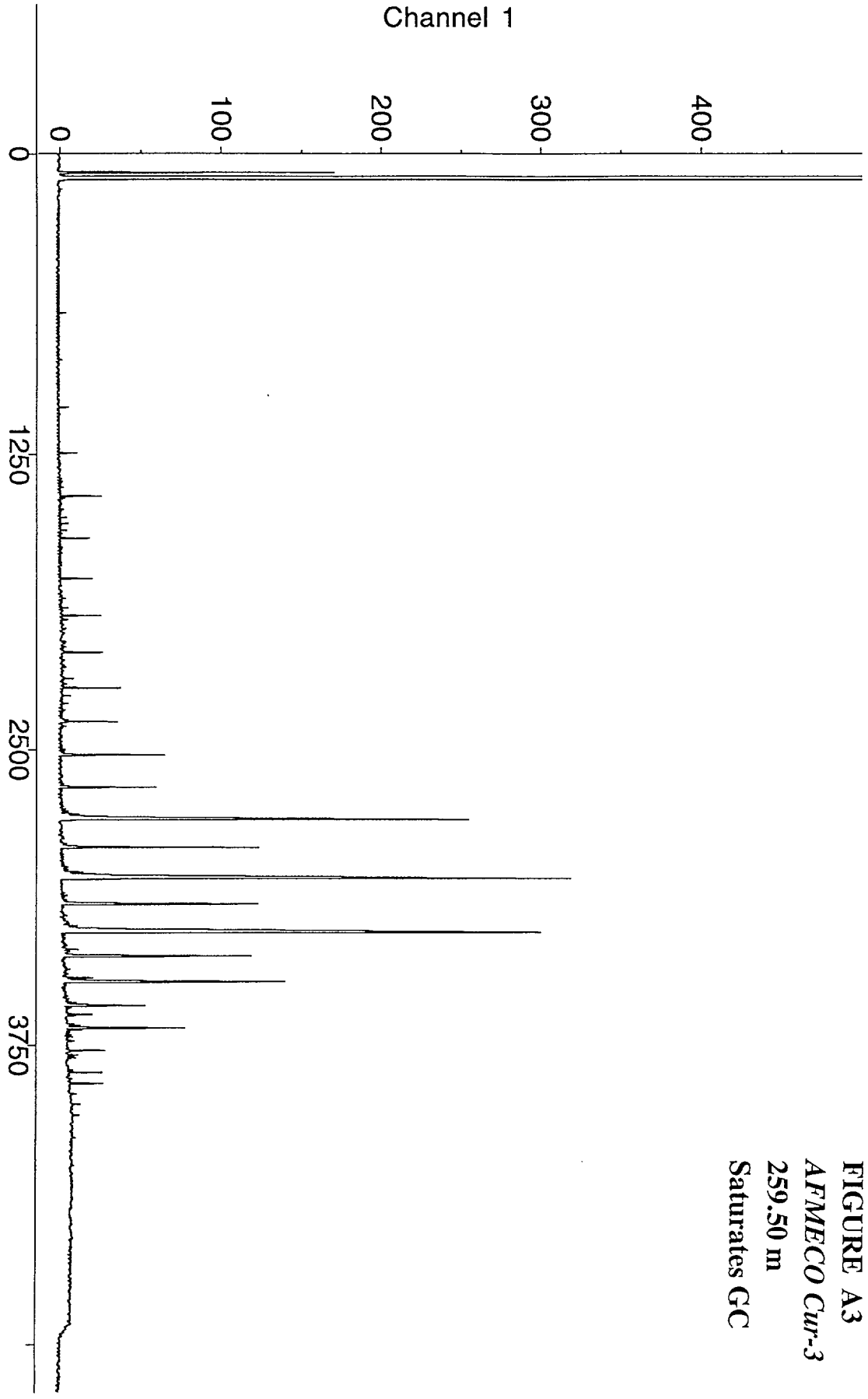


FIGURE A3
AFMECO Cur-3
259.50 m
Saturates GC

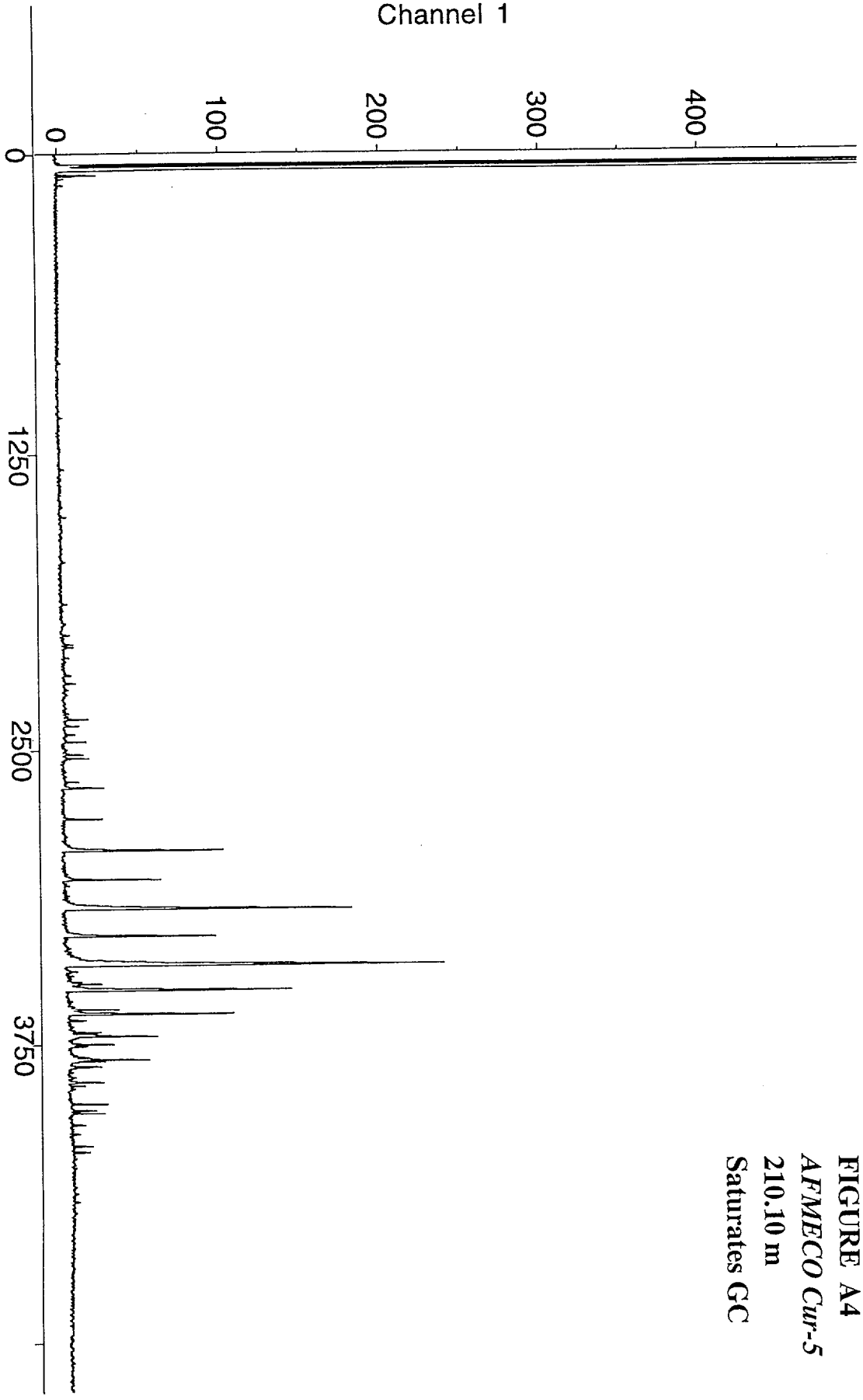


FIGURE A4
AFMECO Cur-5
210.10 m
Saturates GC

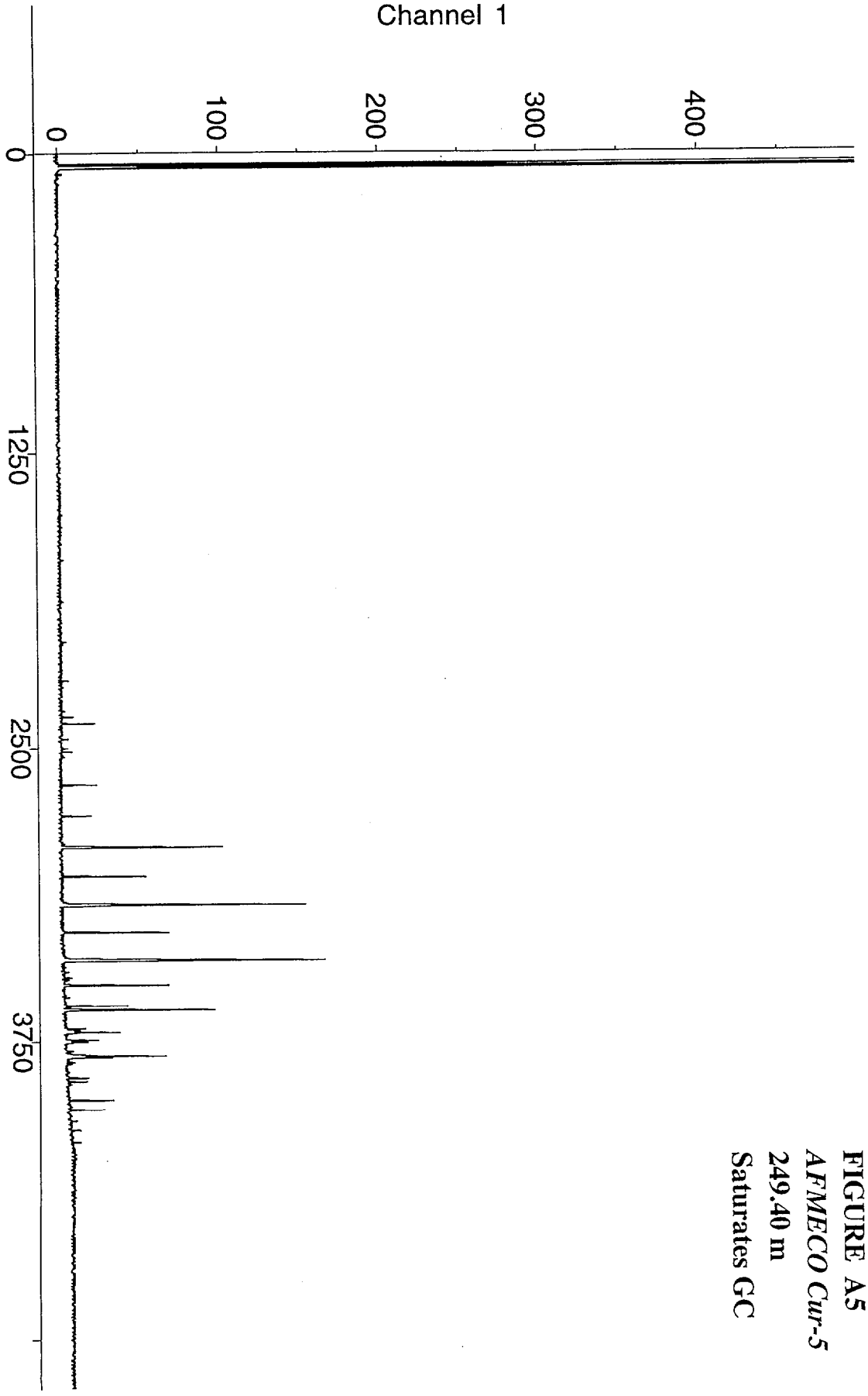


FIGURE A5
AFMECO Cur-5
249.40 m
Saturates GC

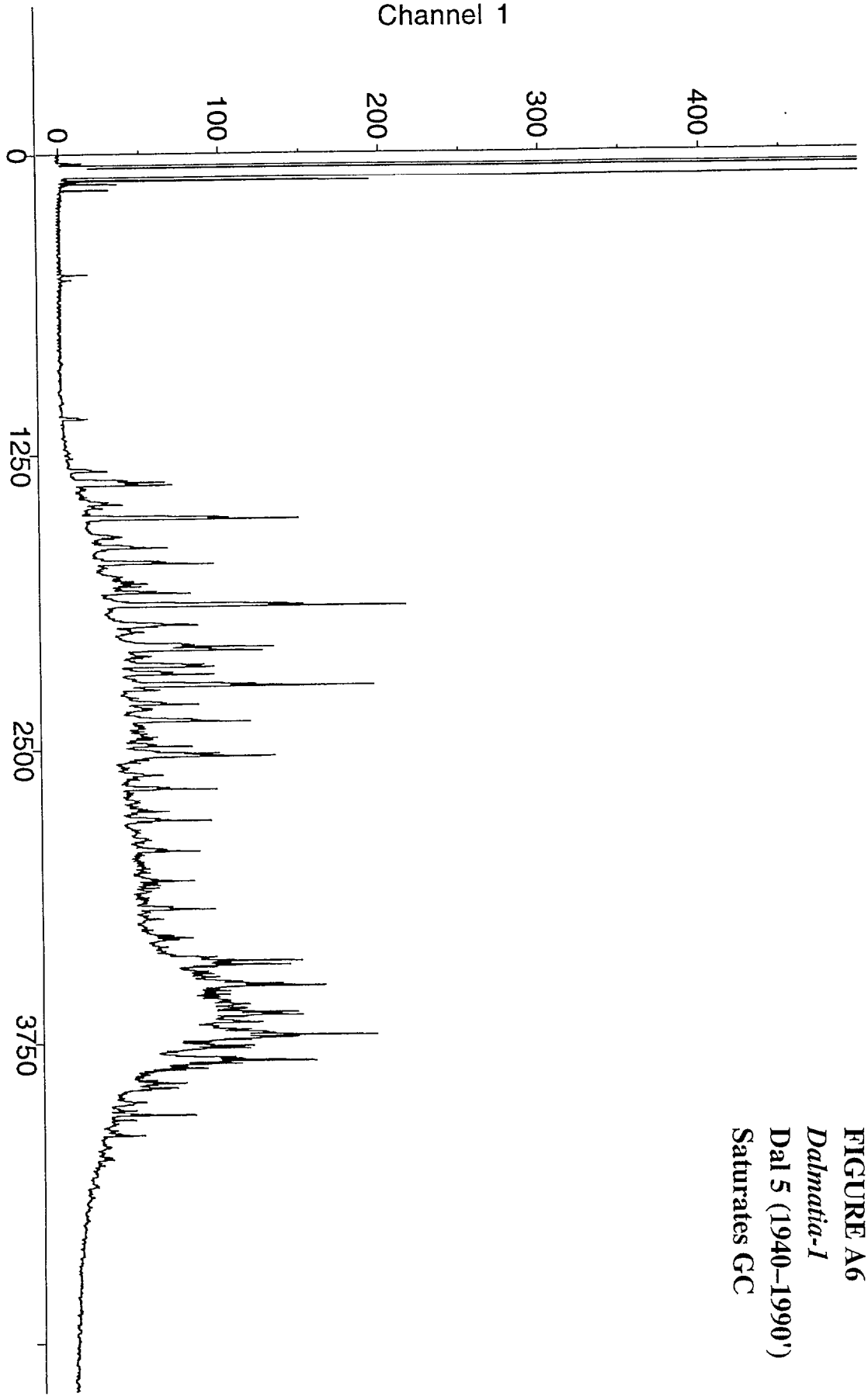
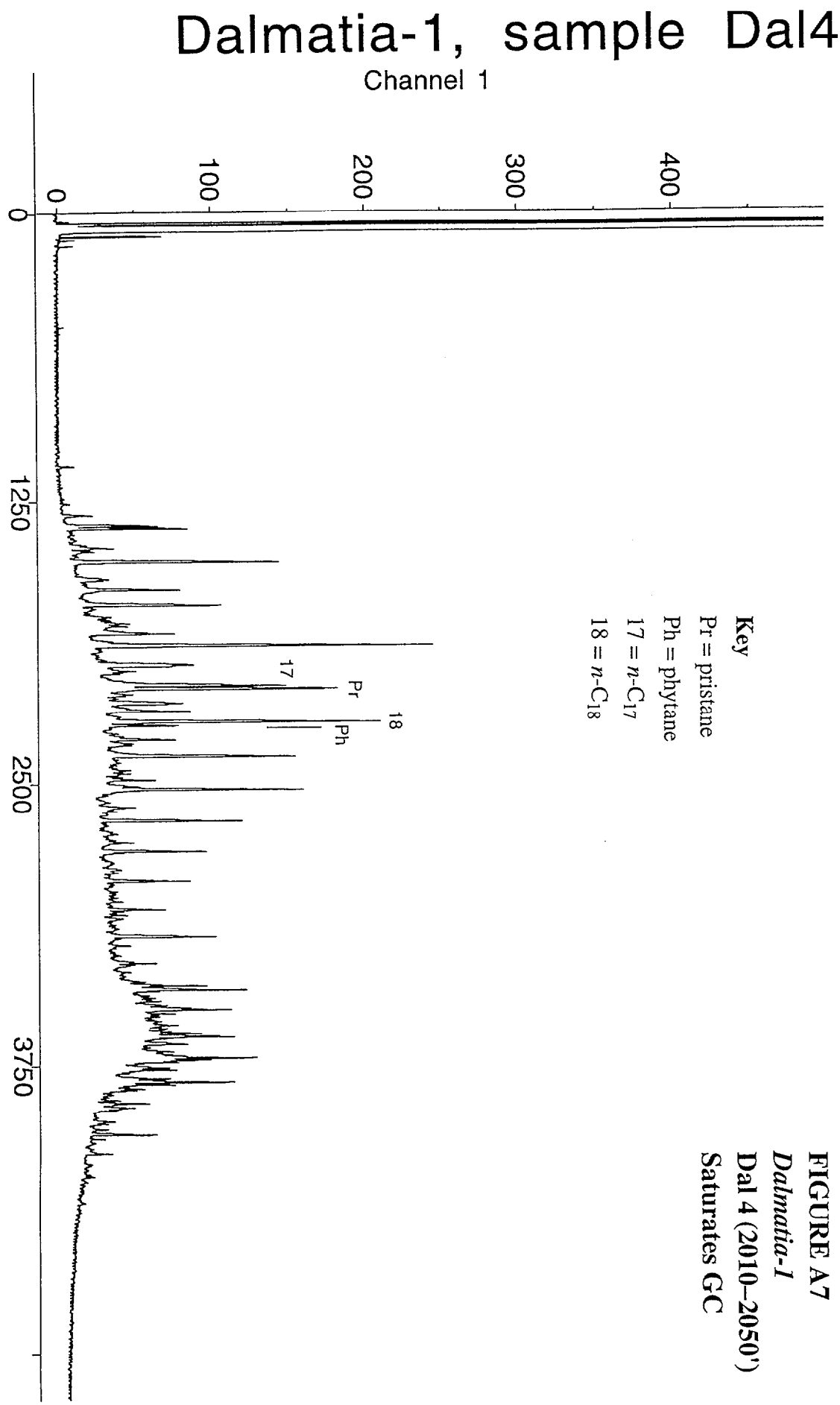


FIGURE A6
Dalmatia-1
Dal 5 (1940–1990')
Saturates GC



Key

Pr = pristane

Ph = phytane

17 = *n*-C_{17}

18 = *n*-C_{18}

FIGURE A7

Dalmatia-1

Dal 4 (2010–2050')

Saturates GC

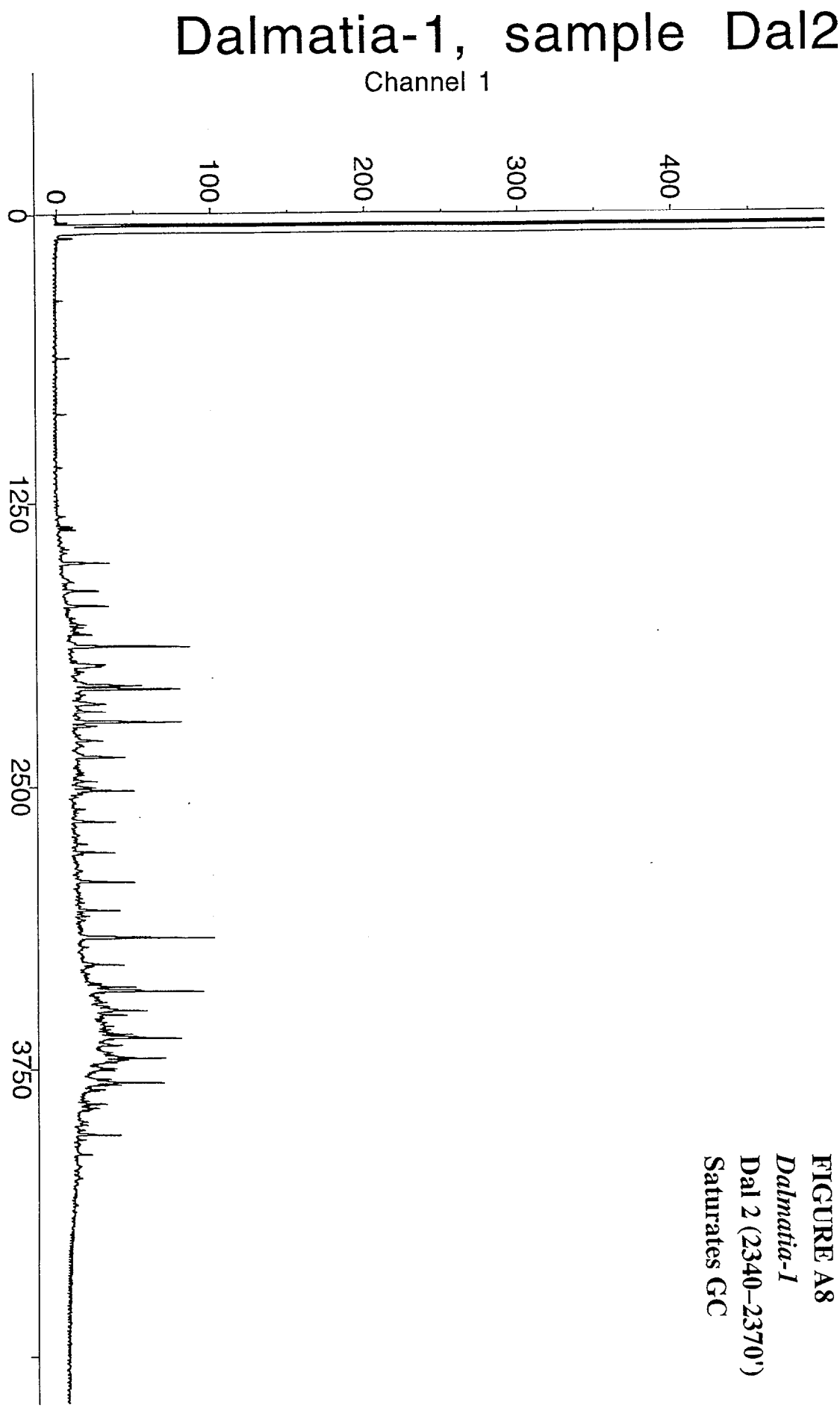


FIGURE A8
Dalmatia-1
Dal 2 (2340–2370')
Saturates GC

Mt Hammersley-1, sample MH8

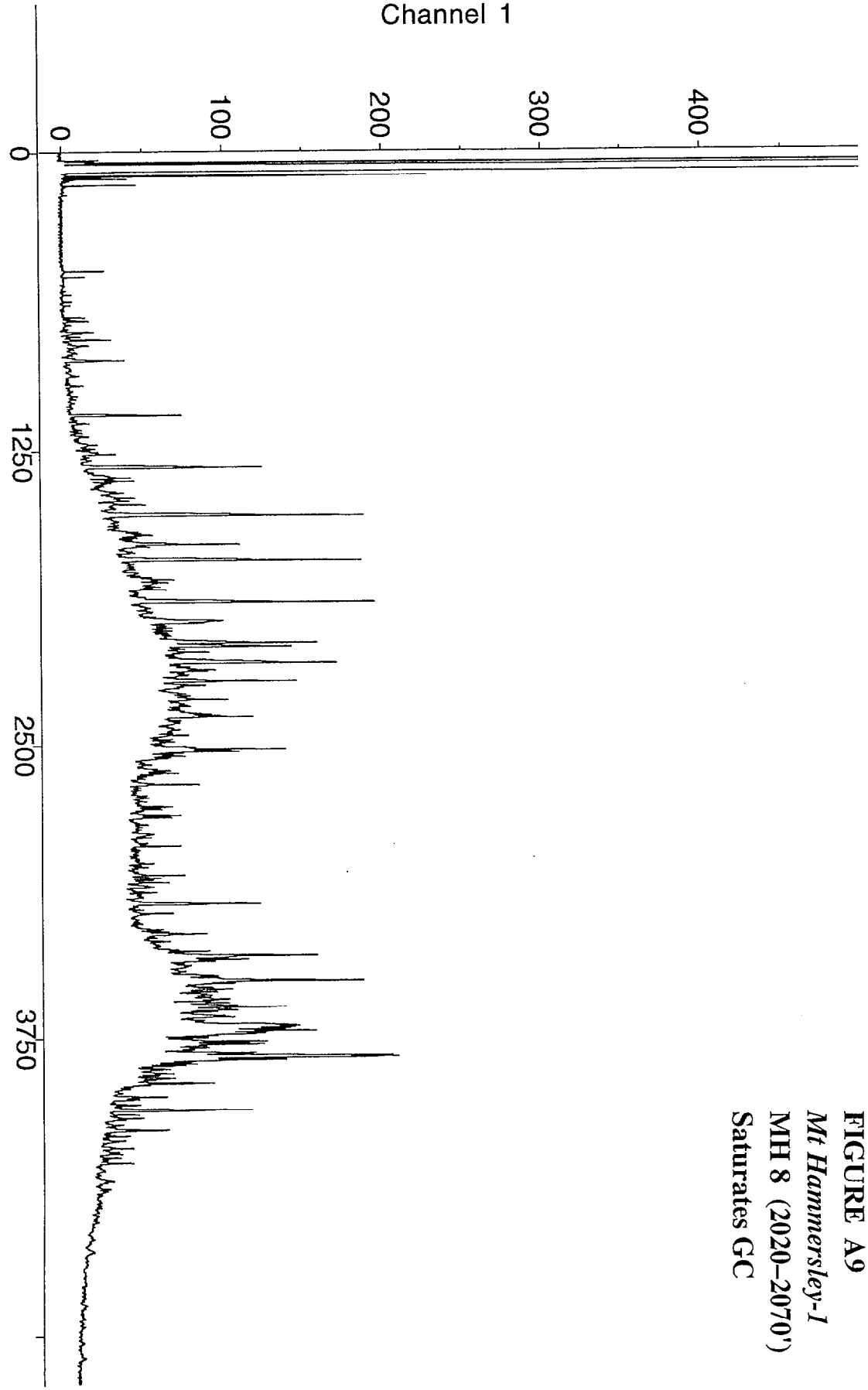


FIGURE A9
Mt Hammersley-1
MH 8 (2020–2070')
Saturates GC

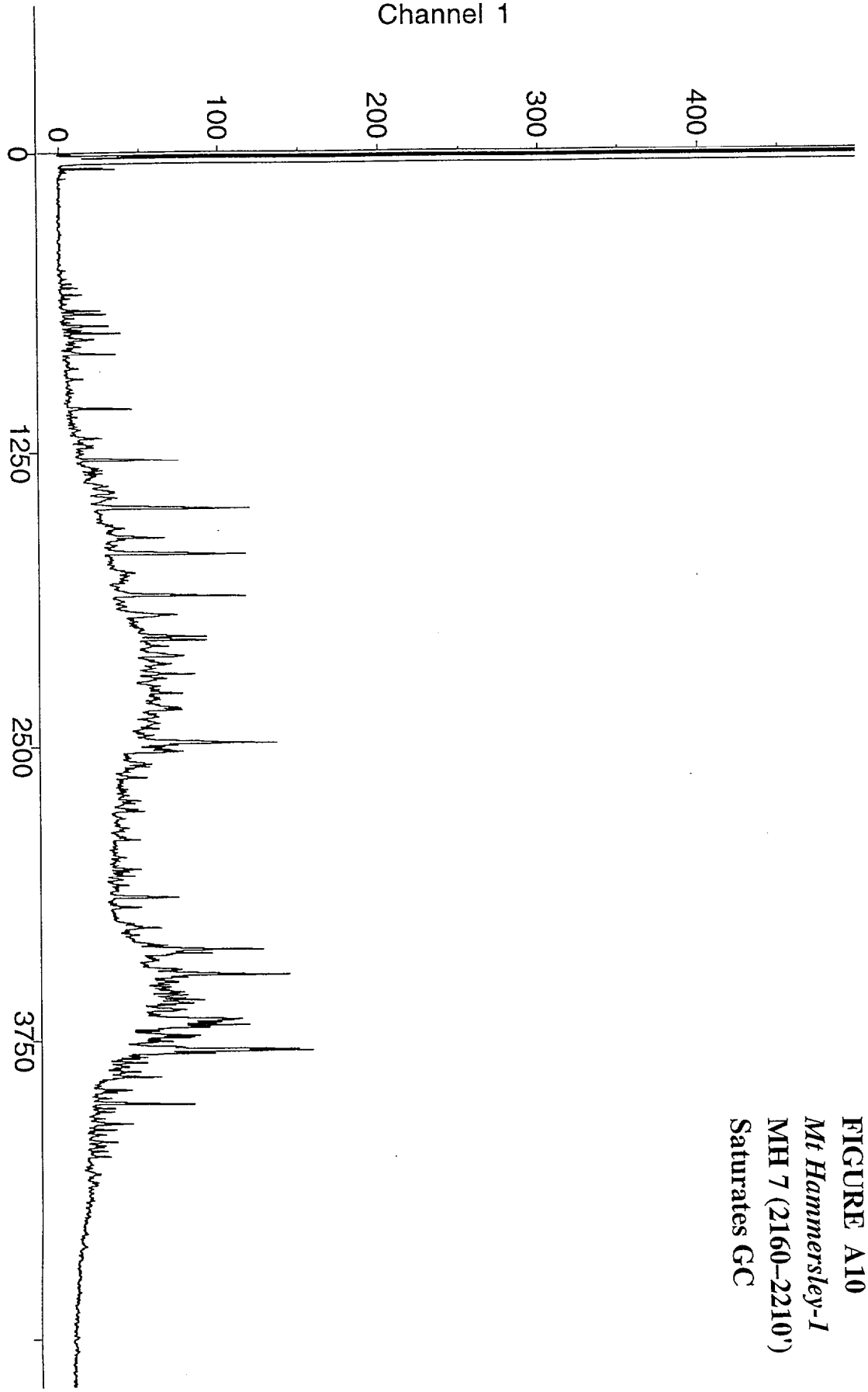


FIGURE A10
Mt Hammersley-1
MH 7 (2160–2210')
Saturates GC

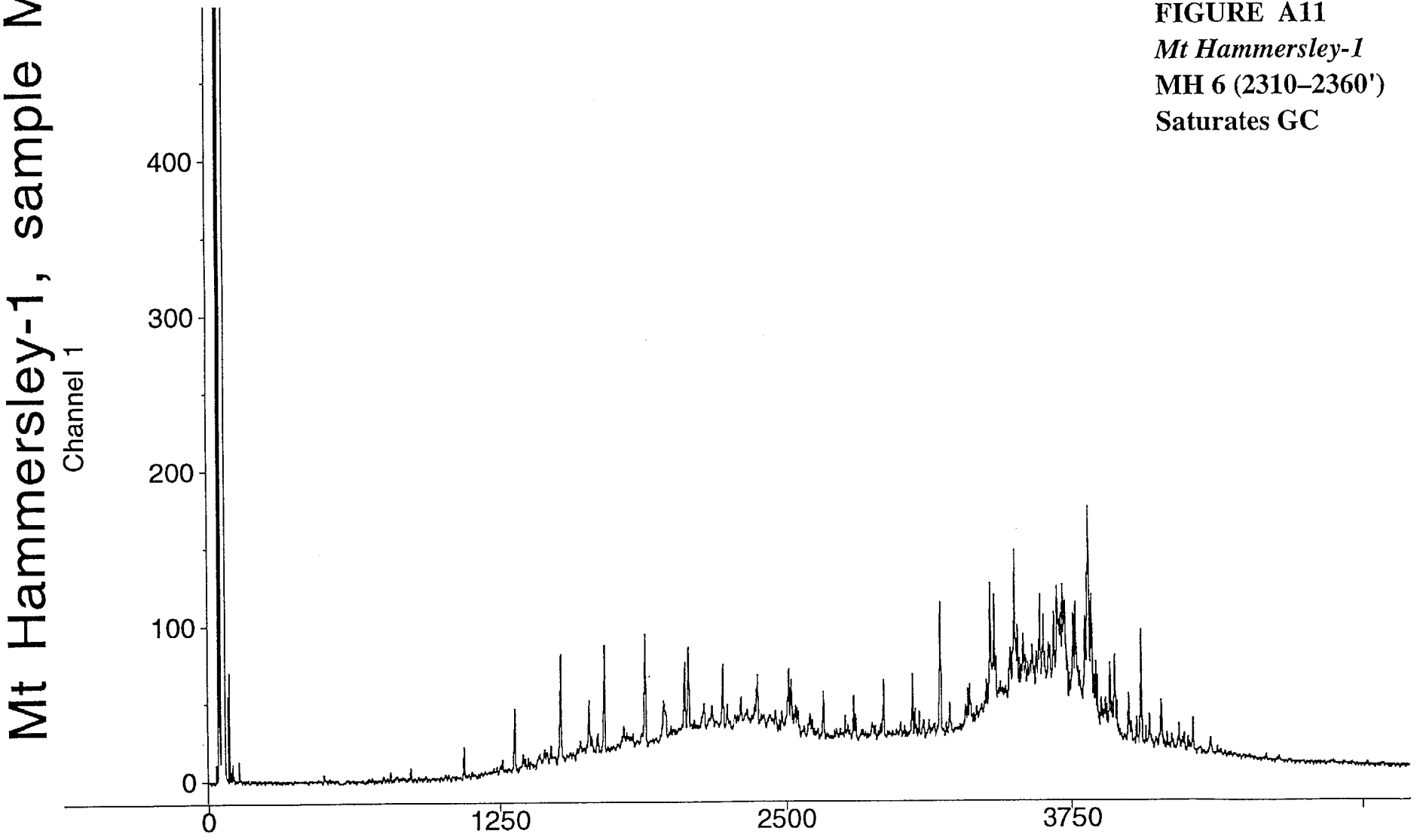


FIGURE A11
Mt Hammersley-1
MH 6 (2310–2360')
Saturates GC

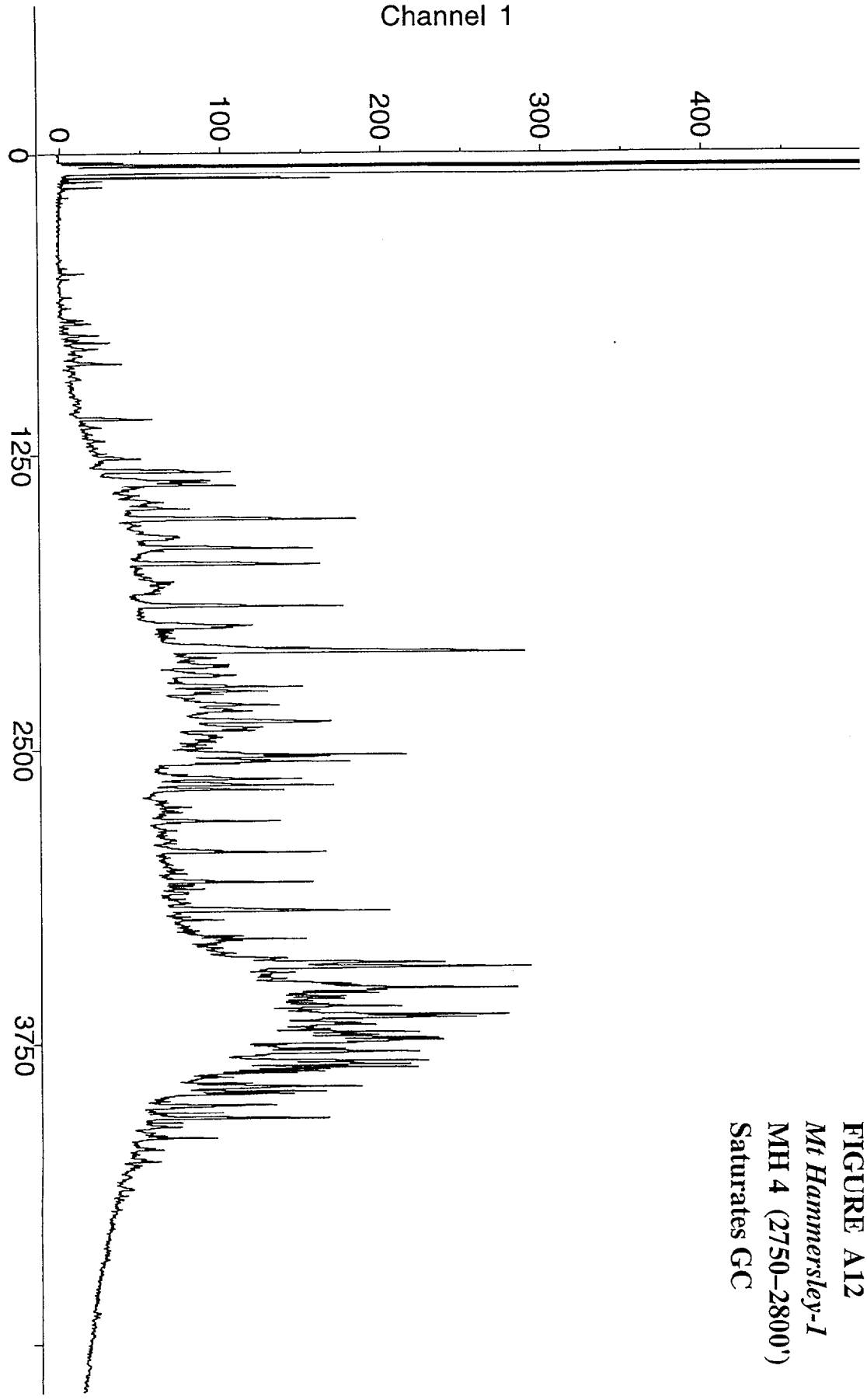


FIGURE A12
Mt Hammersley-1
MH 4 (2750–2800')
Saturates GC

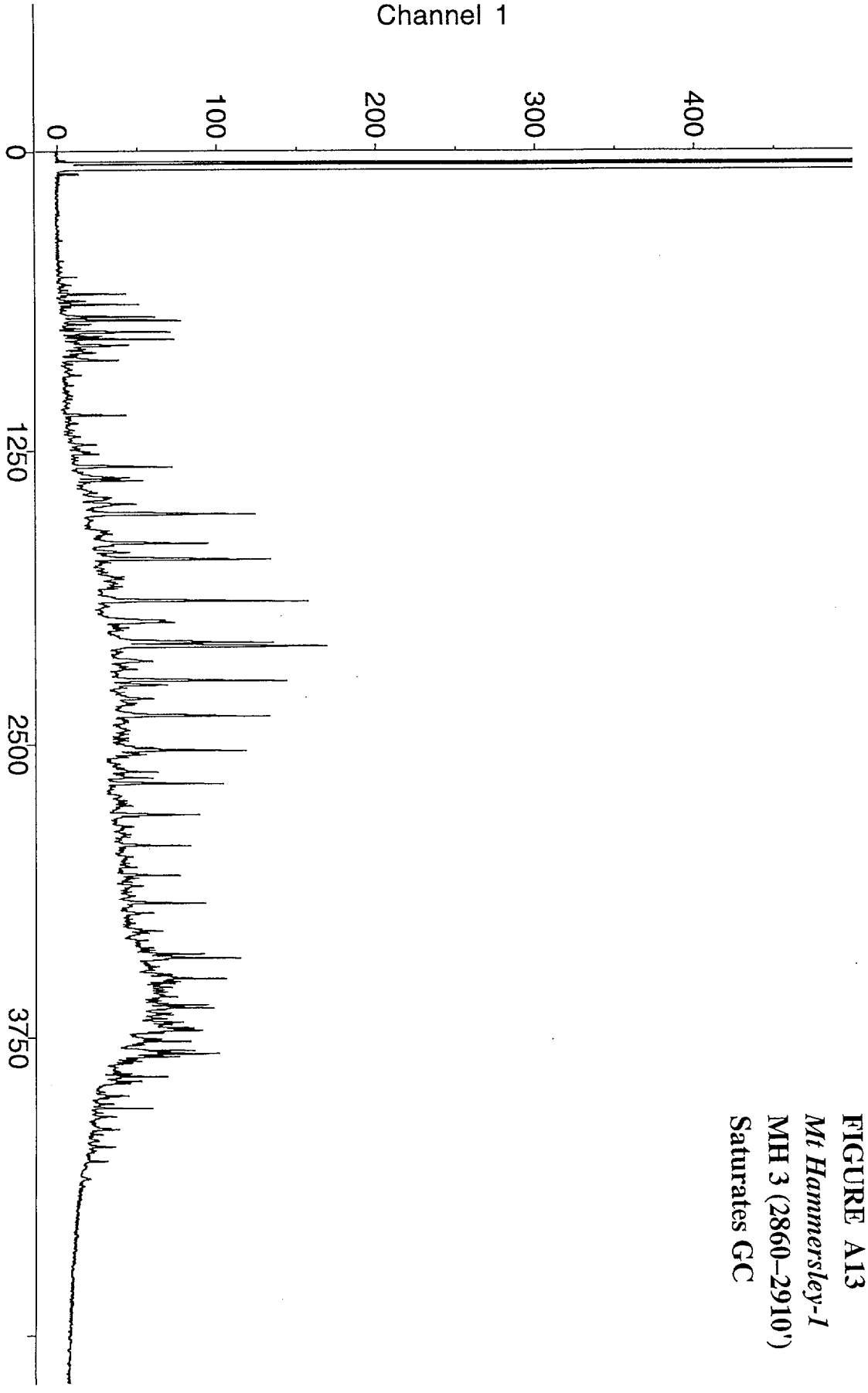


FIGURE A13
Mt Hammersley-1
MH 3 (2860–2910')
Saturates GC

0110

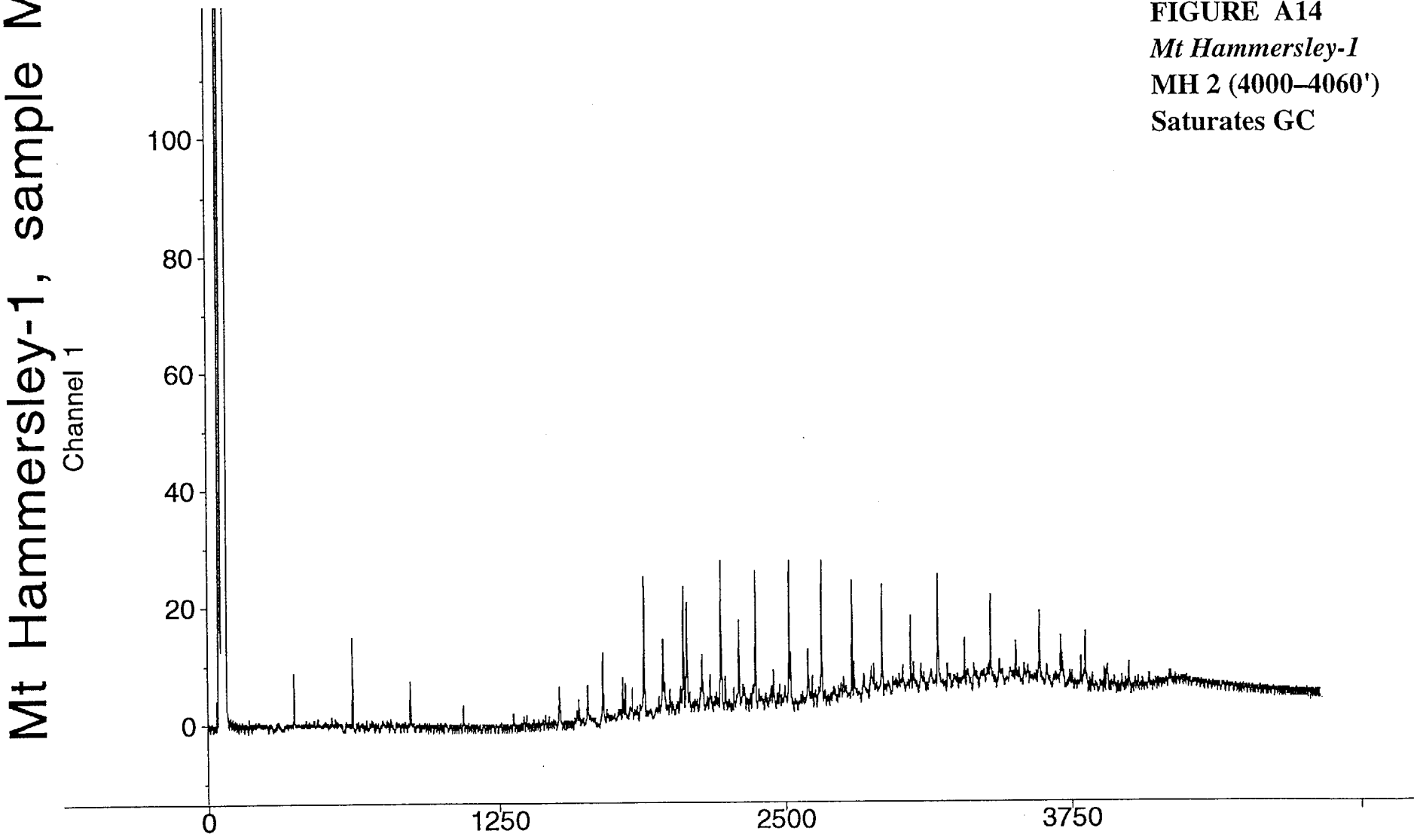


FIGURE A14
Mt Hammersley-1
MH 2 (4000–4060')
Saturates GC

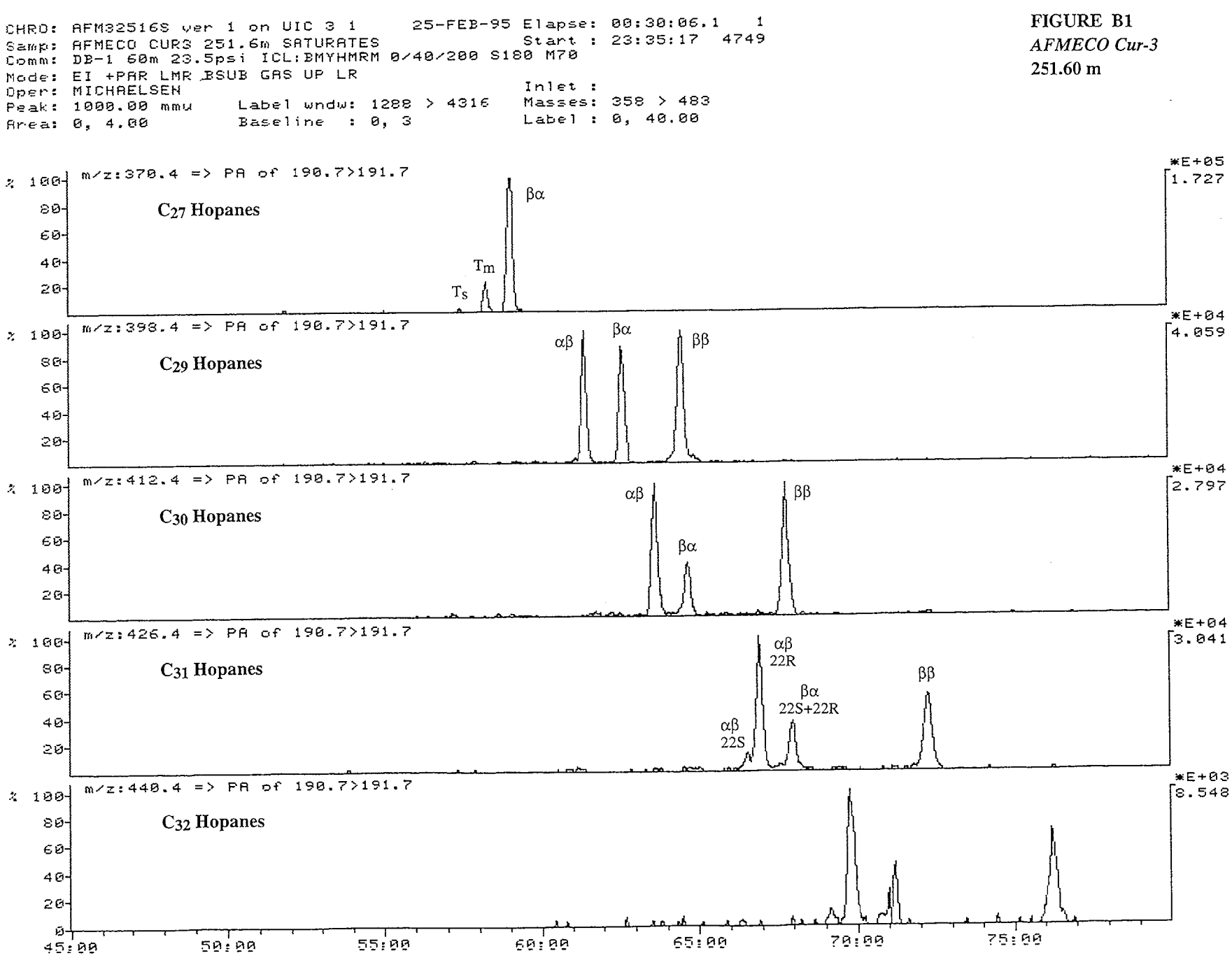


FIGURE B1
AFMECO Cur-3
251.60 m

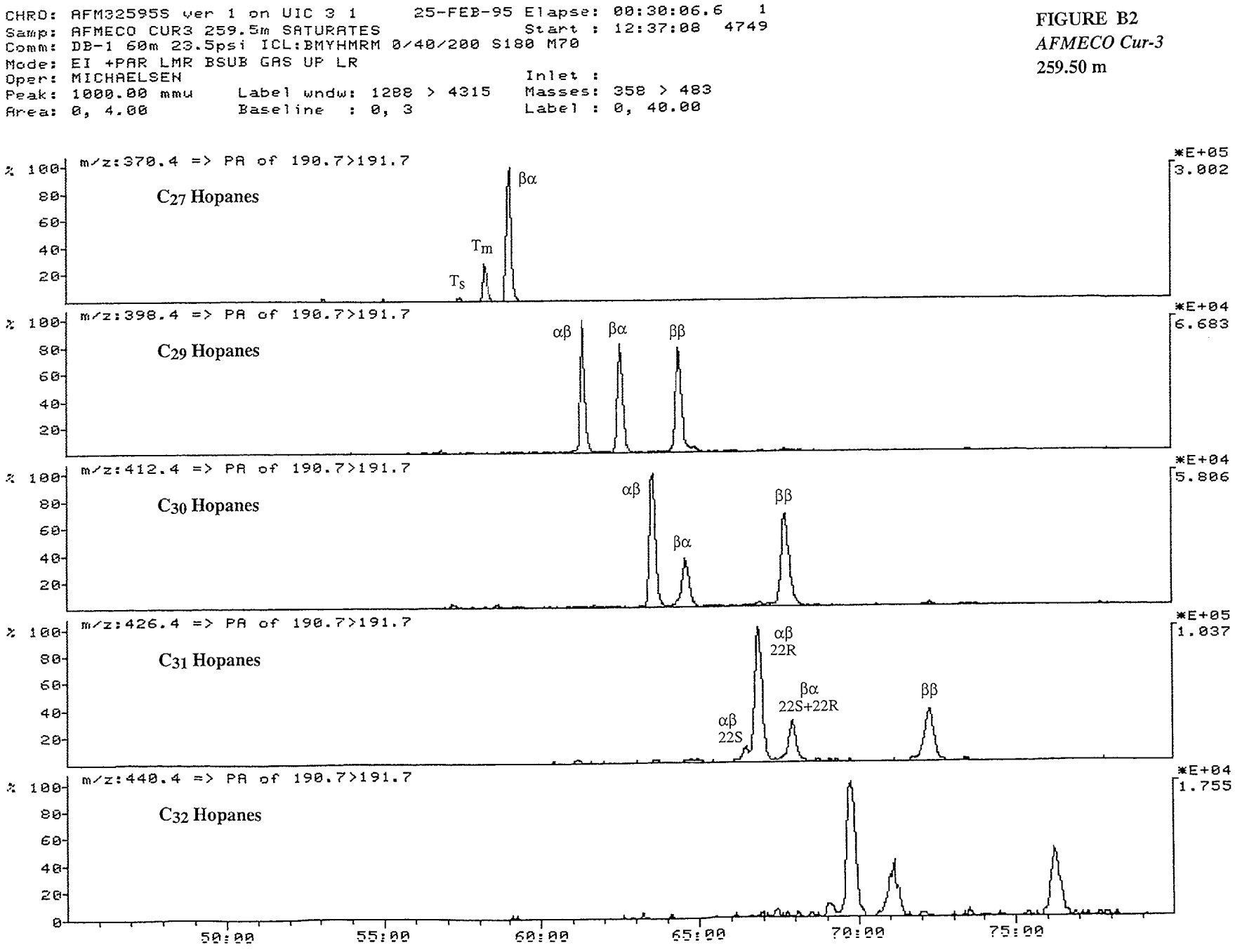


FIGURE B2
AFMECO Cur-3
259.50 m

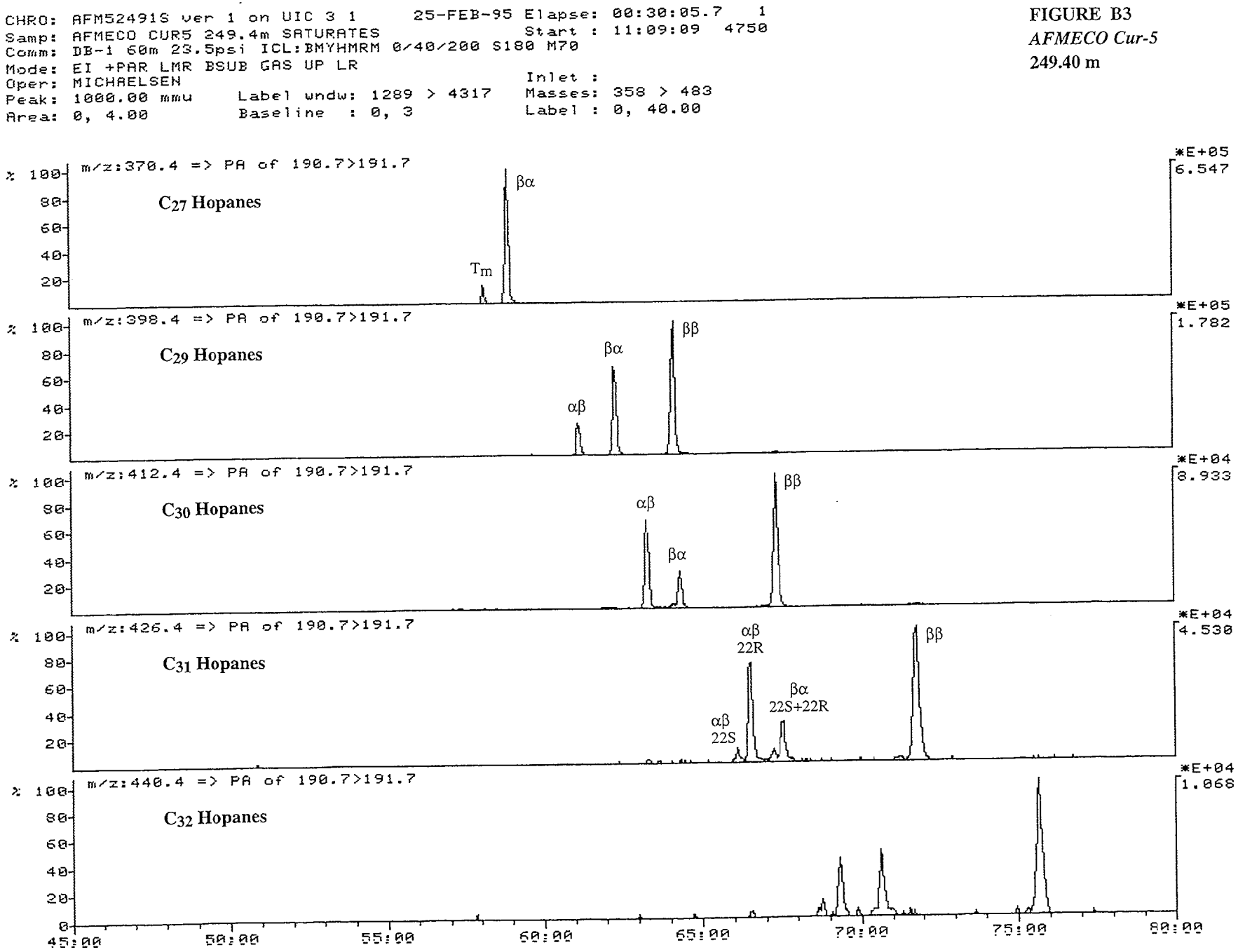


FIGURE B3
AFMECO Cur-5
249.40 m

FIGURE B4
Dalmatia-1
Dal 5 (1940–1990')

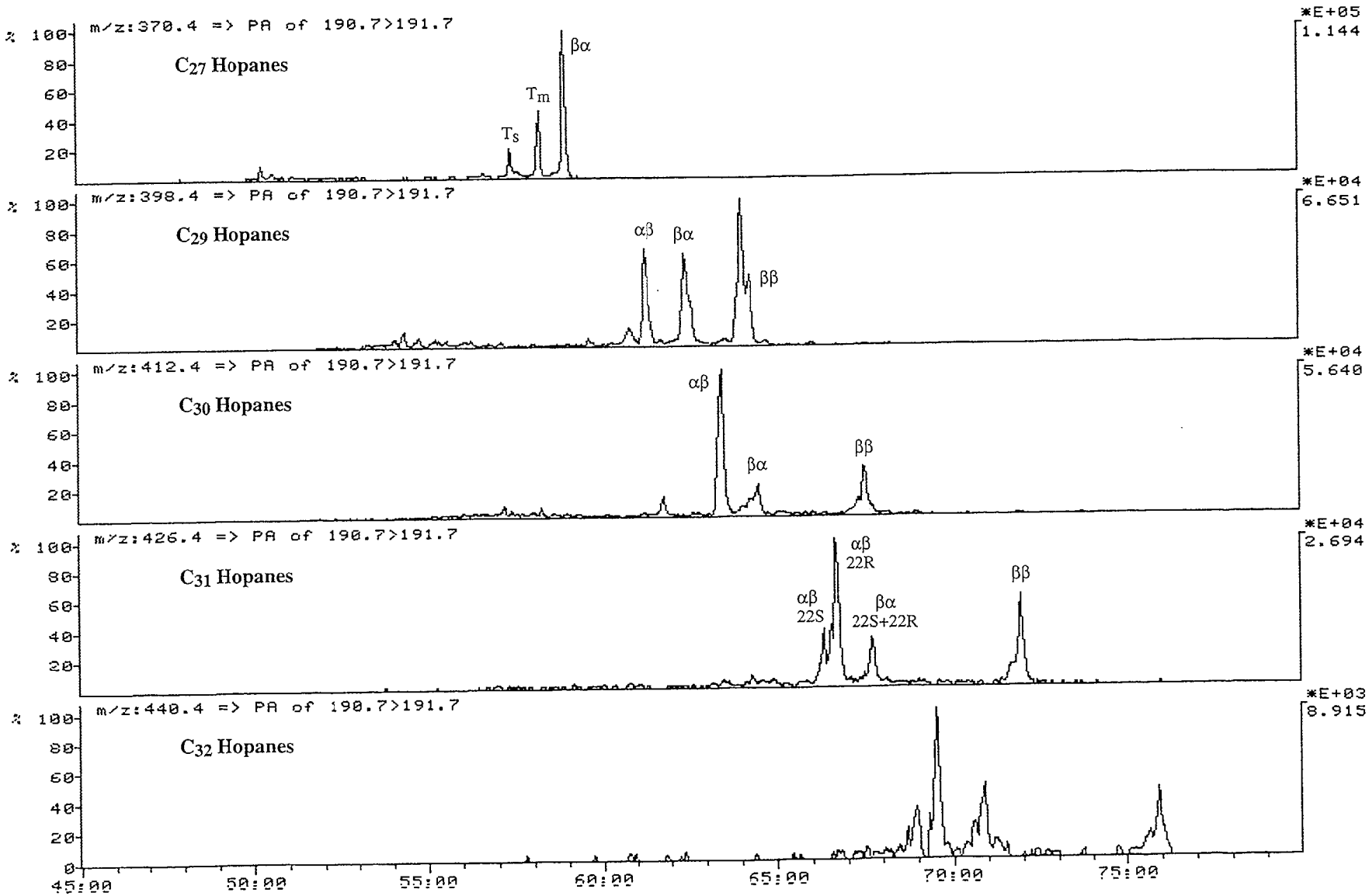
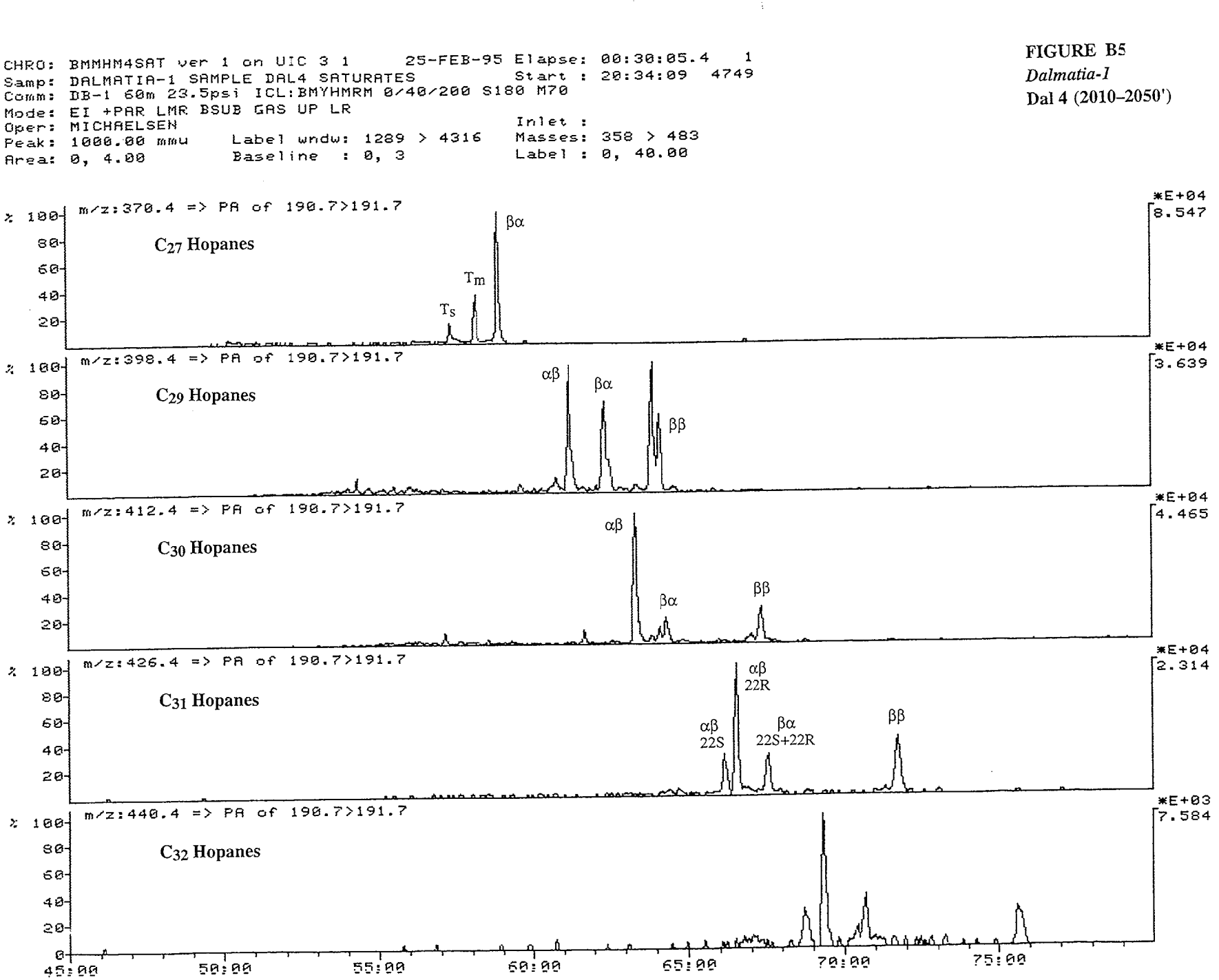


FIGURE B5
Dalmatia-1
Dal 4 (2010–2050')



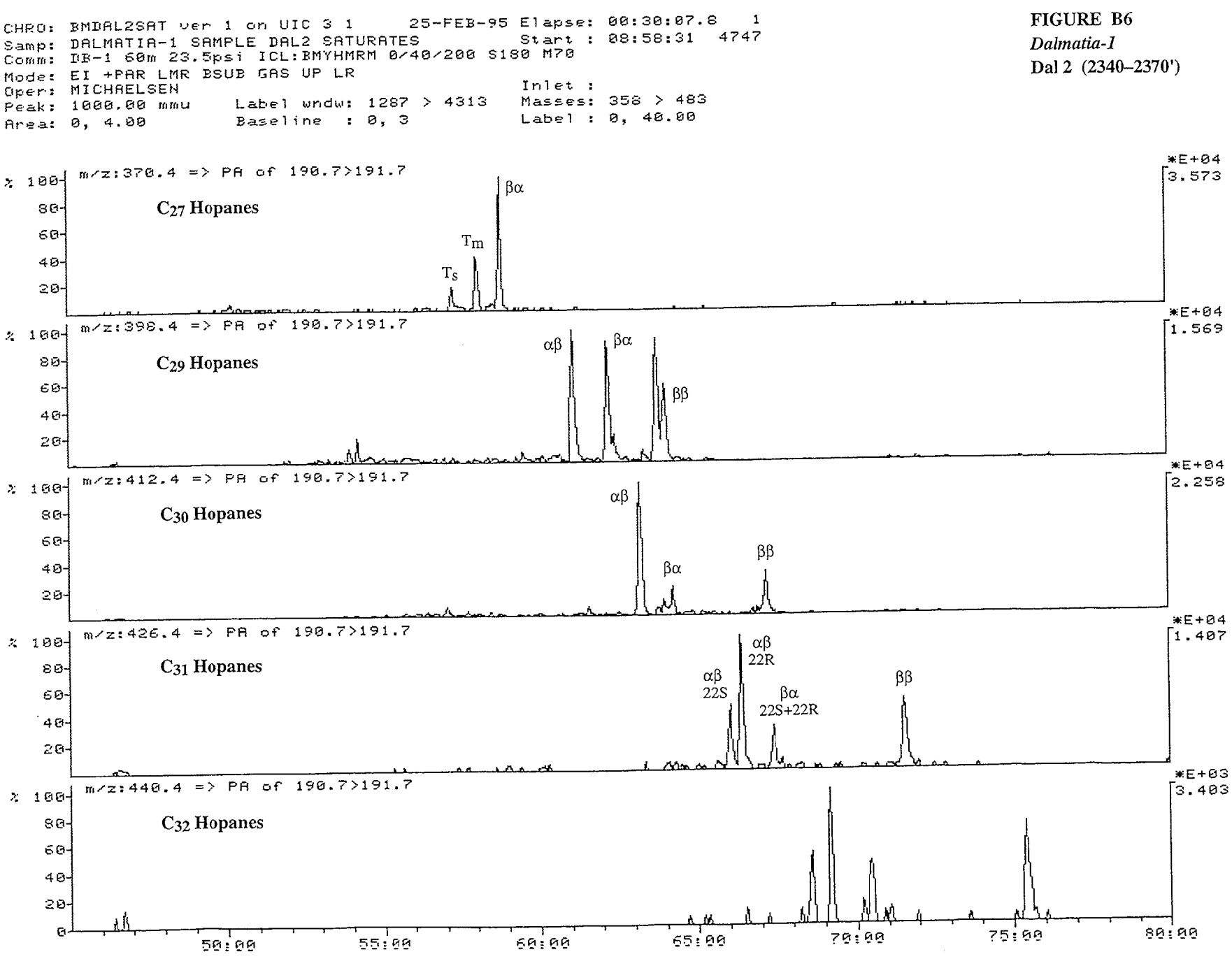


FIGURE B6
Dalmatia-1
Dal 2 (2340–2370')

FIGURE B7
Mt Hammersley-1
MH 8 (2020–2070')

```
CHRO: BMMHMH8S ver 1 on UIC 3 1       25-FEB-95 Elapse: 00:30:05.8    1
Samp: MT HAMMERSLEY-1 SAMPLE MH8 SATURATES      Start : 17:33:48   4749
Comm: DB-1 60m 23.5psi ICL:BMYHMRM 0/40/200 S180 M70
Mode: EI +PAR LMR BSUB GAS UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 1289 > 4316   Masses: 358 > 483
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
```

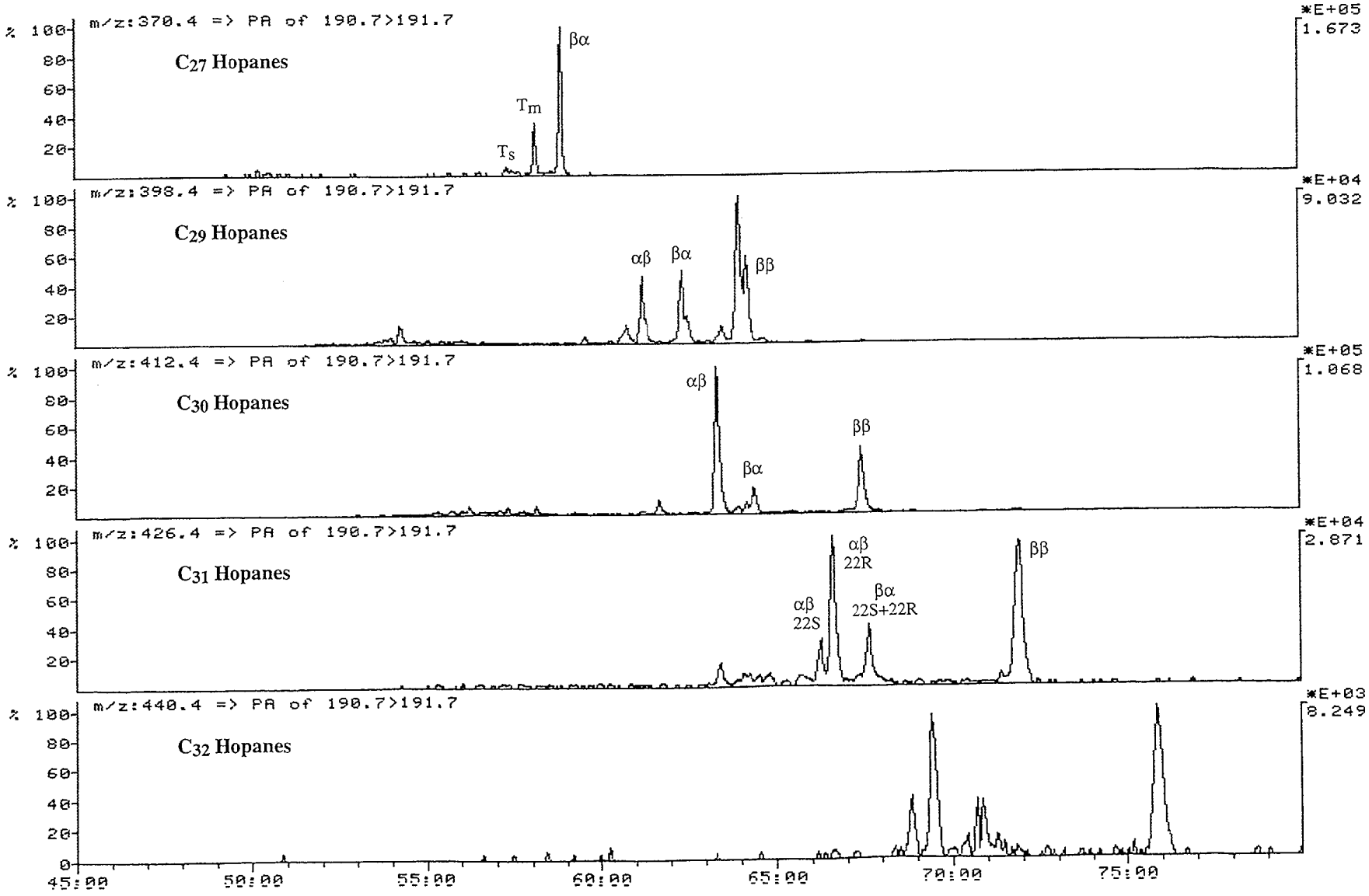


FIGURE B8
Mt Hammersley-1
MH 6 (2310–2360')

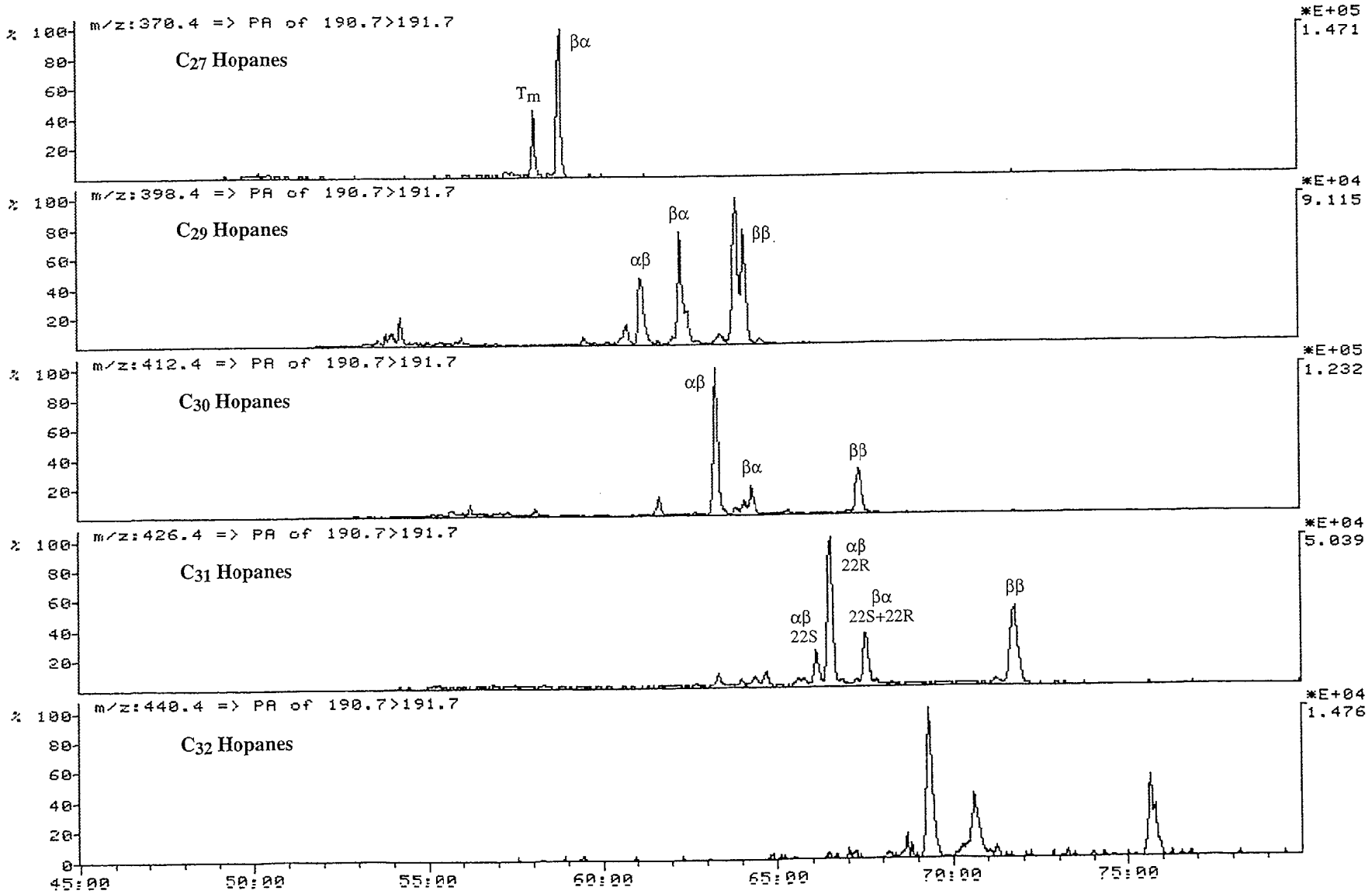


FIGURE B9
Mt Hammersley-1
MH 4 (2750–2800')

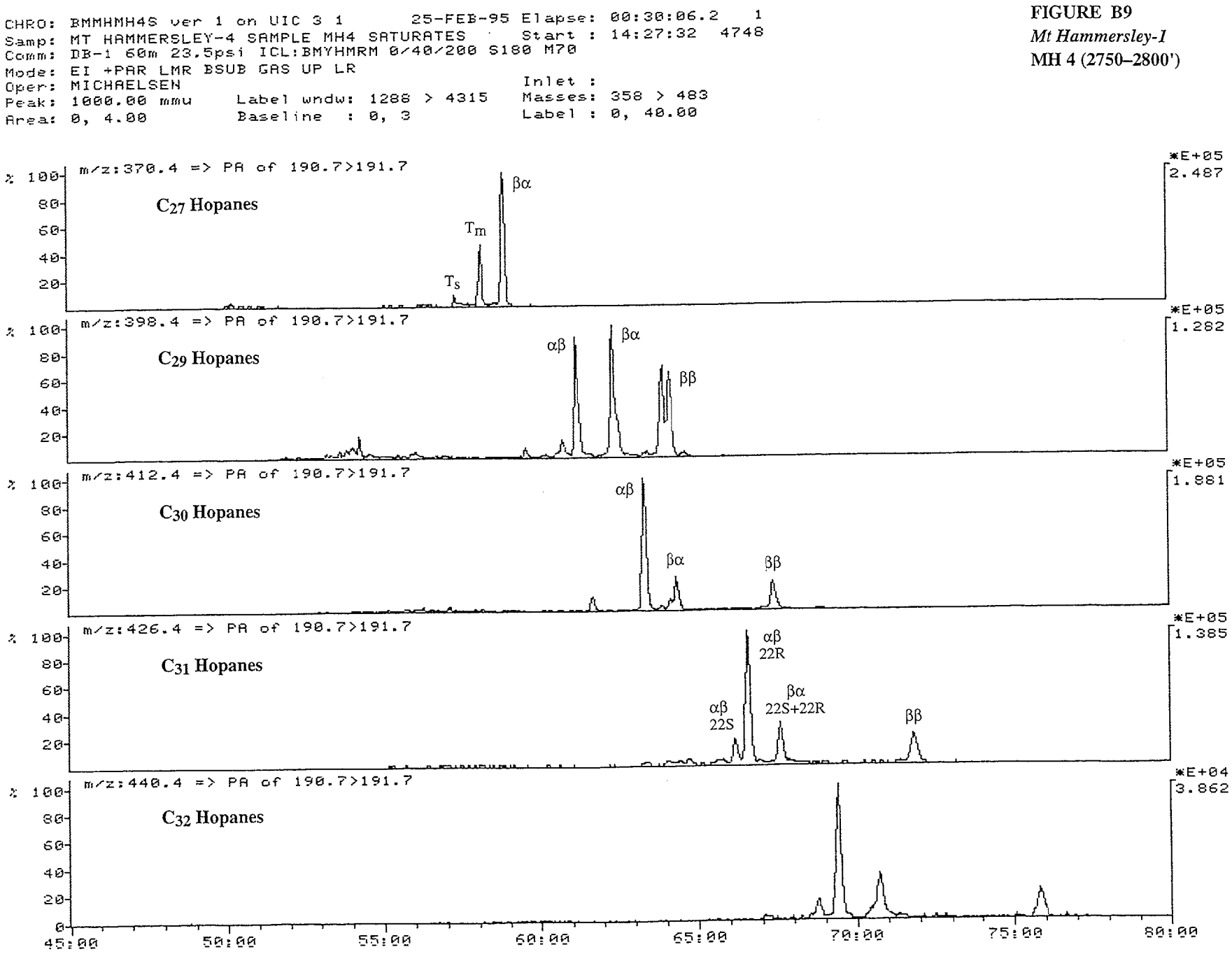
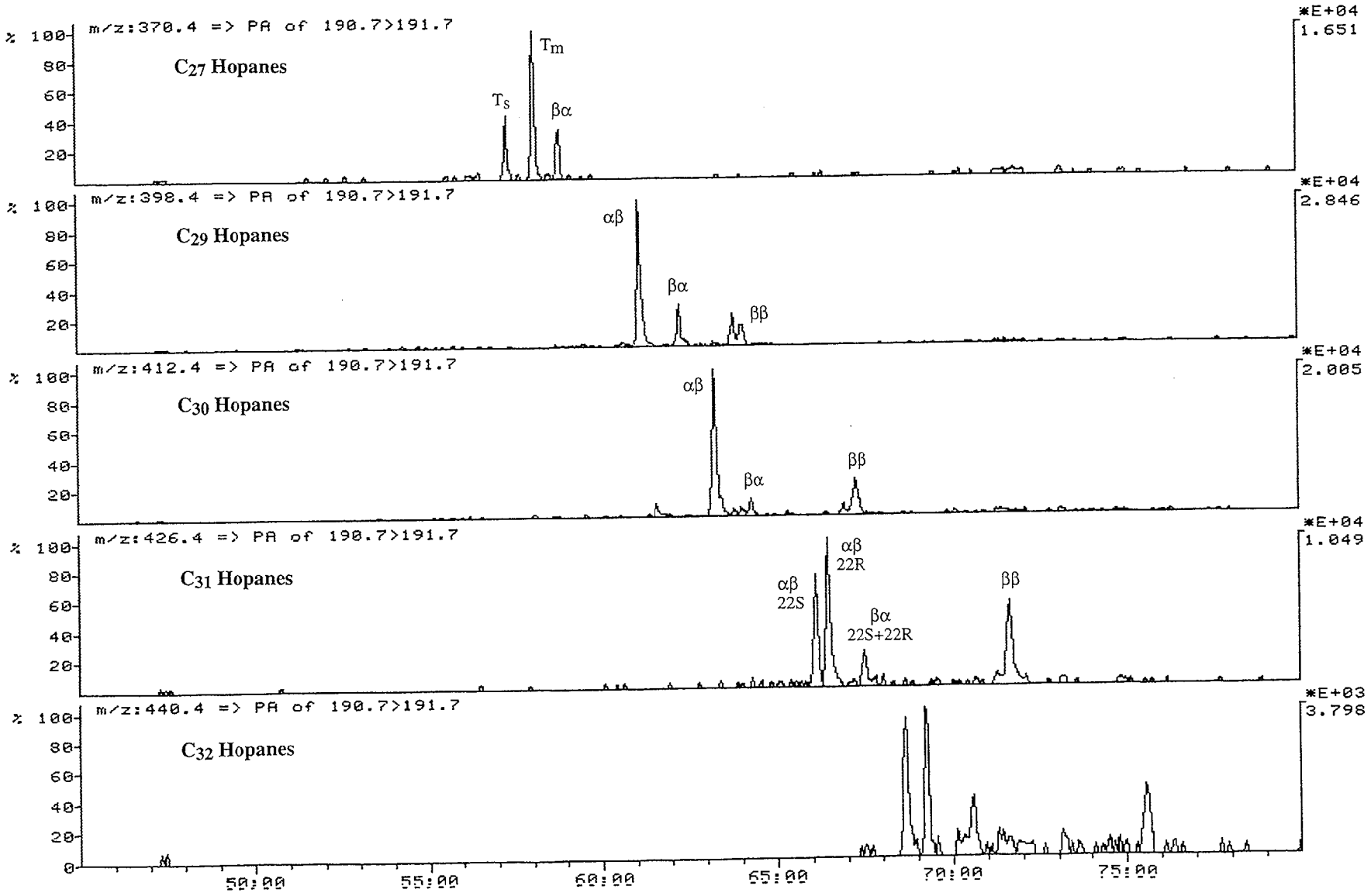


FIGURE B10
Mt Hammersley-1
MH 2 (4000–4060')



0120

CHRO: AFM32516S ver 1 on UIC 3 1 25-FEB-95 Elapse: 00:30:06.1 1
Samp: AFMECO CUR3 251.6m SATURATES Start : 23:35:17 4749
Comm: DB-1 60m 23.5psi ICL:BMYHMRM 0/40/200 S180 M70
Mode: EI +PAR LMR BSUB GAS UP LR
Oper: MICHAELSEN Inlet :
Peak: 1000.00 mmu Label wndw: 1288 > 4316 Masses: 358 > 483
Area: 0, 4.00 Baseline : 0, 3 Label : 0, 40.00

FIGURE C1
AFMECO Cur-3
251.60 m

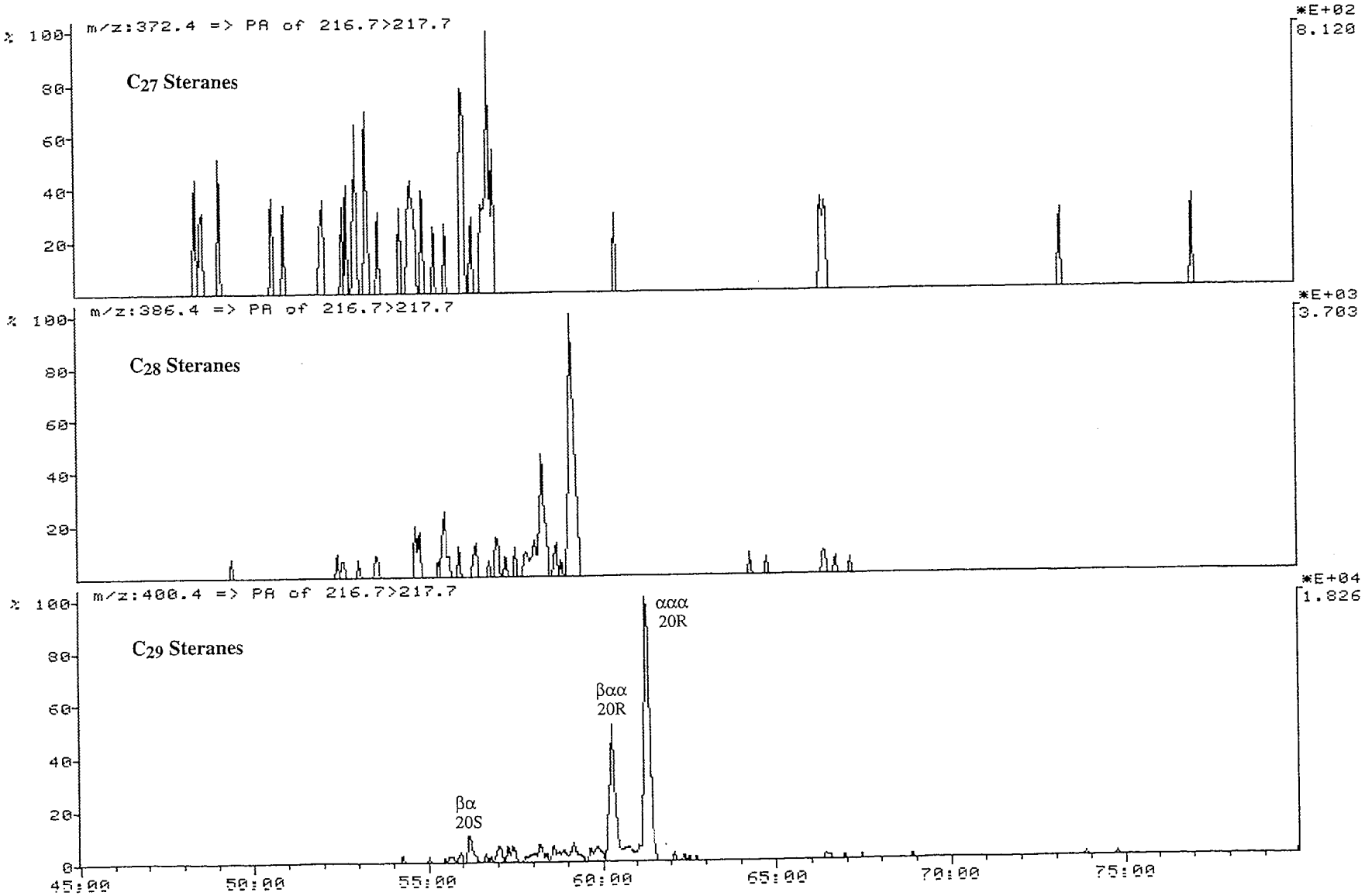


FIGURE C2
AFMECO Cur-3
259.50 m

```
CHRO: AFM32595S ver 1 on UIC 3 1      25-FEB-95 Elapse: 00:30:06.6    1
Samp: AFMECO CUR3 259.5m SATURATES              Start : 12:37:08   4749
Comm: DB-1 60m 23.5psi ICL:BMYHMRM 0/40/200 S180 M70
Mode: EI +PAR LMR BSUB GAS UP LR
Oper: MICHAELSEN                                Inlet :
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Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
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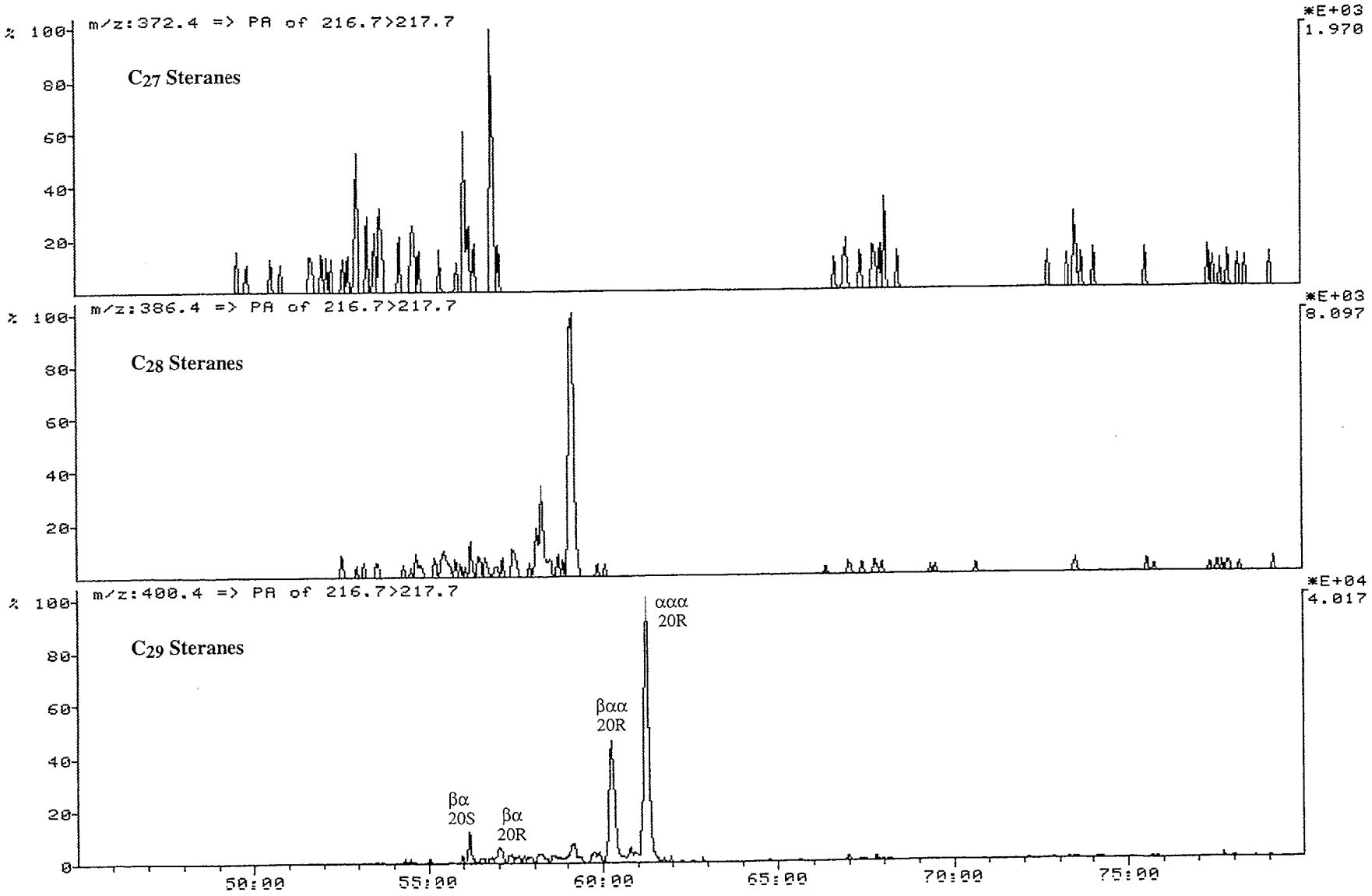

0122

FIGURE C3
AFMECO Cur-5
249.40 m

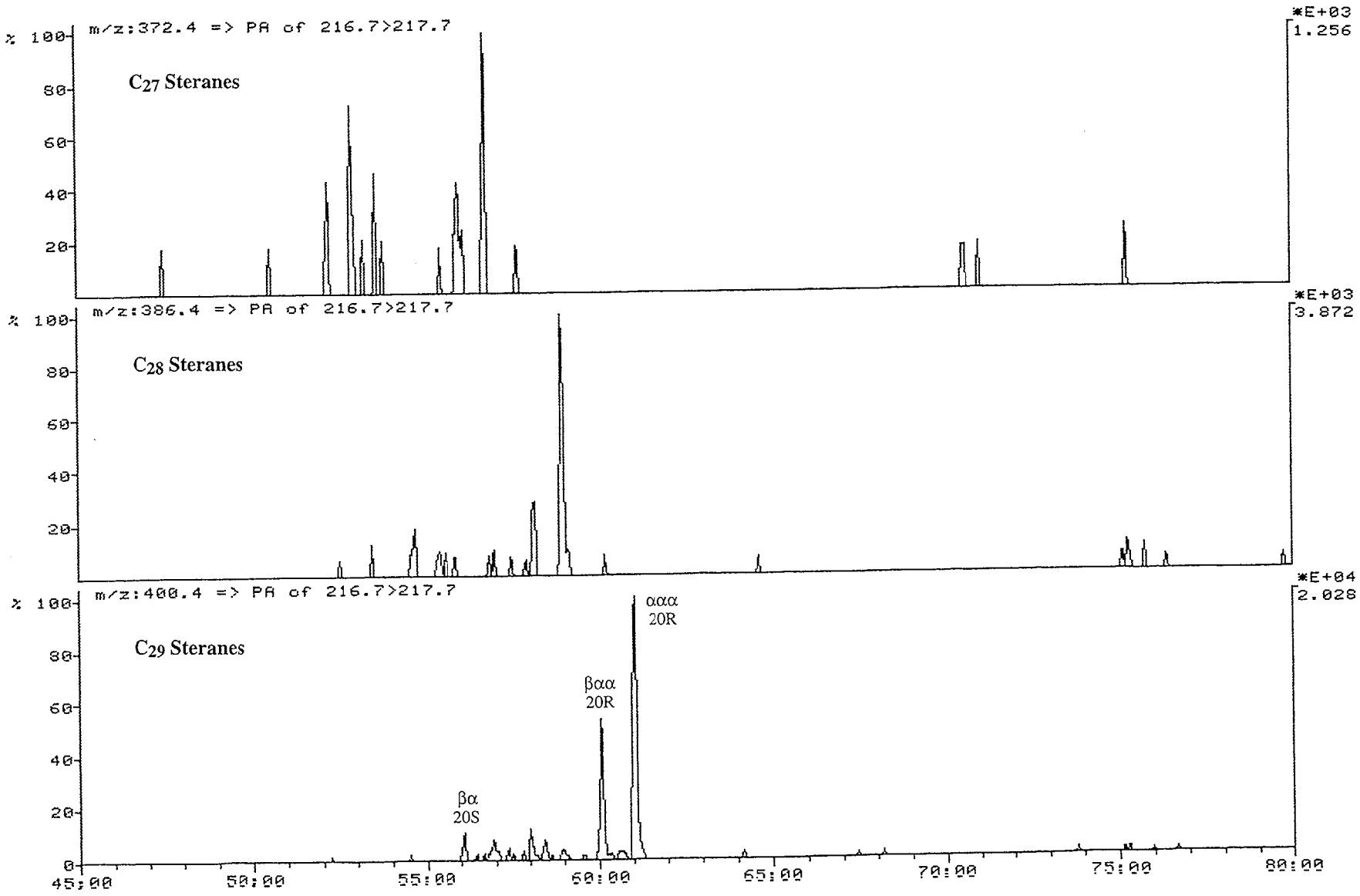

FIGURE C4
Dalmatia-1
Dal 5 (1940–1990')

```
CHRO: BMDAL5SAT ver 1 on UIC 3 1      25-FEB-95 Elapse: 00:30:04.2    1
Samp: DALMATIA-1 SAMPLE DAL5 SATURATES          Start : 22:05:39   4750
Comm: DB-1 60m 23.5psi ICL:BMYHMRM 0/40/200 S180 M70
Mode: EI +PAR LMR BSUB GAS UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 1292 > 4317   Masses: 358 > 483
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
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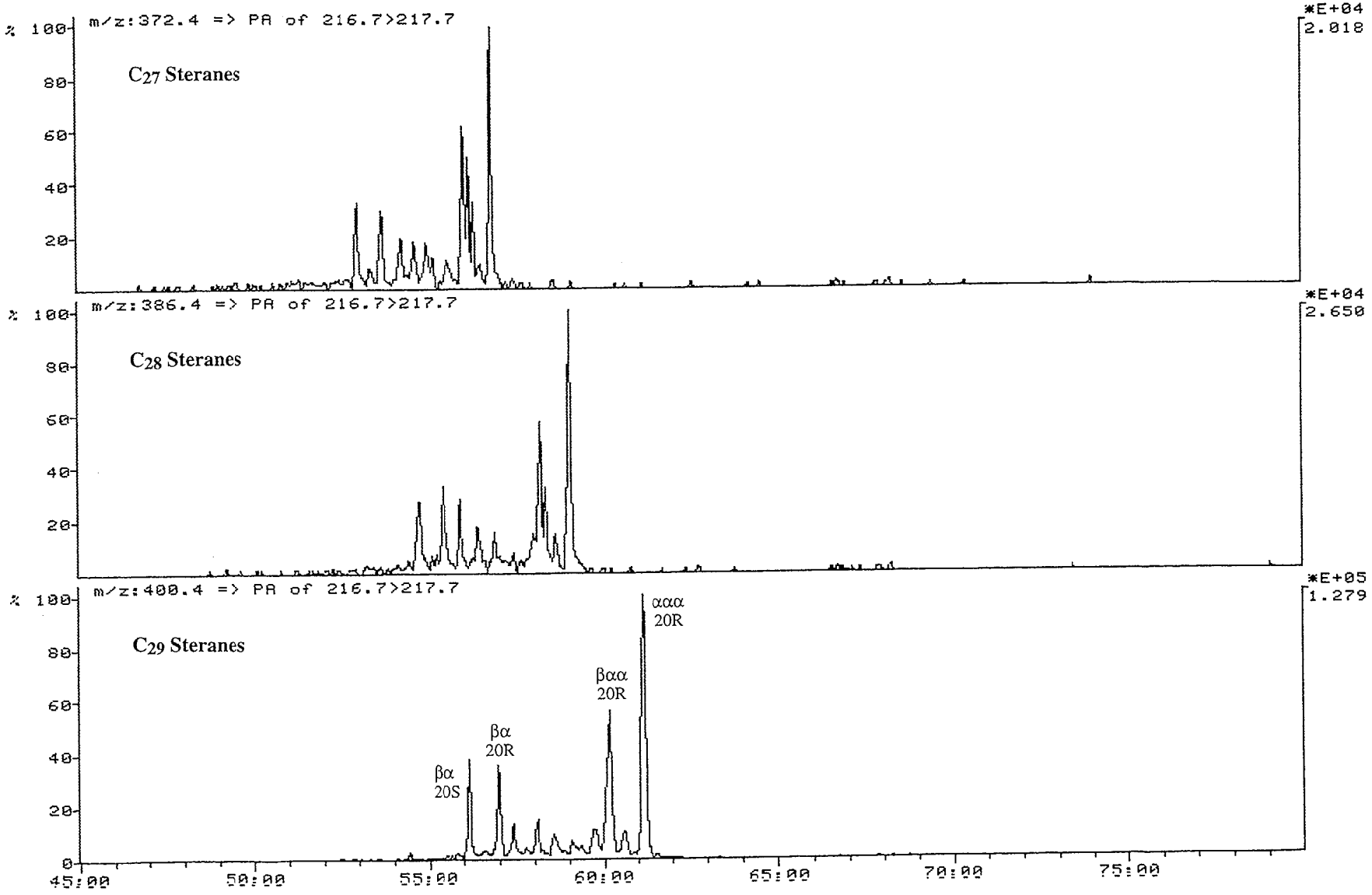


FIGURE C5
Dalmatia-1
Dal 4 (2010–2050')

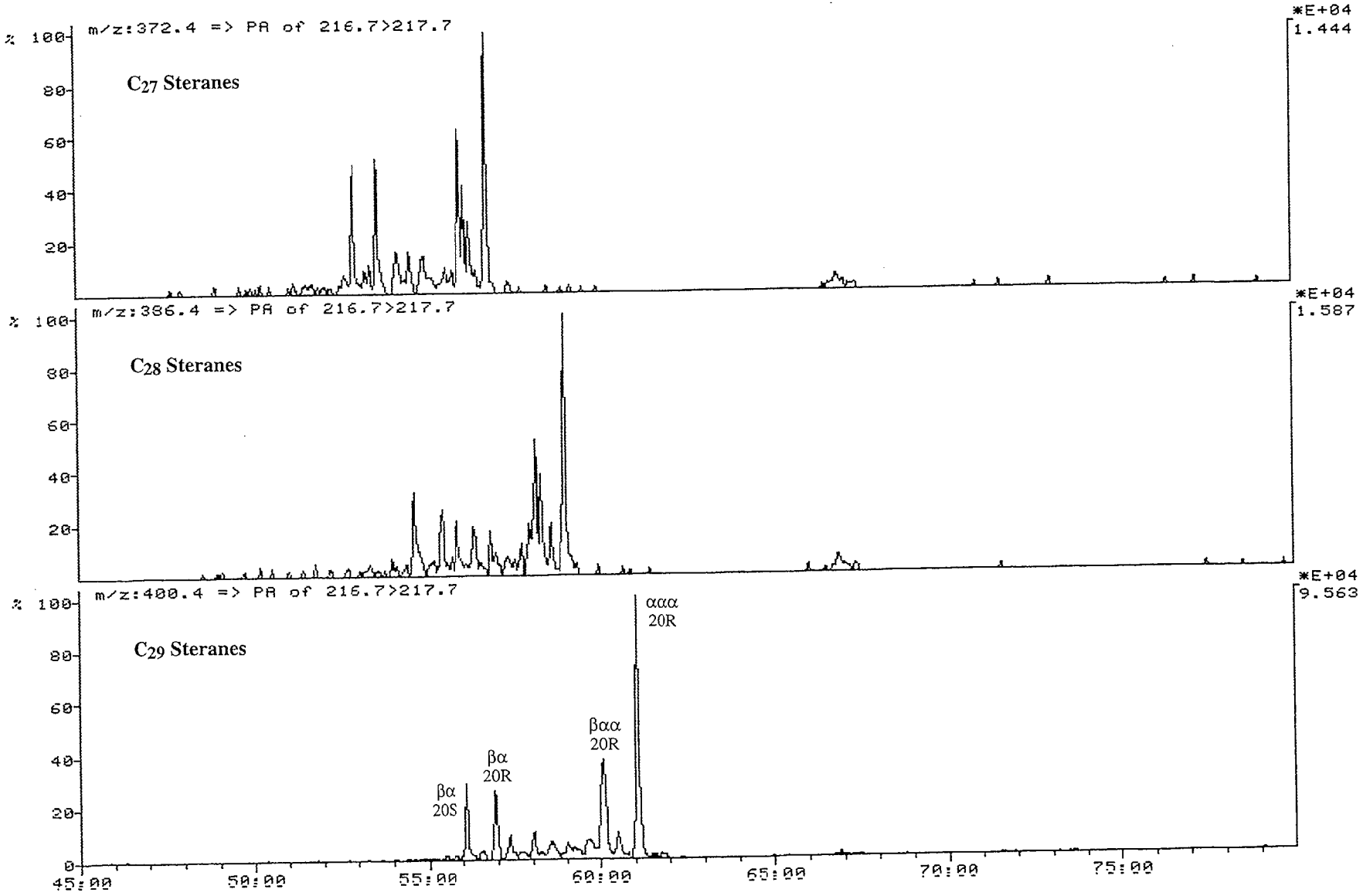
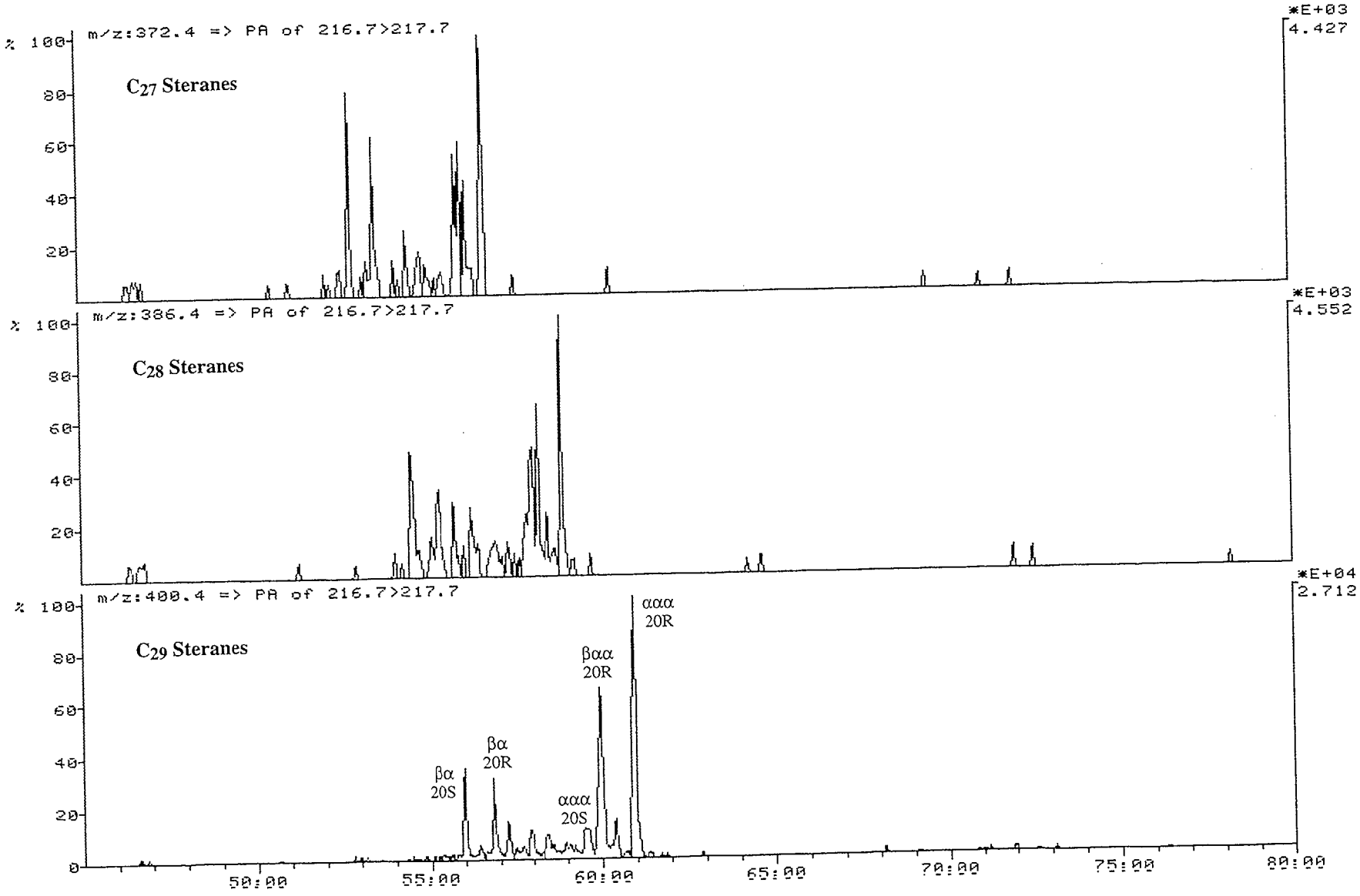


FIGURE C6
Dalmatia-1
Dal 2 (2340–2370')



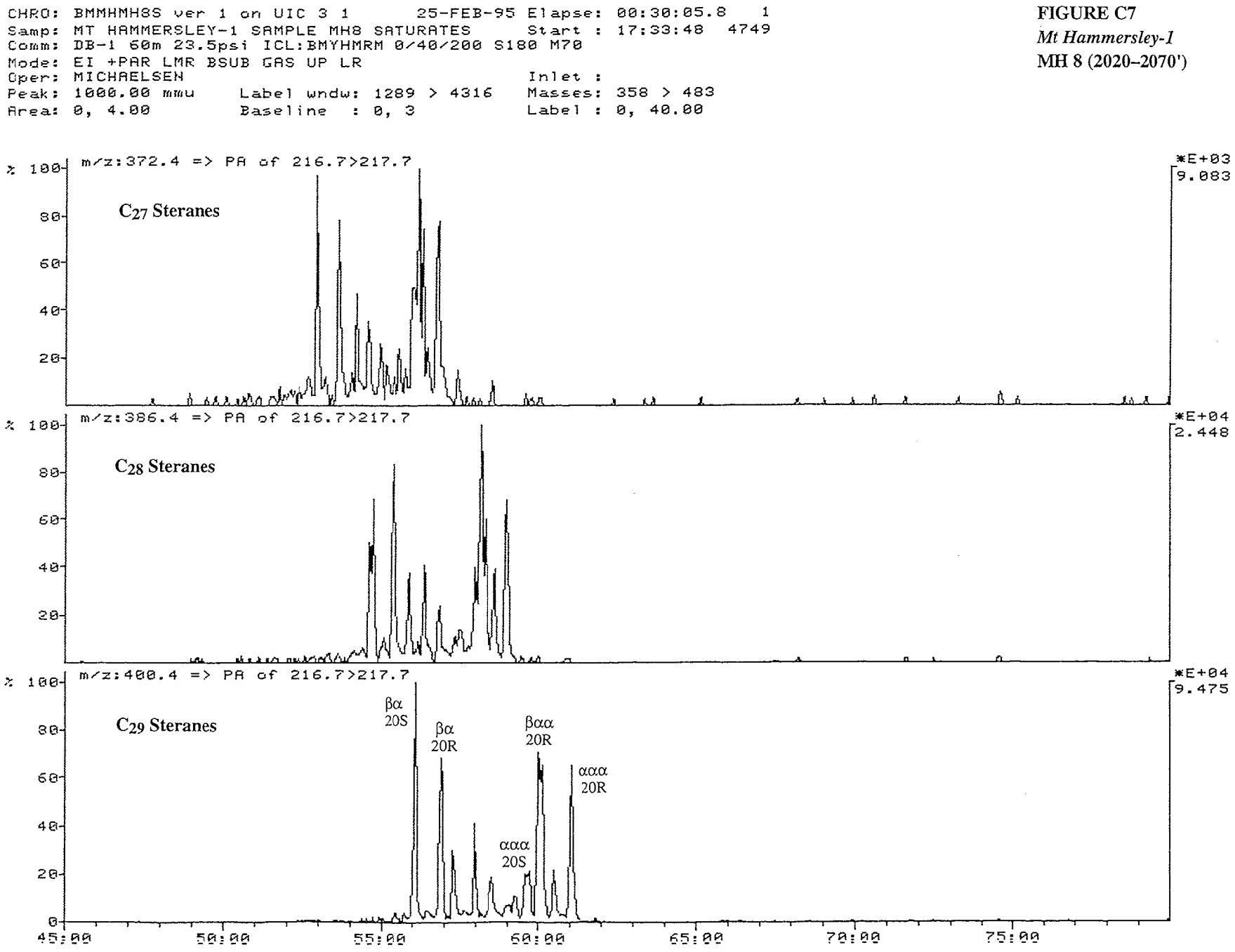


FIGURE C7
Mt Hammersley-1
MH 8 (2020–2070')

FIGURE C8
Mt Hammersley-1
MH 6 (2310–2360')

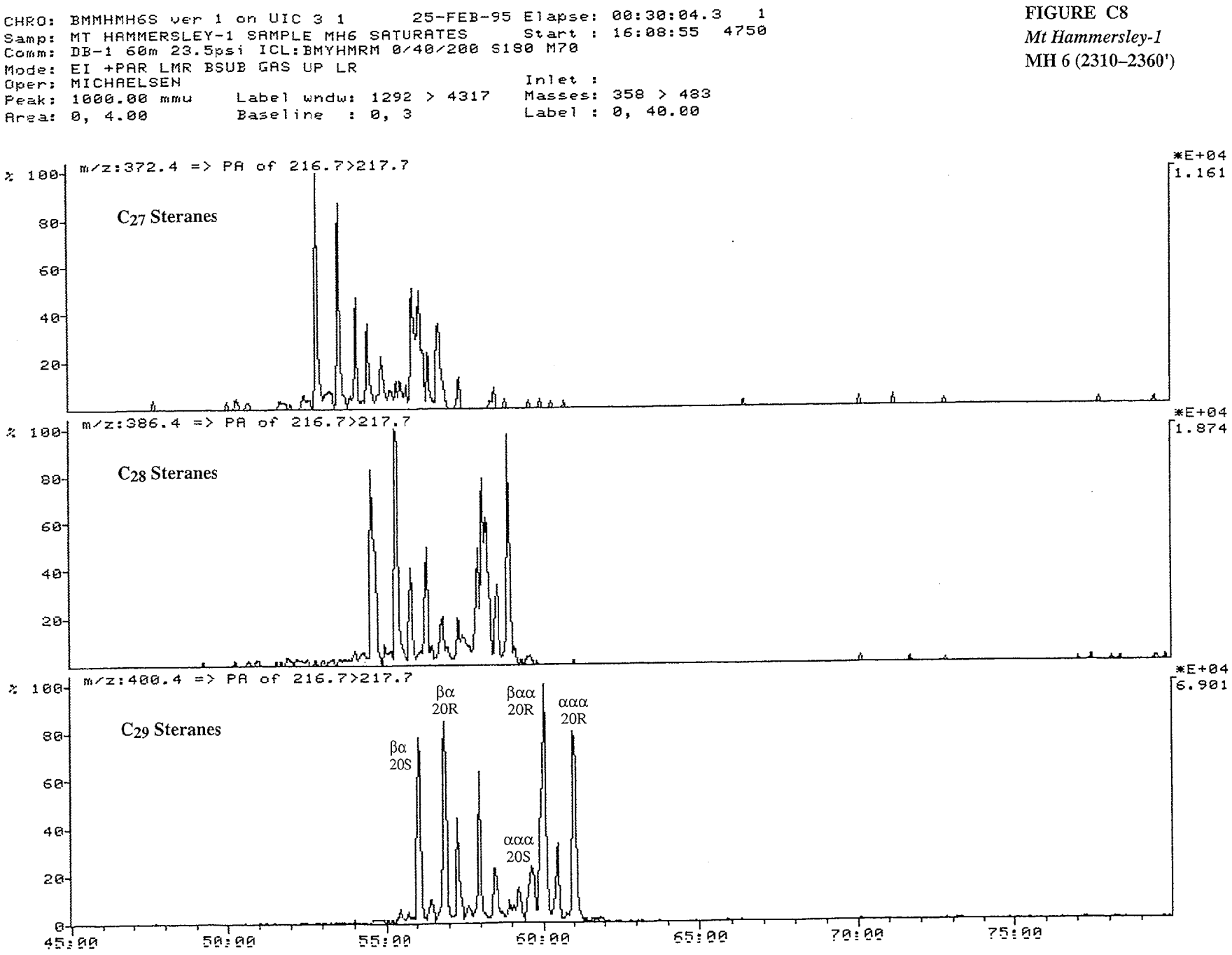


FIGURE C9
Mt Hammersley-1
MH 4 (2750–2800')

```
CHRO: BMMHMH4S ver 1 on UIC 3 1        25-FEB-95 Elapse: 00:30:06.2    1
Samp: MT HAMMERSLEY-4 SAMPLE MH4 SATURATES      Start : 14:27:32   4748
Comm: DB-1 60m 23.5psi ICL:BMYHMRM 0/40/200 S180 M70
Mode: EI +PAR LMR BSUB GAS UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 1288 > 4315   Masses: 358 > 483
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
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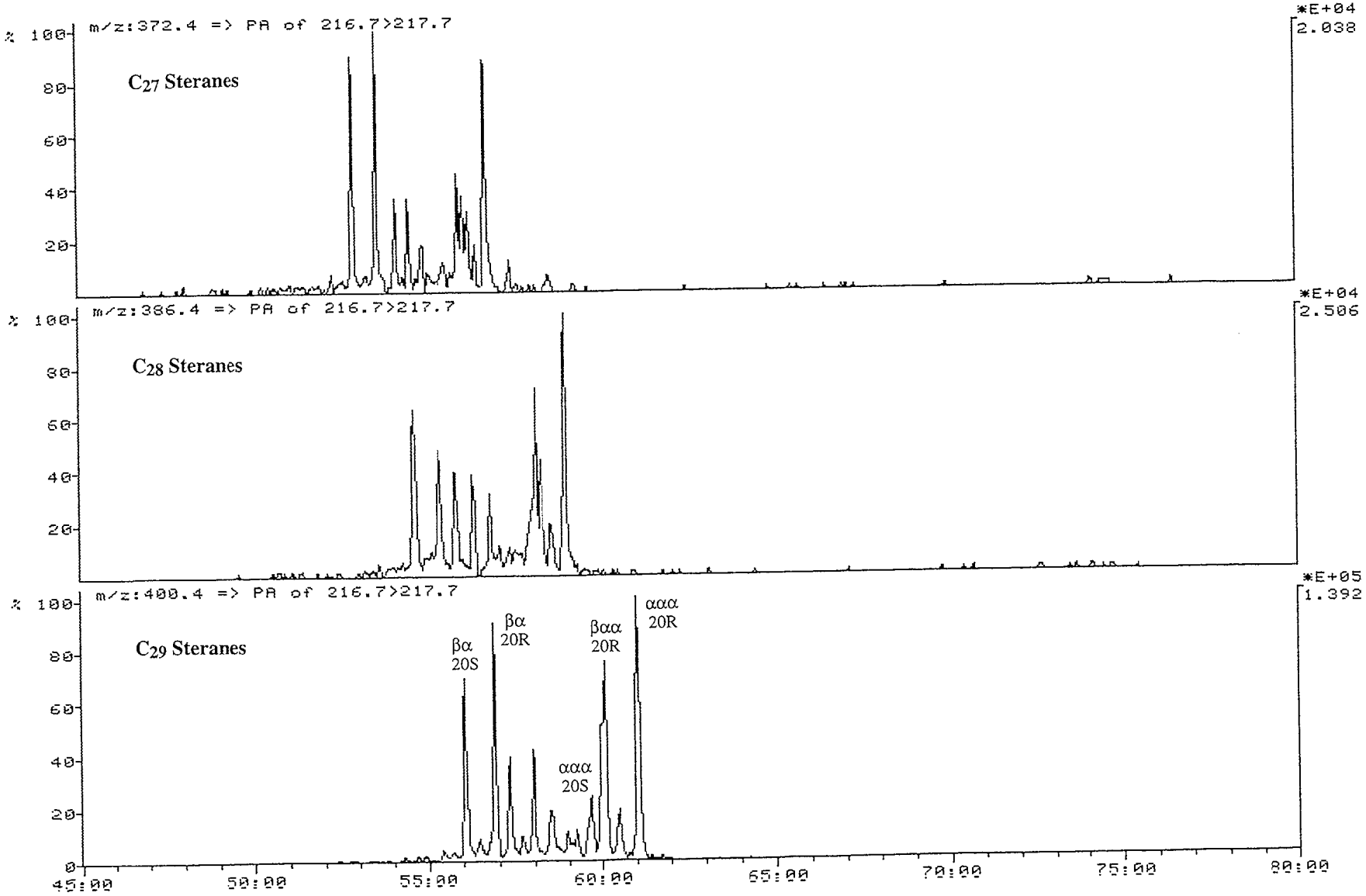
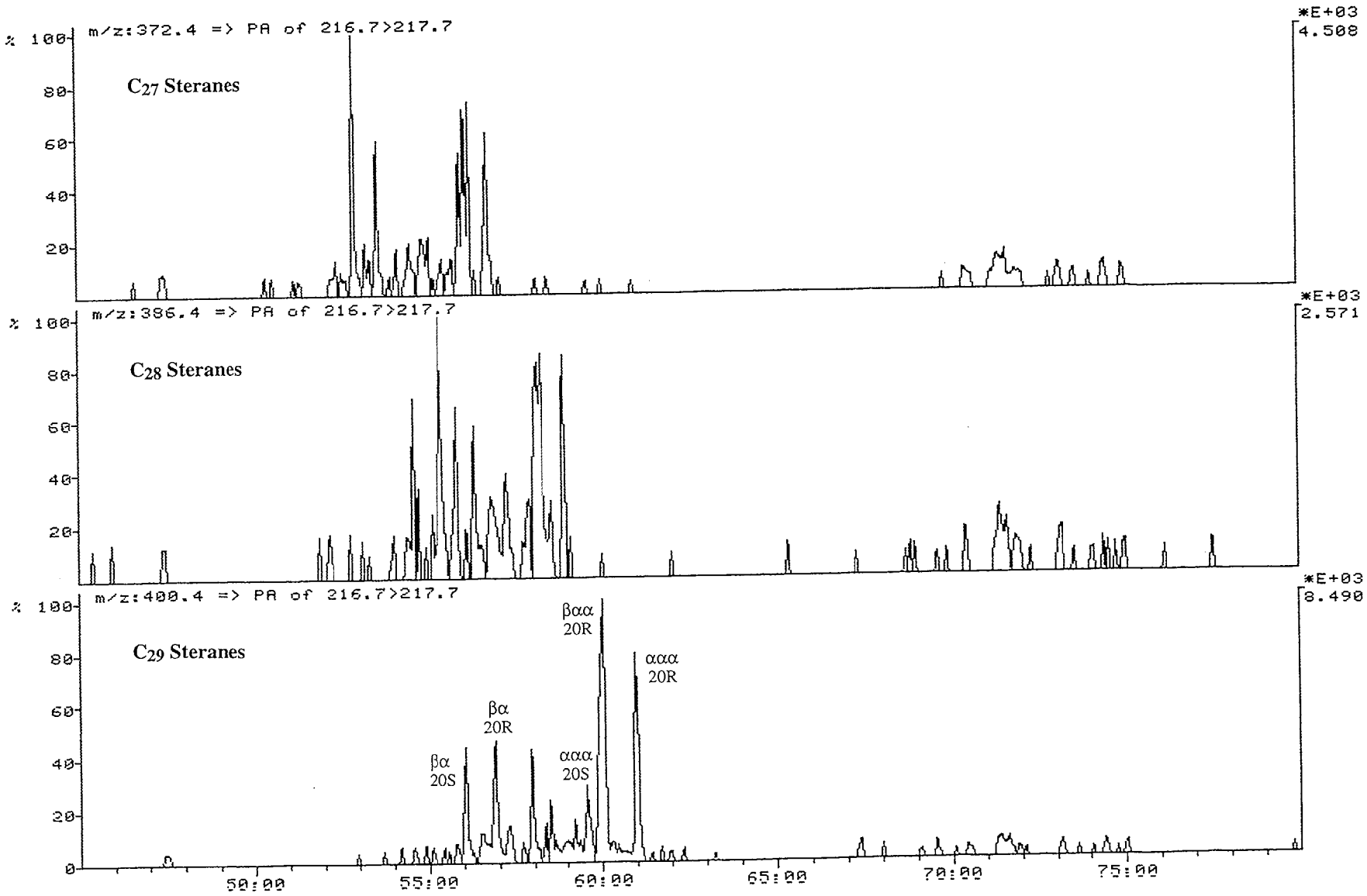
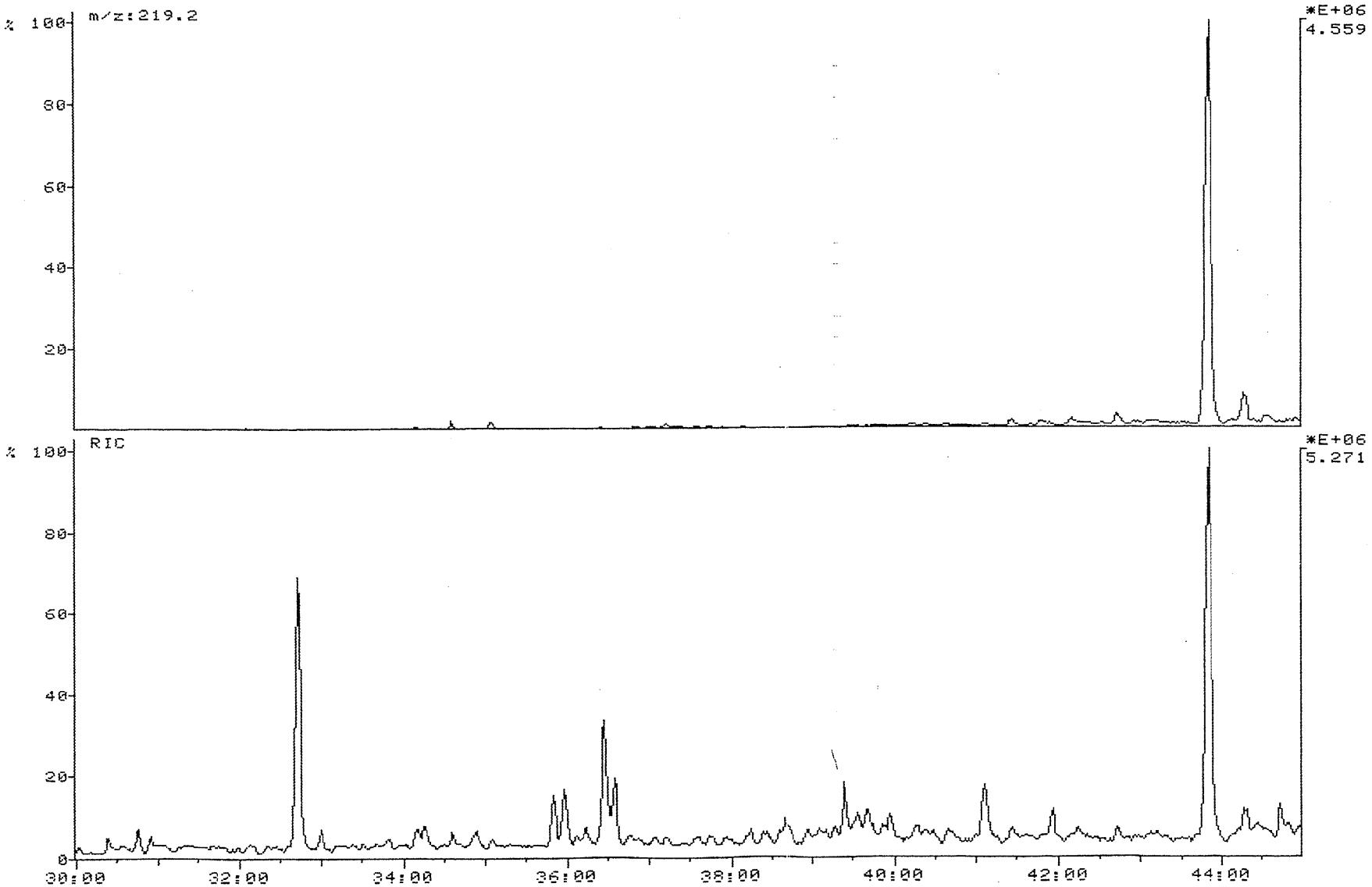


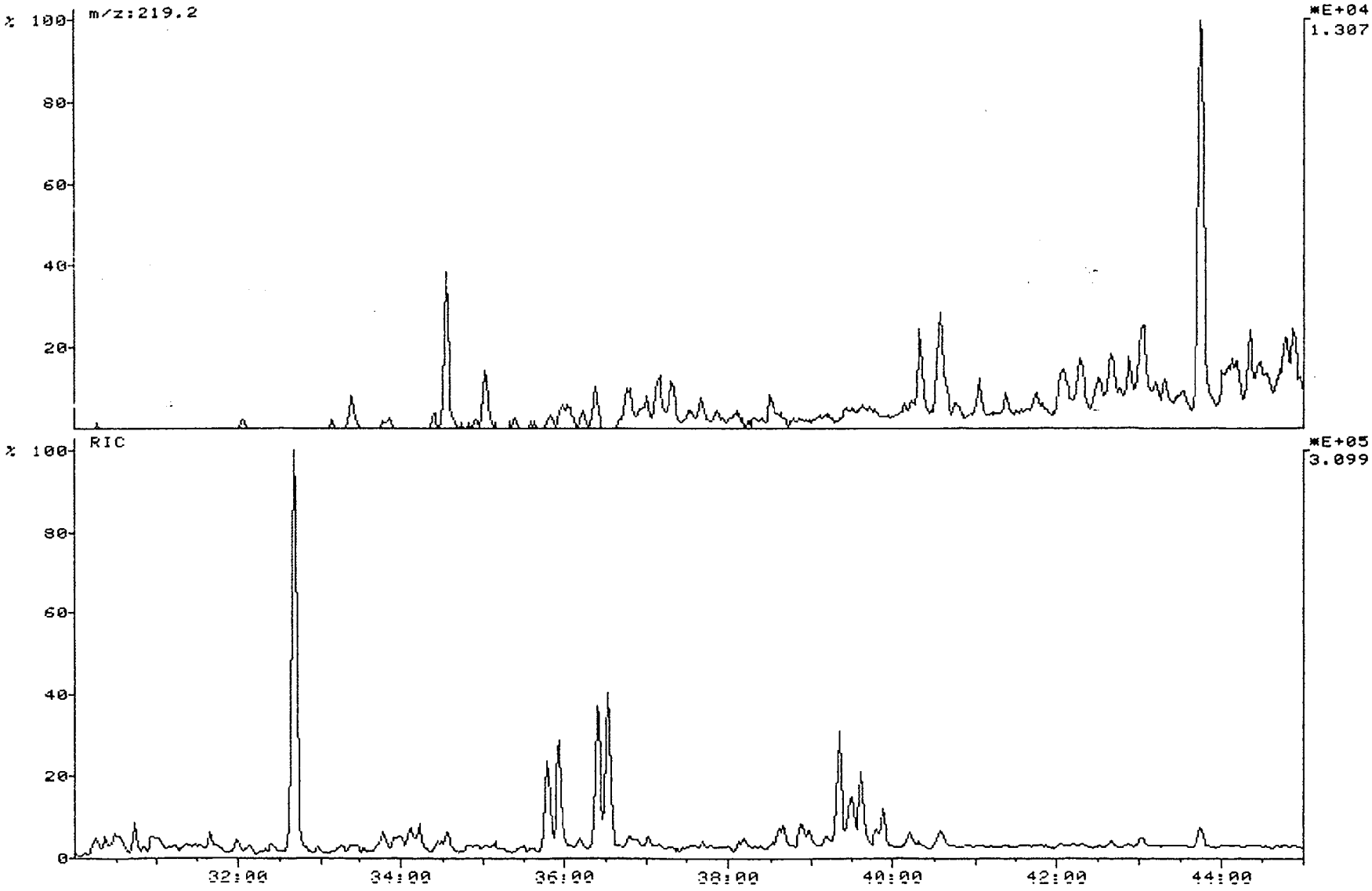
FIGURE C10
Mt Hammersley-1
MH 2 (4000–4060')



CHRO: BMMH1MH4 ver 1 on UIC 3 1 21-FEB-95 Elapse: 00:01:04.7 1
Samp: MT HAMMERSLEY-1 SAMPLE MH4 AROMATICS Start : 01:05:59 4362
Comm: DB-1 60m 23.5psi ICL:BMAROM60M 0/40/200 S180 M70
Mode: EI +Q3MS LMR UP LR
Oper: MICHAELSEN Inlet :
Peak: 1000.00 mmu Label wndw: 1504 > 2283 Masses: 128 > 254
Area: 0, 4.00 Baseline : 0, 3 Label : 0, 40.00



CHRO: BMIN1DST1 ver 1 on UIC 3 1 20-FEB-95 Elapse: 00:01:04.3 1
Samp: INLAND-1 HUTTON 5200' Start : 02:27:33 4360
Comm: DB-1 60m 23.5 psi ICL:BMAROM60M 0/40/200 S180 M70
Mode: EI +Q3MS LMR UP LR
Oper: MICHAELSEN Inlet :
Peak: 1000.00 mmu Label wndw: 1504 > 2283 Masses: 128 > 254
Area: 0, 4.00 Baseline : 0, 3 Label : 0, 40.00



0133

SOURCE ROCK AND PETROLEUM GEOCHEMISTRY OF THE PEDIRKA BASIN, SIMPSON DESERT BASIN AND SUPERJACENT EROMANGA BASIN

Report for Department of Mines and Energy South Australia

by

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JUNE 1995

Mines & Energy SA
R96/01685
00135017

INTRODUCTION

This report is an addendum to our previous work on the Eringa Trough (Staples *et al.*, 1995). Both reports were prepared for MESA to assist reevaluation of the hydrocarbon prospectivity of the Pedirka Basin and the far western Eromanga Basin. Here we collate MESA's open-file data, published data from the literature on the Pedirka Basin, Simpson Desert Basin and overlying Eromanga Basin, and other measurements from our own library.

Included in this report are analyses by Staples *et al.* (1995) who recently studied the petroleum geochemistry of Permian and Jurassic rocks on the western and eastern margins of the Eringa Trough (Pedirka Basin); and also the large data set prepared by McKirdy (1981) for Delhi Petroleum Pty Ltd. The discussion presented herein is based mainly upon Rock-Eval pyrolysis data (Table 1). However, other data (Tables 2–4) are presented for incorporation into MESA's PEPS database.

RESULTS

The analytical data are presented herein as follows:

	Table	Figure
Rock-Eval pyrolysis	1	1
Kerogen elemental and isotopic data, and vitrinite reflectance	2	
Oil geochemistry (general)	3a	
Oil geochemistry (stable isotopes)	3b	
Rock extract data	4	

DISCUSSION AND SUMMARY

Rock-Eval data from Table 1 are presented on a T_{max} *versus* HI crossplot (Figure 1). Data obtained from conventional cores and side-wall cores are presented are solid symbols, whereas open symbols represent cuttings data. Evolution pathways for kerogen Types I, II, and III are shown, as are iso-reflectance lines corresponding to the upper and lower limits of the oil window (0.5% and 1.35% R_o, respectively). These results may be summarized as follows:

Age of potential source rocks	HI range	T_{max} range	Oil potential	Maturity
Permian (E.margin of Eringa Trough)	34–359	422–427	V.poor–Good	Immature–marginally mature (*cf.* Staples *et al.*, 1995)
Triassic	68–334	428–441	V.poor–Good	Marginally mature–mature
Basal Jurassic	108–459	427–452	Poor–V.good	Mature
Jurassic (W.margin of Eringa Trough)	87–542	419–424	V.poor–Excellent	Immature–marginally mature (*cf.* Staples *et al.*, 1995)
Cretaceous	13–125	423–438	V.poor–Poor	Immature–marginally mature

CONCLUSIONS

The best potential source rocks for oil in the western Eromanga province appear to be Jurassic coaly sediments from the Early (Basal) Poolowanna Formation, and also resinite- and fluorinite-rich coals of the Early–Late Jurassic Algebuckina Sandstone. The Poolowanna coals contain oil-prone Type II kerogen and are presently mature for liquid hydrocarbon generation. These sediments have probably been effective source rocks in the geologically-recent past, although this needs to be confirmed by thermal modelling of their burial history.

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TABLE 1: Rock-Eval pyrolysis database, Pedirka Basin, Simpson Desert Basin, and superjacent Eromanga Basin.

Well	Depth	Sample type/ID	Formation	T_{max}	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI	Reference
AFMECO Cur-3	251.60 m	Core	Algebuckina	421	11.88	123.20	13.20	135.08	9.33	0.09	11.21	34.30	359	38	Staples *et al.* 1995
AFMECO Cur-3	251.90 m	Core	Algebuckina	423	16.79	151.50	13.86	168.29	10.93	0.10	13.97	39.00	388	36	Staples *et al.* 1995
AFMECO Cur-3	259.50 m	Core	Algebuckina	419	23.65	255.76	17.50	279.41	14.61	0.08	23.19	47.20	542	37	Staples *et al.* 1995
AFMECO Cur-5	209.20 m	Core	Algebuckina	421	3.51	45.90	24.97	49.41	1.84	0.07	4.10	52.90	87	47	Staples *et al.* 1995
AFMECO Cur-5	210.10 m	Core	Algebuckina	424	18.27	157.45	19.72	175.72	7.98	0.10	14.58	50.50	312	39	Staples *et al.* 1995
AFMECO Cur-5	249.40 m	Core	Algebuckina	424	32.52	216.07	27.19	248.59	7.95	0.13	20.63	58.70	368	46	Staples *et al.* 1995
Dalmatia-1	1940–1990'	Cuttings	Purni	423	5.32	150.09	11.96	155.41	12.55	0.03	12.90	49.20	305	24	Staples *et al.* 1995
Dalmatia-1	2010–2050'	Cuttings	Purni	425	4.11	118.72	13.03	122.83	9.11	0.03	10.19	44.30	268	29	Staples *et al.* 1995
Dalmatia-1	2080–2120'	Cuttings	Purni	426	1.85	91.11	12.87	92.96	7.08	0.02	7.72	37.70	242	34	Staples *et al.* 1995
Dalmatia-1	2340–2370'	Cuttings	Purni	425	3.90	122.36	8.45	126.26	14.48	0.03	10.48	38.50	318	22	Staples *et al.* 1995
Dalmatia-1	2600–2660'	Cuttings	Purni	422	4.23	125.09	11.25	129.32	11.12	0.03	10.73	39.40	317	29	Staples *et al.* 1995
Mt Hammersley-1	2020–2070'	Cuttings	Purni	424	2.12	80.18	17.96	82.30	4.46	0.03	6.83	63.10	127	28	Staples *et al.* 1995
Mt Hammersley-1	2160–2210'	Cuttings	Purni	425	1.58	71.21	17.66	72.79	4.03	0.02	6.04	62.80	113	28	Staples *et al.* 1995
Mt Hammersley-1	2310–2360'	Cuttings	Purni	425	2.77	96.20	15.74	98.97	6.11	0.03	8.21	58.70	164	27	Staples *et al.* 1995
Mt Hammersley-1	2500–2540'	Cuttings	Purni	425	6.37	172.94	9.70	179.31	17.83	0.04	14.88	59.10	293	16	Staples *et al.* 1995
Mt Hammersley-1	2750–2800'	Cuttings	Purni	427	6.34	200.38	8.17	206.72	24.53	0.03	17.16	55.80	359	15	Staples *et al.* 1995
Mt Hammersley-1	2860–2910'	Cuttings	Purni	427	5.38	139.13	9.13	144.51	15.24	0.04	11.99	52.80	264	17	Staples *et al.* 1995
Mt Hammersley-1	4000–4060'	Cuttings	Undiff. Permian	nd	0.03	0.16	0.14	0.19	1.14	0.16	0.02	0.41	39	34	Staples *et al.* 1995
Mt Hammersley-1	4620–4670'	Cuttings	Crown Point	nd	0.07	0.12	0.12	0.19	1.00	0.37	0.02	0.35	34	34	Staples *et al.* 1995
Poeppel's Corner-1	2500'	Cuttings	Winton	438	0.0	1.94	1.32	1.94	1.46	0.0	0.16	2.34	82	56	McKirdy *et al.* 1984
Poeppel's Corner-1	3000'	Cuttings	Oodnadatta	428	0.0	0.33	0.89	0.0	0.37	0.0	0.02	0.98	33	90	McKirdy *et al.* 1984
Poeppel's Corner-1	3500'	Cuttings	Oodnadatta	433	0.0	0.59	1.03	0.59	0.57	0.0	0.04	1.01	58	101	McKirdy *et al.* 1984
Poeppel's Corner-1	4000'	Cuttings	Bulldog Shale	425	0.1	0.48	3.75	0.49	0.12	0.02	0.04	0.78	61	480	McKirdy *et al.* 1984
Poeppel's Corner-1	4400'	Cuttings	Bulldog Shale	431	0.02	0.67	0.98	0.69	0.68	0.03	0.05	1.10	60	89	McKirdy *et al.* 1984
Poeppel's Corner-1	4900'	Cuttings	Algebuckina									0.12			McKirdy *et al.* 1984
Poeppel's Corner-1	5500'	Cuttings	Algebuckina									0.16			McKirdy *et al.* 1984
Poeppel's Corner-1	6000'	Cuttings	Algebuckina									0.23			McKirdy *et al.* 1984
Poeppel's Corner-1	6500'	Cuttings	Algebuckina									0.26			McKirdy *et al.* 1984
Poeppel's Corner-1	6600'	Cuttings	Algebuckina									0.06			McKirdy *et al.* 1984
Poeppel's Corner-1	6700'	Cuttings	Algebuckina									0.26			McKirdy *et al.* 1984
Poeppel's Corner-1	6717'	SWC	Poolowanna	436	0.10	1.59	1.04	1.69	1.52	0.06	0.14	1.10	144	94	McKirdy *et al.* 1984
Poeppel's Corner-1	6800'	Cuttings	Poolowanna	433	0.08	2.70	0.28	2.78	9.64	0.03	0.23	2.42	111	11	McKirdy *et al.* 1984
Poeppel's Corner-1	6900'	Cuttings	Poolowanna	427	0.07	1.07	0.0	1.14	0.0	0.06	0.09	0.50	214	0	McKirdy *et al.* 1984
Poeppel's Corner-1	6977'	SWC	Poolowanna	435	0.28	5.19	0.14	5.47	37.07	0.05	0.45	1.13	459	12	McKirdy *et al.* 1984
Poeppel's Corner-1	7000'	Cuttings	Poolowanna	431	0.03	1.38	1.93	1.41	0.71	0.02	0.11	1.27	108	151	McKirdy *et al.* 1984
Poeppel's Corner-1	7100'	Cuttings	Poolowanna									0.23			McKirdy *et al.* 1984
Poeppel's Corner-1	7176'	SWC	Poolowanna	438	0.26	2.47	0.06	2.73	41.16	0.10	0.22	1.61	153	3	McKirdy *et al.* 1984

Poeppel's Corner-1	7200'	Cuttings	Poolowanna									0.29			McKirdy *et al.* 1984
Poeppel's Corner-1	7248'	SWC	Poolowanna	443	2.16	43.85	0.11	46.01	398.63	0.05	3.83	9.70	452	1	McKirdy *et al.* 1984
Poeppel's Corner-1	7300'	Cuttings	Poolowanna									0.18			McKirdy *et al.* 1984
Poeppel's Corner-1	7367.5'	SWC	Peera Peera	436	0.31	5.28	0.25	5.59	21.12	0.06	0.46	2.36	223	10	McKirdy *et al.* 1984
Poeppel's Corner-1	7400'	Cuttings	Peera Peera									0.36			McKirdy *et al.* 1984
Poeppel's Corner-1	7500	Cuttings	Peera Peera	433	0.16	1.87	0.33	2.03	5.66	0.08	0.16	1.26	148	26	McKirdy *et al.* 1984
Poeppel's Corner-1	7528'	SWC	Peera Peera									0.39			McKirdy *et al.* 1984
Poeppel's Corner-1	7556'	SWC	Peera Peera	437	0.58	10.51	0.51	11.09	20.60	0.05	0.92	3.14	334	16	McKirdy *et al.* 1984
Poeppel's Corner-1	7563'	SWC	Peera Peera	432	0.65	8.24	0.13	8.89	63.38	0.07	0.74	4.90	168	2	McKirdy *et al.* 1984
Poeppel's Corner-1	7588'	SWC	Peera Peera	441	0.19	1.35	0.04	1.54	33.75	0.12	0.12	1.62	83	2	McKirdy *et al.* 1984
Poeppel's Corner-1	7600'	Cuttings	Peera Peera	428	0.54	5.98	0.44	6.52	13.59	0.08	0.54	2.28	262	19	McKirdy *et al.* 1984
Poeppel's Corner-1	7633'	SWC	Peera Peera									0.12			McKirdy *et al.* 1984
Poeppel's Corner-1	7700'	Cuttings	Walkandi	440	0.03	0.31	8.13	0.34	0.03	0.09	0.02	0.45	68	1806	McKirdy *et al.* 1984
Poeppel's Corner-1	7800'	Cuttings	Walkandi									0.17			McKirdy *et al.* 1984
Poeppel's Corner-1	7900'	Cuttings	Basement									0.02			McKirdy *et al.* 1984
Poeppel's Corner-1	8000'	Cuttings	Basement									0.02			McKirdy *et al.* 1984
Poeppel's Corner-1	8100'	Cuttings	Basement									0.02			McKirdy *et al.* 1984
Poeppel's Corner-1	8200'	Cuttings	Basement									0.02			McKirdy *et al.* 1984
Poeppel's Corner-1	8300'	Cuttings	Basement									0.03			McKirdy *et al.* 1984
Poeppel's Corner-1	8400'	Cuttings	Basement									0.02			McKirdy *et al.* 1984
Poolowanna-1	7930–7940'	Cuttings	Poolowanna	447	3.65	38.25	1.13	41.90	33.85	0.09	3.48	16.30	235	7	Kagya & McKirdy 1995
Poolowanna-1	7950–7990'	Cuttings	Poolowanna	441	1.36	9.64	0.39	11.00	24.72	0.12	0.91	5.08	190	8	Kagya & McKirdy 1995
Poolowanna-1	8000–8020'	Cuttings	Poolowanna	447	7.44	46.29	1.53	53.73	30.25	0.14	4.46	19.50	237	8	Kagya & McKirdy 1995
Poolowanna-1	8100–8110'	Cuttings	Poolowanna	447	5.34	22.51	1.09	27.85	21.24	0.19	2.31	11.80	191	9	Kagya & McKirdy 1995
Poolowanna-1	8200–8220'	Cuttings	Poolowanna	442	6.43	65.21	1.91	71.64	34.14	0.09	5.95	20.70	315	9	Kagya & McKirdy 1995
Poolowanna-1	8350–8360'	Cuttings	Poolowanna	448	4.60	38.45	1.07	43.05	35.93	0.11	3.57	15.40	250	7	Kagya & McKirdy 1995
Poolowanna-1	8390–8410'	Cuttings	Poolowanna	449	3.49	29.34	0.77	32.83	38.10	0.11	2.72	11.20	262	7	Kagya & McKirdy 1995
Poolowanna-2	8190–8210'	Cuttings	Poolowanna	449	13.46	146.33	2.47	159.79	59.24	0.08	13.26	42.10	348	6	Kagya & McKirdy 1995
Poolowanna-2	8280–8290'	Cuttings	Poolowanna	452	8.69	106.43	1.50	115.12	70.95	0.08	9.55	30.70	347	5	Kagya & McKirdy 1995
Poolowanna-2	8340–8350'	Cuttings	Poolowanna	451	4.72	52.76	0.96	57.48	54.96	0.08	4.77	19.80	266	5	Kagya & McKirdy 1995
Poolowanna-3	7950–7970'	Cuttings	Poolowanna	447	3.93	41.18	1.22	45.11	33.75	0.09	3.74	18.30	225	7	Kagya & McKirdy 1995
Poolowanna-3	8000–8040'	Cuttings	Poolowanna	444	1.38	13.69	0.44	15.07	31.11	0.09	1.25	7.30	188	6	Kagya & McKirdy 1995
Poolowanna-3	8220–8260'	Cuttings	Poolowanna	441	1.61	12.35	0.43	13.96	28.72	0.12	1.16	5.44	227	8	Kagya & McKirdy 1995
Poolowanna-3	8370–8400'	Cuttings	Poolowanna	451	11.19	96.60	2.01	107.79	48.06	0.10	8.95	33.50	288	6	Kagya & McKirdy 1995
Poolowanna-3	8400–8420'	Cuttings	Poolowanna	450	4.44	44.27	0.88	48.71	50.31	0.09	4.04	16.30	272	5	Kagya & McKirdy 1995
Toodla-1	151.7–151.8m	Core	Bulldog Shale	425	0.03	0.15	0.69	0.18	0.22	0.17	0.01	0.85	17	81	McKirdy *et al.* 1986
Toodla-1	157.4–157.6m	Core	Bulldog Shale	429	0.03	0.15	0.73	0.18	0.21	0.17	0.01	0.82	18	89	McKirdy *et al.* 1986
Toodla-1	160.0–160.5m	Core	Bulldog Shale	429	0.03	0.14	0.75	0.17	0.19	0.18	0.01	0.91	15	82	McKirdy *et al.* 1986
Toodla-1	165.1–165.9m	Core	Bulldog Shale	429	0.03	0.13	0.74	0.16	0.18	0.19	0.01	0.94	13	78	McKirdy *et al.* 1986
Toodla-1	170.3–170.9m	Core	Bulldog Shale	435	0.02	0.11	0.65	0.13	0.17	0.15	0.01	0.77	14	84	McKirdy *et al.* 1986
Toodla-1	179.0–179.3m	Core	Bulldog Shale	429	0.05	0.28	0.86	0.33	0.33	0.15	0.03	1.08	25	79	McKirdy *et al.* 1986
Toodla-1	183.1–183.4m	Core	Bulldog Shale	430	0.02	0.23	0.77	0.25	0.30	0.08	0.02	1.06	21	72	McKirdy *et al.* 1986
Toodla-1	186.5–186.7m	Core	Bulldog Shale	430	0.04	0.18	0.88	0.22	0.20	0.18	0.02	0.96	18	91	McKirdy *et al.* 1986

Toodla-1	194.5–194.5m	Core	Bulldog Shale	427	0.04	0.27	0.93	0.31	0.29	0.13	0.03	0.97	27	95	McKirdy *et al.* 1986
Toodla-1	195.5–195.8m	Core	Bulldog Shale	425	0.03	0.38	0.81	0.41	0.47	0.07	0.03	1.10	34	73	McKirdy *et al.* 1986
Toodla-1	203.0–203.3m	Core	Bulldog Shale	425	0.02	0.18	0.70	0.20	0.26	0.10	0.02	0.71	25	98	McKirdy *et al.* 1986
Toodla-1	209.0–209.3m	Core	Bulldog Shale	425	0.03	0.39	0.79	0.42	0.49	0.07	0.03	1.00	39	79	McKirdy *et al.* 1986
Toodla-1	214.7–215.0m	Core	Bulldog Shale	423	0.03	0.36	0.83	0.39	0.43	0.08	0.03	1.10	32	75	McKirdy *et al.* 1986
Toodla-1	217.3–217.6m	Core	Bulldog Shale	424	0.03	0.26	0.84	0.29	0.31	0.10	0.02	0.90	28	93	McKirdy *et al.* 1986
Toodla-1	222.8–223.0m	Core	Bulldog Shale	429	0.03	0.31	1.19	0.34	0.26	0.09	0.03	1.20	25	99	McKirdy *et al.* 1986
Toodla-1	225.2–225.5m	Core	Bulldog Shale	429	0.02	0.30	1.16	0.32	0.26	0.06	0.03	1.12	26	103	McKirdy *et al.* 1986
Toodla-1	230.6–230.9m	Core	Bulldog Shale	428	0.03	0.29	1.33	0.32	0.22	0.09	0.03	1.09	26	122	McKirdy *et al.* 1986
Toodla-1	236.1–236.4m	Core	Bulldog Shale	431	0.04	0.44	1.39	0.48	0.32	0.08	0.04	1.39	31	100	McKirdy *et al.* 1986
Toodla-1	241.0–241.4m	Core	Bulldog Shale	429	0.03	0.40	1.31	0.43	0.31	0.07	0.04	1.46	27	89	McKirdy *et al.* 1986
Toodla-1	246.5–246.8m	Core	Bulldog Shale	429	0.03	0.44	1.30	0.47	0.34	0.06	0.04	1.44	30	90	McKirdy *et al.* 1986
Toodla-1	254.6–255.0m	Core	Bulldog Shale	429	0.02	0.42	1.39	0.44	0.30	0.05	0.04	1.29	32	107	McKirdy *et al.* 1986
Toodla-1	258.8–259.4m	Core	Bulldog Shale	436	0.03	0.92	1.58	0.95	0.58	0.03	0.08	1.85	49	85	McKirdy *et al.* 1986
Toodla-1	260.1–260.4m	Core	Bulldog Shale	433	0.02	0.79	1.67	0.81	0.47	0.02	0.07	1.63	48	102	McKirdy *et al.* 1986
Toodla-1	265.3–266.0m	Core	Cadna-owie	426	0.07	2.50	1.70	2.57	1.47	0.03	0.21	1.99	125	85	McKirdy *et al.* 1986

T_{max} = temperature of maximum generation of S2 hydrocarbons

S1 = mg hydrocarbons/g rock; S2 = mg hydrocarbons/g rock; S3 = mg CO_2/g rock

PI = S1/(S1+S2); PC = pyrolysable carbon; TOC = total organic carbon

HI = S2/g TOC; OI = S3/g TOC

TABLE 2: Kerogen composition and vitrinite reflectance database, Pedirka Basin, Simpson Desert Basin an superjacent Eromanga Basin.

Well	Depth	Sample type/ID	Formation	Atomic composition H/C	O/C	C/N	$\delta^{13}C_{PDB}$ (‰)	Vitrinite reflectance data R_o (%)	Comments	Reference
Macumba-1	2344.9m	Core-1	Peera Peera	0.70	0.058	72				Smyth & Saxby 1981
Mokari-1	1755.0m							0.64		Kantsler 1981
Mokari-1	1763.9m	Core-1	Algebuckina	0.66	0.13	72		0.67		Smyth & Saxby 1981; McKirdy 1981
Mokari-1	1764.1m	Core-1	Algebuckina	0.86	0.10	42	-26.2	0.65		McKirdy 1981
Mokari-1	1766.4m	Core-1	Algebuckina	0.67	0.12	26	-23.8	0.61		McKirdy 1981
Mokari-1	1851.7m	Core-2	Purni	0.63	0.12	55	-25.1	1.00	Oxidised	McKirdy 1981
Mokari-1	1855.1m	Core-2	Purni	0.65	0.12	48	-24.0	0.74	Oxidised	McKirdy 1981
Mokari-1	1917.2m							0.63		Kantsler 1981
Mokari-1	1926.3m							0.70		Kantsler 1981
Mokari-1	1994.6m	Core-3	Purni	0.70	0.096	73	-25.1			McKirdy 1981
Mokari-1	1997.9m	Core-3	Purni	1.00	0.080	30	-28.5	0.58	Vit. B	McKirdy 1981
Mokari-1	2017.1m	Core-4	Purni	0.75	0.089	36	-25.0	0.82	Oxidised	McKirdy 1981
Mokari-1	2018.1m	Core-4	Purni	0.74	0.092	31	-23.9			McKirdy 1981
Mokari-1	2060.4m							0.69		Kantsler 1981
Mokari-1	2104.6m							0.68		Kantsler 1981
Poeppel's Corner-1	2500'	Cuttings	Winton					0.37		McKirdy *et al.* 1984
Poeppel's Corner-1	3000'	Cuttings	Oodnadatta					0.41		McKirdy *et al.* 1984
Poeppel's Corner-1	3500'	Cuttings	Oodnadatta					0.41		McKirdy *et al.* 1984
Poeppel's Corner-1	4000'	Cuttings	Bulldog Shale					0.43		McKirdy *et al.* 1984
Poeppel's Corner-1	4400'	Cuttings	Bulldog Shale					0.46		McKirdy *et al.* 1984
Poeppel's Corner-1	4900'	Cuttings	Algebuckina					0.62	Reworked	McKirdy *et al.* 1984
Poeppel's Corner-1	5500'	Cuttings	Algebuckina					0.51		McKirdy *et al.* 1984
Poeppel's Corner-1	6000'	Cuttings	Algebuckina					0.52		McKirdy *et al.* 1984
Poeppel's Corner-1	6500'	Cuttings	Algebuckina					0.51		McKirdy *et al.* 1984
Poeppel's Corner-1	6700'	Cuttings	Algebuckina					0.52		McKirdy *et al.* 1984
Poeppel's Corner-1	6717'	SWC	Poolowanna					0.54	Reworked	McKirdy *et al.* 1984
Poeppel's Corner-1	6800'	Cuttings	Poolowanna					0.52		McKirdy *et al.* 1984
Poeppel's Corner-1	6900'	Cuttings	Poolowanna					0.52		McKirdy *et al.* 1984
Poeppel's Corner-1	6977'	SWC	Poolowanna					0.51		McKirdy *et al.* 1984
Poeppel's Corner-1	7000'	Cuttings	Poolowanna					0.52		McKirdy *et al.* 1984
Poeppel's Corner-1	7100'	Cuttings	Poolowanna					0.51		McKirdy *et al.* 1984
Poeppel's Corner-1	7176'	SWC	Poolowanna					0.53		McKirdy *et al.* 1984
Poeppel's Corner-1	7200'	Cuttings	Poolowanna					0.55		McKirdy *et al.* 1984
Poeppel's Corner-1	7248'	SWC	Poolowanna					0.54		McKirdy *et al.* 1984
Poeppel's Corner-1	7300'	Cuttings	Poolowanna					0.56		McKirdy *et al.* 1984
Poeppel's Corner-1	7367.5'	SWC	Peera Peera					0.58		McKirdy *et al.* 1984
Poeppel's Corner-1	7400'	Cuttings	Peera Peera					0.57		McKirdy *et al.* 1984
Poeppel's Corner-1	7500'	Cuttings	Peera Peera					0.62		McKirdy *et al.* 1984

Poeppel's Corner-1	7500'	Cuttings	Peera Peera					0.62		McKirdy *et al.* 1984
Poeppel's Corner-1	7528'	SWC	Peera Peera					0.60		McKirdy *et al.* 1984
Poeppel's Corner-1	7556'	SWC	Peera Peera					0.60		McKirdy *et al.* 1984
Poeppel's Corner-1	7563'	SWC	Peera Peera					0.61		McKirdy *et al.* 1984
Poeppel's Corner-1	7600'	Cuttings	Peera Peera					0.61		McKirdy *et al.* 1984
Poeppel's Corner-1	7633'	SWC	Peera Peera					0.63		McKirdy *et al.* 1984
Poeppel's Corner-1	7800'	Cuttings	Walkandi					0.69		McKirdy *et al.* 1984
Poeppel's Corner-1	8000'	Cuttings	Basement					0.78		McKirdy *et al.* 1984
Poolowanna-1	2364.6m	Core-1	Algebuckina				-24.9			McKirdy 1981
Poolowanna-1	2414.0–2417.1m	Cuttings	Poolowanna	0.79	0.089	85	-24.7			McKirdy 1981
Poolowanna-1	2445.1m	SWC	Poolowanna	0.67	0.071	114	-24.4			McKirdy 1981
Poolowanna-1	2478.0–2481.1m	Cuttings	Poolowanna	0.75	0.063	62	-25.0			McKirdy 1981
Poolowanna-1	2569.5m	Core-3	Poolowanna	0.76	0.059	40	-25.9			McKirdy 1981
Poolowanna-1	2596.9m	SWC	Peera Peera	0.65	0.072	74	-26.8			McKirdy 1981
Poolowanna-1	2601.5m	SWC	Peera Peera	0.67	0.058	55	-27.2			McKirdy 1981
Purni-1	1445.1m	Core-2	Purni	0.64	0.14	51	-24.3	0.7–0.8	Oxidised	McKirdy 1981
Purni-1	1454.5m	Core-2	Purni					0.5–0.6		McKirdy 1981
Purni-1	1547.2m	Core-3	Purni	0.74	0.16	48	-25.0			McKirdy 1981
Purni-1	1549.3m	Core-3	Purni					0.47		McKirdy 1981
Purni-1	1550.1m	Core-3	Purni	0.87	0.10	50		0.49		Smyth & Saxby 1981
Purni-1	1601.7m	Core-4	Purni	0.81	0.15	50	-24.4	0.4–0.5	Resinous	McKirdy 1981
Purni-1	1772.1m	Core-7	Crown Point	0.58	0.13	50	-25.2			McKirdy 1981
Toodla-1	151.70m	Core	Bulldog	0.68	0.24	51	-24.21	0.34		McKirdy *et al.* 1986
Toodla-1	160.00m	Core	Bulldog	0.58	0.23	53	-24.18			McKirdy *et al.* 1986
Toodla-1	170.35m	Core	Bulldog	0.60	0.24	51	-23.68			McKirdy *et al.* 1986
Toodla-1	183.10m	Core	Bulldog	0.67	0.22	54	-23.19	0.37		McKirdy *et al.* 1986
Toodla-1	194.47m	Core	Bulldog	0.71	0.23	53	-24.26	0.36		McKirdy *et al.* 1986
Toodla-1	209.00m	Core	Bulldog	0.71	0.21	53	n.d.			McKirdy *et al.* 1986
Toodla-1	214.70m	Core	Bulldog	0.75	0.22	52	-25.46			McKirdy *et al.* 1986
Toodla-1	222.80m	Core	Bulldog	0.68	0.21	59	-23.98			McKirdy *et al.* 1986
Toodla-1	230.62m	Core	Bulldog	0.70	0.21	55	n.d.	0.34		McKirdy *et al.* 1986
Toodla-1	236.12m	Core	Bulldog	0.72	0.23	53	n.d.			McKirdy *et al.* 1986
Toodla-1	241.04m	Core	Bulldog	0.76	0.23	51	n.d.			McKirdy *et al.* 1986
Toodla-1	258.85m	Core	Bulldog	0.89	0.21	40	-28.02			McKirdy *et al.* 1986
Toodla-1	265.28m	Core	Cadna-owie	1.03	0.17	43	-28.17			McKirdy *et al.* 1986

TABLE 3a: Oil geochemistry (general) database, Pedirka Basin, Simpson Desert Basin and superjacent Eromanga Basin.

Well	Depth	DST	Formation	API gravity	S content	Pour point (°C)	C_{15+} bulk composition Sat (%)	Aro (%)	Res (%)	Asp (%)	$\frac{Pr}{Ph}$	$\frac{Pr}{n\text{-}C_{17}}$	$\frac{Ph}{n\text{-}C_{18}}$	Reference
Poolowanna-1	2504.2–2538.4m	2	Poolowanna	37.2	0.09	41	82.8	11.7	2.0	3.5				Esso (McKirdy 1981)
				36.9			78.0	12.1	8.8	1.1				BMR (McKirdy 1981)
				35.4	0.1	41	77.2	13.6	9.3	-	5.6	0.23	0.04	AMDEL (McKirdy 1981)
Poolowanna-1	2616.7–2634.1m	3	Peera Peera	41.7	0.09	-1	67.2	17.4	13.4	2.0				Esso (McKirdy 1981)
							67.6	17.2	14.2	1.0	6.8	0.39	0.06	AMDEL (McKirdy 1981)

TABLE 3b: Oil geochemistry (stable carbon isotopes) database, Pedirka Basin, Simpson Desert Basin and superjacent Eromanga Basin.

Well	Depth	DST	Formation	$\delta^{13}C_{PDB}$ Sat (‰)	Aro (‰)	Res (‰)	Asp (‰)	Reference
Poolowanna-1	2504.2–2538.4m	2	Poolowanna	-28.8	-27.1			Esso (McKirdy 1981)
				-30.8	-27.7	-26.4	-26.6	BMR/WAIT (McKirdy 1981)
								AMDEL (McKirdy 1981)
Poolowanna-1	2616.7–2634.1m	3	Peera Peera	-29.4	-27.4			Esso (McKirdy 1981)

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TABLE 4: Rock extract database, Pedirka Basin, Simpson Desert Basin and superjacent Eromanga Basin.

Well	Depth	Sample type/ID	Formation	TOC%	EOM ppm	EOM mg/g TOC	EOM Sat (%)	EOM Aro (%)	EOM Res (%)	EOM Asp (%)	EOM Pol (%)	$\frac{Pr}{Ph}$	$\frac{Pr}{n\text{-}C_{17}}$	$\frac{Ph}{n\text{-}C_{18}}$	Reference
AFMECO Cur-3	251.6m	Core	Algebuckina	34.30	46519	432	20.6	4.7			74.7				Staples *et al.* 1995
AFMECO Cur-3	251.9m	Core	Algebuckina	39.00	69412	178	4.3	3.8			91.9				Staples *et al.* 1995
AFMECO Cur-3	259.5m	Core	Algebuckina	47.20	76429	162	4.8	3.0			92.2				Staples *et al.* 1995
AFMECO Cur-5	209.2m	Core	Algebuckina	52.90											Staples *et al.* 1995
AFMECO Cur-5	210.1m	Core	Algebuckina	50.50	71317	141	2.4	5.5			92.1				Staples *et al.* 1995
AFMECO Cur-5	249.4m	Core	Algebuckina	58.70	80691	137	1.9	2.9			95.2				Staples *et al.* 1995
Colson-1	1310.6–1325.9m	Cuttings	Roma	1.20	465	9	7.5	14.7	35.1	42.7		3.64	1.76	0.50	McKirdy 1981
Colson-1	1325.9–1341.1m	Cuttings	Transition Beds	0.93	357	8	10.9	8.9	37.0	43.2		2.83	1.76	0.58	McKirdy 1981
Colson-1	1804.4–1807.5m	Cuttings	Algebuckina	0.02	63										McKirdy 1981
Colson-1	1810.5–1813.6m	Cuttings	Algebuckina	0.05	166	36	4.7	6.5	25.2	63.6		5.00	1.57	0.27	McKirdy 1981
Colson-1	1906.5	Cuttings	Algebuckina	1.47	770	8	6.0	9.1	36.2	48.7		5.35	1.22	0.17	McKirdy 1981
Colson-1	1920.2	Cuttings	Algebuckina	0.30	502	21	3.9	8.4	33.3	54.3		4.07	0.96	0.18	McKirdy 1981
Colson-1	1935.5	Cuttings	Algebuckina	0.10	89	8	6.3	2.5	23.2	68.1		2.76	0.53	0.18	McKirdy 1981
Colson-1	1956.8	Cuttings	Poolowanna	31.6	22560	13	4.5	13.9	35.1	46.5		4.80	0.66	0.12	McKirdy 1981
Colson-1	2072.6	Cuttings	Peera Peera	0.57	243	12	15.7	13.2	20.3	50.7		5.54	0.81	0.12	McKirdy 1981
Colson-1	2137.3–2139.1m	Cuttings	Purni	74.0	35065	12	4.8	19.8	31.1	44.3		6.67	1.07	0.14	McKirdy 1981
Colson-1	2154.9–2158.0m	Cuttings	Purni	75.5	48175	14	5.2	16.2	32.3	46.2		6.59	1.09	0.15	McKirdy 1981
Colson-1	2164.1m	Cuttings	Purni	2.85	1480	137.5	17.5	46.9	40.1	0.80		5.89	0.80	0.12	McKirdy 1981
Colson-1	2173.2–2176.3m	Cuttings	Purni	13.9	8000	13	6.3	16.8	31.4	45.4		5.88	0.95	0.13	McKirdy 1981
Colson-1	2182.4–2185.4m	Cuttings	Purni	74.1	46755	14	6.6	16.2	36.7	40.4		6.77	1.40	0.17	McKirdy 1981
Colson-1	2423.2m	SWC	Pre-Permian	0.21	620	161*	47.1	7.4	20.6	24.8		6.82	0.89	0.12	McKirdy 1981
Dalmatia-1	1940–1990'	Cuttings	Purni	49.20	26427	54	6.3	7.0			86.7	4.0	0.91	0.16	Staples *et al.* 1995
Dalmatia-1	2010–2050'	Cuttings	Purni	44.30	21482	48	6.8	8.6			84.6	3.0	1.27	0.28	Staples *et al.* 1995
Dalmatia-1	2080–2120'	Cuttings	Purni	37.70											Staples *et al.* 1995
Dalmatia-1	2340–2370'	Cuttings	Purni	38.50	30298	79	6.3	4.9			88.8	4.2	1.50	0.23	Staples *et al.* 1995
Dalmatia-1	2600–2660'	Cuttings	Purni	39.40											Staples *et al.* 1995
Macumba-1	2351.5m	Core-1	Peera Peera	3.20	1158	8	7.0	15.6	32.3	45.1		2.76	0.25	0.065	McKirdy 1981
Macumba-1	2353.5m	Core-1	Peera Peera	3.15	1340	12	9.4	17.4	32.2	40.6		3.52	0.33	0.085	McKirdy 1981
Mokari-1	1764.1m	Core-1	Algebuckina	1.17	1090	28	6.8	23.0	13.7	56.5		2.62	1.20	0.46	McKirdy 1981
Mokari-1	1766.4m	Core-1	Algebuckina	0.93	890	13	5.2	8.4	6.9	79.5		1.44	0.81	0.57	McKirdy 1981
Mokari-1	1767.2m	Core-1	Algebuckina	0.14											McKirdy 1981
Mokari-1	1850.4m	Core-2	Purni	0.41											McKirdy 1981
Mokari-1	1850.7m	Core-2	Purni	2.37	1111	7	5.0	17.5	66.9						Burns & Partridge 1976
Mokari-1	1851.7m	Core-2	Purni	11.4	3657	9	7.8	21.3	29.3	41.6		2.26	0.59	0.29	McKirdy 1981
Mokari-1	1853.5m	Core-2	Purni	0.34											McKirdy 1981
Mokari-1	1855.1m	Core-2	Purni	1.49	1100	15	7.2	12.4	17.5	62.9		1.61	0.68	0.43	McKirdy 1981

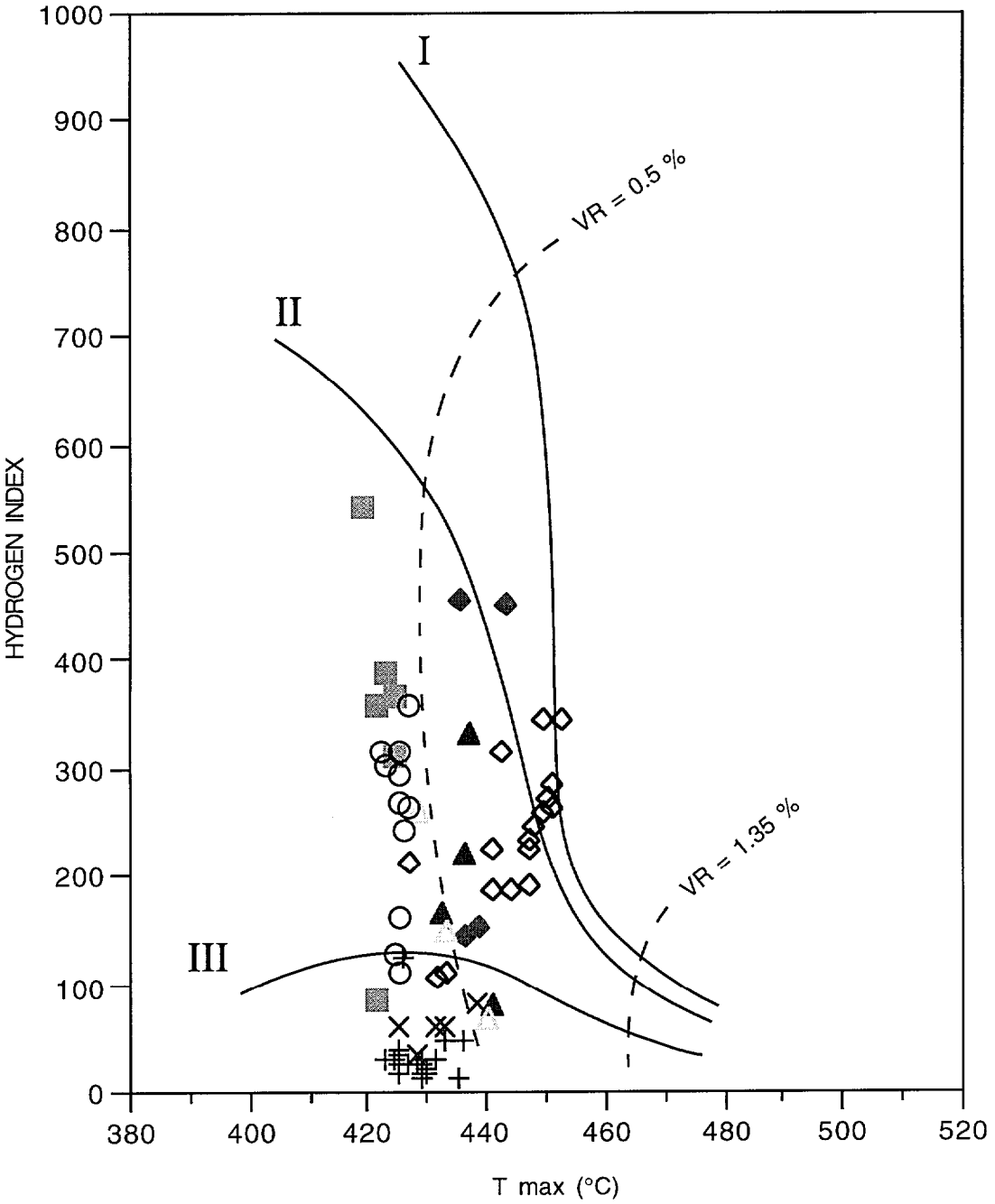
Mokari-1	1994.6m	Core-3	Purni	0.75	978	32	12.1	12.3	20.6	55.0		1.69	0.65	0.35	McKirdy 1981
Mokari-1	1997.4m	Core-3	Purni	0.94											McKirdy 1981
Mokari-1	1997.9m	Core-3	Purni	9.01	7099	33.1	22.8	18.9	25.2	33.1		2.84	2.07	0.66	McKirdy 1981
Mokari-1	2017.1m	Core-4	Purni	0.95	888	34	14.2	22.5	13.2	50.1		2.38	1.01	0.44	McKirdy 1981
Mokari-1	2917.5m	Core-4	Purni	3.61	2421	20	12.2	17.4	26.7	43.7					Burns & Partridge 1976
Mokari-1	2018.1m	Core-4	Purni	1.19	1496	28	3.8	19.9	25.8	50.5		2.32	0.95	0.41	McKirdy 1981
Mokari-1	2019.3m	Core-4	Purni	0.48											McKirdy 1981
Mokari-1	2384.5m	Core-6	?Stairway Sst	0.03	26	65	17.1	54.3			28.6	0.79	0.56	0.50	McKirdy 1981
Mt Hammersley-1	2020–2070'	Cuttings	Purni	63.10	18267	29	4.7	7.1			88.2	3.4	0.81	0.33	Staples *et al.* 1995
Mt Hammersley-1	2160–2210'	Cuttings	Purni	62.80	16985	27	5.5	8.5			86.0	2.3	1.00	0.50	Staples *et al.* 1995
Mt Hammersley-1	2310–2360'	Cuttings	Purni	58.70	19704	34	4.7	9.0			86.3	3.8	1.25	0.38	Staples *et al.* 1995
Mt Hammersley-1	2500–2540'	Cuttings	Purni	59.10	31962	54	6.4	10.2			83.4	3.5			Staples *et al.* 1995
Mt Hammersley-1	2750–2800'	Cuttings	Purni	55.80	31680	57	7.1	7.9			85.0	3.8		0.75	Staples *et al.* 1995
Mt Hammersley-1	2860–2910'	Cuttings	Purni	52.80	26155	50	11.2	8.3			80.5	3.3	1.33	0.33	Staples *et al.* 1995
Mt Hammersley-1	4000–4060'	Cuttings	Undiff. Permian	0.41	367	89	25.8	6.6			67.6		0.87	0.22	Staples *et al.* 1995
Mt Hammersley-1	4620–4670'	Cuttings	Crown Point	0.35											Staples *et al.* 1995
Poolowanna-1	2364.0m	Core-1	Algebuckina	13.5	24310	33	6.3	12.1	36.3	45.3		4.90	0.70	0.14	McKirdy 1981
Poolowanna-1	2364.5m	Core-1	Algebuckina	6.20	11545	31	5.0	11.7	23.5	59.8		3.82	0.89	0.22	McKirdy 1981
Poolowanna-1	2388.7m	SWC	Poolowanna	1.22	7460	157	20.6	5.1	28.3	46.0		6.17	0.70	0.11	McKirdy 1981
Poolowanna-1	2414.0–2417.1m	Cuttings	Poolowanna	3.55	4509	38	9.8	19.8	27.8	42.6		4.71	0.32	0.064	McKirdy 1981
Poolowanna-1	2418.9m	SWC	Poolowanna	1.89	2537	59	28.7	15.2	33.6	22.5		6.95	0.71	0.11	McKirdy 1981
Poolowanna-1	2445.1	SWC	Poolowanna	9.28	5717	22	16.7	16.8			66.5	6.39	0.63	0.11	BMR data
Poolowanna-1	2478.0–2481.1m	Cuttings	Poolowanna	1.36	1761	42	17.8	14.9	30.7	36.6		6.08	0.58	0.10	McKirdy 1981
Poolowanna-1	2503.9m	SWC	Poolowanna	2.30	5291	58	13.8	11.5	39.9	34.8		6.07	0.71	0.12	McKirdy 1981
Poolowanna-1	2569.5m	Core-3	Poolowanna	5.01	3333	14	13.8	9.0			77.2	3.47	0.37	0.10	BMR data
Poolowanna-1	2571.1m	Core-3	Poolowanna	5.15	3186	23	17.6	19.9	17.8	44.7		3.71	0.36	0.088	McKirdy 1981
Poolowanna-1	2571.9m	Core-3	Poolowanna	7.95	3960	20	14.0	26.1	37.0	22.9		3.03	0.23	0.078	McKirdy 1981
Poolowanna-1	2596.9–2599.9m	Cuttings	Peera Peera	6.40	3394	17	13.0	19.9	21.7	35.4		5.32	0.53	0.10	McKirdy 1981
Poolowanna-1	2599.9–2603.0m	Cuttings	Peera Peera	5.25	2147	16	14.6	24.4	38.8	22.2		5.32	0.51	0.10	McKirdy 1981
Purni-1	1445.1m	Core-2	Purni	2.85	955	4	5.3	7.7	27.8	59.2		3.80	1.23	0.45	McKirdy 1981
Purni-1	1447.2m	Core-2	Purni	0.85											McKirdy 1981
Purni-1	1451.2m	Core-2	Purni	1.17	1044	14	3.5	12.3	28.3	56.1		2.64	0.75	0.37	McKirdy 1981
Purni-1	1452.7m	Core-2	Purni	0.17											McKirdy 1981
Purni-1	1454.5m	Core-2	Purni	2.29	692	5	8.3	14.4	26.7	50.6		2.24	0.83	0.49	McKirdy 1981
Purni-1	1544.1m	Core-3	Purni	0.06											McKirdy 1981
Purni-1	1547.2m	Core-3	Purni	0.77	647	9	8.7	1.6	36.8	52.9		2.5	0.65	0.48	McKirdy 1981
Purni-1	1549.3m	Core-3	Purni	0.46											McKirdy 1981
Purni-1	1550.5m	Core-3	Purni	1.56	1331	8	4.0	5.0	40.2	50.7		2.71	0.72	0.33	McKirdy 1981
Purni-1	1551.1m	Core-3	Purni	0.49	1145	35	4.5	11.1	32.7	61.7		5.02	1.29	0.43	McKirdy 1981
Purni-1	1601.7m	Core-4	Purni	0.51	482	34	18.6	17.2	33.7	30.5		1.76	0.60	0.52	McKirdy 1981
Purni-1	1607.8m	Core-4	Purni	0.45											McKirdy 1981
Purni-1	1609.7m	Core-4	Purni	0.50	480	10	5.2	5.3	21.7	67.8		4.10	1.28	0.69	McKirdy 1981
Purni-1	1770.9m	Core-7	Crown Point	0.16											McKirdy 1981
Purni-1	1772.1m	Core-7	Crown Point	0.17	89	45*	65.0	20.5			14.5	1.50	0.58	0.45	McKirdy 1981

Purni-1	1773.9m	Core-7	Crown Point	0.05											McKirdy 1981
Purni-1	1860.8m	Core-8	?Stairway Sst	0.05											McKirdy 1981
Purni-1	1863.9m	Core-8	?Stairway Sst	0.05											McKirdy 1981
Purni-1	1866.0m	Core-8	?Stairway Sst	0.41	27	4	32.4	27.0			27.0	0.53	0.50	0.34	McKirdy 1981
Purni-1	1870.9m	Core-8	?Stairway Sst	0.05	23	10	7.1	14.3			78.6	0.72	0.35	0.58	McKirdy 1981
Purni-1	1873.3m	Core-8	?Stairway Sst	0.04											McKirdy 1981
Toodla-1	151.70m	Core	Bulldog	0.85	208	6	24.7	1.2	35.9	38.2		0.77	0.31	0.33	McKirdy *et al.* 1986
Toodla-1	160.00m	Core	Bulldog	0.91	149	1	6.8	2.1	64.6	26.5		1.2	0.41	0.32	McKirdy *et al.* 1986
Toodla-1	170.35m	Core	Bulldog	0.77	133	3	10.8	4.6	47.7	36.9		1.6	0.64	0.34	McKirdy *et al.* 1986
Toodla-1	183.10m	Core	Bulldog	1.06	157	2	9.8	3.3	58.8	28.1		1.5	1.0	0.64	McKirdy *et al.* 1986
Toodla-1	194.47m	Core	Bulldog	0.97	308	3	6.6	1.3	52.8	39.3		1.7	1.0	0.65	McKirdy *et al.* 1986
Toodla-1	203.00m	Core	Bulldog	0.71	219	6	18.3	2.4	42.7	36.6		1.2	0.79	0.56	McKirdy *et al.* 1986
Toodla-1	209.00m	Core	Bulldog	1.00	265	2	4.9	3.8	35.8	55.5		0.24	3.6	14.9	McKirdy *et al.* 1986
Toodla-1	214.70m	Core	Bulldog	1.10	302	3	7.7	3.5	43.5	45.3		0.27	6.5	27.5	McKirdy *et al.* 1986
Toodla-1	222.80m	Core	Bulldog	1.20	352	3	7.6	3.8	61.0	27.6		1.4	1.5	1.0	McKirdy *et al.* 1986
Toodla-1	230.62m	Core	Bulldog	1.09	271	4	8.6	4.9	48.3	38.2		1.6	1.3	0.82	McKirdy *et al.* 1986
Toodla-1	241.00m	Core	Bulldog	1.46	307	3	9.3	5.0	18.2	18.2		2.2	1.6	0.68	McKirdy *et al.* 1986
Toodla-1	254.65m	Core	Bulldog	1.29	251	2	10.1	1.6	62.0	26.3		1.9	0.68	0.39	McKirdy *et al.* 1986
Toodla-1	258.85m	Core	Bulldog	1.85	342	4	13.8	5.4	63.7	17.1		1.7	1.4	0.95	McKirdy *et al.* 1986
Toodla-1	260.14m	Core	Bulldog	1.63	366	4	10.2	5.8	61.7	22.3		1.9	0.93	0.55	McKirdy *et al.* 1986
Toodla-1	265.28m	Core	Cadna-owie	1.99	455	5	13.9	6.4	60.5	19.2		1.7	1.6	1.1	McKirdy *et al.* 1986

Pol = Resins + Asphaltenes

* Oil stained

Figure 1
Rock-Eval pyrolysis:
Pedirka Basin, Simpson Desert Basin and superjacent Eromanga Basin



+ Cretaceous (Core)
× Cretaceous (Cuttings)
■ Jurassic (Core)
◆ Basal Jurassic (Core)
◇ Basal Jurassic (Cuttings)
▲ Triassic (Core)
△ Triassic (Cuttings)
○ Permian (Cuttings)

0146

SOURCE ROCK AND PETROLEUM GEOCHEMISTRY OF THE ERINGA TROUGH, PEDIRKA BASIN

Supplementary Report

Report for Department of Mines and Energy South Australia

by

CHRISTINE J. STAPLES, BERND H. MICHAELSEN and DAVID M. McKIRDY

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August 1995

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INTRODUCTION AND RATIONAL

This report is an adjunct to our earlier investigation (Staples *et al.*, 1995) concerning the petroleum potential of coals and carbonaceous sediments from the margins of the Eringa Trough, Pedirka Basin. Based on cuttings samples from Dalmatia-1 and Mt Hammersley-1 wells, Staples *et al.* (1995) indicated that the Crown Point Formation (1 sample; Early Permian) and an undifferentiated Permian unit (1 sample), are organically lean and have poor source potential (TOC = 0.35–0.41%; HI = 34–39). These units are immature for liquid hydrocarbon generation. The Purni Formation (11 samples; Early Permian) contains organic matter of considerably better source potential (TOC = 37.7–62.8%; HI = 113–359) which is similarily immature with respect to oil generation (R_o = 0.33–0.45%; T_{max} = 422–427° C).

Alexander *et al.* (1988) used aromatic hydrocarbons to establish oil-source rock correlations in the Cooper and Eromanga Basins. These correlations were established on the premise that Araucariaceae flora which evolved in the Early Jurassic and became prominent by the Middle Jurassic produced high concentrations of diterpenoid resins which gave rise to particular aromatic hydrocarbons, *viz* 1,2,5-trimethylnaphthalene, 1-methylphenanthrene, 1,7-dimethylnaphthalene and retene. Thus, source rocks of Jurassic age and younger commonly have high concentrations of these biomarkers. Conversely, Permian rocks from the Cooper Basin were found to contain low levels of these compounds.

Additional GC-MS analyses not detailed by Staples *et al.* (1995) but conveyed to Elinor Alexander (MESA) by Bernd Michaelsen showed that retene occurs in very high abundance relative to phenanthrene in many cuttings samples from the Purni Formation. The above finding was unexpected but potentially important for oil-source rock correlation strategies based on aromatic biomarkers. Therefore, this adjunct study of 3 *core* samples from the Purni and Crown Point Formations in the nearby Purni-1 and Witcherie-1 wells was initiated. The use of core samples eliminated potential down–hole contamination by cavings of younger sediments.

SAMPLE SELECTION AND EXPERIMENTAL METHODS

Sample details are provided in Table 1. The three core samples were analysed for total organic carbon (TOC) and by Rock-Eval pyrolysis. For each sample polished blocks were made and petrographically examined. The two most organic-rich samples (from Purni-1) were extracted using Soxhlet apparatus, and the resulting extract was fractionated using liquid chromatography. Saturated and aromatic hydrocarbon fractions were analysed by GC-MS. The experimental details were identical to those described in Staples *et al.* (1995).

RESULTS

Analytical data are summarised and presented herein as follows:

	Table	Figure
TOC and Rock–Eval pyrolysis	2	-
Petrographic descriptions and vitrinite reflectance data	3	-
Extract and biomarker data	4	1

DISCUSSION AND CONCLUSIONS

Total organic carbon, Rock-Eval pyrolysis, petrographic and vitrinite reflectance data are presented in Tables 2, 3, and 4. These data are included for addition to MESA's database (PEPS). The important findings of this study are based on the data in Table 4 and Figure 1 which may be summarised as follows:

1 Retene is essentially *absent* in both core samples from Purni-1. This may throw into question the integrity of previously reported data from Dalmatia-1 and Mt Hammersley-1 cuttings samples. We suggest that the high retene concentrations in Dalmatia-1 and Mt Hammersley-1 cuttings may be due to cavings from overlying Jurassic strata. Nevertheless, all Permian samples (n = 8) have lower $\frac{\text{retene}}{\text{phenanthrene}}$ ratios when compared to the Jurassic data (n = 3).

2 Concentrations of the demethylated hopane 28,30-bisnorhopane are consistently higher, relative to 17α-hopane, in Permian rocks (Purni, Crown Point Formations) than in Jurassic Algebuckina Sandstone samples. High concentrations of 28,30-bisnorhopane are indicative of rocks deposited under suboxic and anoxic conditions (especially the latter: *cf.* Peters and Moldowan, 1993).

The second of these findings presents explorers of the Eringa Trough with a potentially useful parameter which is independant of aromatic hydrocarbon distribution.

Future oil discoveries with elevated $\frac{\text{28,30-bisnorhopane}}{\text{17}\alpha\text{-hopane}}$ ratios are likely to be sourced from the Permian, whereas those with low 28,30-bisnorhopane contents could be expulsion products of Jurassic source rocks. Caution should be exercised when applying this hypothesis, as the Eringa Trough geochemical database is presently derived from a very small sample set.

Finally, we recommend that, wherever possible, source rock studies should be based on core material.

REFERENCES

Alexander R., Larcher A. V., Kagi R. I. and Price P. L. (1988) The use of plant-derived biomarkers for correlation of oils with source rocks in the Cooper/Eromanga Basin system, Australia. *APEA J.* **28**(1), 310–324.

Staples C. J., Michaelsen B. H. and McKirdy D. M. (1995) Source rock and petroleum geochemistry of the Eringa Trough, Pedirka Basin. Unpublished report for Mines and Energy South Australia.

Peters K. E. and Moldowan J. M. (1993) *The Biomarker Guide: Interpreting Molecular Fossils in Petroleum and Ancient Sediments*. Prentice Hall, Englewood Cliffs.

TABLE 1: Core sample details

Well/depth	Formation	Sample description
Purni–1		
4743'6"	Purni Formation	Laminated dark grey to green siltstone.
5814'	Crown Point Fm	Grey to green siltstone.
Witcherie–1		
1824'10"	Crown Point Fm	Grey to green siltstone.

TABLE 2: Rock-Eval pyrolysis data

Well / Depth	I.D.	T_{max}	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
Purni-1												
4743'6"		429	0.15	10.28	1.34	10.43	0.01	7.67	0.86	7.48	137	17
5814'0"		429	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.22	0	68
Witcherie–1												
1824'10"		420	0.05	3.06	1.42	3.11	0.02	2.15	0.25	3.38	90	42

T_{max} = temperature of maximum generation of S2 hydrocarbons

S1 = mg hydrocarbons/g rock; S2 = mg hydrocarbons/g rock; S3 = mg CO_2/g rock

PI = S1/(S1+S2); PC = pyrolysable carbon; TOC = total organic carbon

HI = S2/g TOC; OI = S3/g TOC

TABLE 3: Petrographic descriptions and vitrinite reflectance data

Sample	Lithology	R_o (%)	Description
Purni–1			
4743'6"	Siltstone	0.89	Inertinites and oxidised vitrinite dominant. Vitrinite comprises oxidised eu–ulminite, corpogelinite and densinites. Liptinites comprise sporinite and rare telalginite. **R_o unreliable**.
5814'	Siltstone	nd	Very sparse organics include liptodetrinite, sporinite, ?telalginite, inertodetrinite and densinite.
Witcherie–1			
1824'24"	Siltstone	0.51	Oxidised vitrinite and inertinite abundant. Liptinite comprises liptodetrinite and sporinite. **R_o possibly unreliable**.

0150

TABLE 4: Geochemical and biomarker data summary

Well	Depth	Sample type	Formation	TOC (%)	EOM ppm	Yield mg/g TOC	EOM Sat (%)	EOM Aro (%)	EOM Pol (%)	Ret / Phen	28,30-Bis / Hop
AFMECO Cur-3	251.6m	Core	Algebuckina	34.30	46519	432	20.6	4.7	74.7	5.95	0.0371
AFMECO Cur-3	251.9m	Core	Algebuckina	39.00	69412	178	4.3	3.8	91.9	26.5	
AFMECO Cur-3	259.5m	Core	Algebuckina	47.20	76429	162	4.8	3.0	92.2	25.9	0.0018
AFMECO Cur-5	209.2m	Core	Algebuckina	52.90							
AFMECO Cur-5	210.1m	Core	Algebuckina	50.50	71317	141	2.4	5.5	92.1	6.44	
AFMECO Cur-5	249.4m	Core	Algebuckina	58.70	80691	137	1.9	2.9	95.2	7.43	~~249.4~~ 0.002
Dalmatia-1	1940–1990'	Cuttings	Purni	49.20	26427	54	6.3	7.0	86.7	0.233	0.340
Dalmatia-1	2010–2050'	Cuttings	Purni	44.30	21482	48	6.8	8.6	84.6	0.162	0.024
Dalmatia-1	2080–2120'	Cuttings	Purni	37.70							
Dalmatia-1	2340–2370'	Cuttings	Purni	38.50	30298	79	6.3	4.9	88.8		0.134
Dalmatia-1	2600–2660'	Cuttings	Purni	39.40							
Mt Hammersley-1	2020–2070'	Cuttings	Purni	63.10	18267	29	4.7	7.1	88.2	0.445	0.275
Mt Hammersley-1	2160–2210'	Cuttings	Purni	62.80	16985	27	5.5	8.5	86.0	0.780	
Mt Hammersley-1	2310–2360'	Cuttings	Purni	58.70	19704	34	4.7	9.0	86.3	0.303	0.965
Mt Hammersley-1	2500–2540'	Cuttings	Purni	59.10	31962	54	6.4	10.2	83.4	0.169	
Mt Hammersley-1	2750–2800'	Cuttings	Purni	55.80	31680	57	7.1	7.9	85.0	1.09	0.140
Mt Hammersley-1	2860–2910'	Cuttings	Purni	52.80	26155	50	11.2	8.3	80.5	0.717	
Mt Hammersley-1	4000–4060'	Cuttings	Undiff. Permian	0.41	367	89	25.8	6.6	67.6	0.232	0.066
Mt Hammersley-1	4620–4670'	Cuttings	Crown Point	0.35							
Purni–1	4743'6"	Core	Purni	7.48	3119	42	5.4	14.2	80.4	0.005	0.35
Purni–1	5814'0"	Core	Crown Point	0.22	116	52	4.7	2.3	93.0	0.003	?0
Witcherie–1	1824'10"	Core	Crown Point	3.38							

Pol = Resins + Asphaltenes

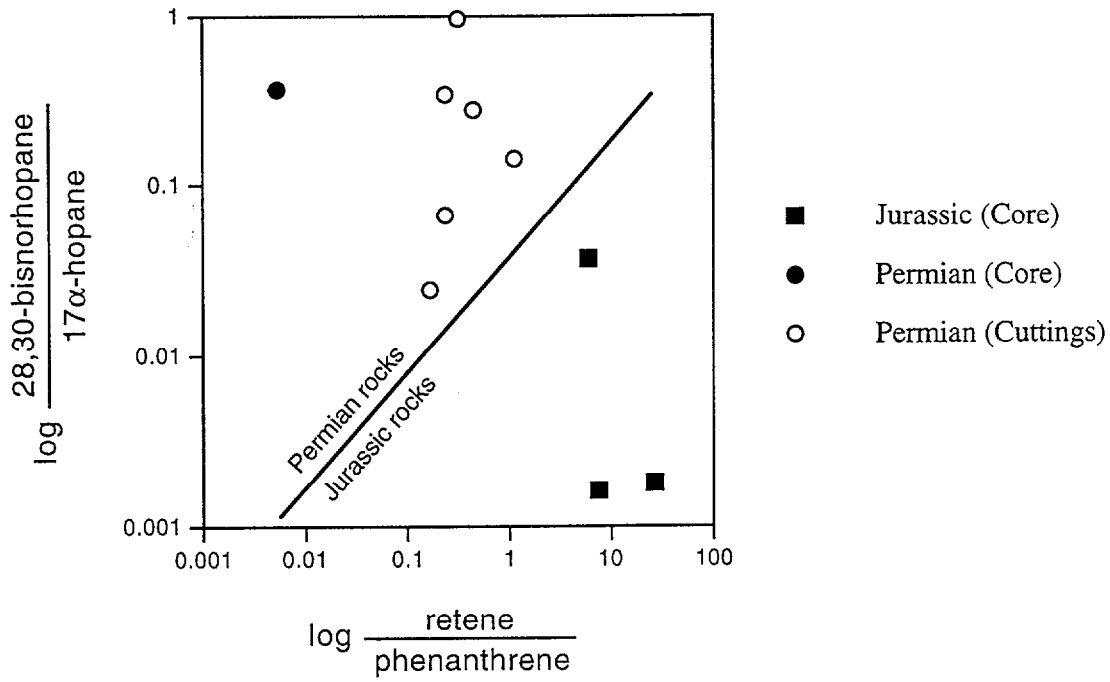
Ret = Retene

Phen = Phenanthrene

28,30-Bis = 17α,21β- and 17β,21α-28,30-bisnorhopane

Hop = 17α-hopane

Fig. 1


log 28,30-bisnorhopane / 17α-hopane
1
0.1
0.01
0.001
0.001
0.01
0.1
1
10
100
log retene / phenanthrene
Permian rocks
Jurassic rocks
Jurassic (Core)
Permian (Core)
Permian (Cuttings)

000153

VITRINITE REFLECTANCE AND ORGANIC PETROGRAPHY OF FOUR SAMPLES FROM THE BIRKHEAD AND MERRIMELIA FORMATIONS, COOPER/EROMANGA BASIN

(Cherri-1, 4361'; Mulapula-1, 4021'7"; Weena-1, 4978'2" & 4981'6")

Report for Department of Mines and Energy South Australia

by

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JANUARY 1995

INTRODUCTION AND METHODOLOGY

The small data set presented in this report is an addendum to our previous work on the western Eromanga Basin (Michaelsen *et al.*, 1995; Staples *et al.*, 1995a,b). Vitrinite reflectance measurements and organic petrographic observations were made on four core samples from the Birkhead and Merrimelia Formations recovered from the Cherri-1, Mulapula-1 and Weena-1 exploration wells. Reflectance measurements were made using a Leitz Ortholux Pol BK microscope under conditions specified by the Standards Association of Australia (1989). Random vitrinite reflectance (R_r %) measurements were converted to the mean of maximum vitrinite reflectance (R_o %) using Kilby's (1991) formula: $R_o = 1.083 \times R_r$.

RESULTS

TABLE 1: Vitrinite reflectance data and petrographic descriptions

Sample	Lithology	R_o (%)	n	Petrographic description
Cherri-1				
Birkhead Formation				
4361'	Coaly layers in sandstone	0.40	48	Vitrinite ≈ inertinite ≈ liptinite. Vitrinite almost entirely texto-ulminite. Resinite ≈ sporinite ≈ cutinite.
Mulapula-1				
Birkhead Formation				
4021'7"	Coal	0.54	37	Almost entirely (*ca* 99%) the vitrinite macerals eu-ulminite and texto-ulminite. Traces of liptodetrinite.
Weena-1				
Merrimelia Formation				
4978'2"	Siltstone/Shale	0.61	6	Siltstone: predominantly free of organics. Shale: Inertinite > vitrinite ≈ liptinite. Sporinite and liptodetrinite-rich. Cutinite common. Minor fluorinite and/or exsudatinite. **Oxidised vitrinite - unreliable R_o.**
4981'6"	Coal	0.49	26	Inertinite > vitrinite ≈ liptinite. Liptinites are abundant, particularly sporinite and liptodetrinite. Cutinite is common. Intact sporangia also present. **Oxidised vitrinite - possibly unreliable R_o.**

R_o = mean of maximum vitrinite reflectance; n = number of determinations used to calculate R_o.

REFERENCES

Kilby W. E. (1991) Vitrinite reflectance measurement — some technique enhancements and relationships. *Int. J. Coal Geol.* **19**, 201–218.

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Staples C. J., Michaelsen B. H. and McKirdy D. M. (1995b) Source rock and petroleum geochemistry of the Eringa Trough, Pedirka Basin. Supplementary report.*Unpublished report for Department of Mines and Energy South Australia.*

GEOTRACK

Dr. Peter Tingate
National Centre for Petroleum Geology and Geophysics
Thebarton Campus
The University of Adelaide
South Australia 5005

8/3/95

Dear Peter

Please find enclosed AFTA™ data on disc for Geotrack Report No. 550. The data consists of files that can be read by the AMOD51 software also on the disc. You cannot make copies of the AMOD 51 software except to place a copy on a secure hard drive of your PC. If you don't have a secure PC please delete the software from the PC you use after each modelling session. The software is confidential and proprietary to Geotrack International Pty. Ltd. and is on loan to you personally for the duration of this project only and must be returned at the end of the project and removed from your hard drive. By using the software you agree to abide by these conditions and agree to return or destroy the software immediately if asked by Geotrack to do so. Please do not demonstrate the software to anyone not involved directly in the project. This is the only copy of this software outside Geotrack so we are anxious that it does not get distributed around the world. For best results you should have a minimum 486 33 Mhz PC with in-built numeric co-processor.

For each sample, the following files are provided:

1. 550-1.TT: A thermal history file based on the default history
2. 550-1.CNT: A file of raw count data for each FT age grain which is uniquely numbered (includes zeta of the analyst and rho D)
3. 550-1.LNG: A file of raw track length data for each confined track length keyed to its unique grain number (includes a lot of other information to do with track orientation and crack width etc).
4. 550-1.CMP: A file of Chlorine contents in wt % for each AFTA age and length grain.
5. 550-1Z.TT: The maximum likelihood thermal history derived from out proprietary interpretation software.

The "Z" file is provided as a guide to get you going on the thermal history analysis, and should be used in conjunction with the hard copy output diagrams which show the 95% confidence intervals for the two thermal events fitted to the data as time-temperature windows on the attached plots. Also provided is a summary data table for each sample for the "Z" interpretation.

To use the software,

1. execute the file by typing AMOD51 <cr>

2. Read all of the data files in at once using menu item 11
   type 11 <cr>
   select a sample number from the list appropriate to the sample you have selected
   eg
   type 550-1 <cr> [again, the .cmp extension should not be typed in]

Telephone 61+3 344 7214
Facsimile 61+3 347 5938
Telex 35185 (UNIMEL)

Geotrack International Pty Ltd
A C N 006 821 209
PO Box 4120
Melbourne University
Victoria 3052 Australia

Samples to:
Room 225 Earth Sciences Bldg
University of Melbourne
Cnr Swanston and Elgin St
Carlton Victoria 3052
Australia

This procedure reads in the DEFAULT HISTORY "TT" file, if you want to read in another sort of "TT" file, eg the "550-1Z.TT file" which contains the maximum likelihood solution, then

Read a "TT" file in using menu item 2.
type "2" <cr>
type "2" <cr> again to read from a file
select a file from the list of "TT" files provided
eg
type "550-1Z" <cr> [the .TT extension should not be typed in]

3. Run the calculations by typing menu item 1 <cr>

which calculates the length distributions for each compositional group.
Press <cr> to step through pages to see length distributions for multiple compositions (when there is a large spread) and then <cr> return to main menu.

Use menu item 6 to get a radial plot and combined track length distribution for the sample
ie
press "6" <cr>

to look at a plot of fission track age versus Cl content go back to main menu and press "13" <cr>

This shows predicted age a black bars for each compositional group and ages of each individual grain with two sigma errors.

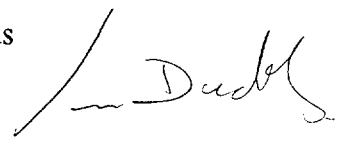
to look at a summary table of measured and predicted fission track age for each Cl group go back to main menu and
press "12" <cr>

Other menu items are pretty self explanatory.

Finally, I have looked briefly at a few of the samples and it looks like there may be multiple source ages in some samples which is going to give trouble in looking at the maximum likelihood solutions as it fits to each compositional group assuming a common source age. The result is that it sometimes doesn't match the youngest grains in the compositional group but takes a path through the middle. You will have to use AMOD51 to try different combinations and see if a common thermal history will match the different groups of ages with different source ages.

Hope all goes well.

Regards



Ian R. Duddy

Table 1. Well, formation top and present temperature data.

Depth Top (m)	Formation	Strati-graphic Age (Ma)	Present * Temp. (°C)
AFMECO CUR 5 (Surf. temp. =21 °C, G.G. = 35 °C/km)			
0	Tertiary	60-1.6	21
22	Bulldog	117.5-108	22
120	Algebuck.	186-138	28
258	Cambrian (Arcoeillinna)	512-510	32
TD(342)			33
AFMECO CUR 3 (Surf. temp. =21 °C, G.G. = 35 °C/km)			
0	Tert. (undif.)	60-1.6	21
18	Bulldog Shale	117.5-108	22
92	Algebuckina	186-138	24
297	Purni Fmn	277-264.5	31
362	Crn Point	286-283	34
377	Cambrian (Arcoeillina)	512-510	34
TD(386)			35
MT HAMMERSLEY 1 (Surf. temp. =21 °C, G.G. = 39.7 °C/km)			
0	Oodnadatta	108-97.5	21
181.1	Bulldog Shale	117.5-108	28
318.2	Cadna-owie	138-117.5	34
340.5	Algebuckina	186-138	35
604.7	Purni Fmn	277-264.5	45
890.6	Permian	283-277	56
1244.8	Crown Point	286-283	70
1591.7	Pacoota	505-485	84
TD(1864.5)			95
PURNI 1 (Surf. temp. =21 °C, G.G. = 38.8C/km)			
0	Tertiary?	60-0	21
116.1	Winton	97.5-90	26
417.6	Mackunda	100-97.5	37
524.3	Allaru	101-100	41
778.5	Toolebuc	102.5-101	51
789.7	Wallumbilla	117.5-102.5	52
980.9	Cadna-owie	138-117.5	59
1037.8	Algebuckina	186-138	61
1416.7	Purni Fmn	277-264.5	76
1575.8	Crown Point	286-283	82
1786.1	Basement	505-485?	90
TD(1880)			94
MT CRISPE 1(Surf. temp. =21 °C, G.G. = 36.4 °C/km)			
4	Surficial	1.6-0	21
9.1	Oodnadatta	108-97.5	21
46	Bulldog Shale	117.5-108	23
184.7	Cadna-owie	138-117.5	28
212.8	Algebuckina	186-138	29
446.5	Crown Pt.	286-283	37
465.7	Pacoota Sst	505-485	38
777.9	Mt Crispe	510-505	49
TD(1721.2)			84

GEOTRACK

To: Elinor Alexander
Eromanga Basin Team Leader, MESA
Fax No. 08 3733269

Date:8th Feb 1995

From: Patrick R Kelly, Operations Manager
FAX No. (61) 3 347 5938 (Telephone enquiries: (61) 3 344 7214)

No. of pages: 2 (including this sheet)

PROVISIONAL APATITE YIELDS *

* This is provisional data and gives an indication only of the potential of the sample for AFTA

Geotrack Report # 550 ARC Project

Geotrack #	Your Ref.#	Apatite Yield			Depth
		Good	Low	Zero	
AFMECO CUR 5					
GC549-1	57		*	Aptian	208.7-209.25
GC549-2	58	*		Cambrian	327.6-328.5
AFMECO CUR 3					
GC550-3	33	*		Permian	376.65-376.9
MT HAMMERSLEY-1					
GC550-4	124		*	Cretaceous	1150-1250
GC550-5	125		*	Triassic	1820-1910
GC550-6	126			* Crown Point	5010-5090
GC550-7	127	*		Proterozoic	6020-6120
GC550-8	128	*		Crown Point	4296-4301
GC550-9	129	*		Permian coal	2954-295

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Geotrack International Pty Ltd
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Melbourne University
Victoria 3052
Australia

Samples to:
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Earth Sciences Bldg
University of Melbourne
Cnr Swanston and Elgin St
Carlton Victoria 3052
Australia

GEOTRACK

Geotrack #	Your Ref.#	Apatite Yield			
		Good	Low	Zero	
PURNI-1					
GC549-10	64	*		Neoproterozoic	4566-4569'
GC549-11	65		*	Winton	460-530'
MT CRISPE-1					
GC550-12	132		*	Mt Crispe beds	5575-5621
GC550-13	133	*		Nyalbinna	720-770'
GC550-14	134		*	Mt Crispe beds	2851-2845
GC550-15	135	*		"	3367-3370
GC550-16	136		*	"	4373'8"-43 3"
GC550-17	137	*		"	5033-5036

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GC550 COB
ARC
Data on COB (3)

Length distribution summary

Sample number GC-550	Irradiation number 506, 507	Mean track length (µm)	Standard deviation (µm)	Number of tracks (N)	Initials of analyst	Number of tracks in length interval																					
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
-1	506 - 1	11.84 ± 0.68	1.81	7	COB									1	0	0	2	2	2								
-2	- 2	13.02 ± 0.09	0.95	104	COB											1	18	34	32	19							
-3	- 3	13.20 ± 0.13	1.25	100	COB											5	11	23	35	19	6	1					
-10	- 9	14.70 ± 0.33	1.62	24	COB									1	0	0	0	2	1	8	8	4					
-11	507 - 1	10.02 ± 0.20	0.94	23	COB									2	13	4	4										
-12	- 2	± not enough			COB											1											
-13	- 3	11.78 ± 0.92	1.77	18	COB								1	0	3	0	6	3	4	1							
-13A	- 4	11.90 ± 0.38	1.20	10	COB										1	1	4	2	1	1							
-14	- 5	± not enough			COB																						
-15A	- 6	11.31 ± 0.24	1.37	32	COB									1	2	11	8	7	2	-	1						
-16	- 7	10.51 ± 0.34	0.94	6	COB										2	2	2										
-16A	- 8	± not enough			COB																						
-17	- 9	11.57 ± 0.24	1.54	41	COB									3	3	9	9	9	5	3							
		±																									
		±																									
		±																									

GC550-1 APATITE

IRRADIATION G506
SLIDE NUMBER 1
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	3	20	32	1.490E+05	9.932E+05	0.150	9.0	0.24	35.7 ± 22.1
4	31	50	20	2.463E+06	3.973E+06	0.620	36.1	0.20	146.4 ± 33.7
5	100	141	60	2.648E+06	3.734E+06	0.709	33.9	0.30	167.2 ± 22.3
6	11	24	70	2.497E+05	5.448E+05	0.458	4.9	0.48	108.6 ± 39.6
	145	235		1.266E+06	2.052E+06		18.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 7.956 with 3 degrees of freedom
P(chi squared) = 4.7 %
Correlation Coefficient = 0.999
Variance of SQR(Ns) = 12.91
Variance of SQR(Ni) = 11.51
Age Dispersion = 23.127 % (did not converge)

Ns/Ni = 0.617 ± 0.065
Mean Ratio = 0.484 ± 0.123

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.256E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 145.7 ± 15.9 Ma
CENTRAL AGE = 129.1 ± 22.7 Ma

GC550-2 APATITE

IRRADIATION G506
SLIDE NUMBER 2
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	193	223	50	6.134E+06	7.087E+06	0.865	64.3	0.06	203.5 ± 20.7
4	11	10	60	2.913E+05	2.648E+05	1.100	2.4	0.03	257.5 ± 112.7
5	150	92	60	3.973E+06	2.437E+06	1.630	22.1	0.02	378.1 ± 51.1
6	55	51	30	2.913E+06	2.701E+06	1.078	24.5	0.00	252.6 ± 49.6
7	13	13	36	5.738E+05	5.738E+05	1.000	5.2	0.01	234.5 ± 92.2
8	198	174	100	3.146E+06	2.765E+06	1.138	25.1	0.05	266.2 ± 28.6
9	35	22	80	6.952E+05	4.370E+05	1.591	4.0	0.01	369.2 ± 100.9
10	25	18	80	4.966E+05	3.575E+05	1.389	3.2	0.03	323.5 ± 100.4
11	78	65	100	1.239E+06	1.033E+06	1.200	9.4	0.15	280.4 ± 47.7
12	180	187	80	3.575E+06	3.714E+06	0.963	33.7	0.02	225.9 ± 24.4
13	3	3	50	9.534E+04	9.534E+04	1.000	0.9	0.07	234.5 ± 191.6
14	180	131	60	4.767E+06	3.469E+06	1.374	31.5	0.13	320.1 ± 37.8
15	106	127	50	3.369E+06	4.036E+06	0.835	36.6	0.00	196.3 ± 26.4
16	71	46	100	1.128E+06	7.310E+05	1.543	6.6	0.07	358.5 ± 68.5
17	156	126	70	3.541E+06	2.860E+06	1.238	26.0	0.03	289.1 ± 35.5
18	14	16	100	2.225E+05	2.542E+05	0.875	2.3	0.04	205.7 ± 75.5
19	33	22	100	5.244E+05	3.496E+05	1.500	3.2	0.06	348.7 ± 96.4
20	63	53	42	2.384E+06	2.005E+06	1.189	18.2	0.03	277.8 ± 52.3
21	51	47	24	3.377E+06	3.112E+06	1.085	28.2	0.00	254.1 ± 51.8
22	19	24	50	6.038E+05	7.628E+05	0.792	6.9	0.02	186.4 ± 57.4
	1634	1450		1.964E+06	1.743E+06		15.8		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 34.462 with 19 degrees of freedom
P(chi squared) = 1.6 %
Correlation Coefficient = 0.953
Variance of SQR(Ns) = 16.08
Variance of SQR(Ni) = 15.14
Age Dispersion = 15.063 %

Ns/Ni = 1.127 ± 0.041
Mean Ratio = 1.169 ± 0.058

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.256E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 263.7 ± 11.9 Ma
CENTRAL AGE = 268.4 ± 16.3 Ma

GC550-3 APATITE

IRRADIATION G506
SLIDE NUMBER 3
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	31	29	20	2.463E+06	2.304E+06	1.069	20.9	0.01	250.4 ± 65.0
4	39	31	24	2.582E+06	2.053E+06	1.258	18.6	0.00	293.7 ± 71.1
5	25	15	15	2.648E+06	1.589E+06	1.667	14.4	0.07	386.2 ± 126.6
6	72	58	30	3.814E+06	3.072E+06	1.241	27.9	0.00	289.8 ± 51.7
7	8	12	30	4.238E+05	6.356E+05	0.667	5.8	0.22	157.3 ± 71.9
8	129	107	60	3.416E+06	2.834E+06	1.206	25.7	0.18	281.7 ± 37.6
9	44	29	50	1.398E+06	9.217E+05	1.517	8.4	0.01	352.5 ± 84.9
10	45	56	24	2.980E+06	3.708E+06	0.804	33.7	0.00	189.1 ± 38.2
11	16	8	21	1.211E+06	6.054E+05	2.000	5.5	0.01	460.8 ± 199.9
13	361	311	70	8.195E+06	7.060E+06	1.161	64.1	0.02	271.4 ± 22.2
14	44	46	28	2.497E+06	2.611E+06	0.957	23.7	0.00	224.5 ± 47.7
16	113	72	48	3.741E+06	2.384E+06	1.569	21.6	0.09	364.3 ± 55.8
17	301	168	100	4.783E+06	2.670E+06	1.792	24.2	0.12	414.3 ± 41.4
18	19	24	100	3.019E+05	3.814E+05	0.792	3.5	0.02	186.3 ± 57.4
19	40	49	40	1.589E+06	1.947E+06	0.816	17.7	0.04	192.1 ± 41.3
20	45	18	50	1.430E+06	5.721E+05	2.500	5.2	0.12	571.0 ± 160.0
21	7	5	24	4.635E+05	3.311E+05	1.400	3.0	0.24	326.0 ± 191.1
22	67	57	50	2.129E+06	1.812E+06	1.175	16.4	0.02	274.8 ± 50.1
12	25	29	45	8.828E+05	1.024E+06	0.862	9.3	0.00	202.7 ± 55.6
	1431	1124		2.743E+06	2.155E+06		19.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 43.594 with 18 degrees of freedom
P(chi squared) = 0.1 %
Correlation Coefficient = 0.964
Variance of SQR(Ns) = 19.15
Variance of SQR(Ni) = 13.69
Age Dispersion = 20.413 %

Ns/Ni = 1.273 ± 0.051
Mean Ratio = 1.287 ± 0.108

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.256E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 297.1 ± 14.3 Ma
CENTRAL AGE = 286.0 ± 21.2 Ma

GC550-4 APATITE

IRRADIATION G506
SLIDE NUMBER 4
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	17	5	30	9.005E+05	2.648E+05	3.400	2.5	0.00	754.0 ± 384.3
4	23	25	8	4.569E+06	4.966E+06	0.920	47.3	0.08	212.9 ± 61.8
5	103	84	40	4.092E+06	3.337E+06	1.226	31.8	0.02	282.2 ± 42.3
6	19	9	36	8.387E+05	3.973E+05	2.111	3.8	0.03	478.5 ± 194.1
7	94	80	18	8.298E+06	7.063E+06	1.175	67.2	0.00	270.7 ± 42.0
	256	203		3.082E+06	2.444E+06		23.3		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 7.234 with 4 degrees of freedom
P(chi squared) = 12.4 %
Correlation Coefficient = 0.989
Variance of SQR(Ns) = 9.15
Variance of SQR(Ni) = 10.58
Age Dispersion = 0.187 % (did not converge)

Ns/Ni = 1.261 ± 0.119
Mean Ratio = 1.766 ± 0.455

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.198E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 290.1 ± 28.6 Ma
CENTRAL AGE = 290.1 ± 28.6 Ma

GC550-5 APATITE

IRRADIATION G506
SLIDE NUMBER 5
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
4	86	55	18	7.592E+06	4.855E+06	1.564	46.7	0.17	354.3 ± 62.1
5	1	4	100	1.589E+04	6.356E+04	0.250	0.6	0.02	58.0 ± 64.8
6	11	6	24	7.283E+05	3.973E+05	1.833	3.8	0.09	413.5 ± 210.2
7	214	181	54	6.297E+06	5.326E+06	1.182	51.2	0.02	269.7 ± 28.4
8	1	4	21	7.567E+04	3.027E+05	0.250	2.9	0.56	58.0 ± 64.8
9	14	13	18	1.236E+06	1.148E+06	1.077	11.0	0.00	246.1 ± 95.1
10	115	90	40	4.569E+06	3.575E+06	1.278	34.4	0.45	291.0 ± 41.9
12	23	27	50	7.310E+05	8.581E+05	0.852	8.2	0.01	195.4 ± 55.8
	465	380		2.274E+06	1.858E+06		17.9		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 9.596 with 7 degrees of freedom
P(chi squared) = 21.3 %
Correlation Coefficient = 0.993
Variance of SQR(Ns) = 24.46
Variance of SQR(Ni) = 17.14
Age Dispersion = 0.127 % (did not converge)

Ns/Ni = 1.224 ± 0.085
Mean Ratio = 1.036 ± 0.201

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.186E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 278.9 ± 21.0 Ma
CENTRAL AGE = 278.9 ± 21.0 Ma

GC550-7 APATITE

IRRADIATION G506
SLIDE NUMBER 6
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
5	59	53	48	1.953E+06	1.755E+06	1.113	17.0	0.04	251.7 ± 48.2
10	71	65	24	4.701E+06	4.304E+06	1.092	41.8	0.29	247.1 ± 43.1
11	71	71	72	1.567E+06	1.567E+06	1.000	15.2	0.08	226.6 ± 38.6
12	21	13	80	4.171E+05	2.582E+05	1.615	2.5	0.29	362.1 ± 128.3
14	41	31	70	9.307E+05	7.037E+05	1.323	6.8	0.08	298.0 ± 71.5
15	33	67	40	1.311E+06	2.662E+06	0.493	25.8	0.04	112.6 ± 24.2
16	156	113	90	2.754E+06	1.995E+06	1.381	19.4	0.12	310.7 ± 39.5
17	50	61	36	2.207E+06	2.693E+06	0.820	26.2	0.10	186.3 ± 36.0
18	40	48	35	1.816E+06	2.179E+06	0.833	21.2	0.10	189.4 ± 40.9
20	22	30	40	8.740E+05	1.192E+06	0.733	11.6	0.07	166.9 ± 47.1
21	178	189	60	4.714E+06	5.006E+06	0.942	48.6	0.01	213.6 ± 23.2
23	157	104	80	3.119E+06	2.066E+06	1.510	20.1	0.16	339.0 ± 44.0
24	150	671	90	2.648E+06	1.185E+07	0.224	115.1	0.01	51.3 ± 4.9
25	63	46	36	2.781E+06	2.030E+06	1.370	19.7	0.01	308.3 ± 60.5
26	43	25	72	9.490E+05	5.518E+05	1.720	5.4	0.19	384.9 ± 97.5
27	66	66	80	1.311E+06	1.311E+06	1.000	12.7	0.04	226.6 ± 40.0
28	205	219	80	4.072E+06	4.350E+06	0.936	42.2	0.06	212.3 ± 21.6
29	39	71	40	1.549E+06	2.821E+06	0.549	27.4	0.09	125.4 ± 25.3
30	202	155	48	6.687E+06	5.131E+06	1.303	49.8	0.46	293.7 ± 32.6
31	2	27	40	7.945E+04	1.073E+06	0.074	10.4	0.00	17.1 ± 12.5
	1669	2125		2.284E+06	2.908E+06		28.2		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 362.409 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.567
Variance of SQR(Ns) = 12.89
Variance of SQR(Ni) = 24.10
Age Dispersion = 48.750 %

Ns/Ni = 0.785 ± 0.026
Mean Ratio = 1.002 ± 0.099

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.174E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 178.6 ± 7.9 Ma
CENTRAL AGE = 204.8 ± 24.7 Ma

GC550-8 APATITE

IRRADIATION G506
SLIDE NUMBER 7
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
4	3	11	70	6.810E+04	2.497E+05	0.273	2.4	0.02	62.0 ± 40.4
5	11	22	36	4.855E+05	9.711E+05	0.500	9.5	0.01	113.1 ± 41.9
6	23	101	80	4.569E+05	2.006E+06	0.228	19.7	0.00	51.8 ± 12.1
7	7	10	30	3.708E+05	5.297E+05	0.700	5.2	0.10	157.8 ± 77.9
8	10	32	90	1.766E+05	5.650E+05	0.312	5.5	0.03	70.9 ± 25.8
9	4	14	12	5.297E+05	1.854E+06	0.286	18.2	0.00	64.9 ± 36.8
11	1	11	45	3.531E+04	3.884E+05	0.091	3.8	0.00	20.7 ± 21.6
13	15	30	32	7.449E+05	1.490E+06	0.500	14.6	0.06	113.1 ± 35.9
14	45	44	45	1.589E+06	1.554E+06	1.023	15.2	0.12	229.3 ± 49.1
15	17	77	60	4.502E+05	2.039E+06	0.221	20.0	0.00	50.2 ± 13.5
16	3	9	60	7.945E+04	2.384E+05	0.333	2.3	0.00	75.6 ± 50.5
18	3	66	80	5.959E+04	1.311E+06	0.045	12.9	0.00	10.4 ± 6.1
21	3	5	40	1.192E+05	1.986E+05	0.600	1.9	0.01	135.5 ± 99.1
22	54	42	50	1.716E+06	1.335E+06	1.286	13.1	0.15	287.0 ± 59.7
23	1	6	70	2.270E+04	1.362E+05	0.167	1.3	0.02	37.9 ± 41.0
25	38	59	42	1.438E+06	2.232E+06	0.644	21.9	0.03	145.4 ± 30.5
27	50	54	30	2.648E+06	2.860E+06	0.926	28.1	0.65	208.0 ± 41.3
28	2	7	50	6.356E+04	2.225E+05	0.286	2.2	0.26	64.9 ± 52.1
29	19	73	25	1.208E+06	4.640E+06	0.260	45.5	0.03	59.1 ± 15.3
30	25	17	36	1.104E+06	7.504E+05	1.471	7.4	0.70	327.2 ± 103.3
	334	690		5.399E+05	1.115E+06		10.9		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 124.644 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.485
Variance of SQR(Ns) = 4.35
Variance of SQR(Ni) = 5.93
Age Dispersion = 66.252 %

Ns/Ni = 0.484 ± 0.032
Mean Ratio = 0.508 ± 0.089

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.162E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 109.6 ± 8.0 Ma
CENTRAL AGE = 101.6 ± 17.8 Ma

GC550-9 APATITE

IRRADIATION G506
SLIDE NUMBER 8
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	15	21	48	4.966E+05	6.952E+05	0.714	6.9	0.00	159.4 ± 54.1
4	27	59	70	6.129E+05	1.339E+06	0.458	13.3	0.00	102.6 ± 24.0
5	0	5	25	0.000E+00	3.178E+05	0.000	3.2	0.05	0.0 ± 0.0
6	11	8	25	6.992E+05	5.085E+05	1.375	5.0	0.31	303.4 ± 141.3
7	2	5	49	6.486E+04	1.621E+05	0.400	1.6	0.01	89.7 ± 75.1
8	18	23	35	8.172E+05	1.044E+06	0.783	10.4	0.08	174.4 ± 55.1
9	35	22	42	1.324E+06	8.324E+05	1.591	8.2	0.19	349.8 ± 95.7
11	62	42	36	2.737E+06	1.854E+06	1.476	18.4	0.16	325.2 ± 65.7
13	13	14	42	4.919E+05	5.297E+05	0.929	5.2	0.00	206.5 ± 79.8
14	11	9	24	7.283E+05	5.959E+05	1.222	5.9	0.17	270.4 ± 121.8
15	61	154	50	1.939E+06	4.894E+06	0.396	48.5	0.04	88.9 ± 13.7
17	94	45	48	3.112E+06	1.490E+06	2.089	14.8	0.16	455.5 ± 83.7
19	12	19	24	7.945E+05	1.258E+06	0.632	12.5	0.17	141.1 ± 52.2
20	8	41	48	2.648E+05	1.357E+06	0.195	13.5	0.02	43.9 ± 17.0
22	63	88	25	4.004E+06	5.594E+06	0.716	55.4	0.01	159.8 ± 26.8
23	26	22	80	5.164E+05	4.370E+05	1.182	4.3	0.17	261.6 ± 76.2
25	0	2	54	0.000E+00	5.885E+04	0.000	0.6	0.02	0.0 ± 0.0
28	11	60	24	7.283E+05	3.973E+06	0.183	39.4	0.00	41.3 ± 13.6
35	1	5	18	8.828E+04	4.414E+05	0.200	4.4	0.04	45.0 ± 49.3
36	49	52	28	2.781E+06	2.951E+06	0.942	29.3	0.01	209.5 ± 42.2
	519	696		1.037E+06	1.391E+06		13.8		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 128.620 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.631
Variance of SQR(Ns) = 7.44
Variance of SQR(Ni) = 7.71
Age Dispersion = 59.510 %

Ns/Ni = 0.746 ± 0.043
Mean Ratio = 0.774 ± 0.129

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.150E+06cm-2; ND = 1856
Rho D interpolated between top of can; Rho D = 1.233E+06cm-2, ND = 970
bottom of can; Rho D = 1.126E+06cm-2, ND = 886

POOLED AGE = 166.3 ± 10.9 Ma
CENTRAL AGE = 158.2 ± 25.2 Ma

GC550-10 APATITE

IRRADIATION G506
SLIDE NUMBER 9
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	4	5	40	1.589E+05	1.986E+05	0.800	1.8	0.32	188.2 ± 126.3
4	3	3	18	2.648E+05	2.648E+05	1.000	2.4	1.15	234.3 ± 191.4
5	31	62	16	3.079E+06	6.158E+06	0.500	55.9	0.24	118.2 ± 26.2
6	15	31	12	1.986E+06	4.105E+06	0.484	37.3	1.84	114.5 ± 36.1
10	1	5	21	7.567E+04	3.783E+05	0.200	3.4	1.04	47.6 ± 52.1
11	2	4	20	1.589E+05	3.178E+05	0.500	2.9	0.51	118.2 ± 102.4
12	10	13	28	5.675E+05	7.378E+05	0.769	6.7	1.12	181.0 ± 76.3
13	33	48	100	5.244E+05	7.628E+05	0.688	6.9	0.73	162.0 ± 36.9
14	1	11	60	2.648E+04	2.913E+05	0.091	2.6	0.56	21.7 ± 22.6
16	18	24	80	3.575E+05	4.767E+05	0.750	4.3	0.69	176.6 ± 55.3
17	6	6	15	6.356E+05	6.356E+05	1.000	5.8	1.06	234.3 ± 135.4
18	33	45	36	1.457E+06	1.986E+06	0.733	18.0	0.48	172.7 ± 39.8
20	20	29	100	3.178E+05	4.608E+05	0.690	4.2	2.23	162.5 ± 47.4
	177	286		5.151E+05	8.324E+05		7.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 10.101 with 12 degrees of freedom
P(chi squared) = 60.7 %
Correlation Coefficient = 0.953
Variance of SQR(Ns) = 3.22
Variance of SQR(Ni) = 4.49
Age Dispersion = 0.171 % (did not converge)

Ns/Ni = 0.619 ± 0.059
Mean Ratio = 0.631 ± 0.075

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.255E+06cm-2; ND = 1975
Rho D interpolated between top of can; Rho D = 1.256E+06cm-2, ND = 988
bottom of can; Rho D = 1.255E+06cm-2, ND = 987

POOLED AGE = 146.0 ± 14.5 Ma
CENTRAL AGE = 146.0 ± 14.5 Ma

GC550-13 APATITE

IRRADIATION 507
SLIDE NUMBER 3
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	13	13	70	2.951E+05	2.951E+05	1.000	2.6	0.02	238.7 ± 93.9
4	1	14	9	1.766E+05	2.472E+06	0.071	22.0	0.01	17.4 ± 18.0
5	68	42	48	2.251E+06	1.390E+06	1.619	12.4	0.32	382.2 ± 75.7
7	353	441	90	6.233E+06	7.786E+06	0.800	69.4	0.04	191.8 ± 14.6
8	120	108	28	6.810E+06	6.129E+06	1.111	54.6	0.29	264.7 ± 35.8
13	11	12	14	1.249E+06	1.362E+06	0.917	12.1	0.00	219.2 ± 91.7
14	25	34	24	1.655E+06	2.251E+06	0.735	20.1	0.01	176.4 ± 46.7
15	68	48	24	4.502E+06	3.178E+06	1.417	28.3	0.45	335.7 ± 63.9
16	9	7	5	2.860E+06	2.225E+06	1.286	19.8	0.00	305.4 ± 154.1
	668	719		3.402E+06	3.662E+06		32.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 31.078 with 8 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.988
Variance of SQR(Ns) = 29.84
Variance of SQR(Ni) = 32.83
Age Dispersion = 31.391 %

Ns/Ni = 0.929 ± 0.050
Mean Ratio = 0.995 ± 0.150

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.279E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 222.1 ± 13.4 Ma
CENTRAL AGE = 232.7 ± 32.6 Ma

GC550-16 APATITE

IRRADIATION 507
SLIDE NUMBER 7
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	21	19	16	2.086E+06	1.887E+06	1.105	17.6	0.03	252.4 ± 80.2
4	171	190	24	1.132E+07	1.258E+07	0.900	117.1	0.18	206.3 ± 22.4
5	10	11	7	2.270E+06	2.497E+06	0.909	23.2	0.09	208.3 ± 91.2
6	10	15	8	1.986E+06	2.980E+06	0.667	27.7	0.02	153.4 ± 62.8
13	11	13	12	1.457E+06	1.721E+06	0.846	16.0	0.05	194.1 ± 79.7
14	5	4	4	1.986E+06	1.589E+06	1.250	14.8	0.04	284.8 ± 191.2
	228	252		5.103E+06	5.640E+06		52.5		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 1.228 with 5 degrees of freedom
P(chi squared) = 94.2 %
Correlation Coefficient = 0.999
Variance of SQR(Ns) = 16.52
Variance of SQR(Ni) = 18.49
Age Dispersion = 0.000 % (did not converge)

Ns/Ni = 0.905 ± 0.083
Mean Ratio = 0.946 ± 0.084

Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.225E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

POOLED AGE = 207.4 ± 19.8 Ma
CENTRAL AGE = 207.4 ± 19.8 Ma

GC550-17 APATITE

IRRADIATION G507
SLIDE NUMBER 9
COUNTED BY: COB

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	112	102	30	5.933E+06	5.403E+06	1.098	51.5	0.04	245.3 ± 34.2
4	22	21	36	9.711E+05	9.270E+05	1.048	8.8	0.02	234.2 ± 71.7
5	6	12	40	2.384E+05	4.767E+05	0.500	4.5	0.00	112.8 ± 56.5
6	30	41	20	2.384E+06	3.258E+06	0.732	31.0	0.07	164.5 ± 39.8
8	52	33	32	2.582E+06	1.639E+06	1.576	15.6	0.02	349.1 ± 78.3
9	147	231	40	5.840E+06	9.177E+06	0.636	87.4	0.22	143.3 ± 15.6
10	29	29	16	2.880E+06	2.880E+06	1.000	27.4	0.09	223.7 ± 59.1
11	8	18	24	5.297E+05	1.192E+06	0.444	11.3	0.01	100.4 ± 42.7
12	23	18	25	1.462E+06	1.144E+06	1.278	10.9	0.01	284.5 ± 89.9
13	64	30	24	4.238E+06	1.986E+06	2.133	18.9	0.04	468.3 ± 104.4
14	39	34	21	2.951E+06	2.573E+06	1.147	24.5	0.01	256.0 ± 60.5
15	33	29	18	2.913E+06	2.560E+06	1.138	24.4	0.07	254.0 ± 65.0
	565	598		2.754E+06	2.915E+06		27.8		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 43.562 with 11 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.915
Variance of SQR(Ns) = 8.14
Variance of SQR(Ni) = 10.54
Age Dispersion = 31.315 %

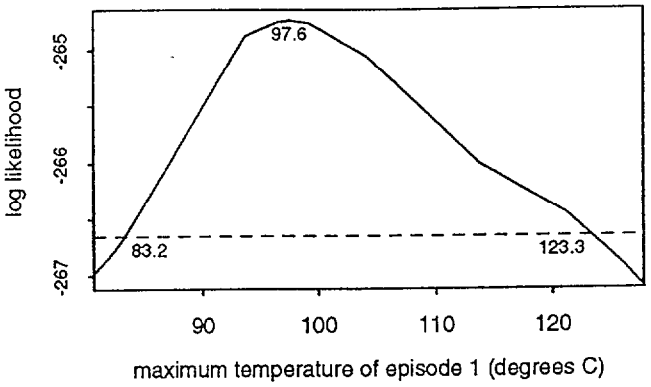
Ns/Ni = 0.945 ± 0.055
Mean Ratio = 1.061 ± 0.137

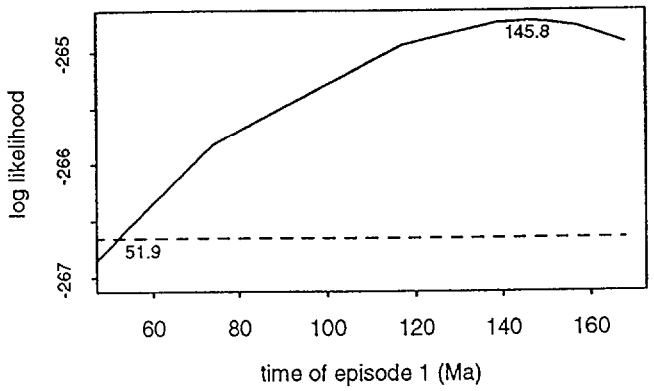
Ages calculated using a zeta of 380.4 ± 5.7 for CN5 glass
Rho D = 1.197E+06cm-2; ND = 1958
Rho D interpolated between top of can; Rho D = 1.306E+06cm-2, ND = 1027
bottom of can; Rho D = 1.184E+06cm-2, ND = 931

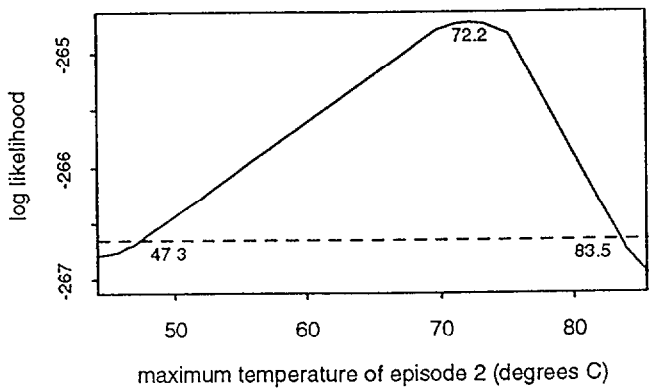
POOLED AGE = 211.6 ± 13.7 Ma
CENTRAL AGE = 226.6 ± 26.9 Ma

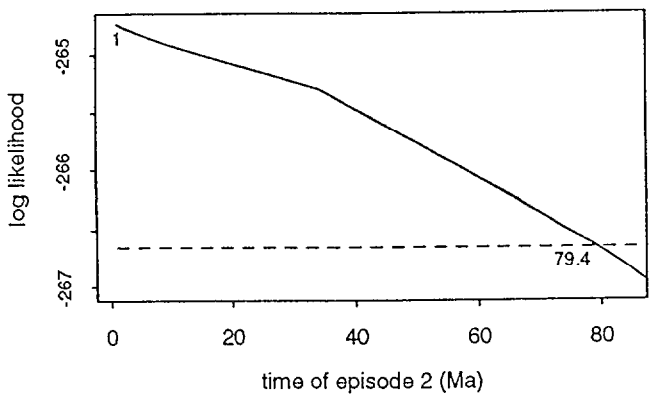
AFMECO CUR-5 GC550-1

profile likelihoods

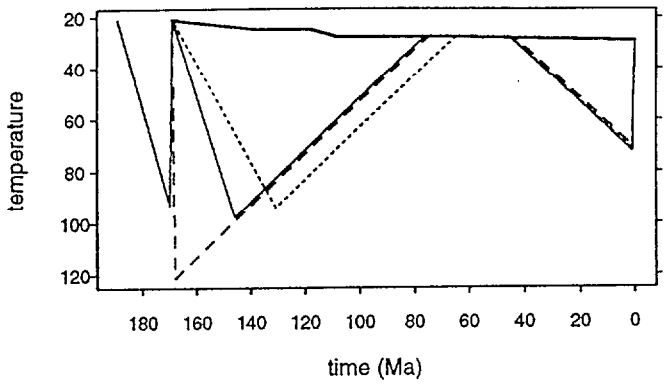


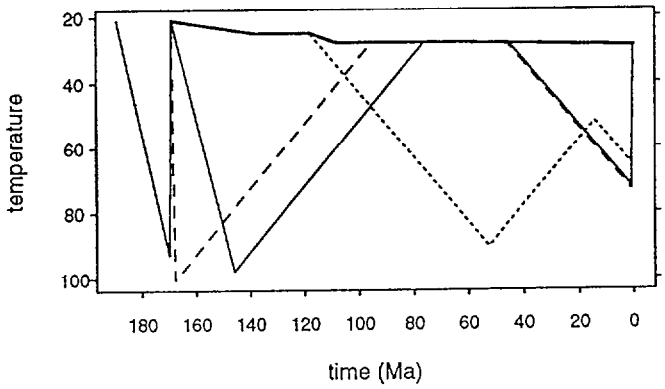


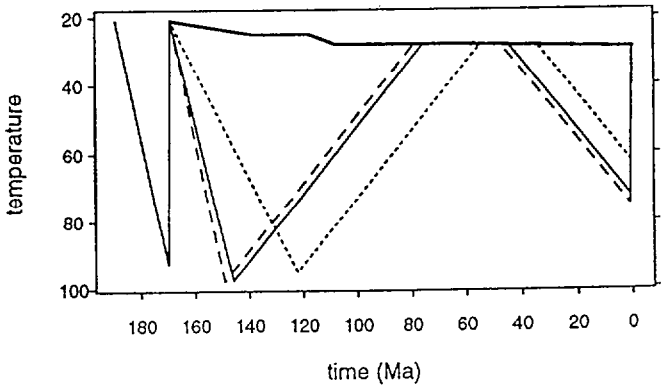


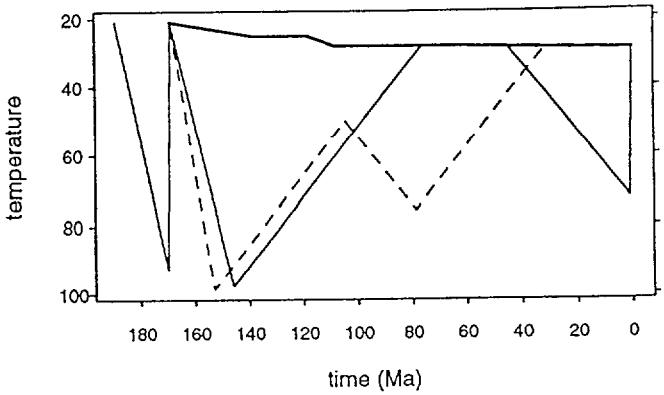


thermal histories



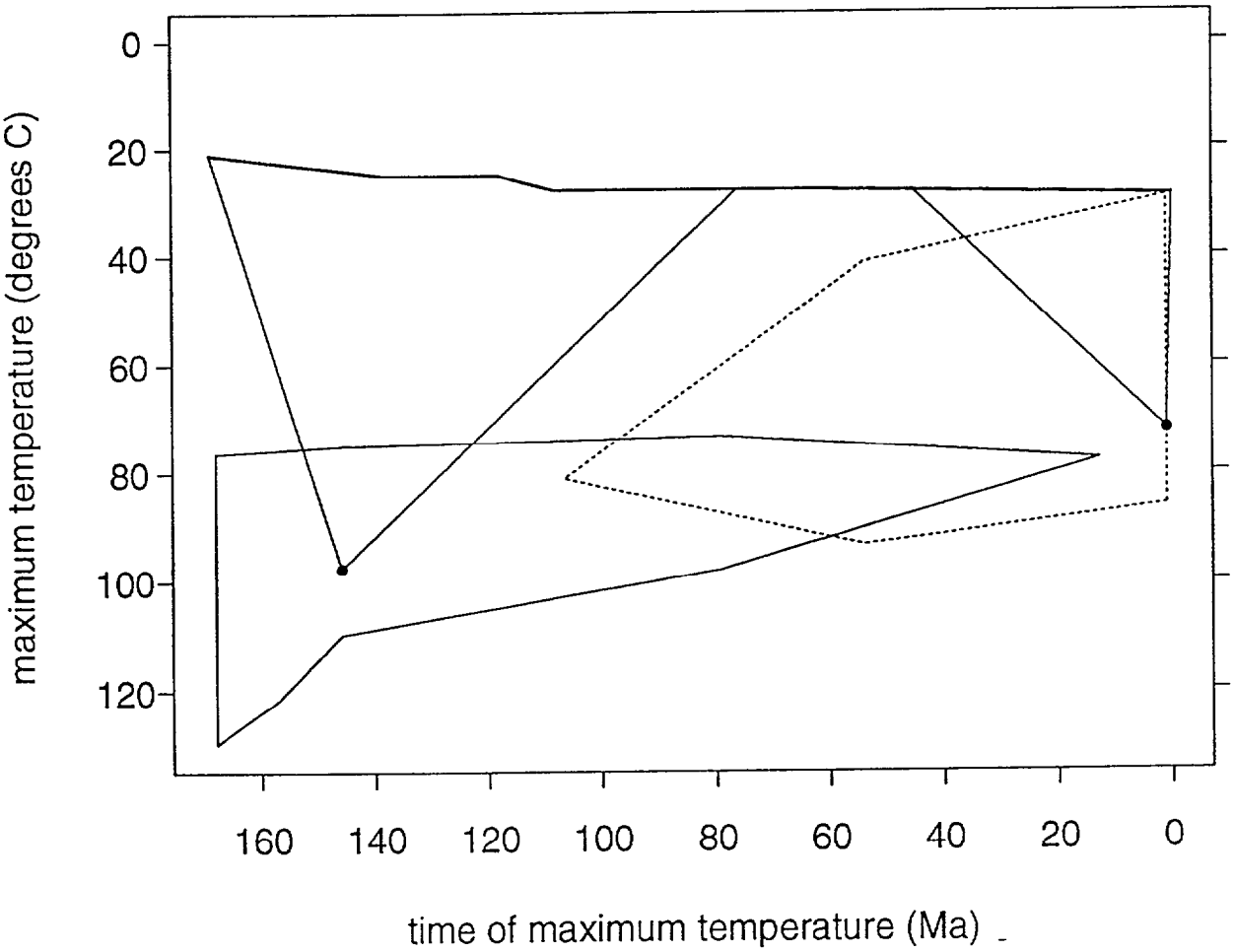






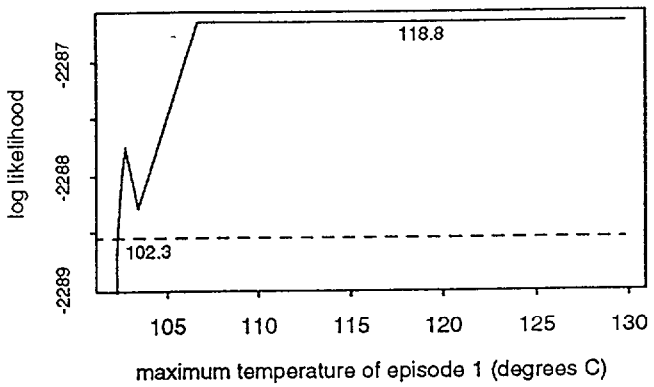
AFMECO CUR-5 GC550-1

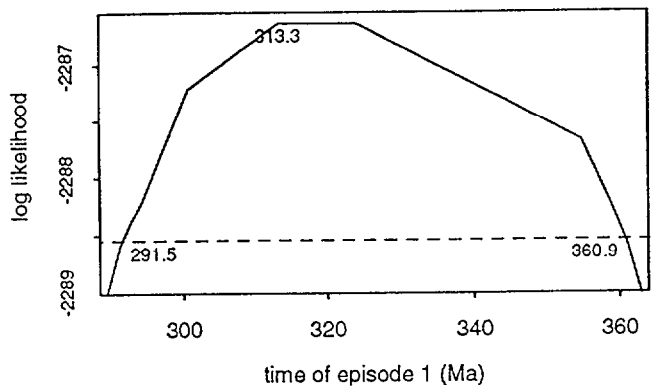
episodes 1 and 2

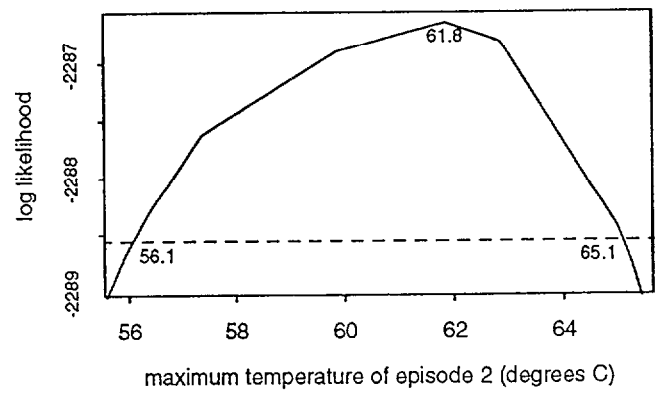


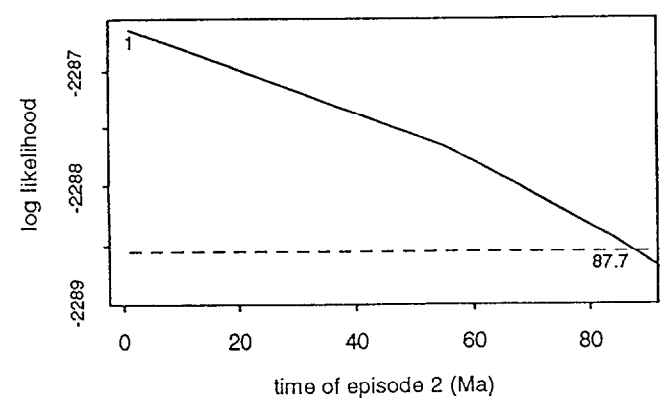
AFMECO CUR 5 Gc550-2

profile likelihoods

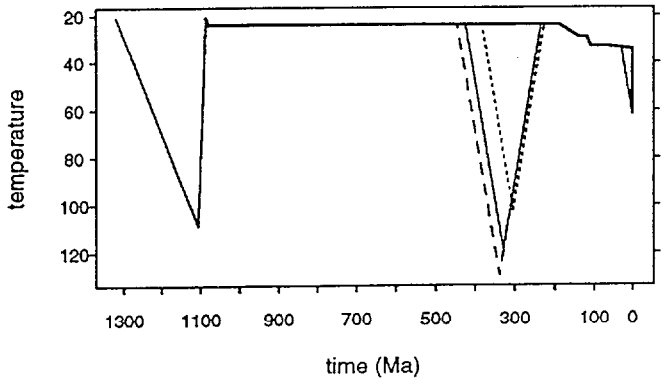


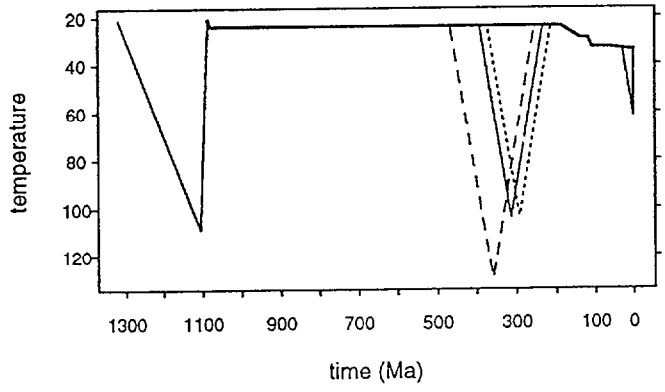


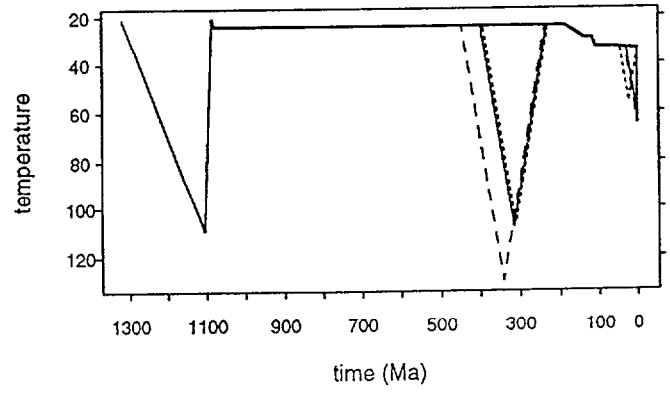


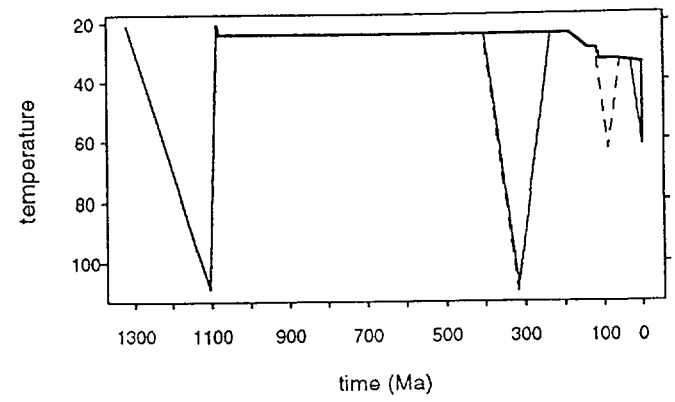


thermal histories



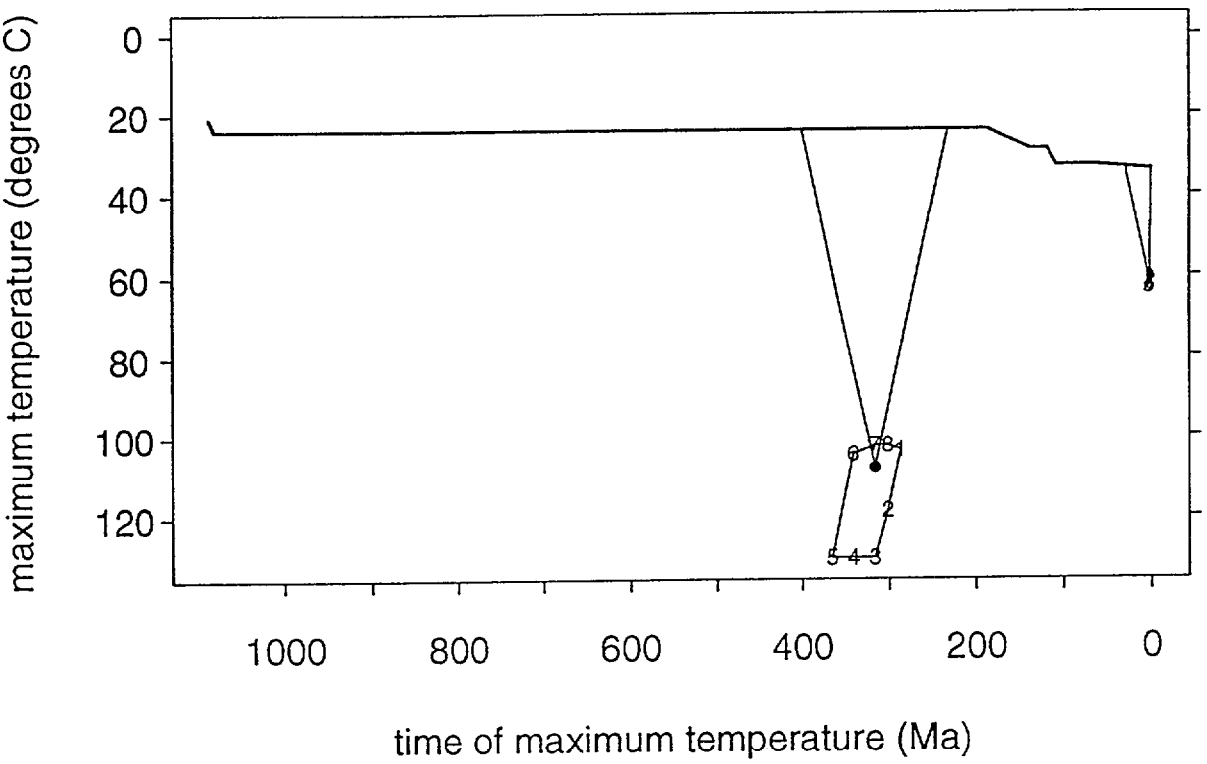




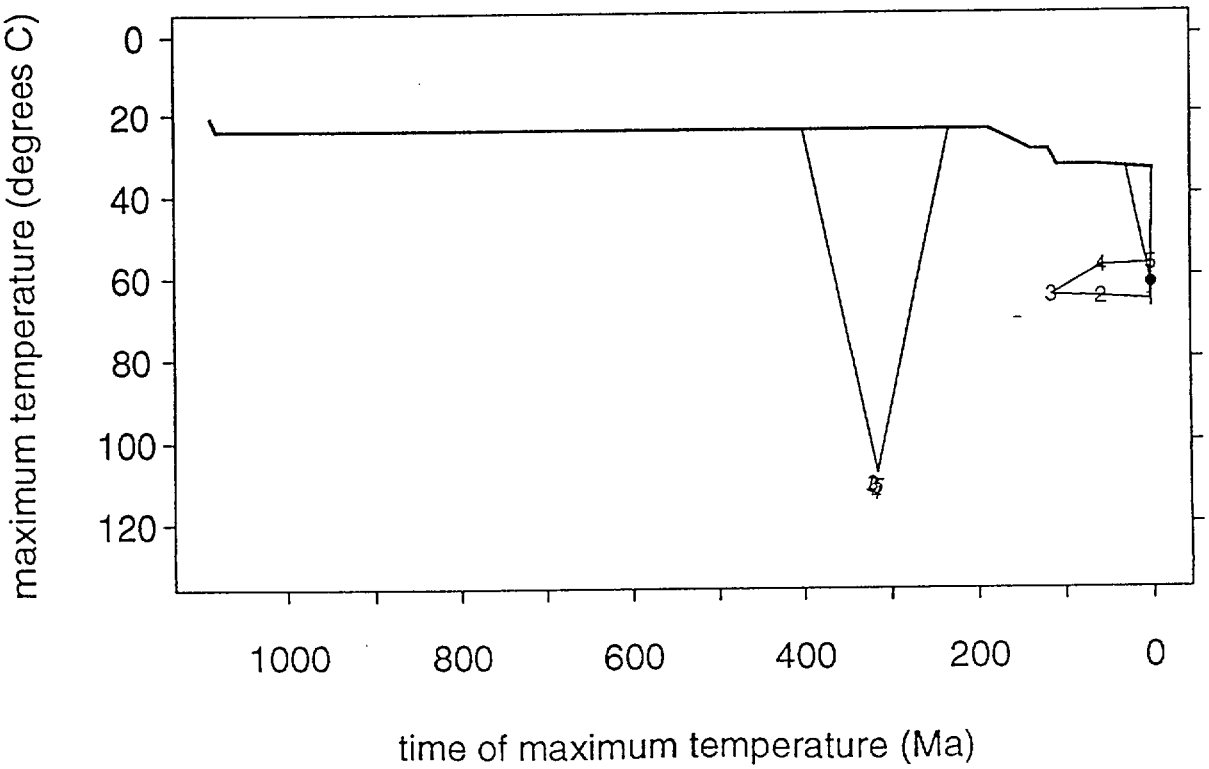


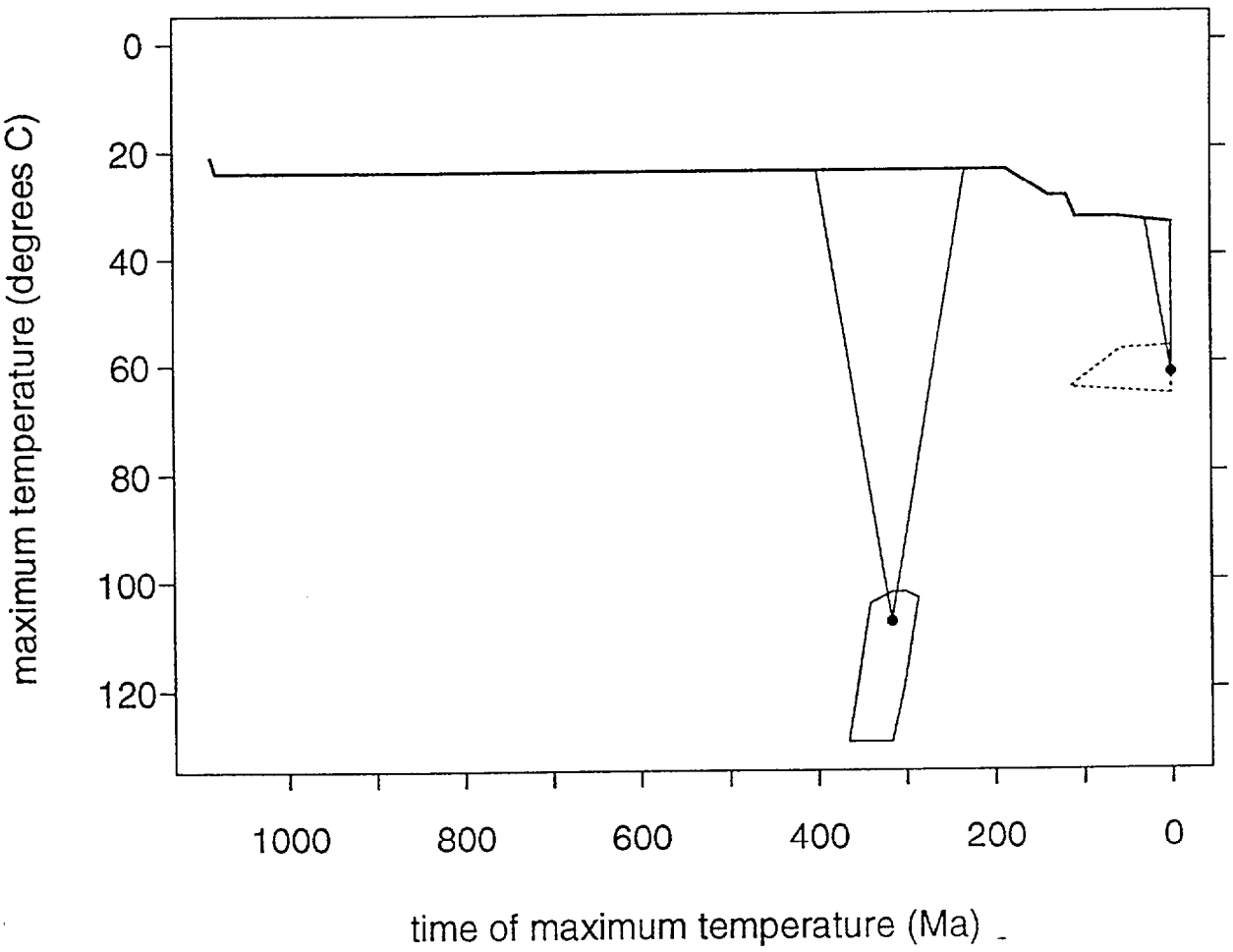
AFMECO CUR 5 Gc550-2

episode 1



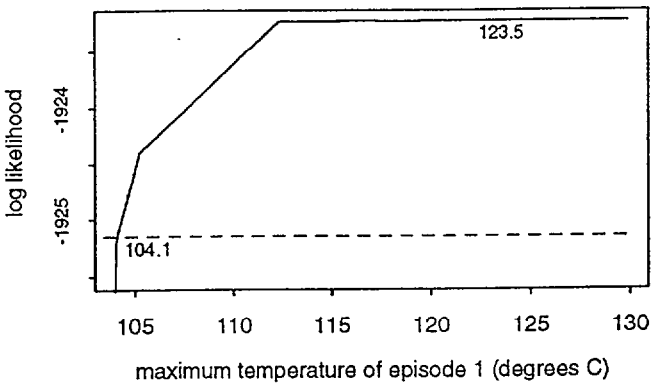
episode 2

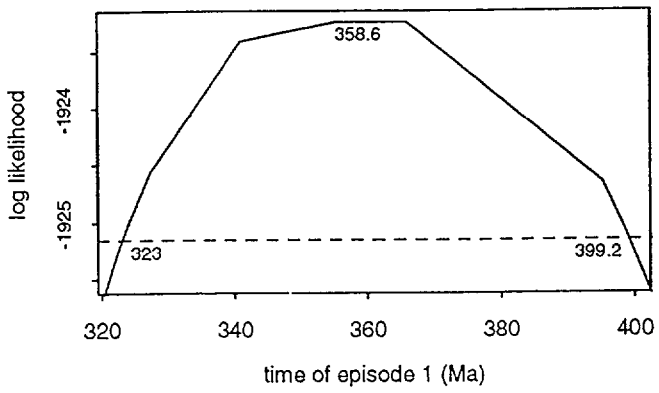


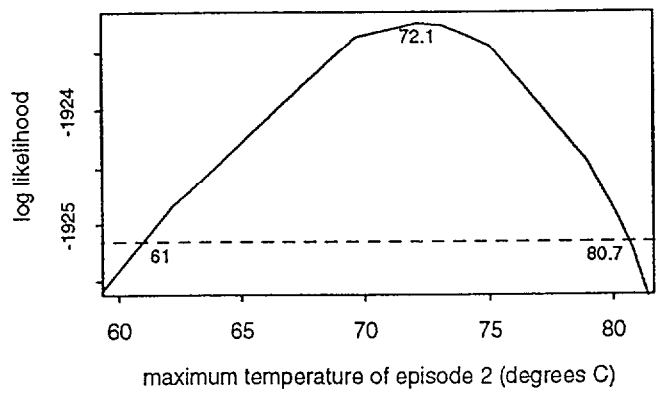

AFMECO CUR 5 Gc550-2
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
1000
800
600
400
200
0
time of maximum temperature (Ma)

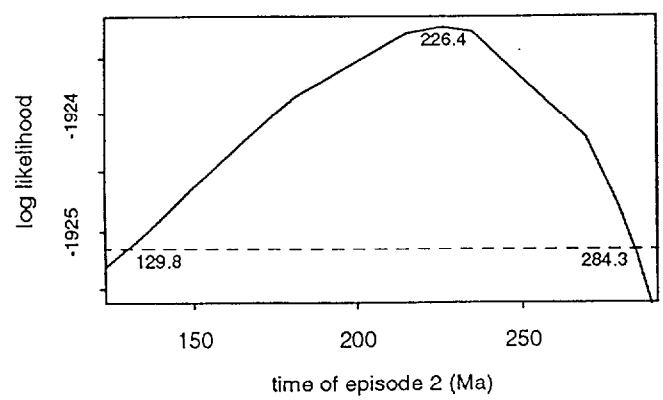
AFMECO CUR 3 GC550-3

profile likelihoods

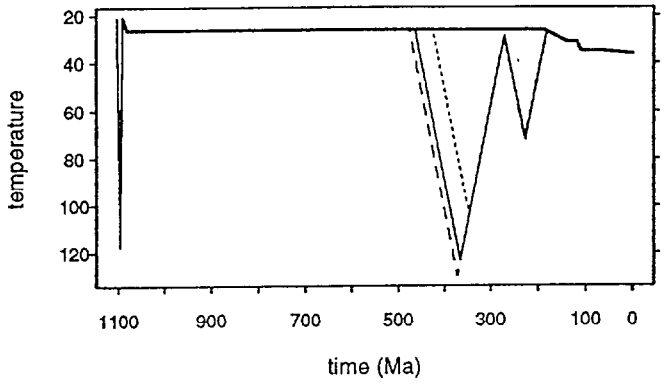


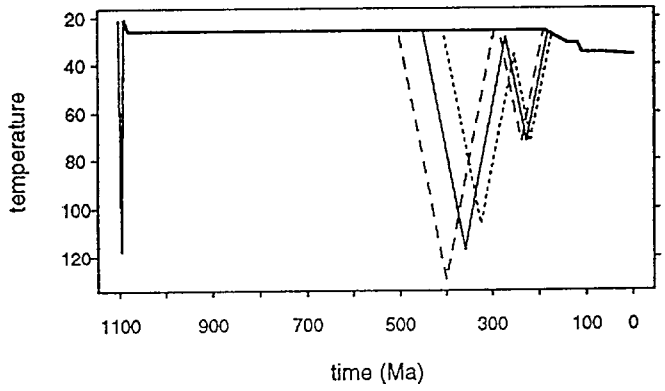


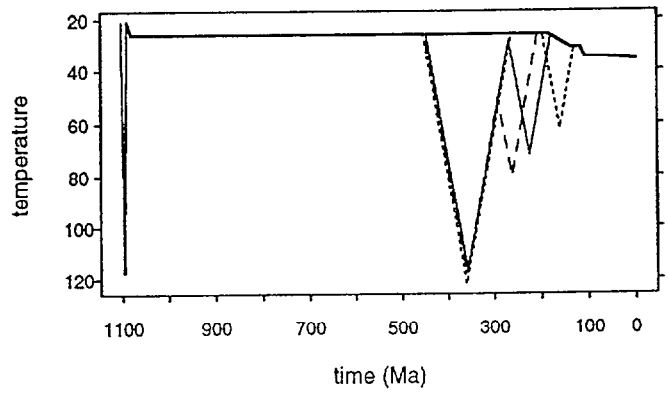


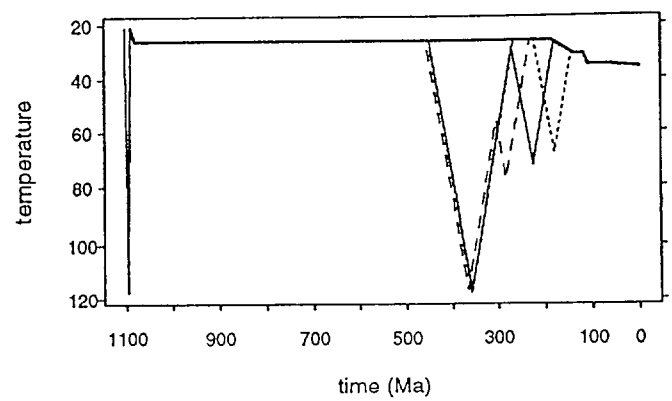


thermal histories



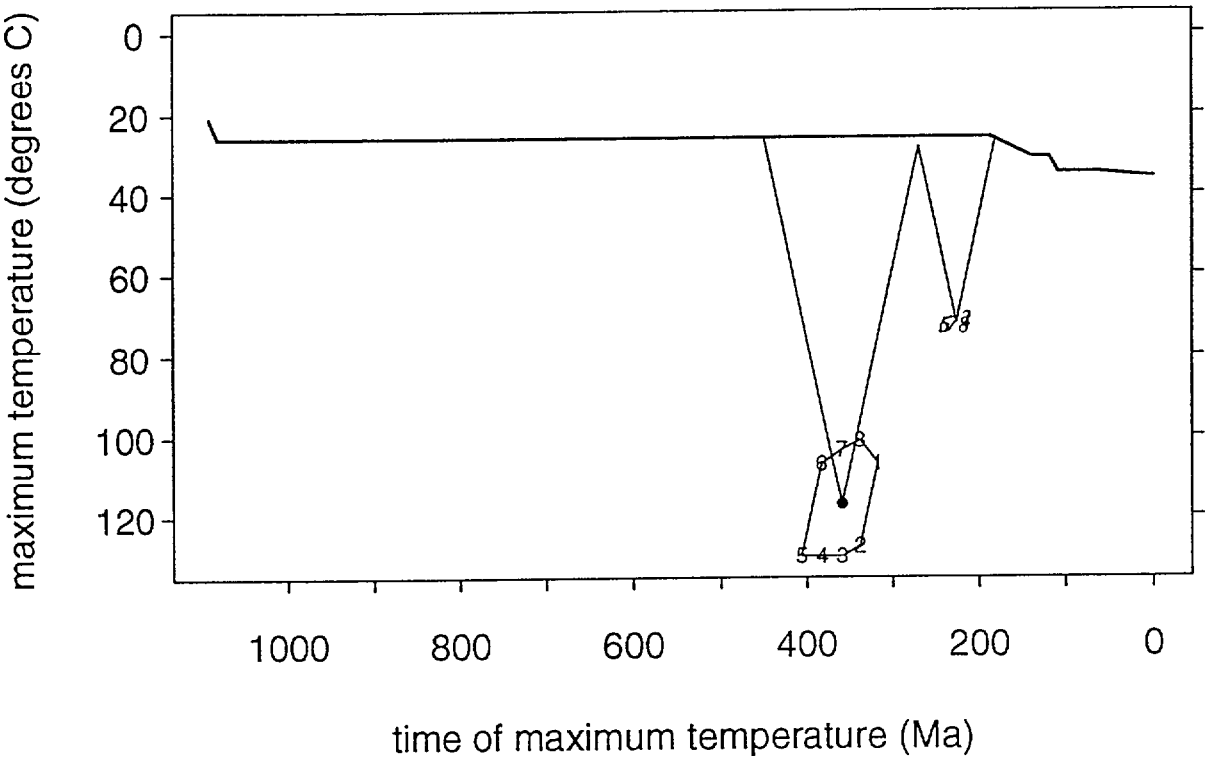




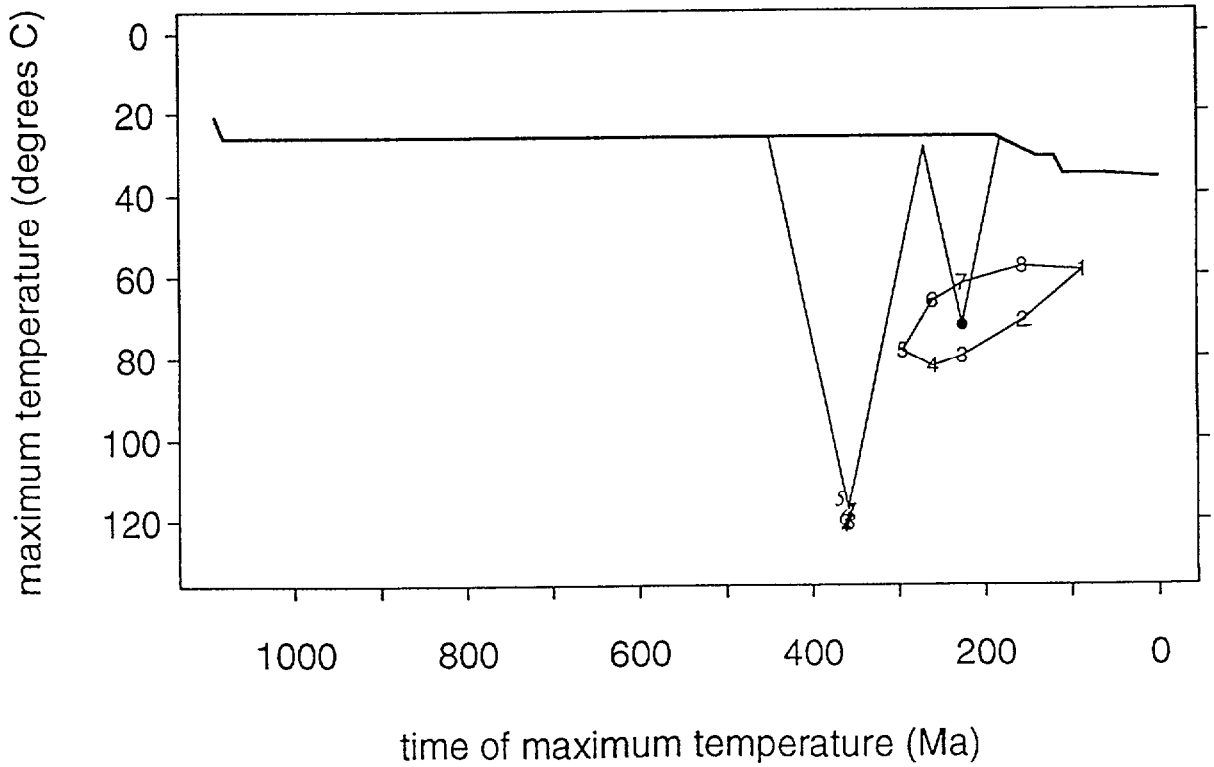


AFMECO CUR 3 GC550-3

episode 1

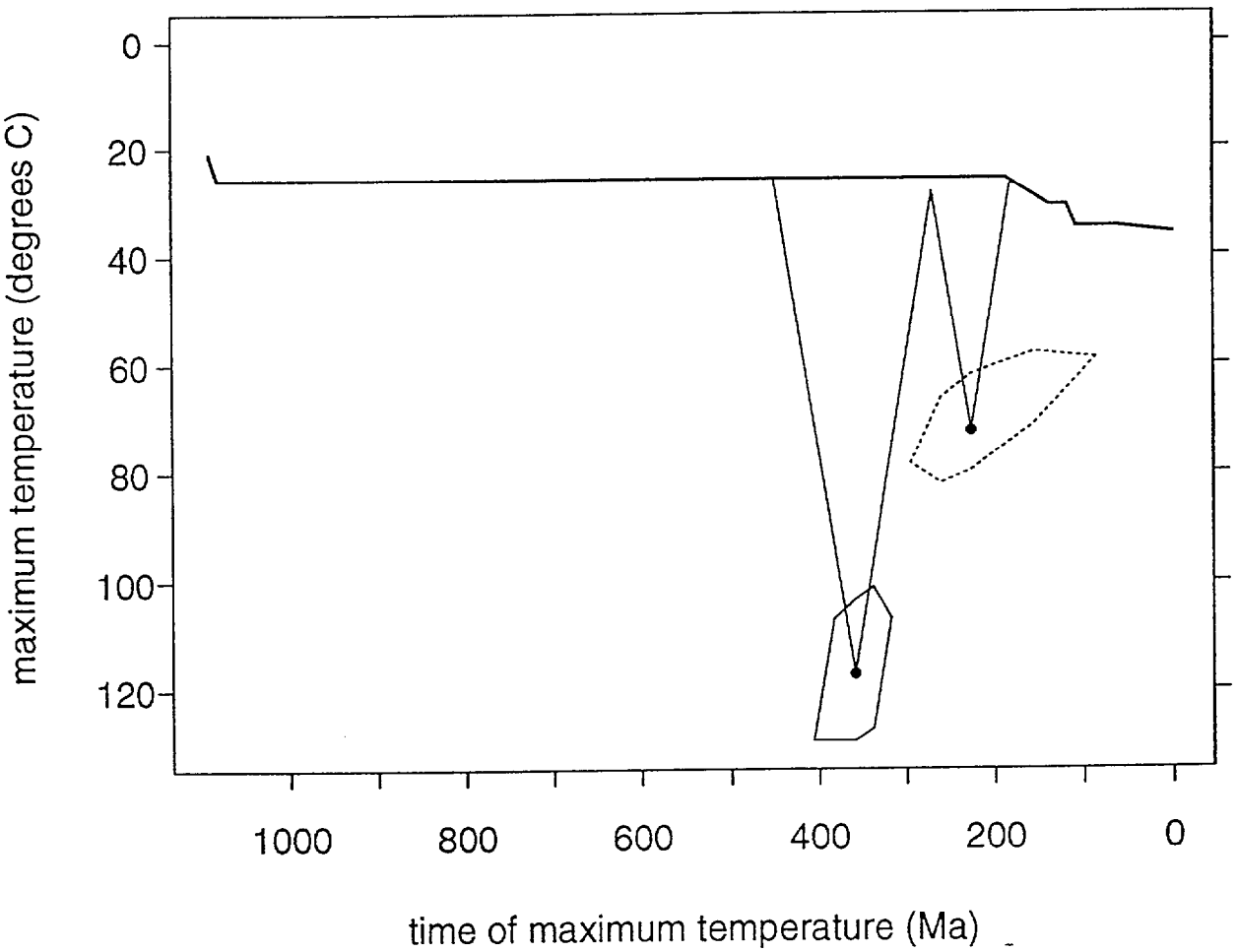


episode 2



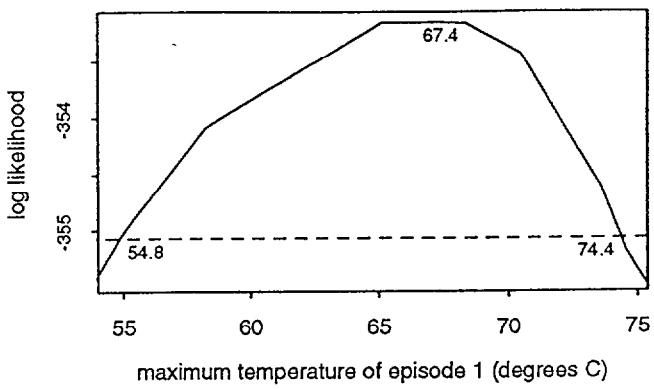
AFMECO CUR 3 GC550-3

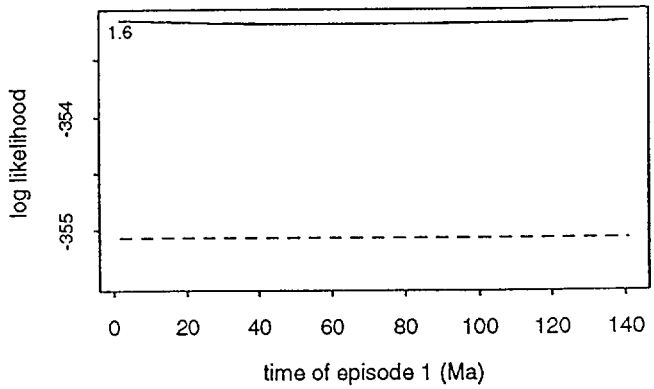
episodes 1 and 2

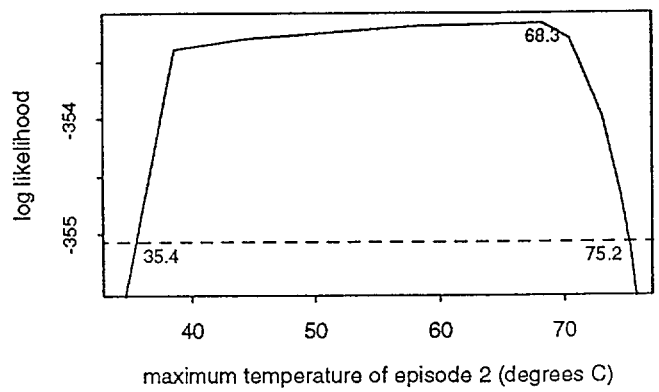


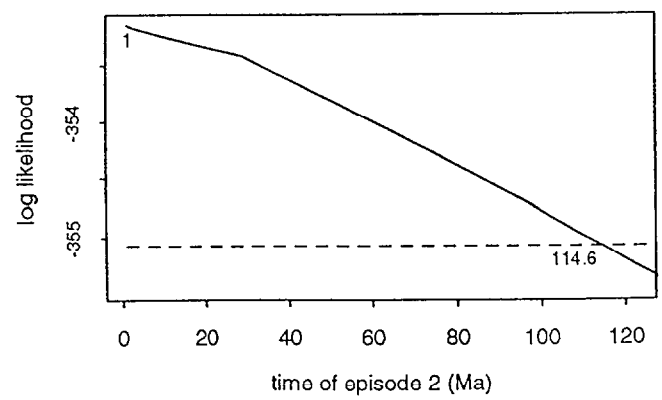
Mt Hammersley-1 GC550-4

profile likelihoods

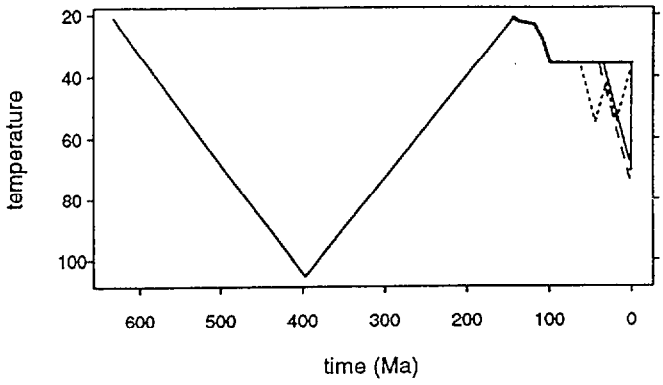


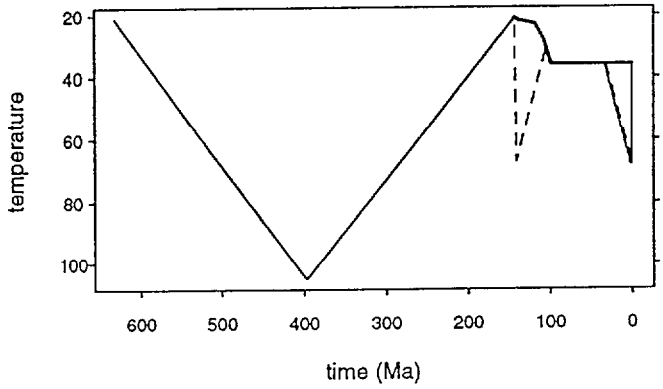


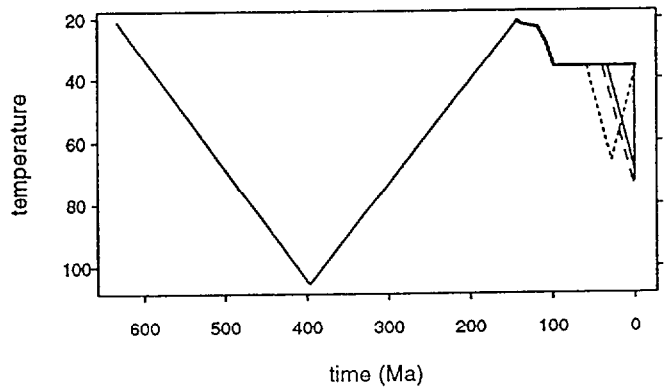


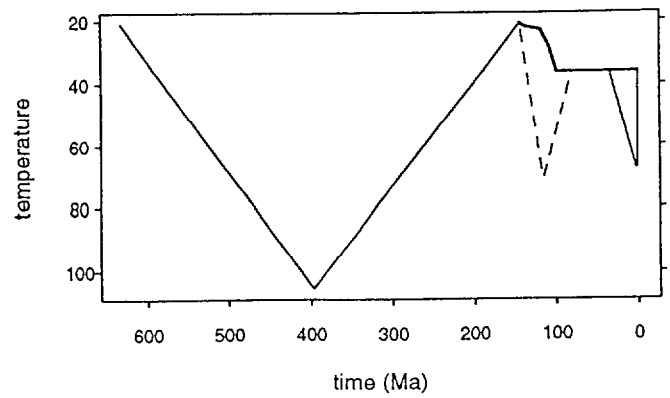


thermal histories



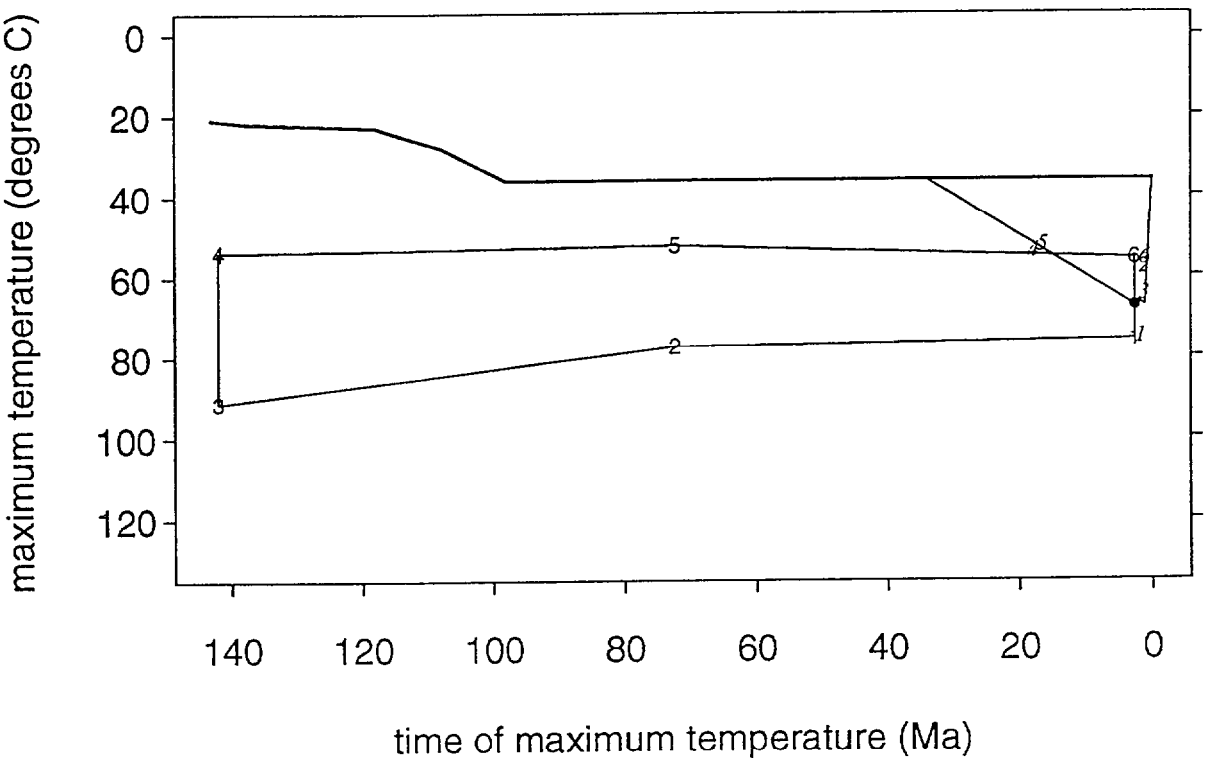




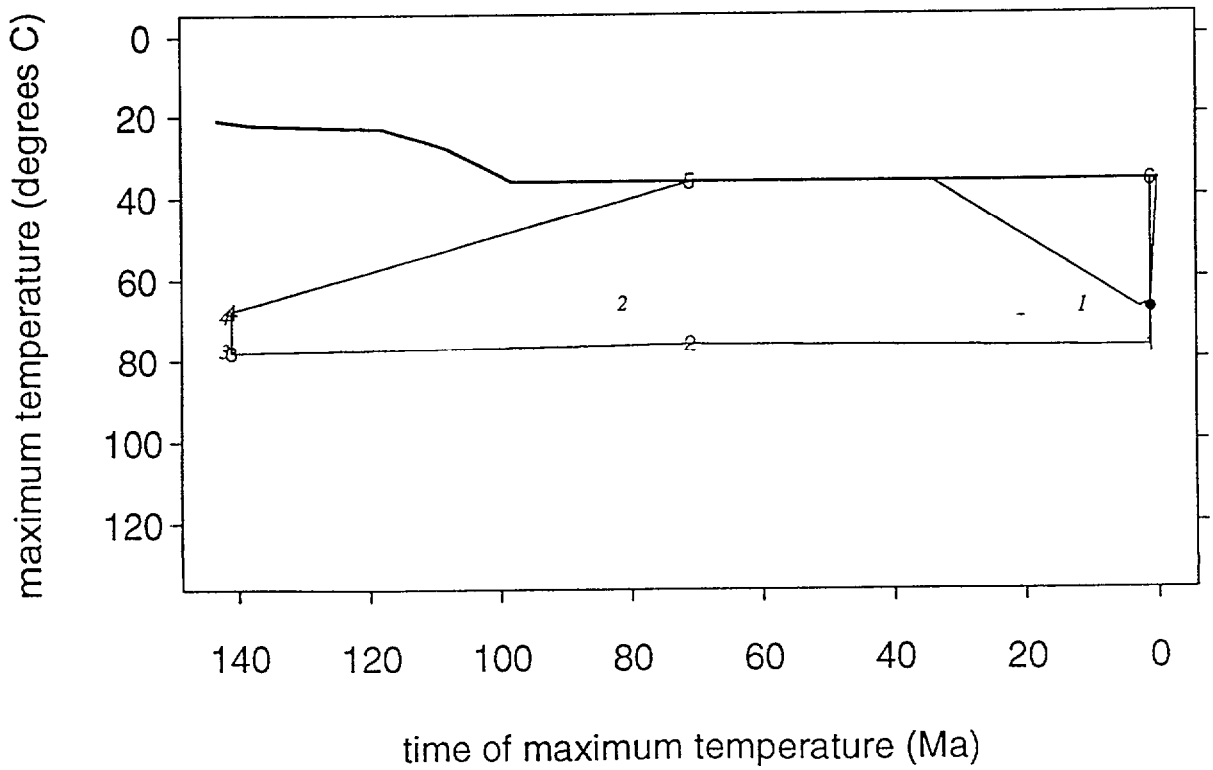


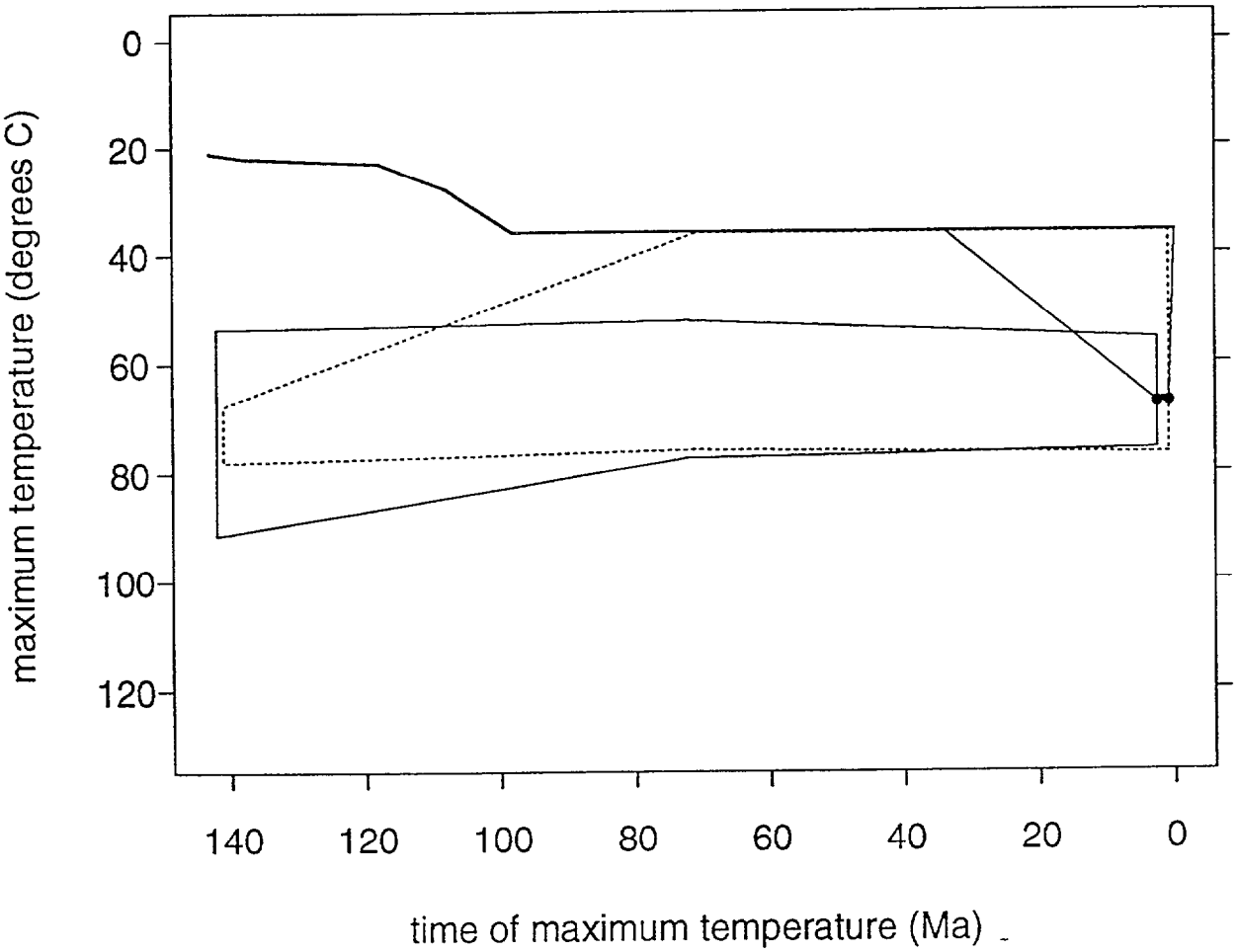
Mt Hammersley-1 GC550-4

episode 1



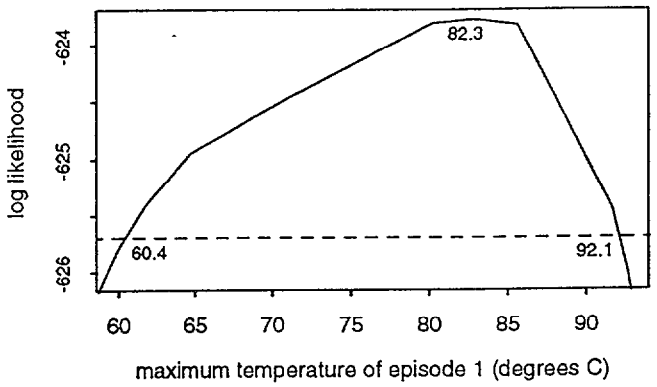
episode 2

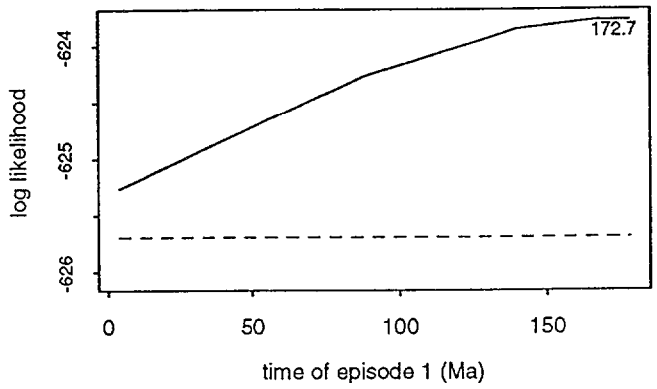


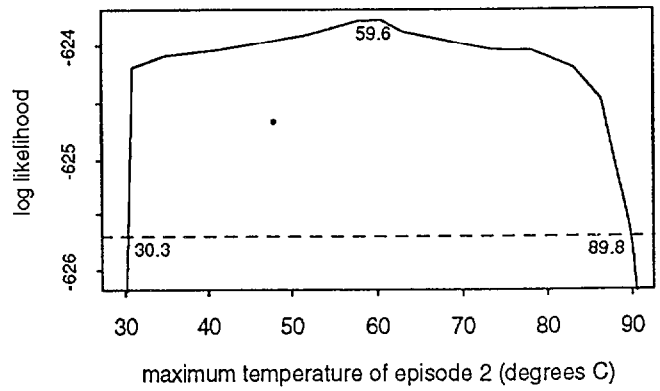

Mt Hammersley-1 GC550-4
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

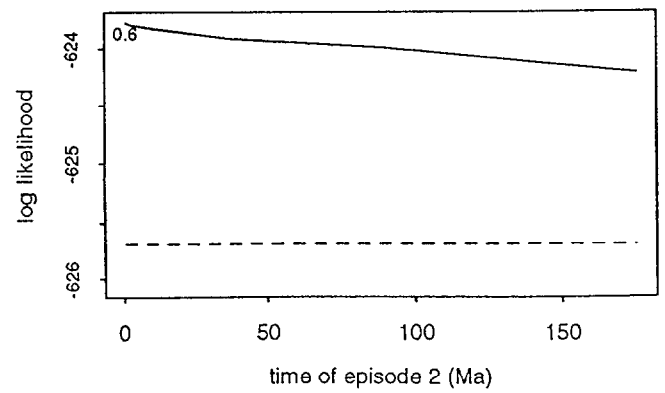
Mt Hammersley-1 GC550-5

profile likelihoods

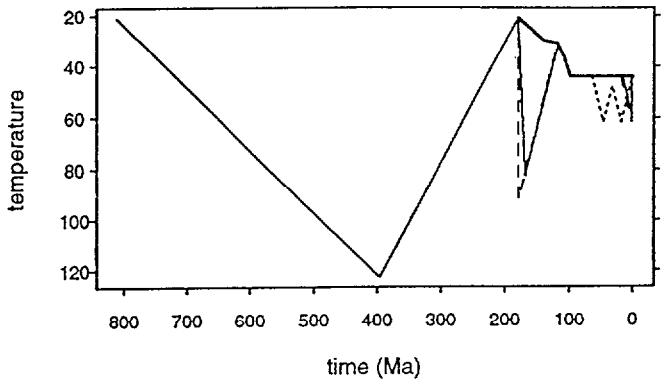


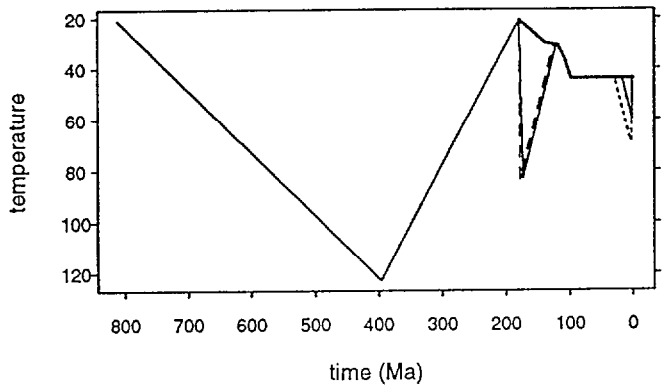


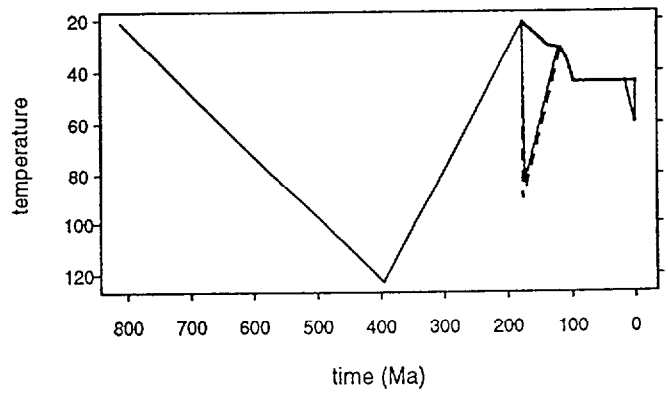


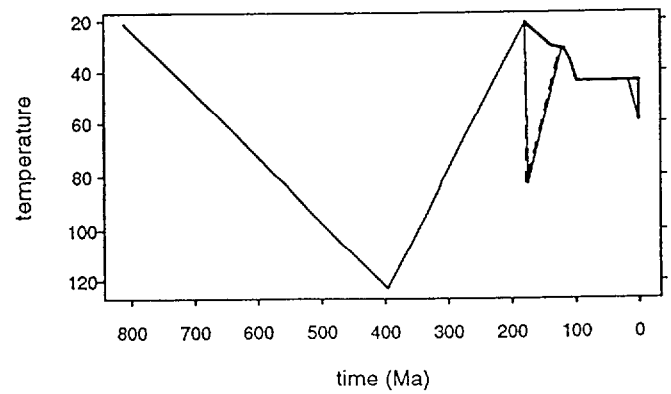


thermal histories



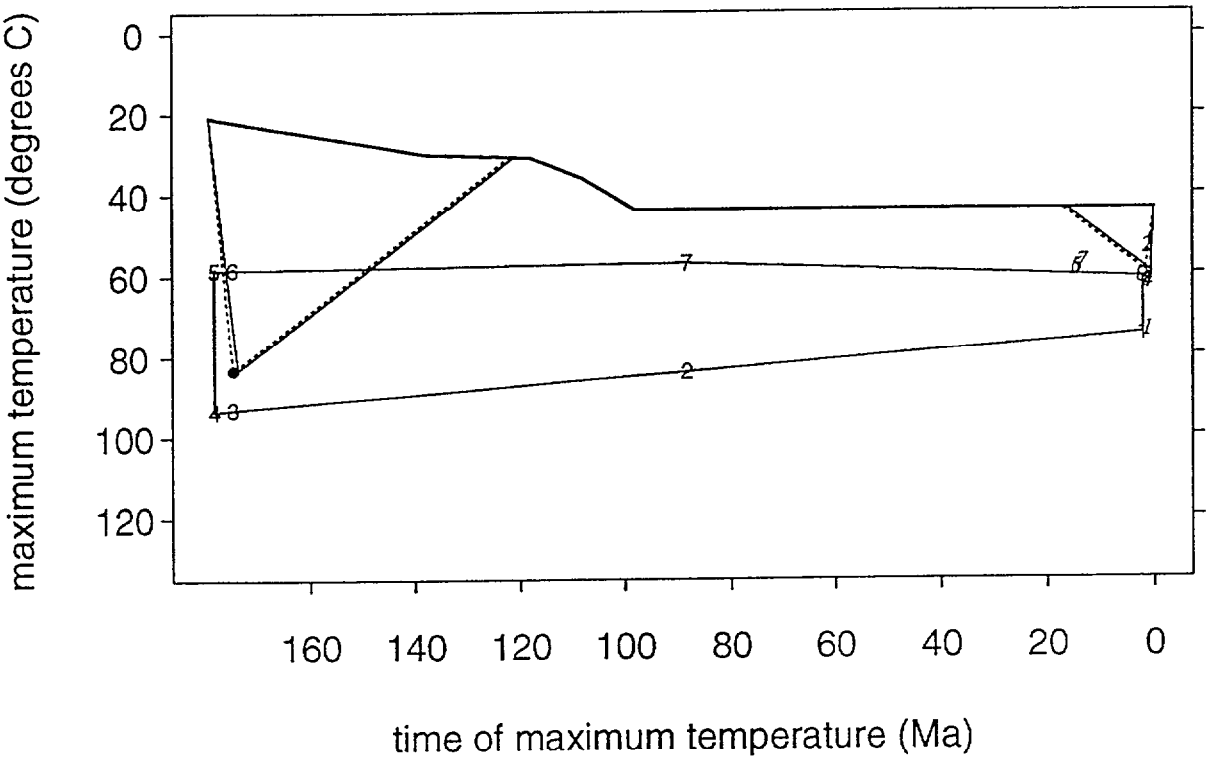




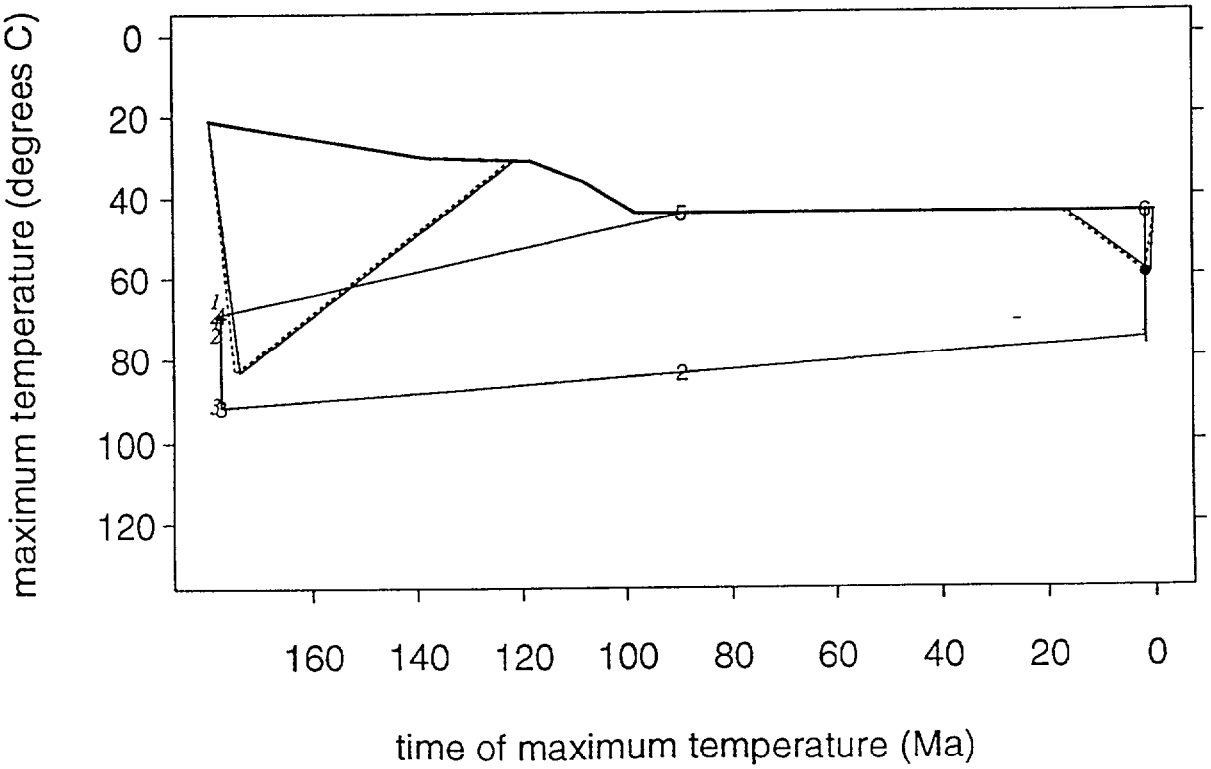


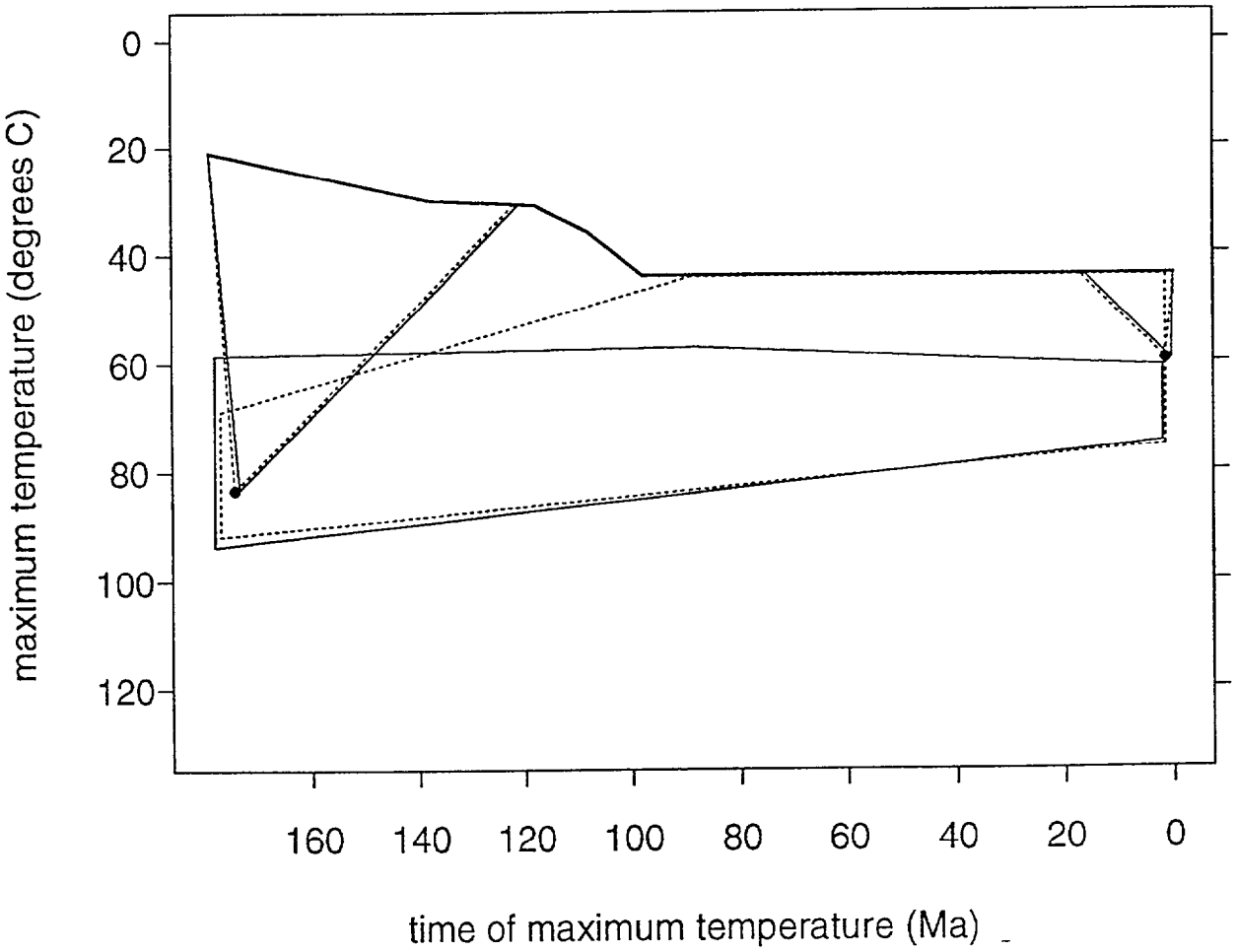
Mt Hammersley-1 GC550-5

episode 1



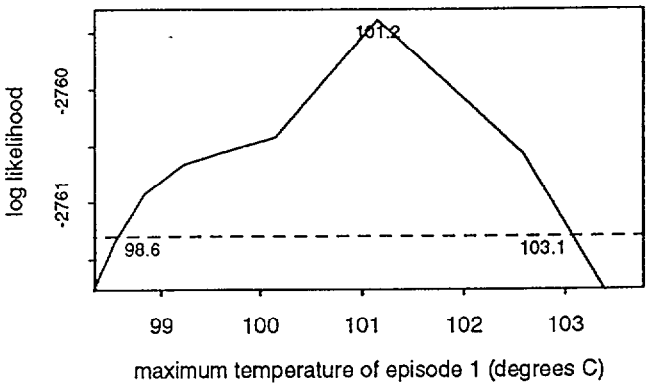
episode 2

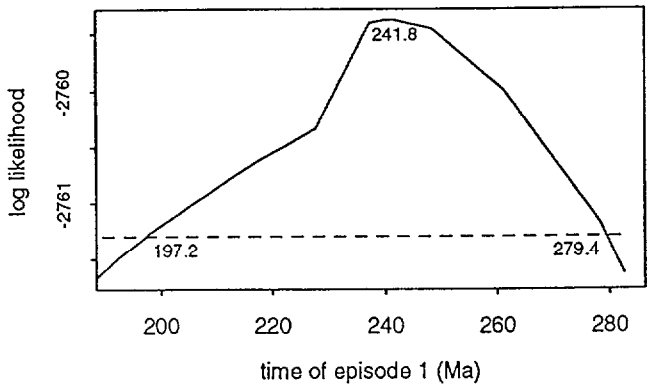


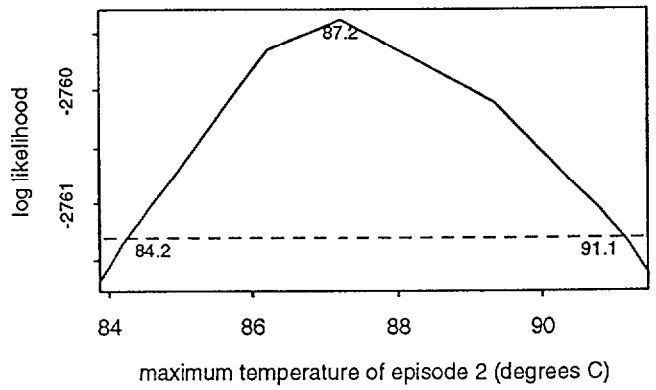

Mt Hammersley-1 GC550-5
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
160
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

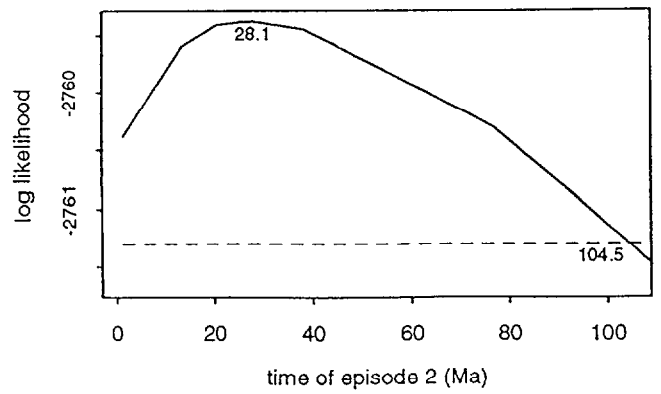
Mt Hammersley-1 GC550-7

profile likelihoods

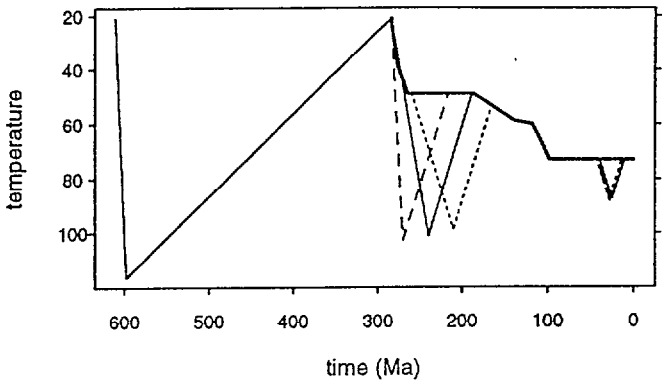


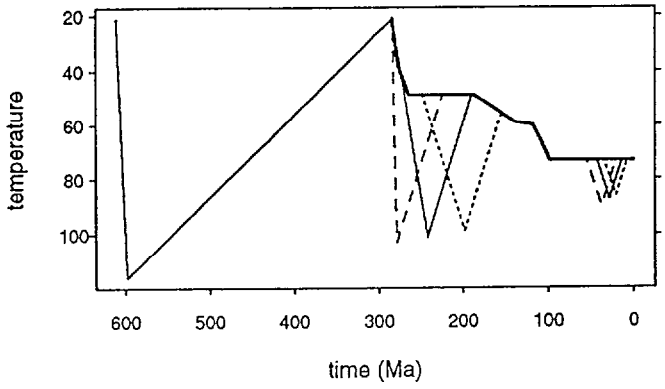


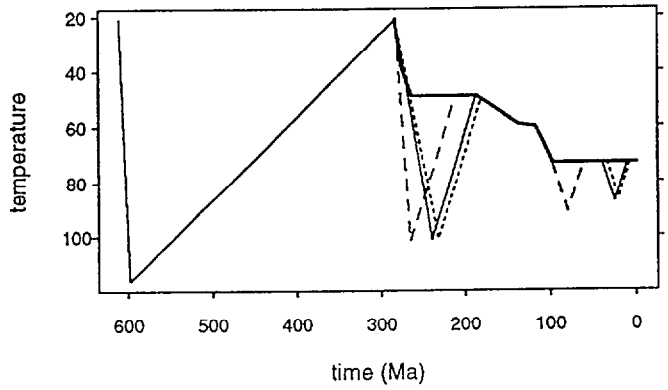


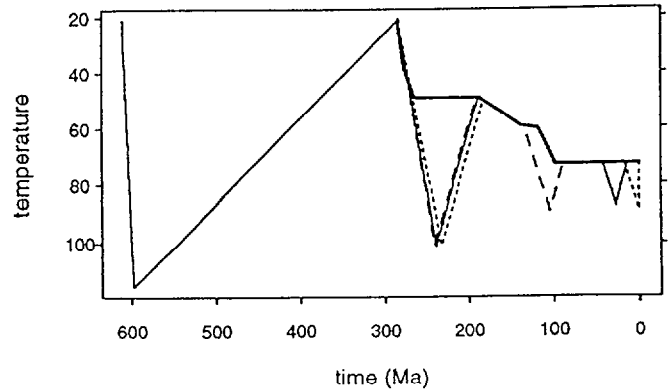


thermal histories



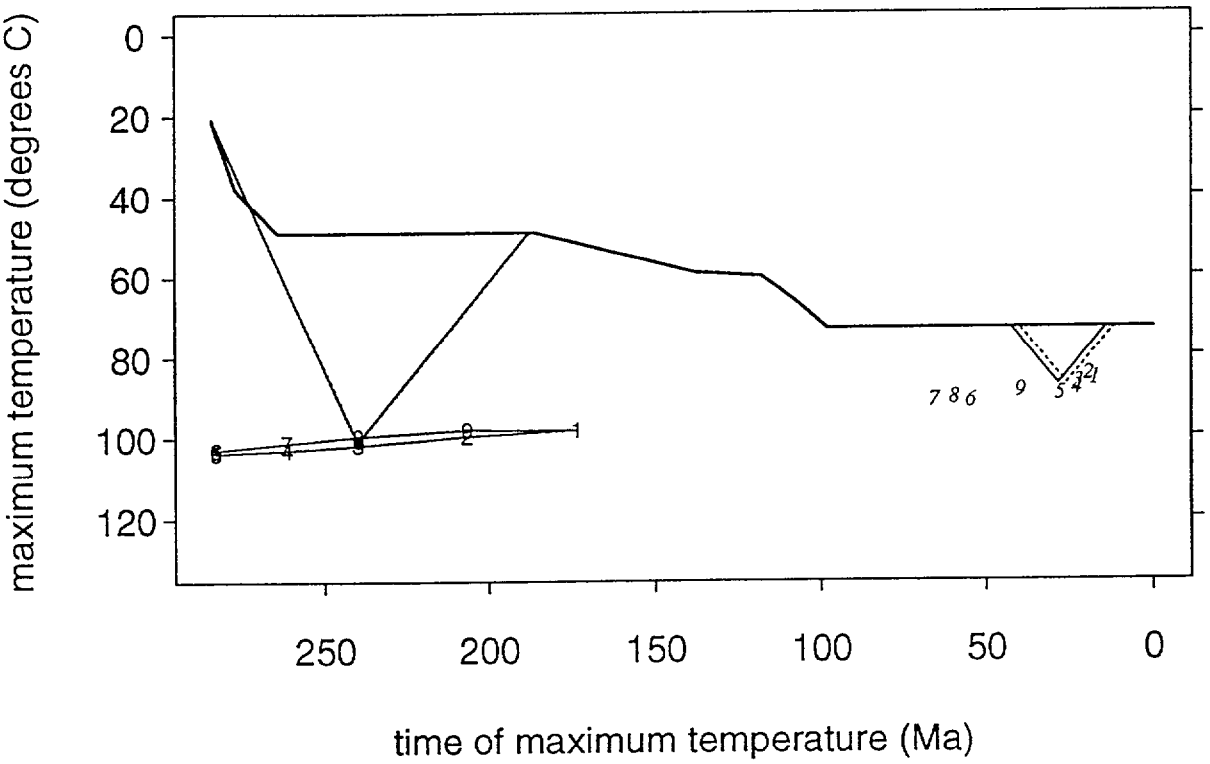




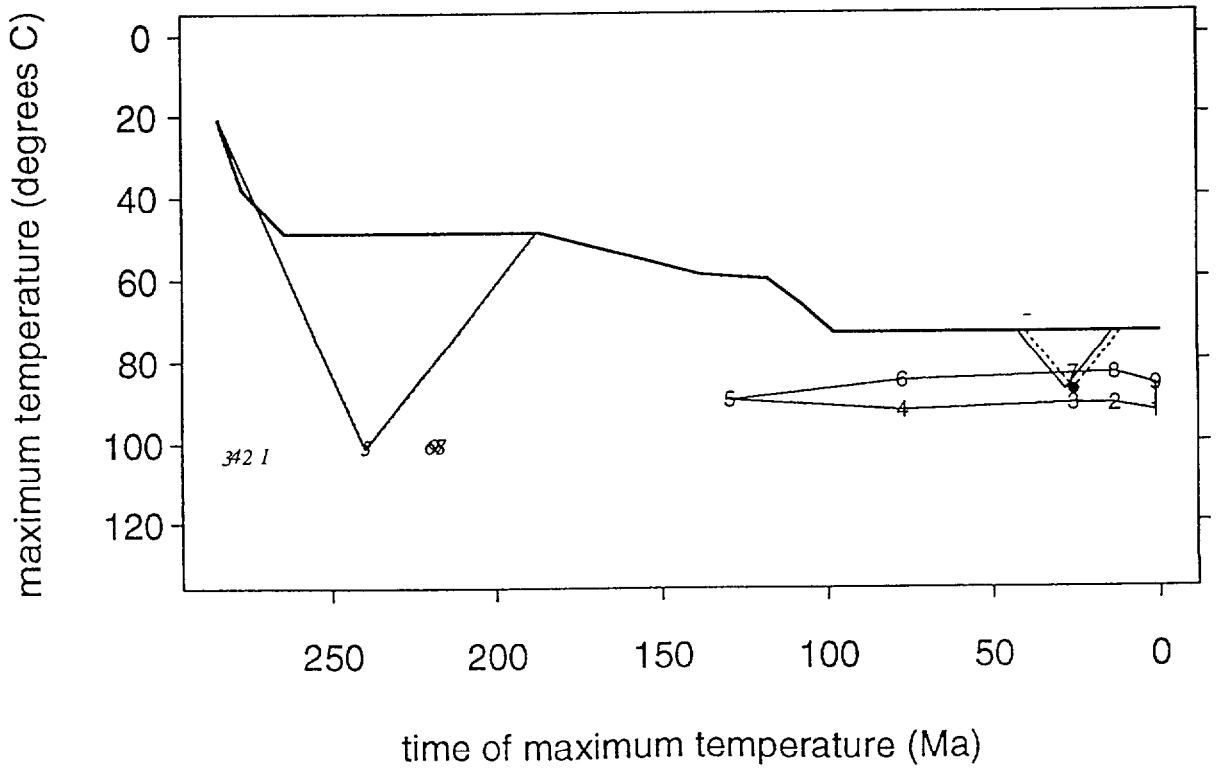


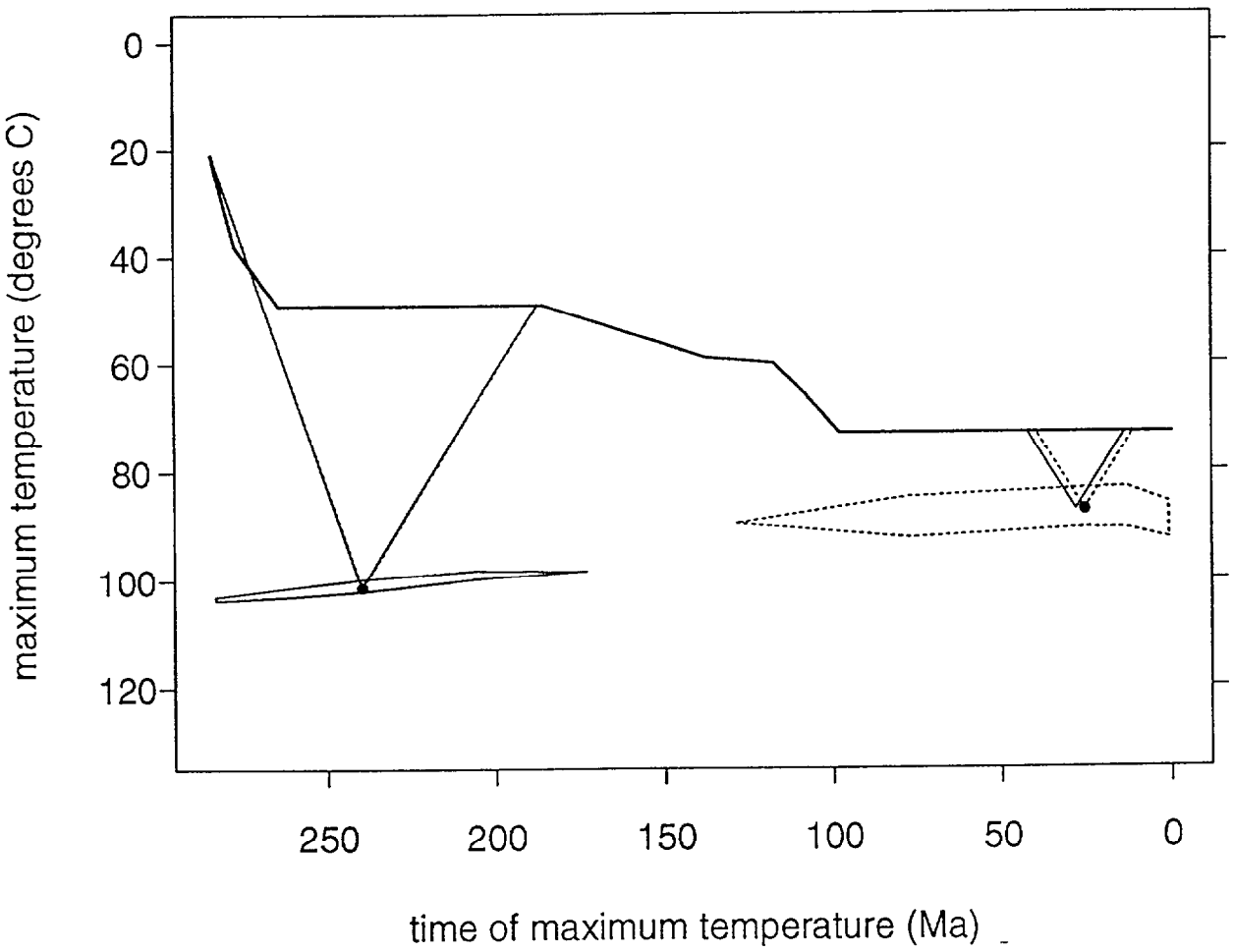
Mt Hammersley-1 GC550-7

episode 1



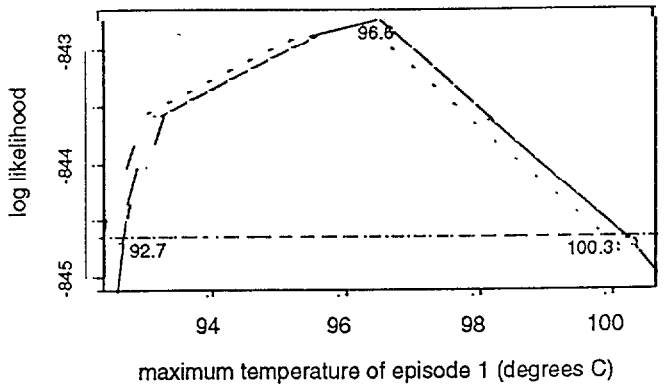
episode 2

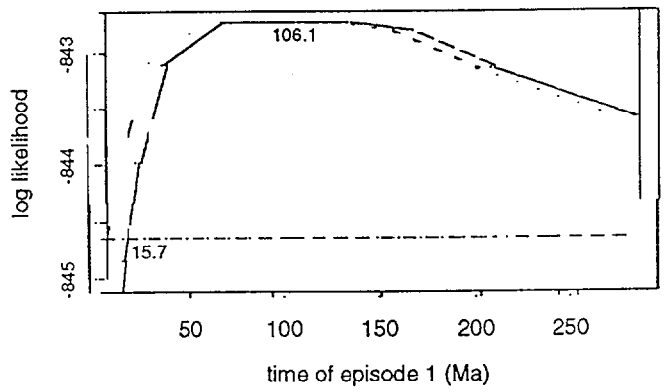


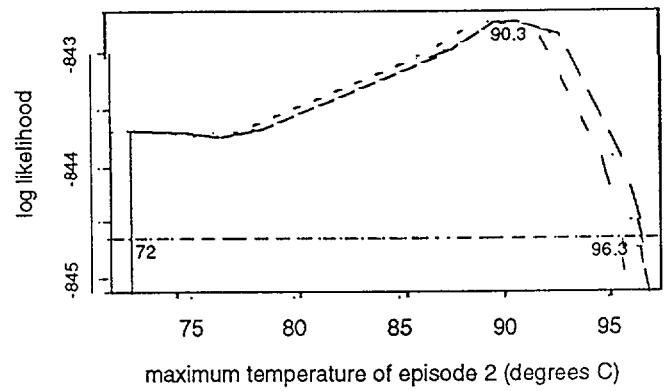

Mt Hammersley-1 GC550-7
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
250
200
150
100
50
0
time of maximum temperature (Ma)

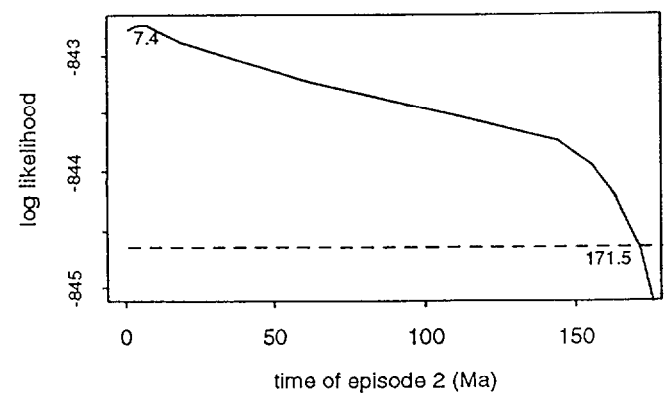
Mt Hammersley-1 GC550-8

profile likelihoods

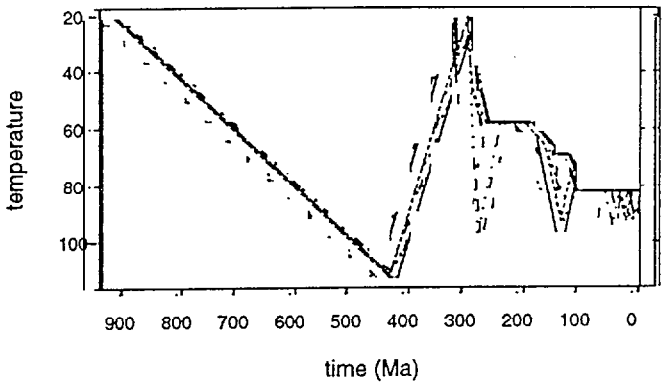


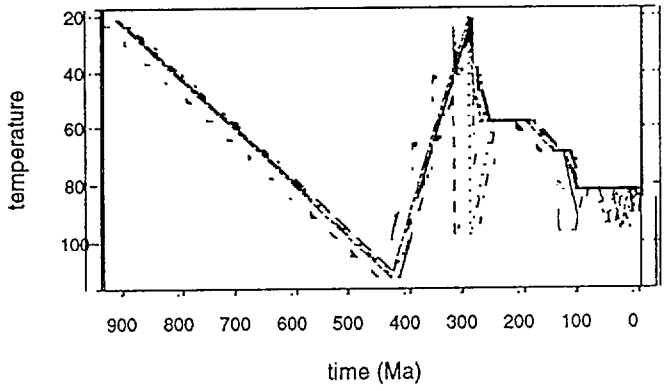


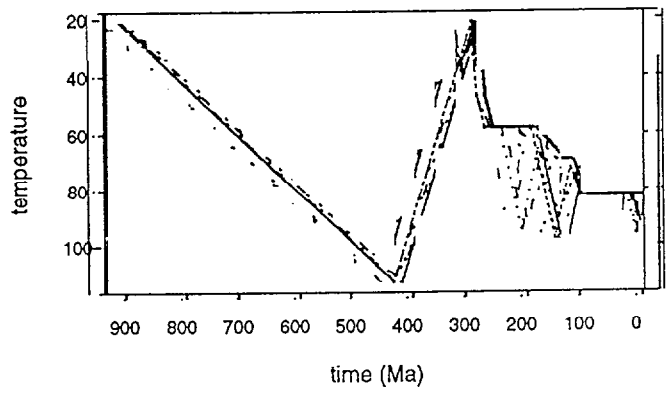


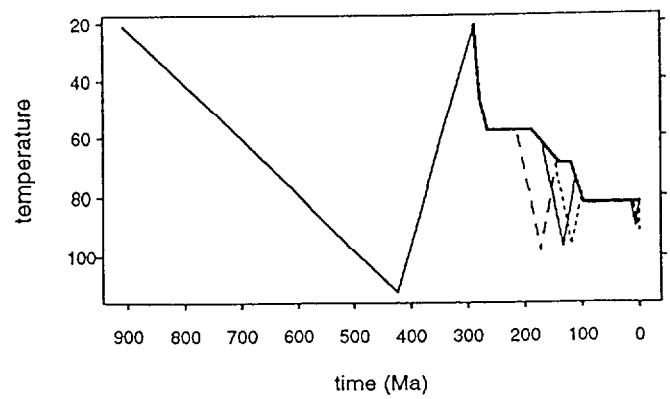


thermal histories



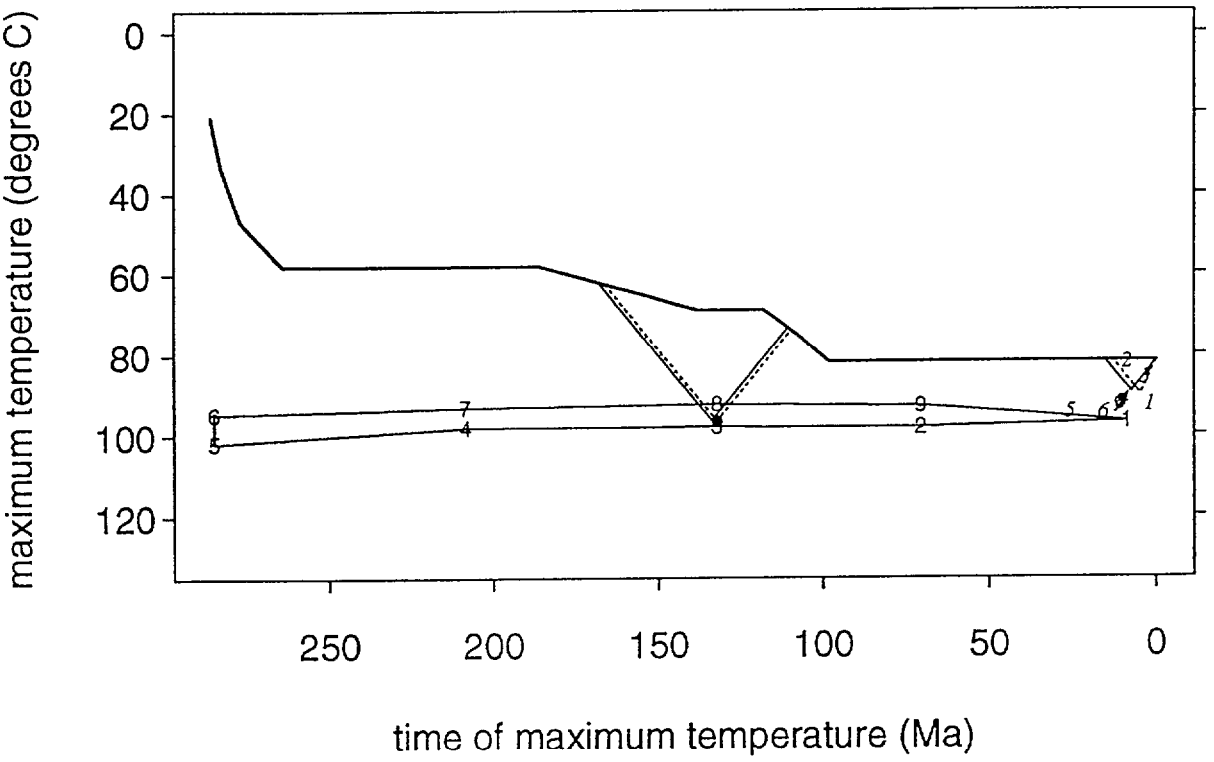




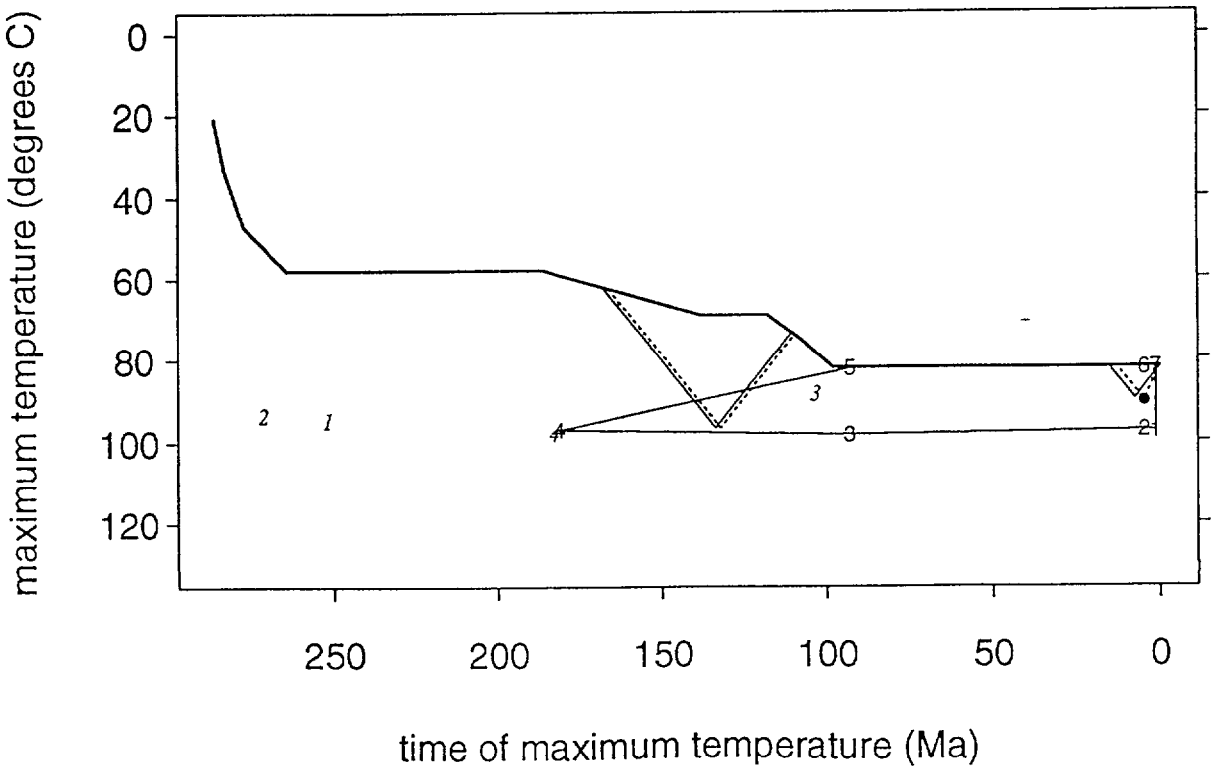


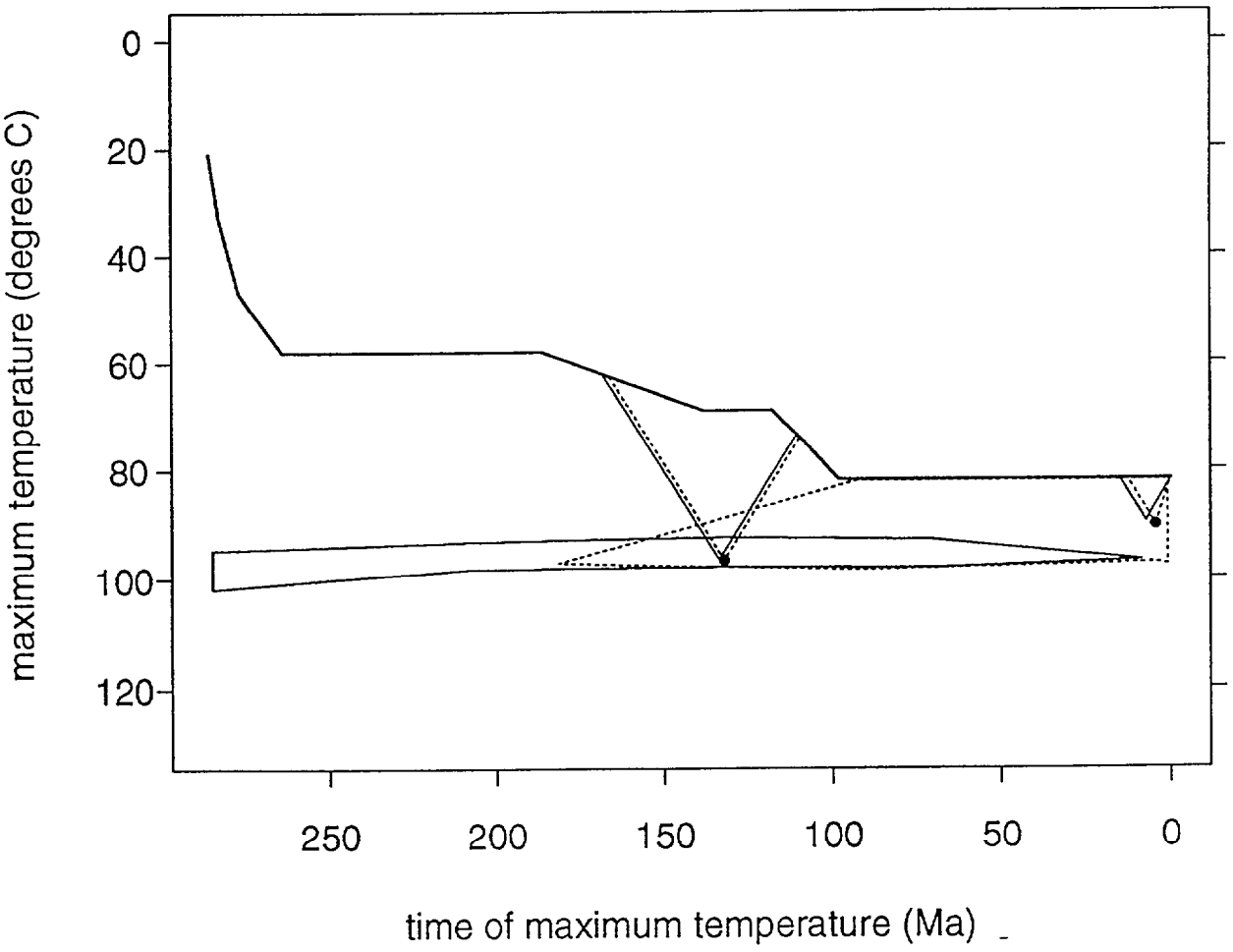
Mt Hammersley-1 GC550-8

episode 1



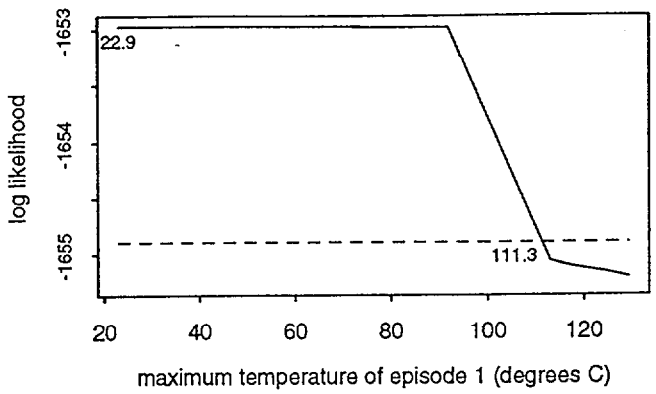
episode 2

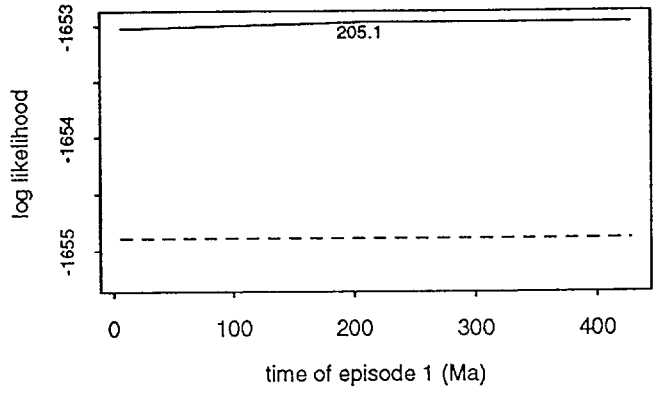


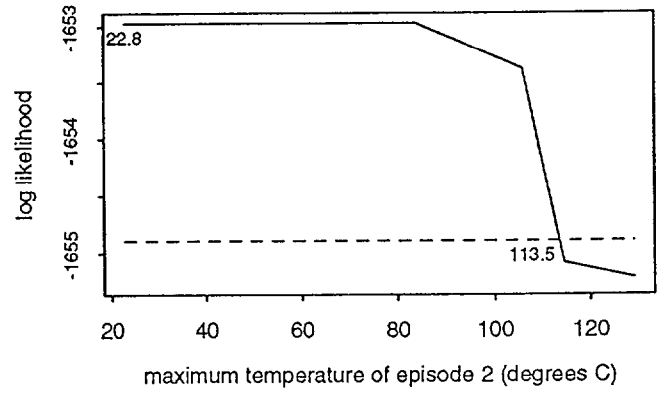

Mt Hammersley-1 GC550-8
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
250
200
150
100
50
0
time of maximum temperature (Ma)

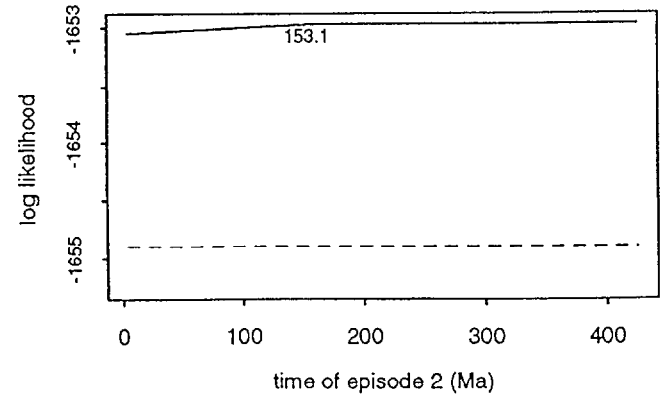
Mt Hammersley-1 GC550-9

profile likelihoods

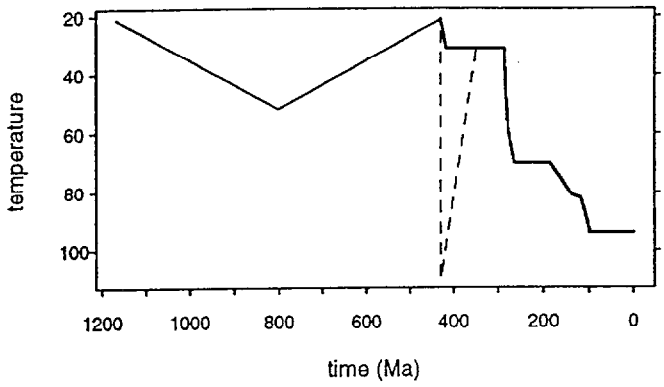


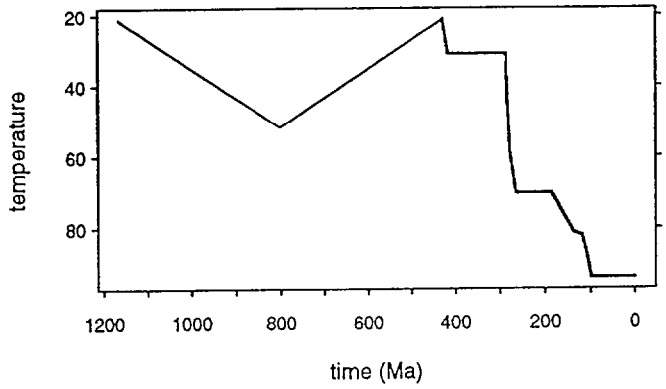


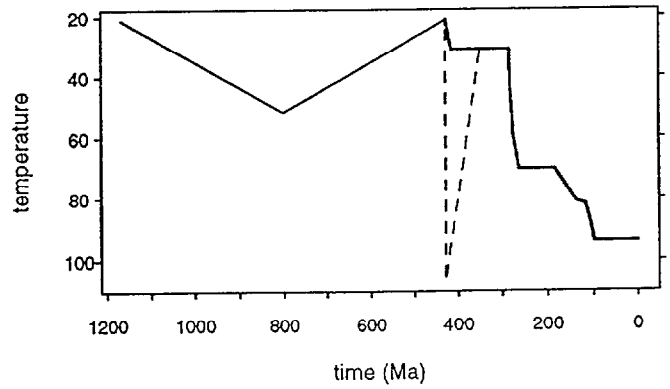


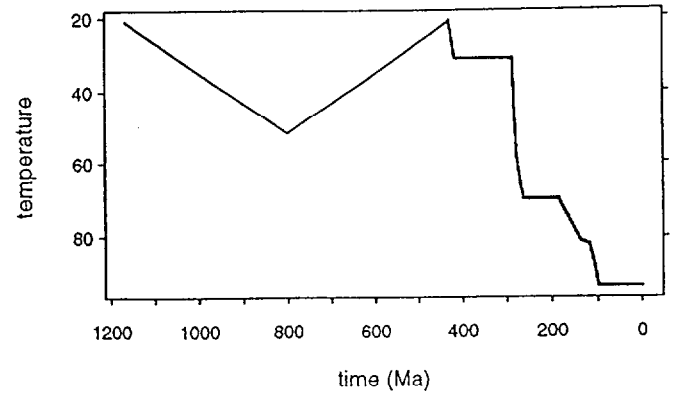


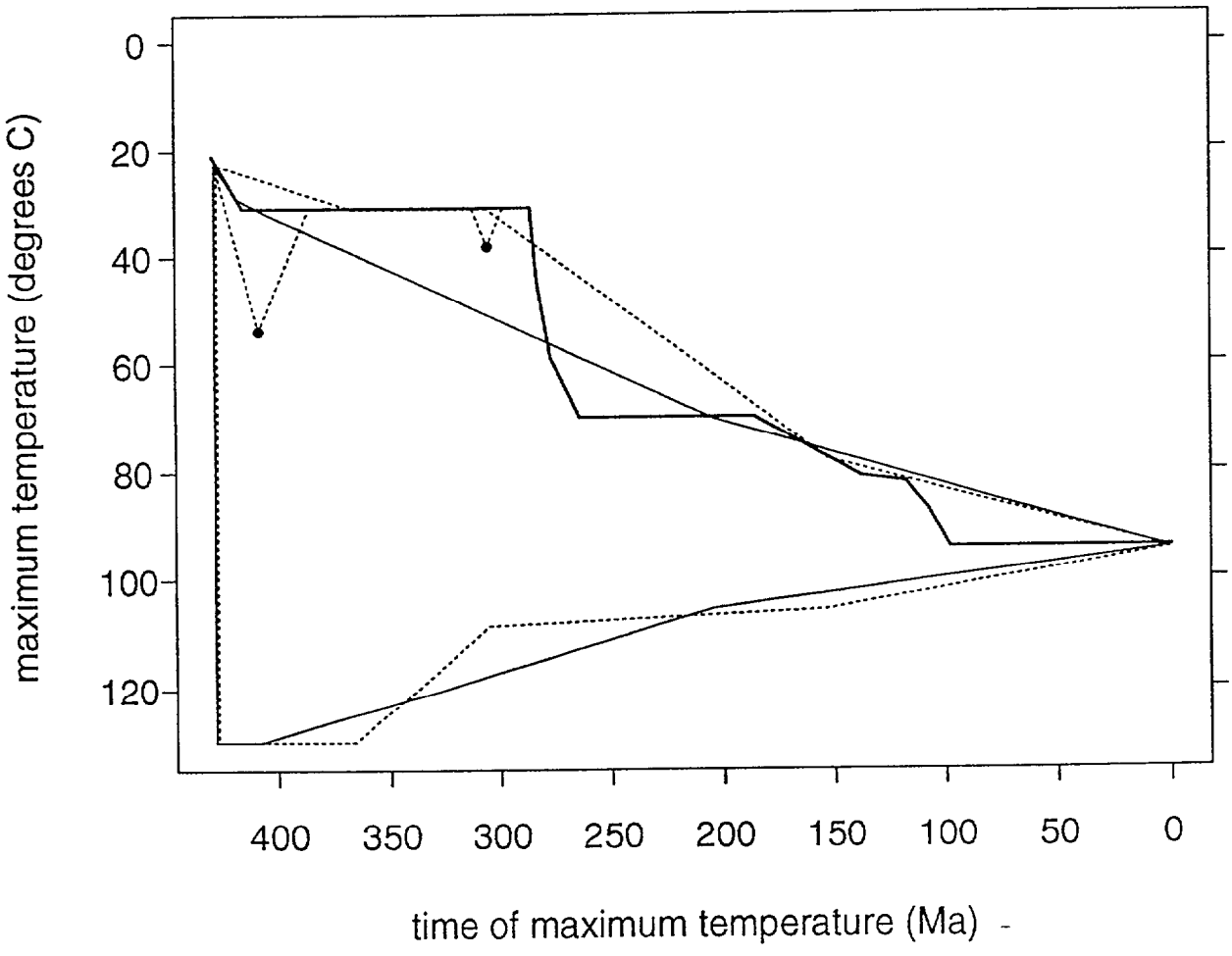
thermal histories





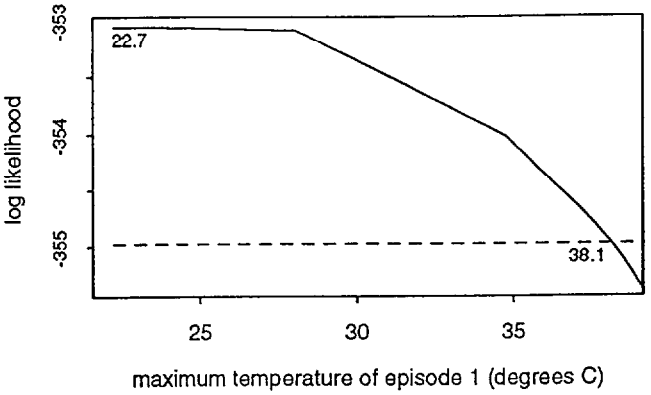


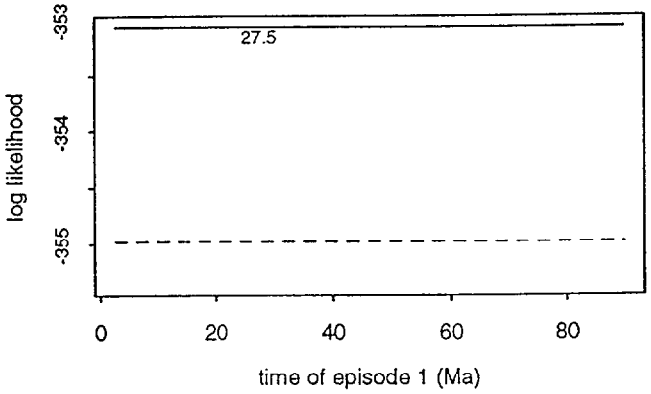


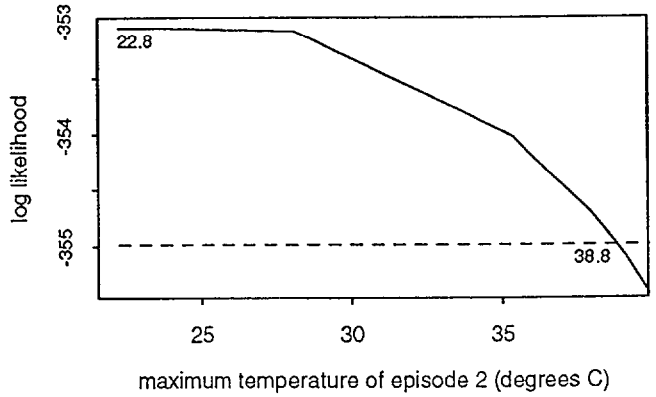

Mt Hammersley-1 GC550-9
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
400
350
300
250
200
150
100
50
0
time of maximum temperature (Ma)

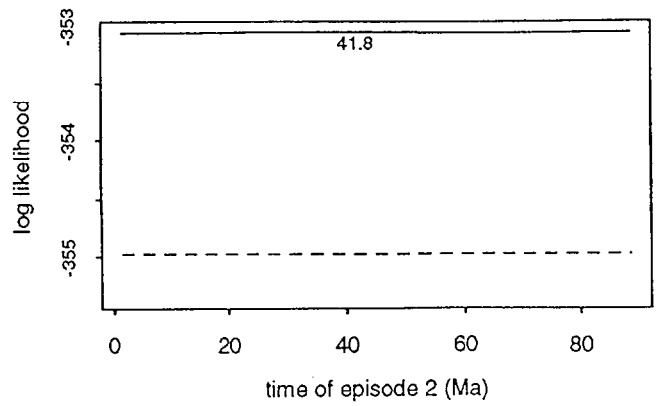
Purni-1 GC550-10

profile likelihoods

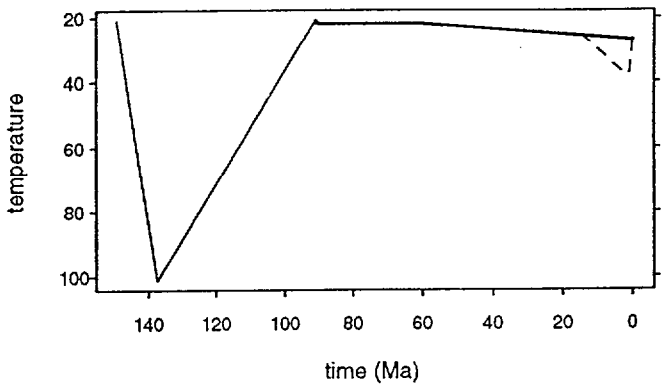


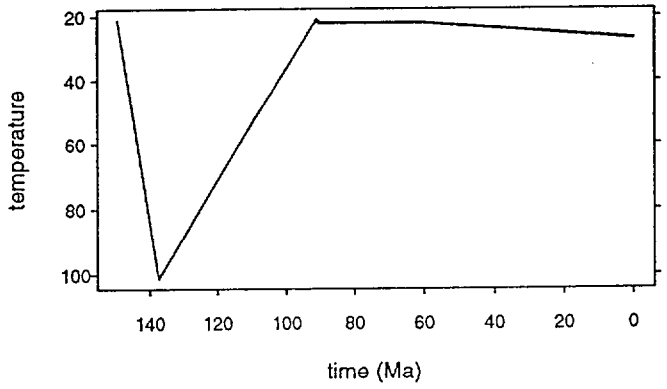


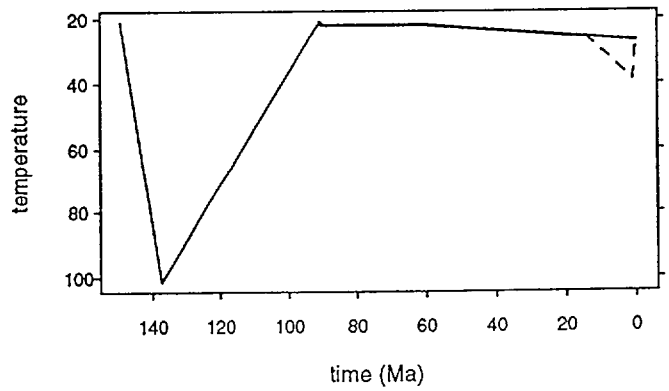


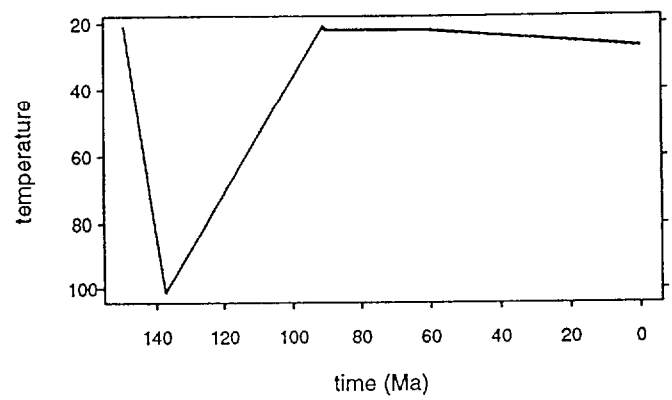


thermal histories



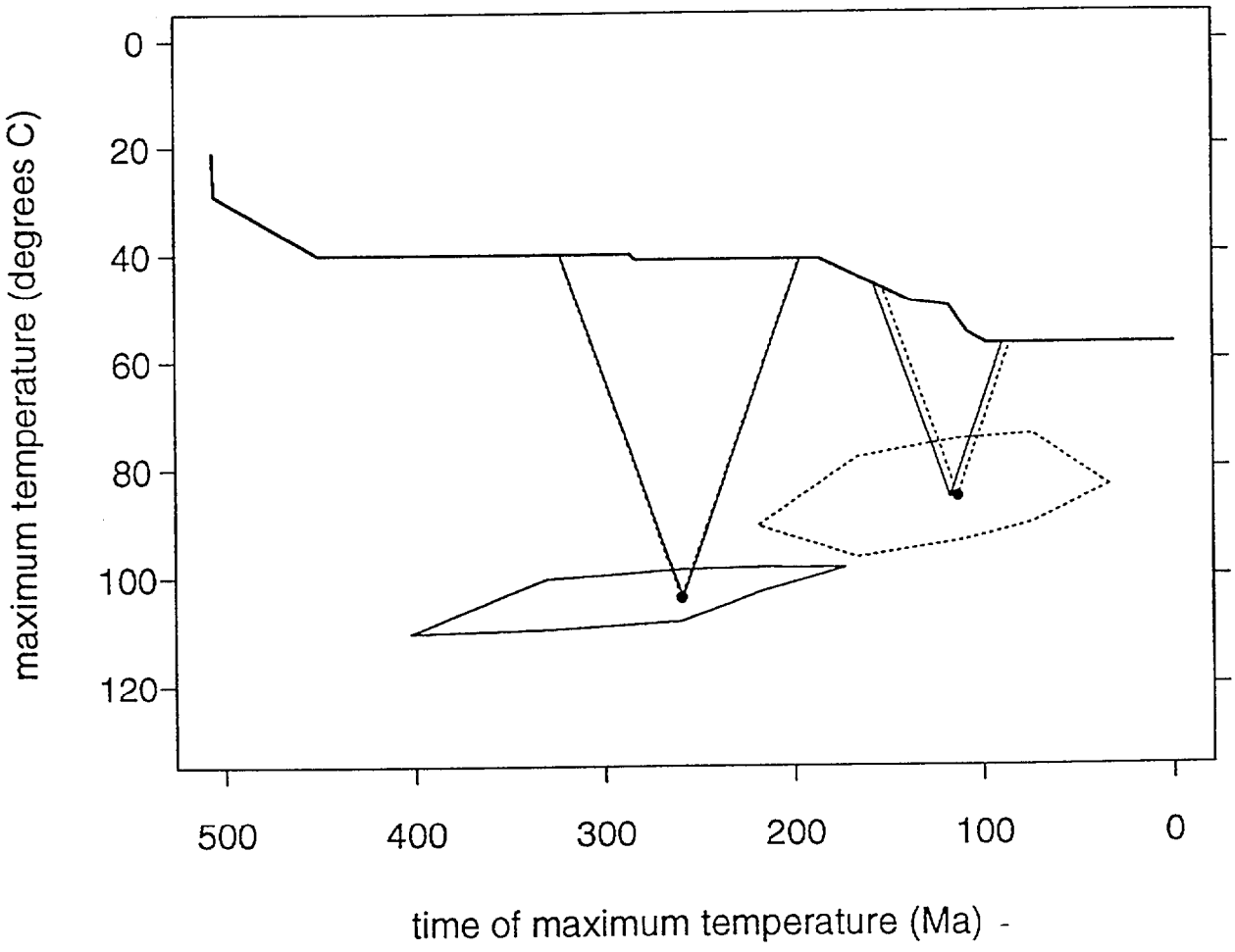






Mt Crispe-1 GC550-13

episodes 1 and 2



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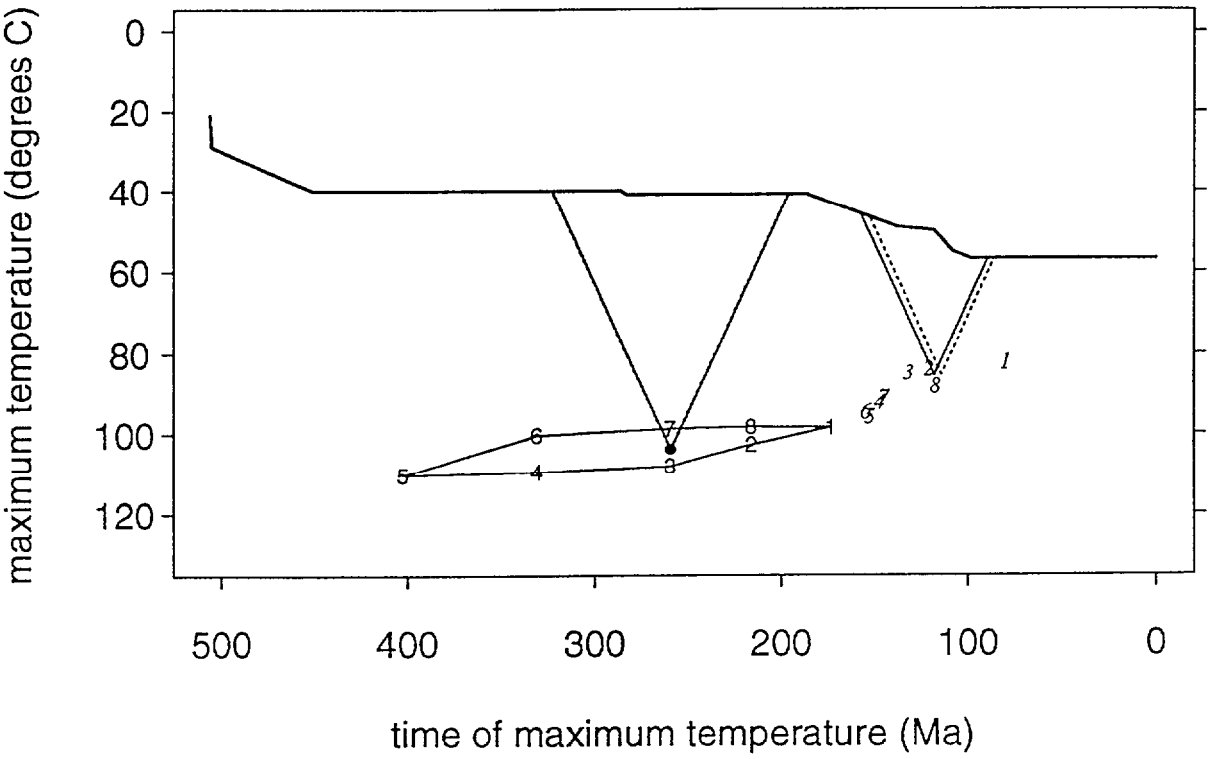
episode 1



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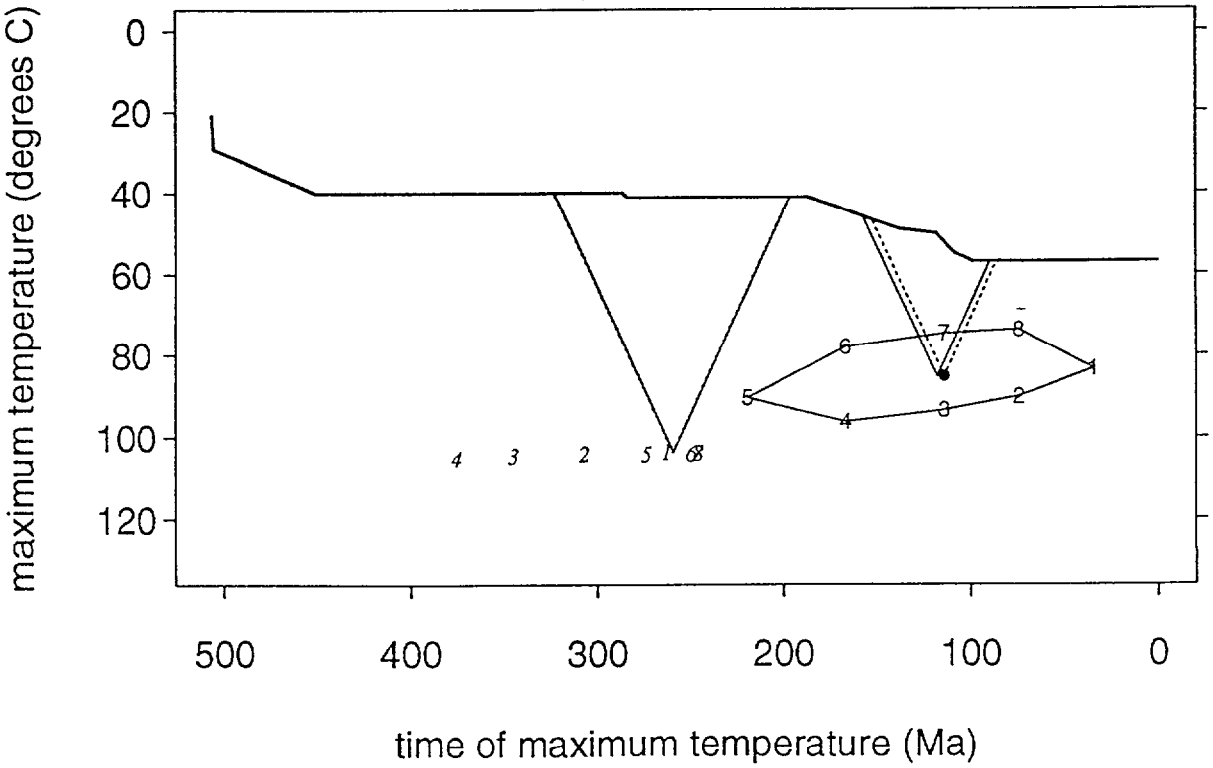

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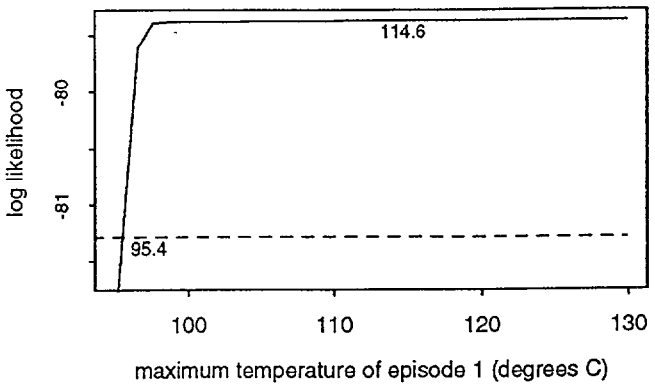
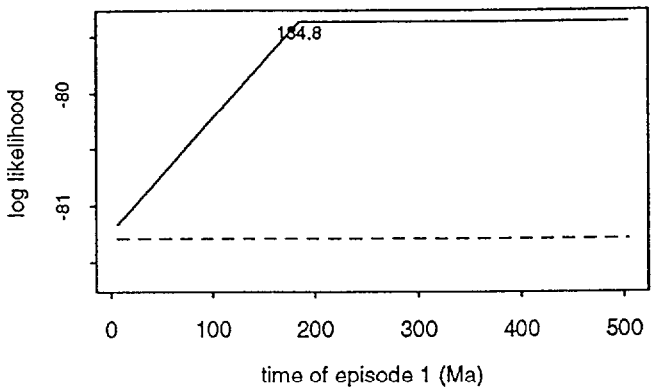
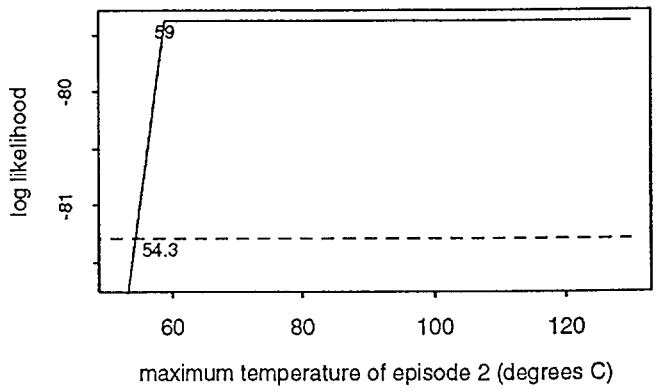
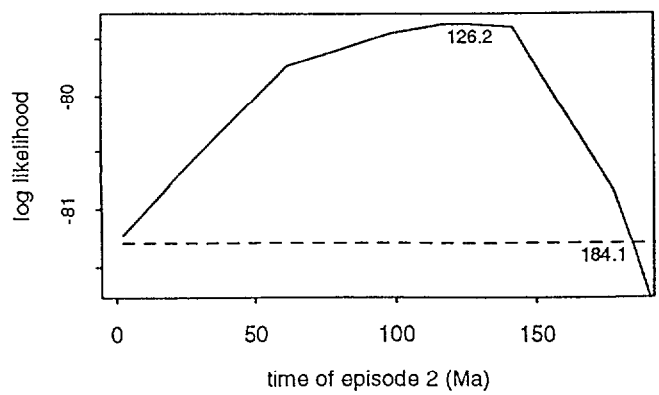
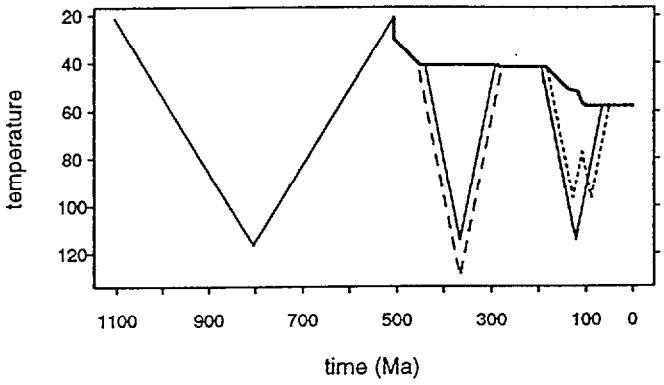


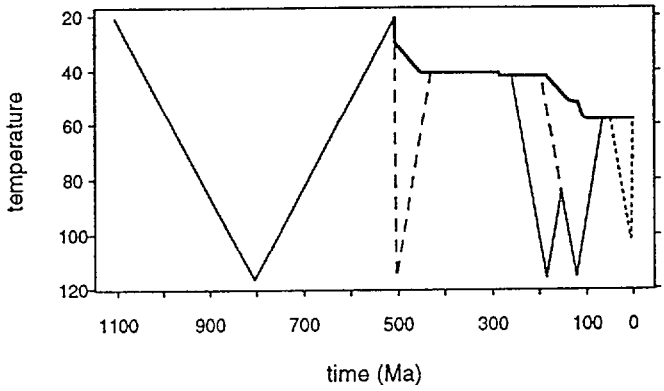


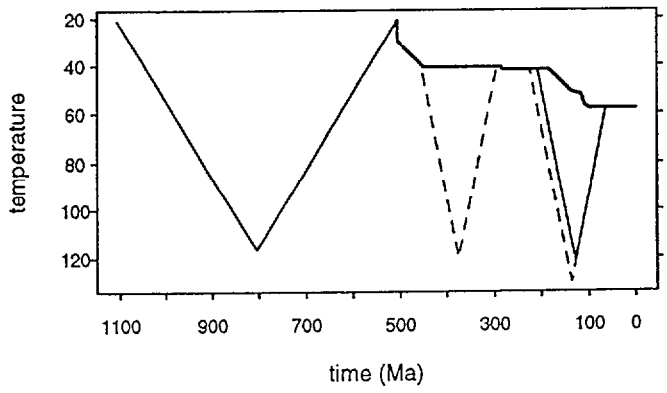


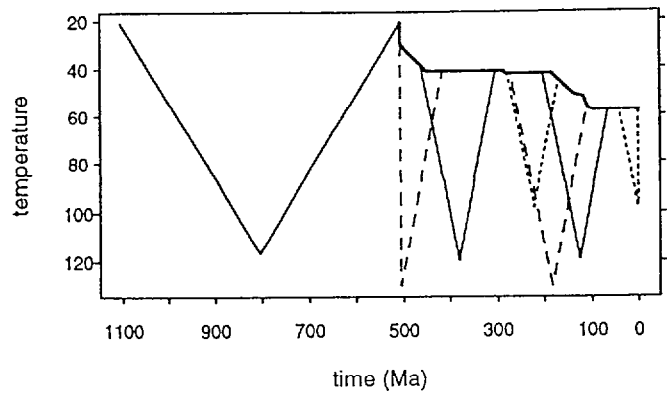


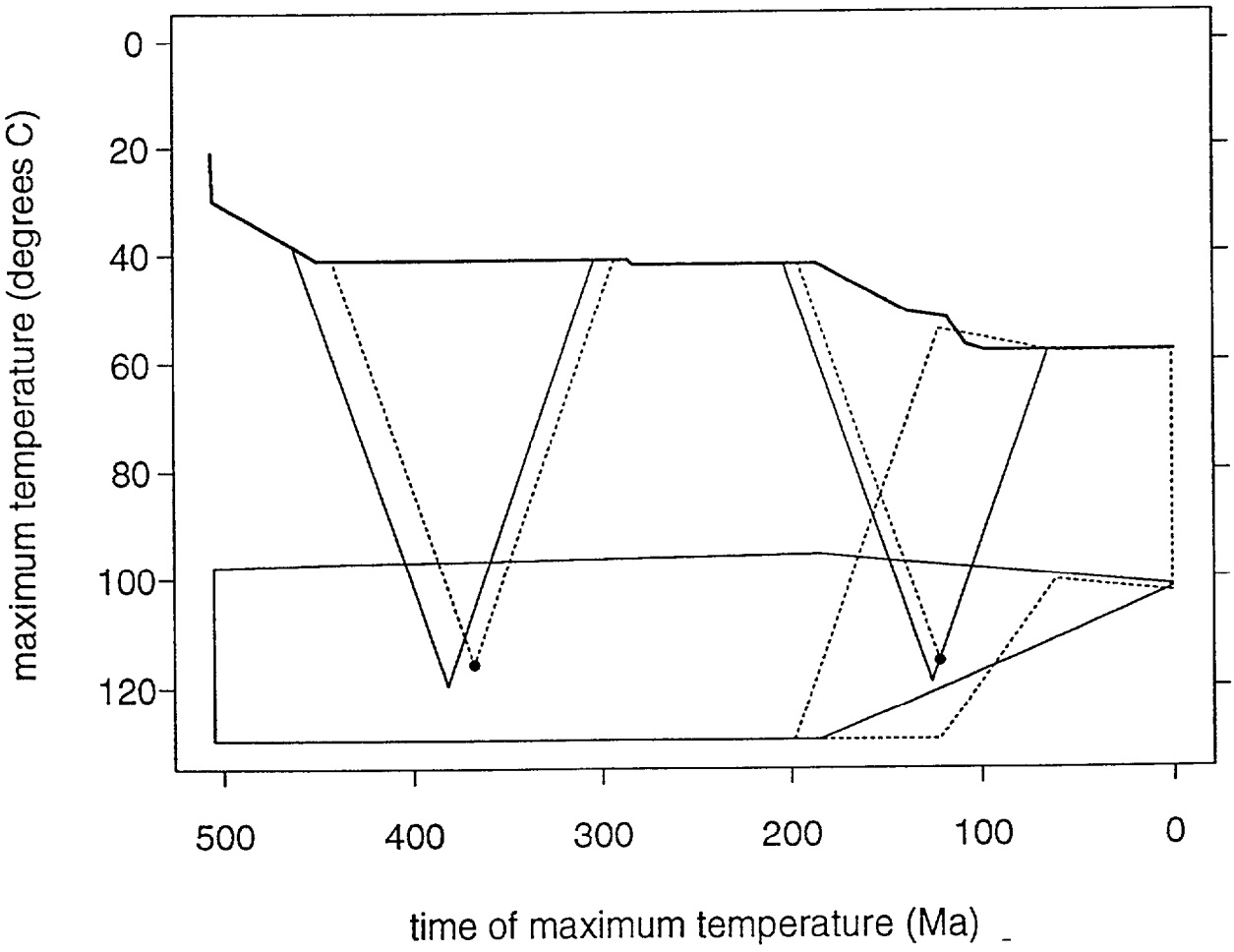
thermal histories





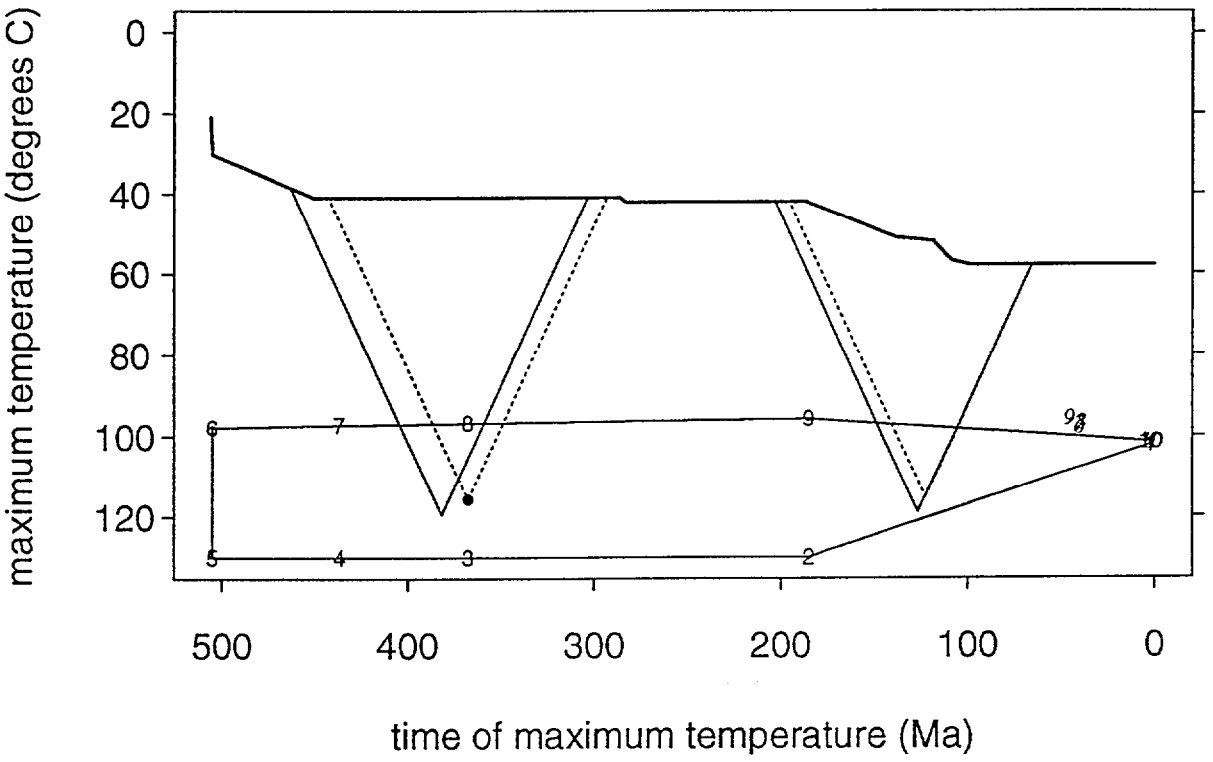





Mt Crispe-1 Gc550-14
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
500
400
300
200
100
0
time of maximum temperature (Ma)

Mt Crispe-1 Gc550-14

episode 1



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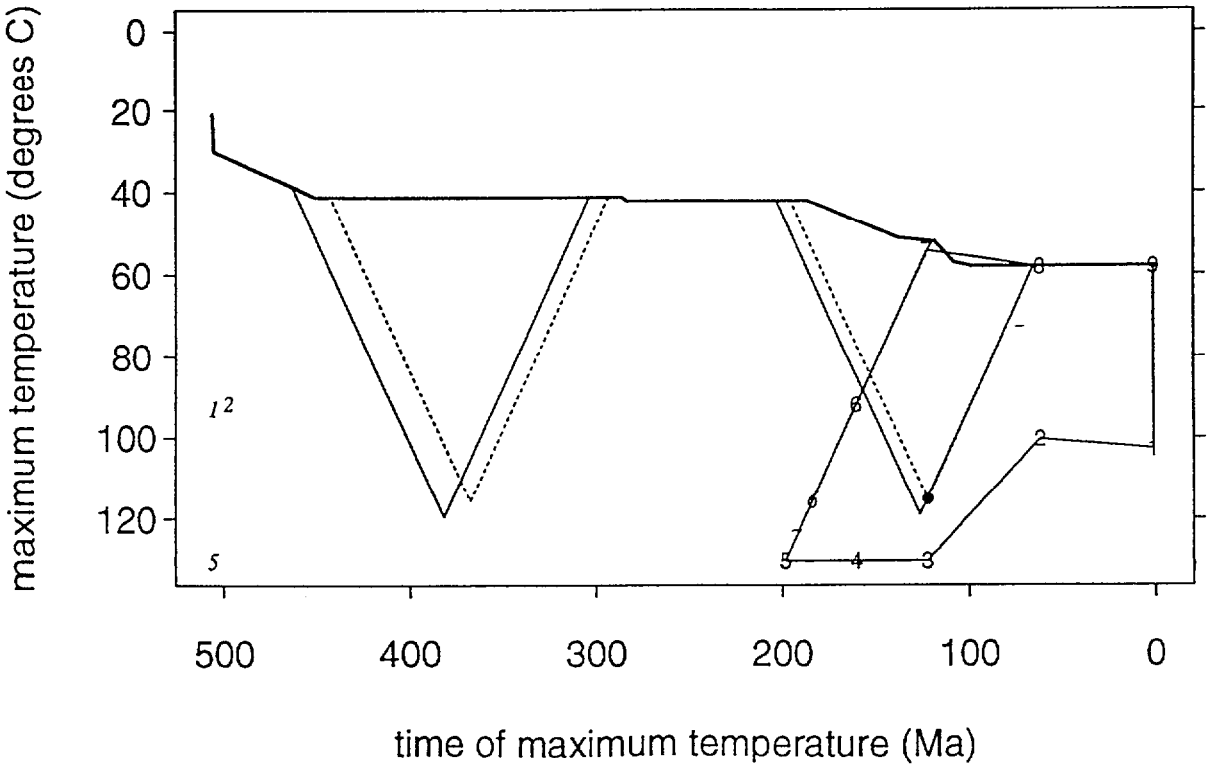

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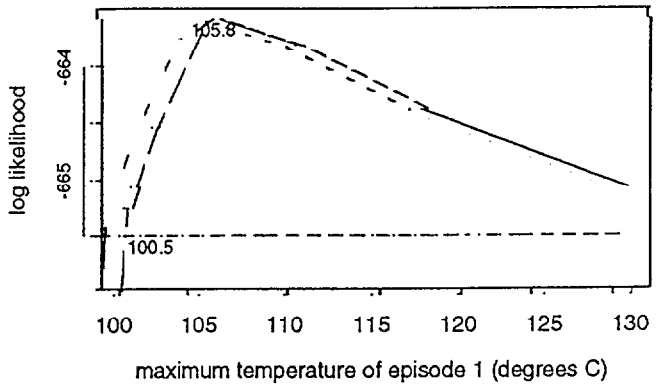
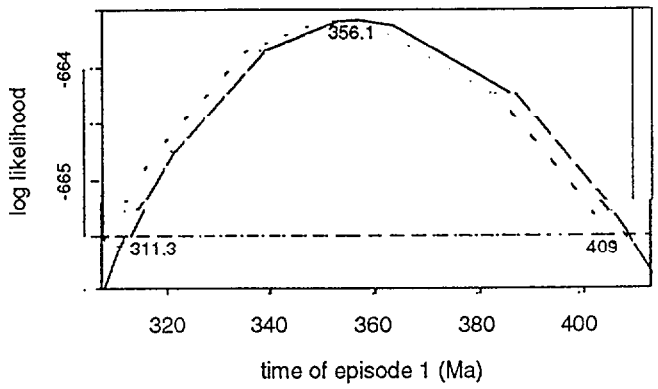
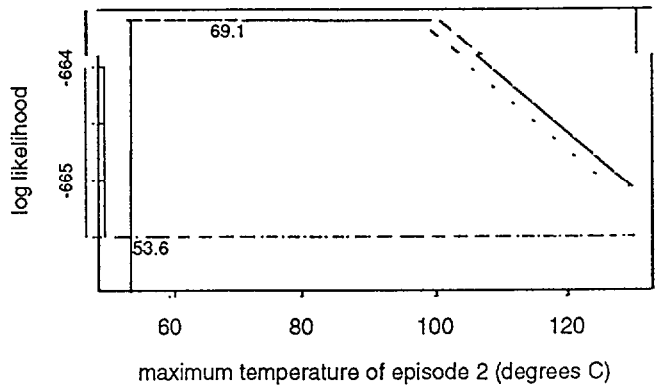
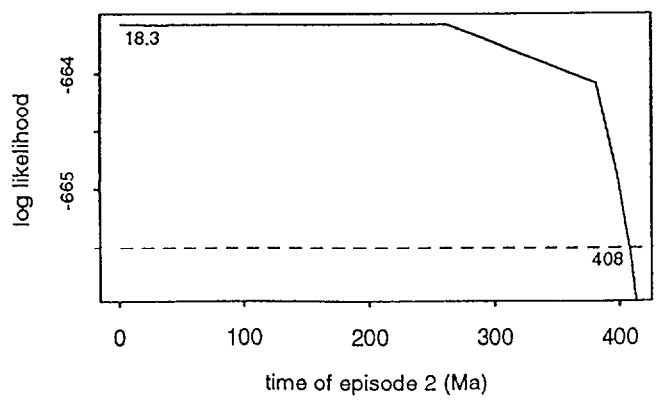
profile likelihoods

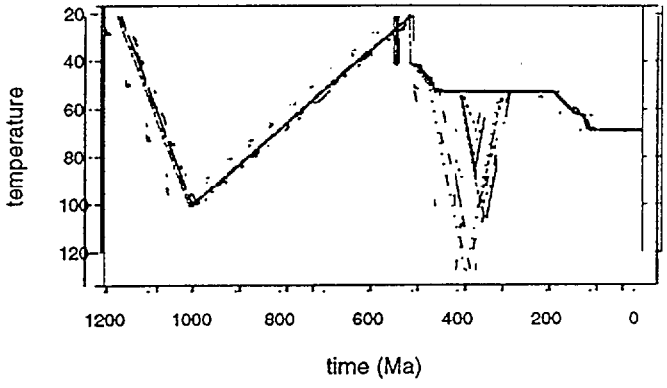


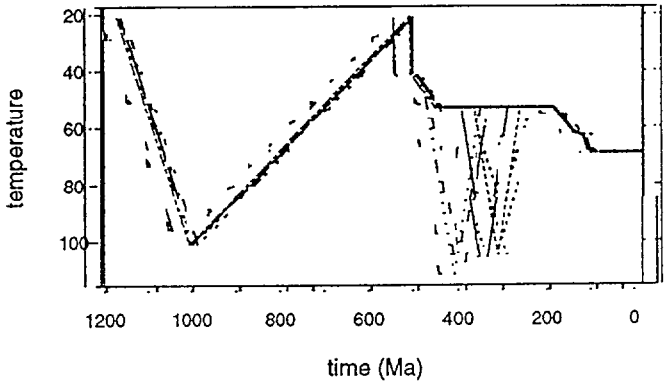


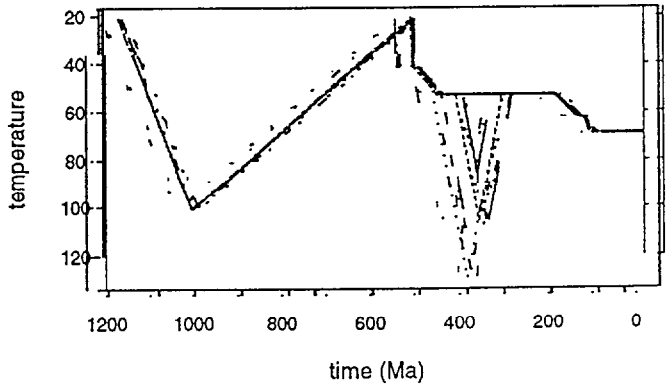


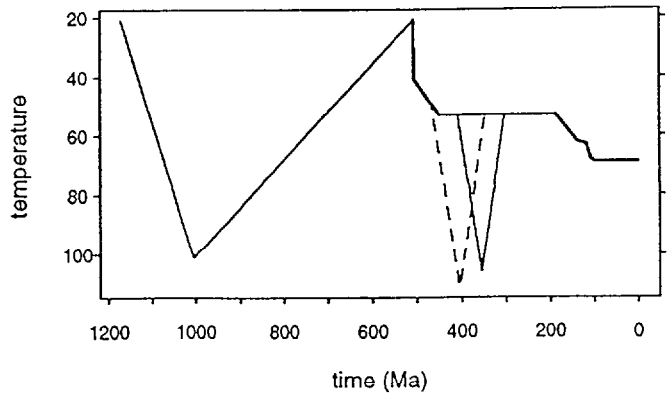


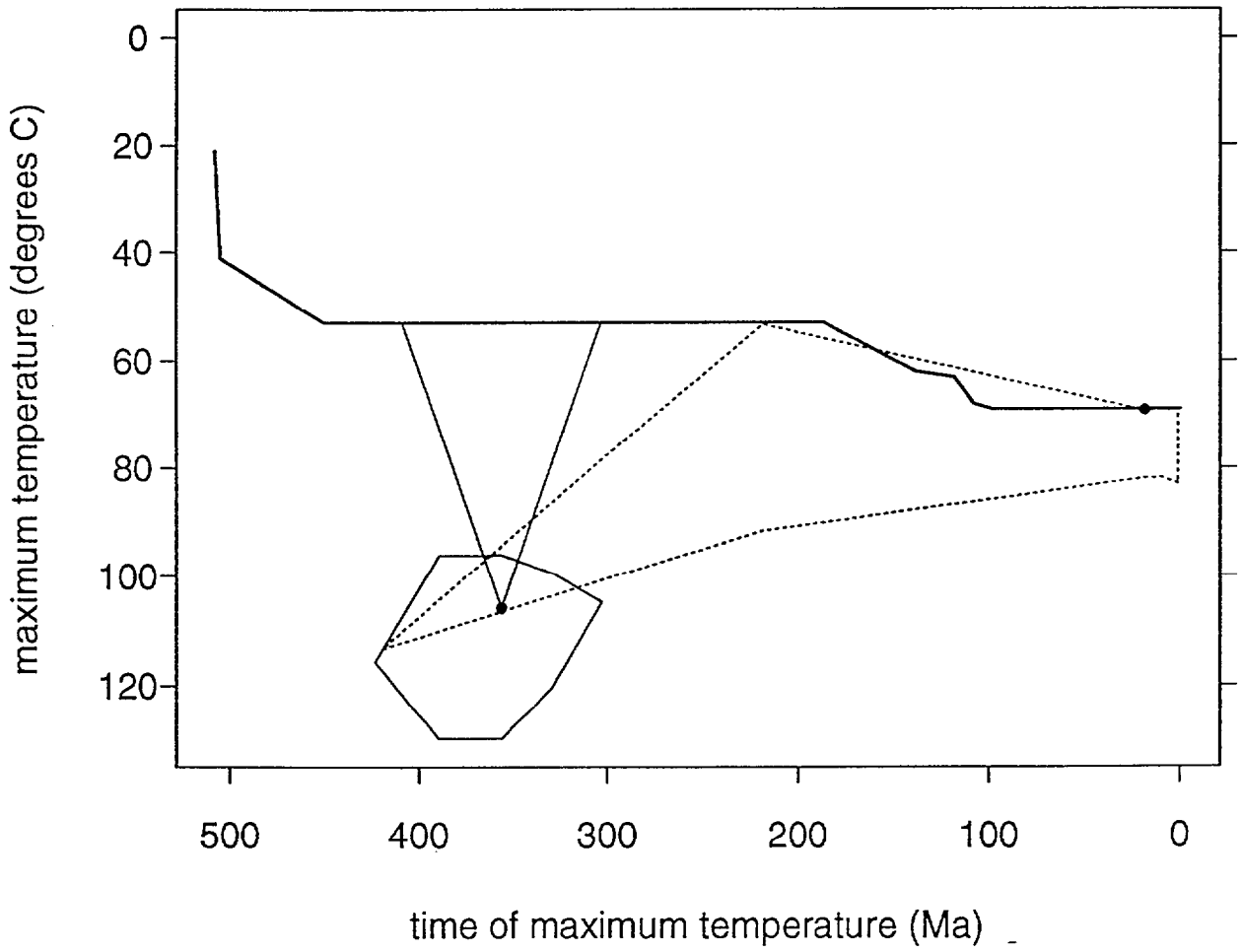
thermal histories





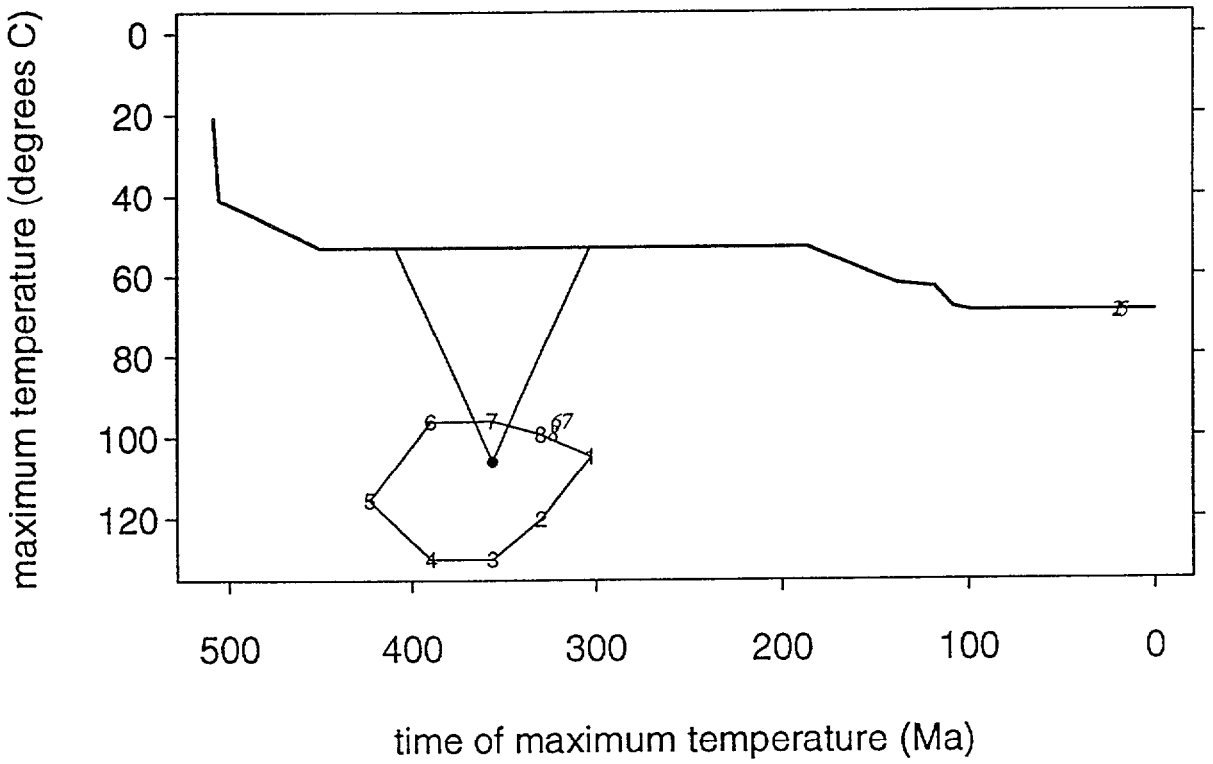




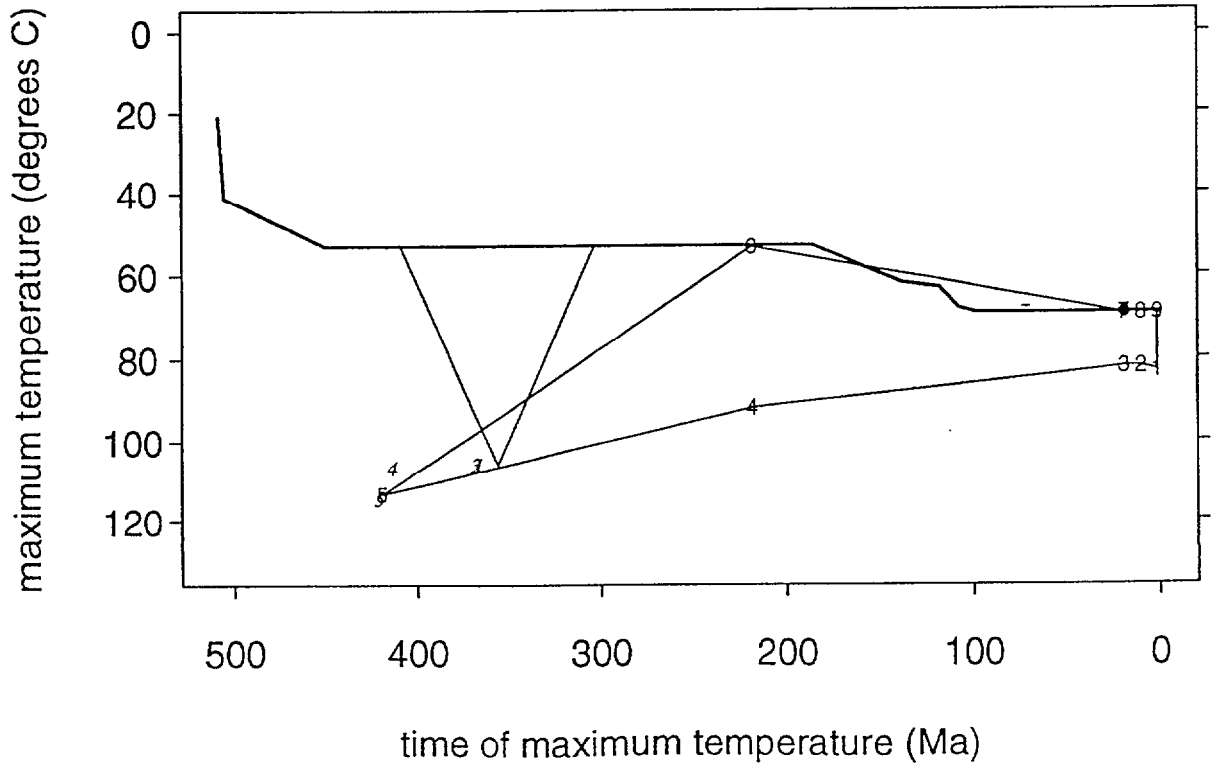

Mt Crispe-1 GC550-15
episodes 1 and 2
maximum temperature (degrees C)
0
20
40
60
80
100
120
500
400
300
200
100
0
time of maximum temperature (Ma)

Mt Crispe-1 GC550-15

episode 1

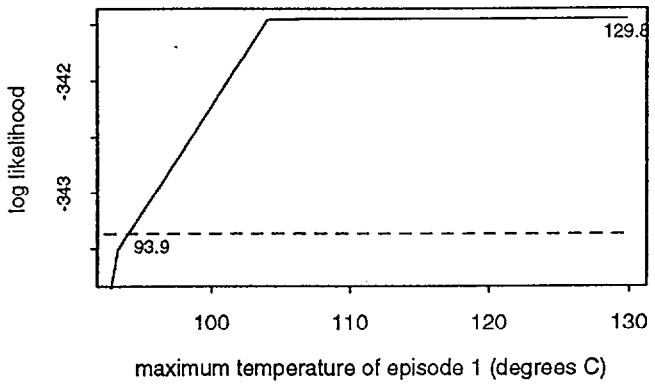


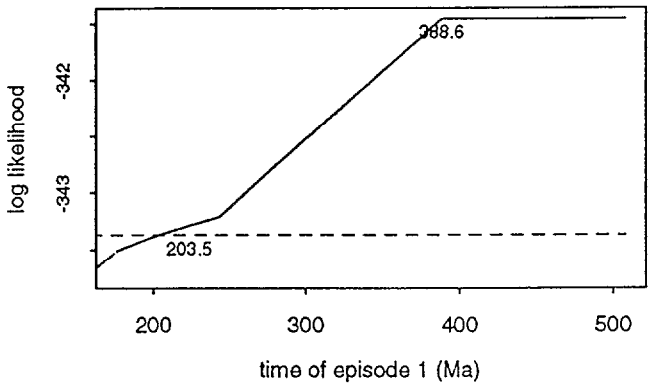
episode 2

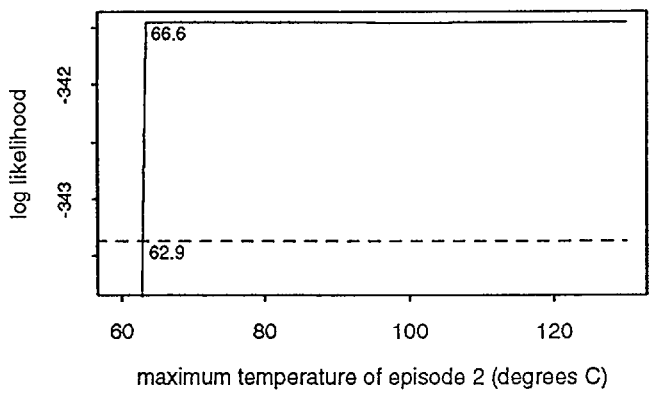


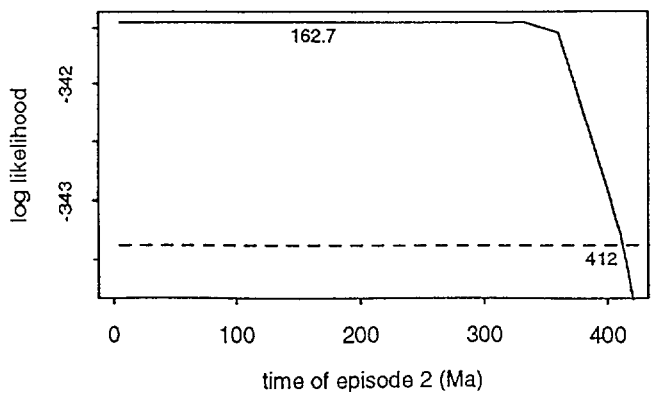
Mt Crispe-1 Gc550-16

profile likelihoods

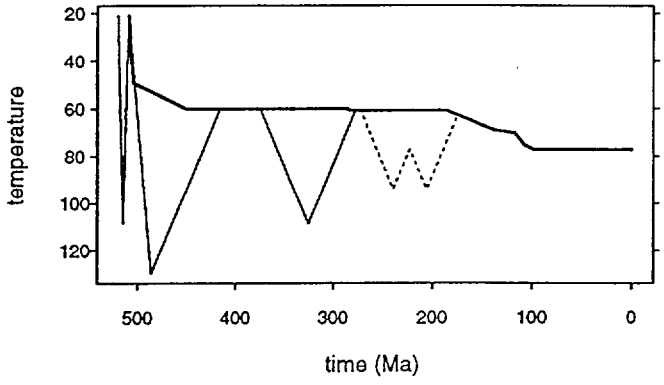


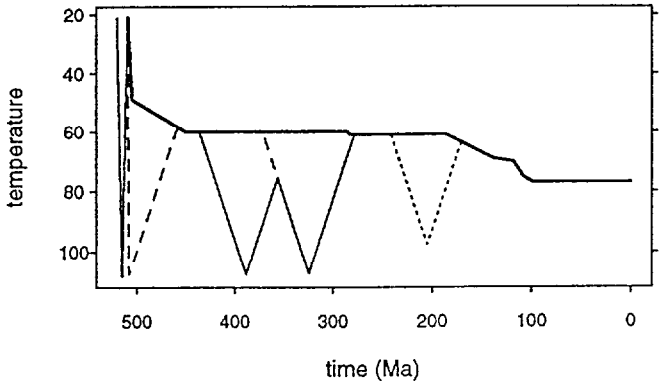


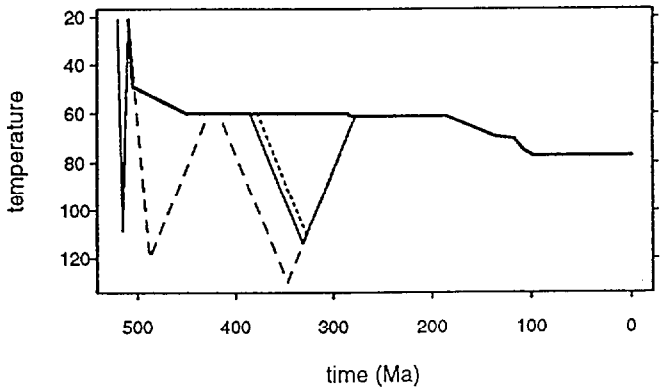


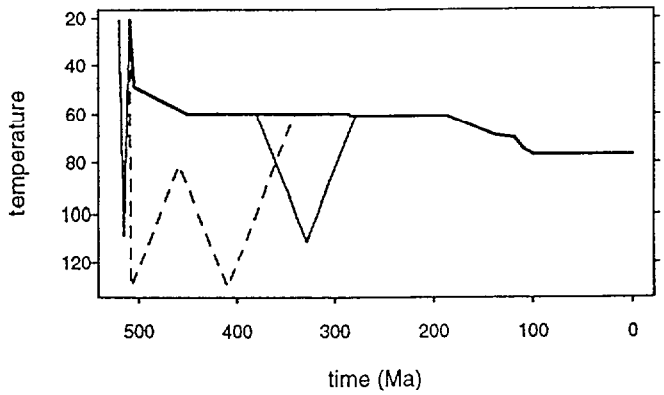


thermal histories









0003

SOURCE ROCK AND PETROLEUM GEOCHEMISTRY OF THE SIMPSON DESERT BASIN AND SUPERJACENT WESTERN EROMANGA BASIN

(Pandieburra-1, Poonarunna-1, Putamurdie-1)

Report for Department of Mines and Energy South Australia

by

BERND H. MICHAELSEN and DAVID M. McKIRDY

Organic Geochemistry in Basin Analysis Group
Department of Geology and Geophysics
University of Adelaide

December 1996

Mines & Energy SA
R97/00135
00141146

INTRODUCTION

This is the final in a series of reports* prepared for MESA, in which the hydrocarbon source potential of the Pedirka, Simpson Desert and western Eromanga Basins is reevaluated. Previous work focused on the Eringa Trough of the Pedirka Basin (Staples *et al.*, 1995a,b; Alexander et al., 1996) and the superjacent Jurassic and Cretaceous sequence comprising the far western Eromanga Basin. In this report we address the source rock geochemistry of the western Eromanga Basin in the area northeast of the Birdsville Track Ridge, and east to southeast of the Simpson Basin/Poolowanna Trough. Our interpretations are based largely on new analytical work commissioned by MESA on core samples from the Pandieburra-1, Poonarunna-1 and Putamurdie-1 exploration wells. We have augmented the new database with existing data from Mulapula-1 (McKirdy *et al.*, 1987) and Poonarunna-1 (McKirdy and Watson, 1986) to provide MESA with all the geochemical data currently available to us in this area.

SAMPLE SELECTION AND PREPARATION

In total 22 core and one cuttings samples were collected from the Pandieburra-1 (5 core), Poonarunna-1 (14 core, 1 cuttings) and Putamurdie-1 (3 core) wells (Table 1). Wherever possible, the darkest (organic-rich) lithologies were selected. The core samples were scraped and brushed clean to remove surficial contamination. The cuttings sample was meticulously washed and rinsed in distilled water using step-wise ultrasonification to remove drilling mud. This washed cuttings sample was then hand-picked to selectively remove sand and thereby concentrate the coaly lithology.

EXPERIMENTAL

Sub-specimens of the 22 core samples were cut perpendicular to bedding, mounted in resin and polished for petrographic analyses (Table 2). A representative sub-specimen of the cuttings sample was also prepared as a polished block. Reflectance measurements were made using a Leitz Ortholux Pol BK microscope under conditions specified by the Standards Association of Australia (1989). The means of random vitrinite (R_r %) reflectance were converted to means of maximum vitrinite reflectance (R_o %) using Kilby's (1991) formula, $R_o = 1.083 \times R_r$. All the samples except two coals from Pandieburra-1 (6157', 6159'5"), and the Poonarunna-1 (800 – 890') cuttings sample were crushed to powder in a Siebtechnik mill, and then analysed for total organic carbon (TOC) using a Leco WR-12 Carbon Determinator, and by Rock-Eval pyrolysis using a Girdel IFP-Fina Mark II operated in Cycle 1 mode (Table 3a).

The powders of four samples from Poonarunna-1 and one sample from Putamurdie-1 were extracted in Soxhlet apparatus using an azeotropic solvent mixture (CH_2Cl_2:CH_3OH, 93:7). The

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* 1 Staples C. J., Michaelsen B. H. and McKirdy D. M. (1995a) (Eringa Trough)

2 Staples C. J., Michaelsen B. H. and McKirdy D. M. (1995b) (Eringa Trough: supplementary report)

3 Michaelsen B. H., McKirdy D. M., Staples C. J. and Kagya M. N. L. (1995a) (Pedirka, Simpson Desert and western Eromanga Basin)

4 Michaelsen B. H. and McKirdy D. M. (1996a) (Vitrinite reflectance and organic petrography: Cherri-1, Mulapula-1, Weena-1)

extract was fractionated by liquid column chromatography on activated silica into saturated hydrocarbons, aromatic hydrocarbons and polar compounds (resins and asphaltenes) (see Table 4).

Gas chromatography-mass spectrometry of aromatic hydrocarbons

Gas chromatography-mass spectrometry (GC-MS) was undertaken using a Varian 3400 gas chromatograph interfaced to a Finnigan TSQ 70 mass spectrometer. The gas chromatograph was fitted with a 60 m x 0.25 mm i.d. fused silica column (DB-1, 0.25 μm film thickness; J&W Scientific). Helium was used as the carrier gas at an inlet pressure of approximately 23.5 psi. The oven was programmed as follows: 50°C for 2 min, 50° to 120°C at 8°C min^{-1}, 120° to 300°C at 4°C min^{-1} and then held at 300°C for 35 min. The injector was held at 60°C for 3 seconds then ramped to 300°C at 180°C min^{-1}, and held at 300°C for 5 minutes. Mass spectrometer operating parameters included an ionization voltage of 70 eV and a filament current of 200 μA. The photomultiplier voltage was set at 1100 V. Aromatic fractions in CH_2Cl_2 were injected on-column. The mass spectrometer was programmed (multiple ion detection: MID) to monitor *m/z* 128 (naphthalene), *m/z* 141 and 142 (methylnaphthalenes), *m/z* 156 (dimethylnaphthalenes), *m/z* 170 (trimethylnaphthalenes), *m/z* 178 (phenanthrene), *m/z* 192 (methylphenanthrenes), *m/z* 206 (dimethylphenanthrenes), *m/z* 219 (retene), *m/z* 231 and 245 (triaromatic steroids), and *m/z* 253 (monoaromatic steroids). A response factor of 0.69 was used to normalise the GC-MS data for phenanthrene (in calculating MPI) relative to the calibrated GC response . All aromatic hydrocarbon GC-MS parameters were calculated using peak areas.

Gas chromatography-mass spectrometry of saturated hydrocarbons

GC-MS conditions were identical to those used in the analysis of the aromatic hydrocarbons except that the photomultiplier voltage was set to 1800 V. The saturated hydrocarbon fractions were dissolved in *n*-hexane prior to injection and the mass spectrometer was programmed (multiple ion detection: MID) to monitor *inter alia m/z* 123 (sesquiterpenoids, triterpanes), *m/z* 163 (25,28,30-trisnorhopane), *m/z* 177 (demethylated hopanes), *m/z* 191 (hopanes/triterpanes), *m/z* 205 (homohopanes, methylhopanes), *m/z* 217 (steranes), *m/z* 218 (5α,14β,17β-steranes), *m/z* 231 (A-ring methylsteranes), and *m/z* 259 (diasteranes). All saturated hydrocarbon GC-MS parameters were calculated using peak areas.

RESULTS

The analytical data are presented herein as follows:

	Table	Figure	Appendix
Sample details	1		
Vitrinite reflectance data and petrographic descriptions	2		
Rock-Eval pyrolysis data: Pandieburra-1, Poonarunna-1, Putamurdie-1	3a		
Previous Rock-Eval pyrolysis data: Mulapula-1, Poonarunna-1	3b		
Rock extract database	4		
Aromatic hydrocarbon database	5		

	Table	Figure	Appendix
Saturated hydrocarbon biomarker database	6		
Rock-Eval pyrolysis data : T_{max} *versus* HI cross-plots			
• Pandieburra-1, Poonarunna-1, Putamurdie-1		1	
• Mulapula-1 (data from McKirdy *et al.*, 1987)		2	
• Poonarunna-1 (data from McKirdy and Watson, 1986)		3	
TOC *versus* HI cross-plot (Pandieburra-1, Poonarunna-1, Putamurdie-1)		4	
Aromatic hydrocarbon source cross-plots for rock extracts		5	
Cross-plots of 1-MP/9-MP *versus* 2-MP/1-MP		6	
Cross-plots of various rearranged hopane parameters		7	
Cross-plots of various source and maturity-related biomarker parameters		8	
Published (open file) Rock-Eval pyrolysis data: T_{max} *versus* HI cross-plots			A
• Poolowanna Formation (western sector)		i	
• Poolowanna Formation (eastern sector)		ii	
• Hutton Sandstone (western sector)		iii	
• Hutton Sandstone (eastern sector)		iv	
• Birkhead Formation (western sector)		v	
• Birkhead Formation (eastern sector)		vi	
• Adori Sandstone (eastern sector)		vii	
• Murta Formation, Namur Sandstone and Adori Sandstone (western sector)		viii	
• Westbourne Formation (eastern sector)		ix	
• Namur Sandstone (eastern sector)		x	
• McKinlay Member (eastern sector)		xi	
• Murta Formation (eastern sector)		xii	
• Cadna-owie Formation (western sector)		xiii	
• Cadna-owie Formation (eastern sector)		xiv	
• Bulldog Shale (western sector)		xv	
• Bulldog Shale (eastern sector)		xvi	
Aromatic hydrocarbons (molecular structures)			B
Triterpenoid biomarkers (molecular structures)			C
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Various hopane biomarker parameters plotted against HI			E
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GC-MS mass fragmentograms of aromatic hydrocarbons			G
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DISCUSSION

Source potential and thermal maturity based on Rock-Eval pyrolysis

Rock-Eval pyrolysis data from Table 3a are plotted on a T_{max} *versus* HI cross-plot (Figure 1). Evolution pathways for Types I, II, and III kerogen are shown, as are iso-reflectance curves which correspond to the upper and lower limits of the oil window (0.5% and 1.35% R_o, respectively). The TOC, Rock-Eval and directly measured R_o data can be summarized as follows:

Birkhead Formation

Two Birkhead Formation samples from Pandieburra-1 have only poor to moderate organic richness (TOC = 0.84 & 1.01%; $S_1 + S_2$ = 1.43 & 1.66 kg hydrocarbons per tonne: Table 3a) and contain gas-prone Type III kerogen (HI = 158 and 165). Under the microscope, vitrinite and liptinite are the most abundant maceral groups, with lesser amounts of inertinite (Table 2). The liptinites comprise chiefly sporinite and liptodetrinite. Vitrinite reflectance (R_o = 0.54 & 0.60%) and Rock-Eval pyrolysis-derived maturity estimates (T_{max} = 437 & 438° C: Table 3) concur in suggesting that these samples are *immature* for liquid hydrocarbon generation, given their Type III kerogen composition (Figure 1).

By contrast, Birkhead samples from the Poonarunna-1 and Putamurdie-1 wells contain highly oil-prone Type II kerogen (HI = 277 – 553) for which Rock-Eval T_{max} values (438 – 444° C) suggest a maturity corresponding to the range 0.65 – 0.85% R_o. Organic richness for these samples ranges from moderate (e.g. TOC = 1.11%; $S_1 + S_2$ = 3.44 kg hydrocarbons per tonne: Putamurdie-1, 4785'1") to excellent (e.g. TOC = 19.70%; $S_1 + S_2$ = 98 kg hydrocarbons per tonne: Poonarunna-1, 5338'2"). There is a hint of a positive correlation between liptinite content and hydrogen index. For example, the best source rock sample (Poonarunna-1, 5209'3": HI = 553, TOC = 3.56%) is exceptionally liptinite-rich and contains abundant cutinite with lesser amounts of sporinite, resinite and minor *Botryococcus*-type telalginite (Table 2). The aforementioned maturity estimates conflict with measured vitrinite reflectance (0.38 – 0.60% R_o) even when excluding the samples where *obvious* R_o suppression is present (see Table 2). Therefore, we conclude that R_o suppression occurs throughout the sequence at the Poonarunna-1 and Putamurdie-1 localities. In such cases Rock-Eval pyrolysis-derived maturity estimates are preferred over directly measured R_o. Since Type II kerogen enters the oil window ahead of Type III kerogen (Type II ≈ 0.5% R_o; Type III ≈ 0.7% R_o), *it is highly likely that the Birkhead sequence intersected at Poonarunna-1 and Putamurdie-1 is presently an effective oil source. Furthermore, the level of maturity suggests the Birkhead Formation may be at the peak of its oil generation.*

Namur Sandstone

The Namur Sandstone, as represented by five samples from Poonarunna-1, has an organic richness ranging from poor (0.77% TOC; $S_1 + S_2$ = 2.03 kg hydrocarbons per tonne: Poonarunna-1, 5018'3") to excellent (6.04% TOC; $S_1 + S_2$ = 28 kg hydrocarbons per tonne: Poonarunna, 4986') and contains *predominantly* Type II kerogen (HI = 251 -- 538; see Fig. 1). As viewed under the microscope, vitrinite is generally dominant over liptinite, with inertinite subordinate (Table 2). However, in the most oil-prone sample (HI = 538: Poonarunna-1, 5001') liptinite is the dominant maceral group. The liptinites in all samples are chiefly sporinite and sporinite-derived liptodetrinite.

Measured vitrinite reflectance suggests a thermal maturity of between 0.4 and 0.5% R_o, at variance with T_{max} data which indicate a significantly higher maturity between 0.65 and 0.80% R_o. Again, we consider the T_{max}-derived maturity estimates to be more accurate.

As in the Birkhead Formation, R_o suppression is probably also an important factor in the Namur Sandstone.

Rock-Eval data from the 1980s

Figures 2 and 3 summarize previously reported Rock-Eval pyrolysis data for Mulapula-1 (McKirdy *et al.*, 1987) and Poonarunna-1 (McKirdy and Watson, 1986).

Hutton Sandstone

Two samples from Mulapula-1 possess fair to good source source richness (TOC = 1.58 & 2.30%; $S_1 + S_2$ = 4 & 7 kg hydrocarbons per tonne) and fair to good source quality (HI = 220 and 273) for liquid hydrocarbon generation.

Birkhead Formation

The ten Mulapula-1 samples from the Birkhead Formation display source richness parameters (TOC = 0.89 – 21.1%; $S_1 + S_2$ = 2 – 85 kg hydrocarbons per tonne) that are generally lower than those of the three Poonarunna-1 samples (TOC = 2.05 – 15.2%; $S_1 + S_2$ = 9 – 87 kg hydrocarbons per tonne). Source quality parameters in both Mulapula-1 and Poonarunna-1 are consistent with the newly acquired Poonarunna-1 data: HI values range from 199 to 561 indicating moderately oil-prone (Type II/III) to highly oil-prone (Type II kerogen). The maturity of the Birkhead at Mulapula-1 (≈ 0.55% R_o: Michaelsen and McKirdy, 1996a) is lower than that in Poonarunna-1 (≈ 0.65 – 0.8% R_o). McKirdy and Watson (1986) noted that the Birkhead facies in Poonarunna-1 is atypical because the liptinites include *lamalginite* as well as telalginite (cf. Table 2, sample 5256'). In the eastern Eromanga (i.e. the Eromanga Basin overlying the southern Cooper Basin), lamalginite is general absent from the Birkhead Formation (e.g. Cook, 1986). McKirdy and Watson (1986) concluded that the presence of lamalginite in the Birkhead Formation "may reflect the isolation of the Poonarunna-1 paludal environment from the main depocentre(s) of the Eromanga Basin during mid-Jurassic time".

Namur Sandstone

Based on three samples from the previous data set for Mulapula-1 and Poonarunna-1, the source richness (TOC = 0.36 – 2.50%; S_1+S_2 = 0.1 – 13 kg hydrocarbons per tonne: poor to good) and quality (HI = 22 – 548: very poor to excellent) of shaley intervals in the Namur Sandstone appears to be highly variable. Even so, the highest hydrogen index (HI = 561) in the old data set closely matches the highest value from the new data (HI = 553).

Cadna-owie Formation

A single sample from the Cadna-owie Formation in Mulapula-1 (TOC = 0.26%; $S_1 + S_2 \approx 3$ kg hydrocarbons per tonne; HI = 280) has poor source richness, but good source quality for liquid hydrocarbon generation. However, based on Rock-Eval analysis, it is submature for liquid hydrocarbon generation ($R_o \leq 0.5\%$).

Overall, the Rock-Eval data of McKirdy and Watson (1986; Poonarunna-1) and McKirdy *et al.* (1987; Mulapula-1) are consistent with the new data presented in this study.

Michaelsen and McKirdy (1996b) assembled all available Rock-Eval pyrolysis data for the Eromanga Basin in South Australia. These data were summarized in sixteen T_{max} *versus* HI cross-plots which are presented in Appendix I. Overall, the best potential source rocks are developed in the Poolowanna, Birkhead and Murta Formations. Of these, the Birkhead Formation has the greatest oil-generative potential. The Birkhead Formation has greater hydrocarbon potential *west* of the Birdsville Track ridge than where it overlies the southern Cooper Basin.

Mineral matrix adsorption of pyrolysate

Figure 4 provides an interesting perspective of the new TOC and Rock-Eval data from the Birkhead Formation and Namur Sandstone. The data are plotted as a TOC *versus* HI cross-plot and fall into one of two fields. The three exceptionally oil-prone samples (HI > 500) plot and have relatively low TOC values of between 1.44 and 3.56%. The more conventional samples with HI values of between 158 and 438 fall along a curve which indicates that there is a broad relationship between source richness (measured by TOC) and source quality (indicated by HI). For samples with TOC values between about 0.5% and 2.5%, there is a corresponding increase in HI with increasing TOC. However, samples with TOC values greater than about 2.5% consistently have hydrogen indices of around 400.

The correlation of HI with TOC for samples containing less than 2.5% TOC can be attributed to the fact that some S_2 pyrolysate is adsorbed by the mineral component of the rock during programmed Rock-Eval pyrolysis, and remains unmeasured by the FID detector. Therefore, samples with low TOC contents provide an unduly pessimistic assessment of source rock quality as measured by hydrogen index. Similar examples of mineral matrix suppression of S_2 pyrolysate (and HI) have been documented in the Eromanga Basin (e.g. Murta Formation: Powell *et al.*, 1989). It is conceivable that the three samples with HI values of greater than 500 could have even higher HI values were it not for their low TOC contents and associated retention of kerogen pyrolysate on the mineral matrix.

In an attempt to explain the exceptional preservation of oil-prone material (i.e. HI ≥ 500) in some samples, we plotted a large number of saturated and aromatic hydrocarbon biomarker parameters against HI (Appendices B and C). With the exception of two out of the three ethylcholestane parameters, there is poor correlation with hydrogen index. HI appears to directly correlate with C_{29} ααα 20S/20R and C_{29} βα-diasteranes/(ααα + αββ-steranes). Both these sterane parameters are known to be maturation as well as facies (source) dependant. Presently we cannot explain the significance (or otherwise!) of these correlations.

Aromatic hydrocarbon biomarkers

Alexander *et al.* (1988) demonstrated that 1,2,5-trimethylnaphthalene (1,2,5-TMN), 1-methylphenanthrene (1-MP), 1,7-dimethylphenanthrene (1,7-DMP) and retene are important biomarkers for the conifer family Araucariaceae. Araucariacean biomarkers are abundant in terrestrial rocks and oils of Jurassic age because these conifers were important members of the land

plant community during that time. However, Araucariaceae were absent from terrestrial plant communities during the Permian, and therefore these biomarkers are found in low concentrations in rocks and oils of this age. Figure 5 is a cross-plot which incorporates two source-dependant aromatic biomarker ratios. These parameters were developed and used by Alexander *et al.* (1988), and are powerful tools which can distinguish between Permian and Jurassic sourced oil in the Eromanga/Cooper Basin system. Michaelsen *et al.* (1996) used these parameters to establish a Jurassic source for the oils reservoired in the Poolowanna Formation in the Sturt and Tantanna fields. Moreover, we (Michaelsen and McKirdy, 1996c) recently showed that Poolowanna source rocks and oils are *intermediate* in composition between the Cooper Basin and those higher in the stratigraphic section. (i.e. from the Hutton Sandstone, Birkhead Formation and Namur Sandstone: Fig. 6). Figure 5 indicates that the Birkhead and Namur extracts from Poonarunna-1 and Putamurdie-1 have high 1,7-DMP/X and retene/9-MP values, characteristic of Jurassic source material. When plotted on a 2-MP/1-MP *versus* 1-MP/9-MP cross-plot (Fig. 6) and compared to data from the western Cooper Basin where a large data set has been compiled, it is evident that the relative concentration of araucariacean biomarkers in these samples is in fact greater than normally encountered in Eromanga Basin sediments. Based on these observations, *it is conceivable that oils derived from coals and shales in the western Eromanga Basin could inherit an atypically strong araucariacean biomarker signature.*

Various maturity estimates based on aromatic hydrocarbons are presented in Table 5. However, due to the exceptionally high araucariacean input into these samples, we consider all R_c estimates to be highly unreliable and they are not considered further.

Saturated hydrocarbon biomarkers

If maturity estimates based on measured vitrinite reflectance (R_o) and calculated vitrinite reflectance (R_c) are unreliable, what yardstick (other than Rock-Eval pyrolysis) does one use to measure maturation in these potential source rocks?

We have attempted to address this problem by comparing the saturated hydrocarbon data from the Birkhead Formation and Namur Sandstone at Poonarunna-1 and Putamurdie-1 with our western Cooper Basin database (Figures 7 and 8). The western Cooper Basin study (Michaelsen et al., 1996) established that the concentrations of rearranged hopanes relative to 17α-hopanes were important maturity parameters. In that study we compared the chemistries of rocks and oils from the Cooper Basin (Patchawarra and Tirrawarra Formations) with those from the Poolowanna Formation and found that the more mature ($R_o \approx 0.85 - 1.2\%$) Cooper Basin samples had elevated T_s/T_m, $C_{29}T_s/17\alpha$-30-norhopane and 17α-diahopane/17α-hopane ratios compared to the less mature ($R_o \approx 0.6 - 0.65\%$) Poolowanna rocks and oils. Figures 7a and b show the new western Eromanga data superimposed onto the fields for the Cooper Basin and the Poolowanna Formation. It appears that the Birkhead and Namur samples are of intermediate composition, and therefore probably of intermediate maturity (ie. $R_o \approx 0.7 - 0.85\%$). This agrees well with the maturity estimates based on Rock-Eval pyrolysis.

In the same study we found that the hopane/sterane ratio was also a useful maturity parameter. Cooper Basin rocks and oils have depleted hopane/sterane ratios because the thermodynamically less stable 17α-hopanes converted to the thermally favoured 18α-neohopane and 17α-hopanes with increasing maturity. However, the less mature Poolowanna samples had significantly higher hopane/sterane ratios and much lower concentrations of rearranged hopanes. Again, by superimposing the Birkhead and Namur data onto the Cooper Basin and Poolowanna Formation fields, it is evident that the Birkhead Formation and Namur Sandstone at Poonarunna-1 and Putamurdie-1 have hopane/sterane ratios which are intermediate between the Patchawarra Formation and Tirrawarra Sandstone (Cooper Basin) and the Poolowanna Formation (Sturt/Tantanna fields). This provides further evidence that directly measured vitrinite reflectance from the Birkhead Formation and Namur Sandstone in the western Eromanga Basin (Poonarunna-1 and Putamurdie-1) is unduly low.

CONCLUSIONS

1. The Birkhead Formation is the best hydrocarbon source rock in the western Eromanga Basin. However, thin shale intervals developed in the Namur Sandstone at Poonarunna-1 and Putamurdie-1 also have considerable oil-generative potential. At Poonarunna-1 and Putamurdie-1, the Birkhead Formation contains oil-prone Type II/III to Type II kerogen and Rock-Eval pyrolysis indicates a thermal maturity of *ca* 0.7 – 0.85% R_o, suggesting that the Birkhead Formation may presently be at (or close to) the peak of its oil generation. The Birkhead Formation and Namur Sandstone are more oil-prone *west* of the Birdsville track ridge, than where the Eromanga Basin overlies the southeastern Cooper Basin.

2. Petrographically measured vitrinite reflectance suggests a maturity of only *ca* 0.4 – 0.6% R_o. Therefore, it appears that significant R_o suppression, of the order of magnitude 0.25 – 0.30%, occurs in both the Birkhead Formation and Namur Sandstone at Poonarunna-1 and Putamurdie-1.

3. The Birkhead Formation is probably even more oil-prone than indicated by conventional Rock-Eval pyrolysis. For organically lean samples (i.e. TOC ≤ 2.5 – 3%), unduly pessimistic assessment of source rock quality is attributable to absorption of some kerogen pyrolysate by the mineral matrix.

4. Exceptional concentrations of the araucariacean biomarkers 1-methylphenanthrene, 1,7-dimethylphenanthrene and retene in the Birkhead Formation and Namur Sandstone at Poonarunna-1 and Putamurdie-1 render unusable maturity estimates (e.g. MPI) based on aromatic hydrocarbons.

5. Various saturated biomarker parameters (*viz* T_s/T_m, $C_{29}T_s$/17α-30-norhopane, 17α-diahopane/17α-hopane and hopane/sterane) confirm that the maturities of the Birkhead Formation and Namur Sandstone at Poonarunna-1 and Putamurdie-1 are considerably greater than indicated by measured vitrinite reflectance.

Key to maturity and source parameters: aromatic hydrocarbons

Molecular structures of the aromatic hydrocarbons, triterpenoid and steroid biomarkers are provided in Appendices B, C and D respectively.

$$\text{DNR} = \frac{\text{2,6-DMN + 2,7-DMN}}{\text{1,5-DMN}} \; ; \; \text{TNR} = \frac{\text{2,3,6-TMN}}{\text{1,3,5-TMN + 1,4,6-TMN}}$$

$$\text{MPI} = \text{methylphenanthrene index} = \frac{1.5\,[\text{2-MP + 3-MP}]}{\text{P + 1-MP + 9-MP}} \; ; \; \text{MPDF} = \frac{\text{2-MP + 3-MP}}{\text{2-MMP + 3-MP + 1-MP + 9-MP}}$$

where 1,5-DMN = 1,5-dimethylnaphthalene ; 2,6-DMN = 2,6-dimethylnaphthalene

2,7-DMN = 2,7-dimethylnaphthalene ; 1,3,5-TMN = 1,3,5-trimethylnaphthalene

1,4,6-TMN = 1,4,6-trimethylnaphthalene ; 2,3,6-TMN = 2,3,6-trimethylnaphthalene

1-MP = 1-methyphenanthrene ; 2-MP = 2-methylphenanthrene

3-MP = 3-methylphenanthrene ; 9-MP = 9-methylphenanthrene

1,7-DMP = 1,7-dimethylphenanthrene ; X = 1,3 + 3,9 + 2,10 + 3,10-dimethylphenanthrene

Key to maturity and source parameters: saturated hydrocarbons

DRIMANES:

$$\frac{C_{15}}{C_{16}} = \frac{\text{drimane}}{\text{homodrimane}}$$

$$\frac{R}{N} = \frac{\text{rearranged drimanes}}{\text{drimanes}} = \frac{\text{8-dimethyl-10-desmethyldrimane\# + 9-dimethyl-10-desmethyldrimane\#}}{\text{drimane + homodrimane}}$$

\# Structures 1 and 2, Peters and Moldowan 1993, p. 167.

HOPANES:

$$\frac{T_s}{T_m} = \frac{\text{18}\alpha\text{-22,29,30-trisnorneohopane}}{\text{17}\alpha\text{-22,29,30-trisnorhopane}} \; ; \; \frac{C_{29}T_s}{C_{29}\alpha\beta} = \frac{\text{18}\alpha\text{-30-norneohopane}}{C_{29}\alpha\beta = \text{17}\alpha\text{-30-norhopane}}$$

$$\frac{C_{30}T_s}{C_{30}\alpha\beta} = \frac{\text{18}\alpha\text{-neohopane}^{\S}}{\text{17}\alpha\text{-hopane}}$$ § $C_{30}T_s$ includes the coeluting C_{29} fernane (*cf.* Michaelsen et al., 1995b).

$$\frac{C_{30}^{*}}{C_{30}\alpha\beta} = \frac{\text{17}\alpha\text{-diahopane}}{\text{17}\alpha\text{-hopane}} \; ; \; \frac{C_{29}\alpha\beta}{C_{30}\alpha\beta} = \frac{\text{17}\alpha\text{-30-norhopane}}{\text{17}\alpha\text{-hopane}} \; ; \; C_{30}\,\frac{\alpha\beta}{\beta\alpha} = \frac{\text{17}\alpha\text{-hopane}}{\text{17}\beta\text{-hopane}}$$

$$C_{31}\,\frac{22S}{22R} = \text{homohopane}\,\frac{22S}{22R} \; ; \; \frac{BNH}{C_{30}\alpha\beta} = \frac{\text{17}\alpha\text{- and 17}\beta\text{-28,30-bisnorhopane}}{\text{17}\alpha\text{-hopane}}$$

$$\frac{Hop}{Ster} = \frac{\text{17}\alpha\text{-hopane + 17}\beta\text{-hopane}}{\text{5}\alpha\text{,14}\alpha\text{,17}\alpha + \text{5}\alpha\text{,14}\beta\text{,17}\beta\text{-ethylcholestane + 13}\beta\text{,17}\alpha\text{-ethyldiacholestane}}$$

STERANES:

$$C_{29}\,\alpha\alpha\alpha\frac{20S}{20R} = \text{5}\alpha\text{,14}\alpha\text{,17}\alpha\text{-ethylcholestane}\,\frac{20S}{20R}$$

$$C_{29}\,\frac{\alpha\beta\beta}{\alpha\alpha\alpha+\alpha\beta\beta} = \text{ethylcholestane (20S+20R)}\,\frac{\text{5}\alpha\text{,14}\beta\text{,14}\beta}{\text{5}\alpha\text{,14}\alpha\text{,17}\alpha+\text{5}\alpha\text{,14}\beta\text{,17}\beta}$$

$$C_{29}\,\frac{\beta\alpha}{\alpha\alpha\alpha+\alpha\beta\beta} = \frac{\text{13}\beta\text{,21}\alpha\text{-ethyldiacholestane}}{\text{5}\alpha\text{,14}\alpha\text{,17}\alpha+\text{5}\alpha\text{,14}\beta\text{,17}\beta\text{-ethylcholestane}}$$

$$\frac{C_{27}}{C_{29}} = \frac{\text{cholestane}}{\text{ethylcholestane}} \; ; \; \frac{Hop}{Ster} = \frac{\text{17}\alpha\text{-hopane + 17}\beta\text{-hopane}}{\text{ethylcholestane + ethyldiacholestane}}$$

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TABLE 1: Sample details (core samples unless indicated).

Well	Depth	Stratigraphy	Lithology
Pandieburra-1	5142'6"	Birkhead Fm	Siltstone/Shale
Pandieburra-1	5752'4"	Birkhead Fm	Siltstone
Pandieburra-1	6157'	Birkhead Fm	Coal (thin layer in sandstone)
Pandieburra-1	6159'5"	Birkhead Fm	Coal (thin layer in sandstone)
Pandieburra-1	7133"	Dullingari Gp	Siltstone
Poonarunna-1 *	800–890'	Winton Fm	Coal
Poonarunna-1	4986'	Namur Sandstone	Coaly shale
Poonarunna-1	4994'9"	Namur Sandstone	Siltstone
Poonarunna-1	5001'	Namur Sandstone	Shale/Siltstone
Poonarunna-1	5018'3"	Namur Sandstone	Siltstone
Poonarunna-1	5019'0–2'	Namur Sandstone	Siltstone
Poonarunna-1	5194'2"	Birkhead Fm	Coaly shale
Poonarunna-1	5209'3"	Birkhead Fm	Siltstone
Poonarunna-1	5253'6–10"	Birkhead Fm	Siltstone
Poonarunna-1	5256'	Birkhead Fm	Siltstone
Poonarunna-1	5318'6–9"	Birkhead Fm	Siltstone
Poonarunna-1	5324'1–3"	Birkhead Fm	Shale/Siltstone
Poonarunna-1	5331'6–8"	Birkhead Fm	Coaly shale
Poonarunna-1	5332'7–9"	Birkhead Fm	Coal shale
Poonarunna-1	5338'2"	Birkhead Fm	Shaley coal
Putamurdie-1	4778'9"	Birkhead Fm	Siltstone/Shale
Putamurdie-1	4785'1"	Birkhead Fm	Siltstone
Putamurdie-1	4785'4"	Birkhead Fm	Shale

* cuttings sample

TABLE 2: Vitrinite reflectance data and petrographic descriptions.

Sample	Lithology	R_o (%)	n	Petrographic description
Pandieburra-1				
5142'6"	Siltstone/Shale	0.54	26	Vitrinite ≥ liptinite > inertinite. Liptinites are almost entirely sporinite with minor liptodetrinite. Traces of resinite and cutinite. Rare ?lamalginite.
5752'4"	Siltstone	0.60	22	Vitrinite ≈ liptinite > inertinite (inertinite rare). Sporinite, liptodetrinite and resinite are common.
6157'	Coal	0.67	22	Entirely telocollinite.
6159'5"	Coal	0.66	24	As above, but also some eu-ulminite.
7133'	Siltstone	n.d.	-	Organically barren. Pyritic.
Poonarunna-1				
800'–890'	*Coal	0.43	45	Almost entirely telovitrinite (telocollinite, eu-ulminite, texto-ulminite). Minor resinite.
4986'	Coaly shale	0.38 0.40 (repeat)	41 41	Vitrinite > liptinite > inertinite. Abundant cutinite. Sporinite, liptodetrinite and bituminite common. Minor resinite/fluorinite.
4994'9"	Siltstone	0.37	15	Vitrinite > liptinite > inertinite. Sporinite and liptodetrinite common. Minor cutinite and resinite.
5001'	Shale/Siltstone	n.d.	-	Liptinite > vitrinite. Sporinite and liptodetrinite very common. Minor cutinite, and rare *Botryococcus*-type telalginite and resinite.
5018'3"	Siltstone	0.42	13	Organically lean. Vitrinite ≈ liptinite ≈ inertinite. Sporinite is the most abundant liptinite. Rare cutinite, resinite and *Botryococcus*-type telalginite. **Possible R_o suppression.**
5019'0–2"	Siltstone	0.50	31	Organically-lean. Vitrinite > liptinite > inertinite. Minor sporinite and liptodetrinite.
5194'2"	Coaly shale	0.48	37	Vitrinite > liptinite. Liptinites are almost entirely sporinite and liptodetrinite. Rare resinite and bituminite. Cutinite is very rare. Vitrinites are well-gelified (telocollinite) or degraded and associated with bituminite.
5209'3"	Siltstone	0.42	21	Exceptionally liptinite-rich sample. Cutinite > sporinite ≈ resinite > telalginite (*Botryococcus*-type). Some vitrinites are degraded and associated with bituminite. Other vitrinites are well gelified and occur as large phytoclasts up to 4 mm in maximum dimension.
5253'6–10"	Siltstone	0.47	22	Vitrinite ≥ liptinite > inertinite. Sporinite is the most abundant liptinite. *Botryococcus*-type telalginite present.
5256'	Siltstone	0.51	37	Vitrinite ≥ liptinite > inertinite (inertinite rare/absent). Sporinite and cutinite very common. Minor resinite, fluorinite and *Botryococcus*. Lamalginite (phytoplankton) also present.
5318'6–9"	Siltstone	0.33	5	Liptinite >> vitrinite > inertinite. Sporinite and sporinite-derived liptodetrinite are the dominant liptinites. Minor cutinite and rare *Botryococcus*-type telalginite. **R_o suppression.**

5324'1–3"	Shale/siltstone	0.40	8	Vitrinite ≈ sporinite > inertinite (inertinite rare/absent). Very minor resinite. **Possible R_o suppression.**
5331'6–8"	Coaly shale	0.60	37	Vitrinite > liptinite > inertinite. Most vitrinites are degraded and associated with bituminite. Other vitrinites have absorbed syngenetic resins causing vitrinite supression of some phytoclasts. Cutinite > sporinite ≈ resinite.
5332'7–9"	Coaly shale	0.58	36	Vitrinite > liptinite >> inertinite (inertinite rare/absent). Cutinite sporinite and resinite common.
5338'2"	Shaley coal	0.43	34	Well-layered coal containing predominantly vitrinite and cutinite. Banded vitrinites are highly gelified (telocollinite predominates). Telocollinite > cutinite > fluorinite/resinite > bituminite/liptodetrinite.
Putamurdie-1				
4778'9"	Siltstone/Shale	0.58	33	Vitrinite ≥ liptinite > inertinite. Vitrinites are well gelified and include telocollinite. Cutinite abundant, resinite common. Traces of *Botryococcus*-related telalginite.
4785'1"	Siltstone	0.50	18	Organically lean. Vitrinite ≈ liptinite (inertinite almost entirely absent). Sporinite is the most common maceral, very minor resinite. Rare cutinite and ?*Botryococcus*-type telalginite.
4785'4"	Shale	0.46	36	Organically lean. However, some horizons are liptinite rich where resinite > sporinite > cutinite. Minor *Botryococcus*-type telalginite. Vitrinite ≈ liptinite >> inertinite (inertinite almost absent).

R_o = mean of maximum vitrinite reflectance; n = number of determinations used to calculate R_o.
* = cuttings sample; all other samples are core.

TABLE 3a: Rock-Eval pyrolysis data: Pandieburra-1, Poonarunna-1, Putamurdie-1.

Well	Depth	T_{max}	S_1	S_2	S_3	S_1+S_2	S_2/S_3	PI	PC	TOC	HI	OI
Pandieburra-1	5142'6"	438	0.06	1.60	0.52	1.66	3.07	0.04	0.13	1.01	158	51
Pandieburra-1	5752'4"	437	0.04	1.39	0.77	1.43	1.80	0.03	0.11	0.84	165	91
Pandieburra-1	7133"	390	0.05	0.09	0.51	0.14	0.17	0.36	0.01	0.56	16	91
Poonarunna-1	4986'	442	1.56	26.41	0.49	27.97	53.89	0.06	2.33	6.04	437	8
Poonarunna-1	4994'9"	437	0.90	11.38	0.27	12.28	42.14	0.07	1.02	2.86	397	9
Poonarunna-1	5001'	441	0.27	7.76	0.32	8.03	24.25	0.03	0.66	1.44	538	22
Poonarunna-1	5018'3"	440	0.06	1.97	0.29	2.03	6.79	0.03	0.16	0.77	255	37
Poonarunna-1	5019'0–2'	440	0.11	2.59	0.14	2.70	18.50	0.04	0.22	1.03	251	13
Poonarunna-1	5194'2"	441	4.20	38.95	1.08	43.15	36.06	0.10	3.59	9.34	417	11
Poonarunna-1	5209'3"	442	1.37	19.70	0.47	21.07	41.91	0.07	1.75	3.56	553	13
Poonarunna-1	5253'6–10"	442	0.34	4.78	0.34	5.12	14.05	0.07	0.42	1.72	277	19
Poonarunna-1	5256'	440	0.29	4.65	0.64	4.94	7.26	0.06	0.41	1.61	288	39
Poonarunna-1	5318'6–9"	443	1.05	9.98	0.52	11.03	19.19	0.10	0.91	1.96	509	26
Poonarunna-1	5324'1–3"	438	0.89	7.42	0.42	8.31	17.66	0.11	0.69	1.96	378	21
Poonarunna-1	5331'6–8"	444	4.25	36.64	0.84	40.89	43.61	0.10	3.40	9.19	398	9
Poonarunna-1	5332'7–9"	444	5.22	32.66	0.45	37.88	72.57	0.14	3.15	8.88	367	5
Poonarunna-1	5338'2"	443	11.33	86.31	1.42	97.64	60.78	0.12	8.13	19.70	438	7
Putamurdie-1	4778'9"	440	1.06	23.39	0.49	24.45	47.73	0.04	2.03	5.98	391	8
Putamurdie-1	4785'1"	438	0.14	3.30	0.34	3.44	9.70	0.04	0.28	1.11	297	30
Putamurdie-1	4785'4"	441	0.19	6.16	0.55	6.35	11.20	0.03	0.52	1.74	354	31

T_{max} = temperature of maximum generation of S_2 hydrocarbons

S_1 = mg hydrocarbons/g rock; S_2 = mg hydrocarbons/g rock; S_3 = mg CO_2/g rock

PI = $S_1/(S_1+S_2)$; PC = pyrolysable carbon; TOC = total organic carbon

HI = S_2/g TOC; OI = S_3/g TOC

TABLE 3b: Previous Rock-Eval pyrolysis data: Mulapula-1, Poonarunna-1.

Well	Depth	Sample type	T_{max}	S_1	S_2	S_3	S_1+S_2	S_2/S_3	PI	PC	TOC	HI	OI	Ref
Cadna-owie Formation														
Mulapula-1	3044'	SWC-54	430	0.13	0.73	0.27	0.86	2.70	0.15	0.07	0.26	280	103	2
Namur Sandstone														
Mulapula-1	3802'	SWC-33	430	0.76	7.81	0.65	8.57	12.01	0.09	0.71	2.50	312	26	2
Poonarunna-1	4999	Core	433	0.01	0.08	0.07	0.09	1.14	0.12	0.00	0.36	22	19	1
Poonarunna-1	5002'3"	Core	438	0.56	12.32	0.17	12.88	72.47	0.04	1.07	2.25	548	8	1
Birkhead Formation														
Mulapula-1	3968'	SWC-26	434	0.32	2.42	2.68	2.74	0.90	0.12	0.22	0.93	260	288	2
Mulapula-1	3993'	SWC-23	435	0.30	4.88	3.70	5.18	1.31	0.06	0.43	1.62	301	228	2
Mulapula-1	3999'9"	Core-1	434	0.26	5.87	1.09	6.13	5.38	0.04	0.51	1.25	470	87	2
Mulapula-1	4009'6"	Core-1	432	0.25	3.48	2.40	3.73	1.45	0.07	0.31	1.75	199	137	2
Mulapula-1	4013'1"	Core-1	432	0.14	2.95	1.18	3.09	2.50	0.05	0.25	1.28	230	92	2
Mulapula-1	4017'	Core-1	433	0.14	2.67	0.82	2.81	3.25	0.05	0.23	1.34	199	61	2
Mulapula-1	4022'11"	Core-1	432	0.23	3.57	2.22	3.80	1.60	0.06	0.31	1.54	357	222	2
Mulapula-1	4023'7"	Core-1	429	0.23	1.96	0.48	2.19	4.08	0.11	0.18	1.05	187	46	2
Mulapula-1	4023'9"	Core-1	422	7.24	78.06	2.44	85.30	31.99	0.08	7.10	21.10	370	12	2
Mulapula-1	4124'	SWC-17	432	0.41	2.44	4.74	2.85	0.51	0.14	0.23	0.89	274	533	2
Poonarunna-1	5194'2"	Core	437	1.49	24.42	0.37	25.91	66.00	0.06	2.15	4.35	561	9	1
Poonarunna-1	5326'2"	Core	435	0.94	8.25	0.69	9.19	11.95	0.10	0.76	2.05	402	34	1
Poonarunna-1	5335'4"	Core	437	7.37	79.51	0.97	86.88	81.96	0.08	7.24	15.20	523	6	1
Hutton Sandstone														
Mulapula-1	4461'	SWC-8	431	0.74	6.27	0.20	7.01	31.35	0.11	0.58	2.30	273	9	2
Mulapula-1	4471'	SWC-7	431	0.58	3.48	0.27	4.06	12.88	0.14	0.33	1.58	220	17	2

T_{max} = temperature of maximum generation of S_2 hydrocarbons

S_1 = mg hydrocarbons/g rock; S_2 = mg hydrocarbons/g rock; S_3 = mg CO_2/g rock

PI = $S_1/(S_1+S_2)$; PC = pyrolysable carbon; TOC = total organic carbon

HI = S_2/g TOC; OI = S_3/g TOC

References: 1. McKirdy and Watson, 1986; 2. McKirdy *et al.*, 1987

TABLE 4: Rock extract database.

Well	Depth	TOC (%)	EOM (ppm)	EOM (mg/g TOC)	EOM bulk composition Sat (%)	Aro (%)	Pol (%)
Pandieburra-1	5001'	1.44	1089	76	50.0	24.2	25.8
Pandieburra-1	5018'3"	0.77	621	81	37.8	23.7	21.6
Poonarunna-1	5209'3"	3.56	3125	88	62.1	21.4	16.3
Poonarunna-1	5253'6–10"	1.72	1641	95	41.4	34.0	19.5
Putamurdie-1	4778'9"	5.98	3928	66	33.2	48.0	18.8

TOC = Total Organic Carbon; EOM = Extractable Organic Matter; Sat = Saturated hydrocarbons; Aro = Aromatic hydrocarbons; Pol = Polar compounds = Resins + Asphaltenes

TABLE 5: Aromatic hydrocarbon database for rock extracts and measured vitrinite reflectance.

Well	Depth	DNR	TNR	1,2,5-TMN / 1,3,6-TMN	1-MP / 9-MP	2-MP / 1-MP	1,7-DMP / X	Retene / 9-MP	MPI	MPDF	Calculated vitrinite reflectance (% R_c) (1)	(2)	(3)	(4)	(5)	(6)	R_o (%) (7)	n
Poonarunna-1	5001'	2.82	-	-	3.96	0.21	4.45	10.03	0.22	0.22	0.37	0.53	2.17	0.27	0.33	1.02	n.d.	-
Poonarunna-1	5018'3"	-	-	-	3.60	0.24	4.86	6.69	0.26	0.22	0.40	0.55	2.14	0.33	0.33	-	0.42	13
Poonarunna-1	5209'3"	2.22	-	-	5.04	0.17	3.96	17.34	0.21	0.20	0.37	0.53	2.17	0.18	0.28	0.99	0.42	21
Poonarunna-1	5253'6–10"	-	-	-	5.16	0.16	5.60	11.28	0.18	0.18	0.35	0.51	2.19	0.15	0.24	-	0.47	22
Poonarunna-1	4778'9"	1.88	-	-	7.50	0.15	5.11	25.00	0.19	0.18	0.35	0.51	2.19	0.12	0.24	0.98	0.58	33

$$DNR = \frac{2,6\text{-DMN} + 2,7\text{-DMN}}{1,5\text{-DMN}} \; ; \; TNR = \frac{2,3,6\text{-TMN}}{1,3,5\text{-TMN} + 1,4,6\text{-TMN}} \; ; \; MPR = \frac{2\text{-MP}}{1\text{-MP}} \; ; \; MPI = \frac{1.5\,[2\text{-MP} + 3\text{-MP}]}{P + 1\text{-MP} + 9\text{-MP}} \; ; \; MPDF = \frac{2\text{-MP} + 3\text{-MP}}{2\text{-MP} + 3\text{-MP} + 1\text{-MP} + 9\text{-MP}}$$

where 1,5-DMN = 1,5-dimethylnaphthalene ; 2,6-DMN = 2,6-dimethylnaphthalene ; 2,7-DMN = 2,7-dimethylnaphthalene

1,3,5-TMN = 1,3,5-trimethylnaphthalene ; 1,4,6-TMN = 1,4,6-trimethylnaphthalene ; 2,3,6-TMN = 2,3,6-trimethylnaphthalene

P = phenanthrene ; 1-MP = 1-methyphenanthrene ; 2-MP = 2-methylphenanthrene ; 3-MP = 3-methylphenanthrene

9-MP = 9-methylphenanthrene ; 1,7-DMP = 1,7-dimethylphenanthrene ; X = 1,3 + 3,9 + 2,10 + 3,10-dimethylphenanthrene

(1) R_c (%) = 0.7MPI + 0.22 (for R_c < 1.7%: Boreham *et al.*, 1988)

(2) R_c (%) = 0.6MPI + 0.4 (for R_c < 1.35%: Radke and Welte, 1983)

(3) R_c (%) = - 0.6MPI + 2.3 (for R_c > 1.35%: Radke and Welte, 1983)

(4) R_c (%) = 0.99 $\log_{10}$MPR + 0.94 (for R_c = 0.5 – 1.7%: Radke *et al.*, 1984)

(5) R_c (%) = 2.242MPDF - 0.166 (Kvalheim *et al.*, 1987)

(6) R_c (%) = 0.046DNR + 0.89 (for R_c = 0.9 – 1.5%: Radke *et al.*, 1984)

(7) R_o (%) = mean of maximum vitrinite reflectance converted from the mean of random (measured) vitrinite reflectance (R_r) using Kilby's (1991) formula (cf. Experimental). n = number of vitrinite reflectance determinations in calculating R_o.

TABLE 6: Saturated hydrocarbon biomarker database.

		DRIMANES		HOPANES							STERANES			
Well	Depth	$\frac{C_{15}}{C_{16}}$	$\frac{R}{N}$	$\frac{T_s}{T_m}$	$\frac{C_{29}T_s}{C_{29}\alpha\beta}$	$\frac{C_{30}T_s}{C_{30}\alpha\beta}$	$\frac{C^*_{30}}{C_{30}\alpha\beta}$	$\frac{C_{29}\alpha\beta}{C_{30}\alpha\beta}$	$\frac{C_{30}}{\alpha\beta/\beta\alpha}$	$\frac{C_{31}}{22S/22R}$	$\frac{C_{29}\ \alpha\alpha\alpha}{20S/20R}$	$\frac{C_{29}}{\alpha\beta\beta/\alpha\alpha\alpha+\alpha\beta\beta}$	$\frac{C_{29}}{\beta\alpha/\alpha\alpha\alpha+\alpha\beta\beta}$	$\frac{Hop}{Ster}$
Poonarunna-1	5001'	0.58	0.23	0.31	0.21	0.097	0.058	0.72	4.78	1.35	0.92	0.39	0.68	3.26
Poonarunna-1	5018'3"	0.46	0.23	0.18	0.16	0.086	0.058	0.67	5.44	1.28	0.62	0.37	0.52	2.82
Poonarunna-1	5209'3"	1.07	0.38	0.49	0.30	0.090	0.090	0.54	7.86	1.28	1.01	0.47	1.16	3.55
Poonarunna-1	5253'6–10"	0.65	0.41	0.43	0.57	0.114	0.090	0.34	4.98	1.39	0.68	0.44	0.52	6.73
Putamurdie-1	4778'9"	0.75	0.33	0.46	0.39	0.097	0.133	0.36	5.10	1.20	0.68	0.42	0.67	3.59

Key to drimane, hopane and sterane biomarker parameters is provided on page 9.

Figure 1

Rock-Eval pyrolysis: Pandieburra-1, Poonarunna-1, Putamurdie-1

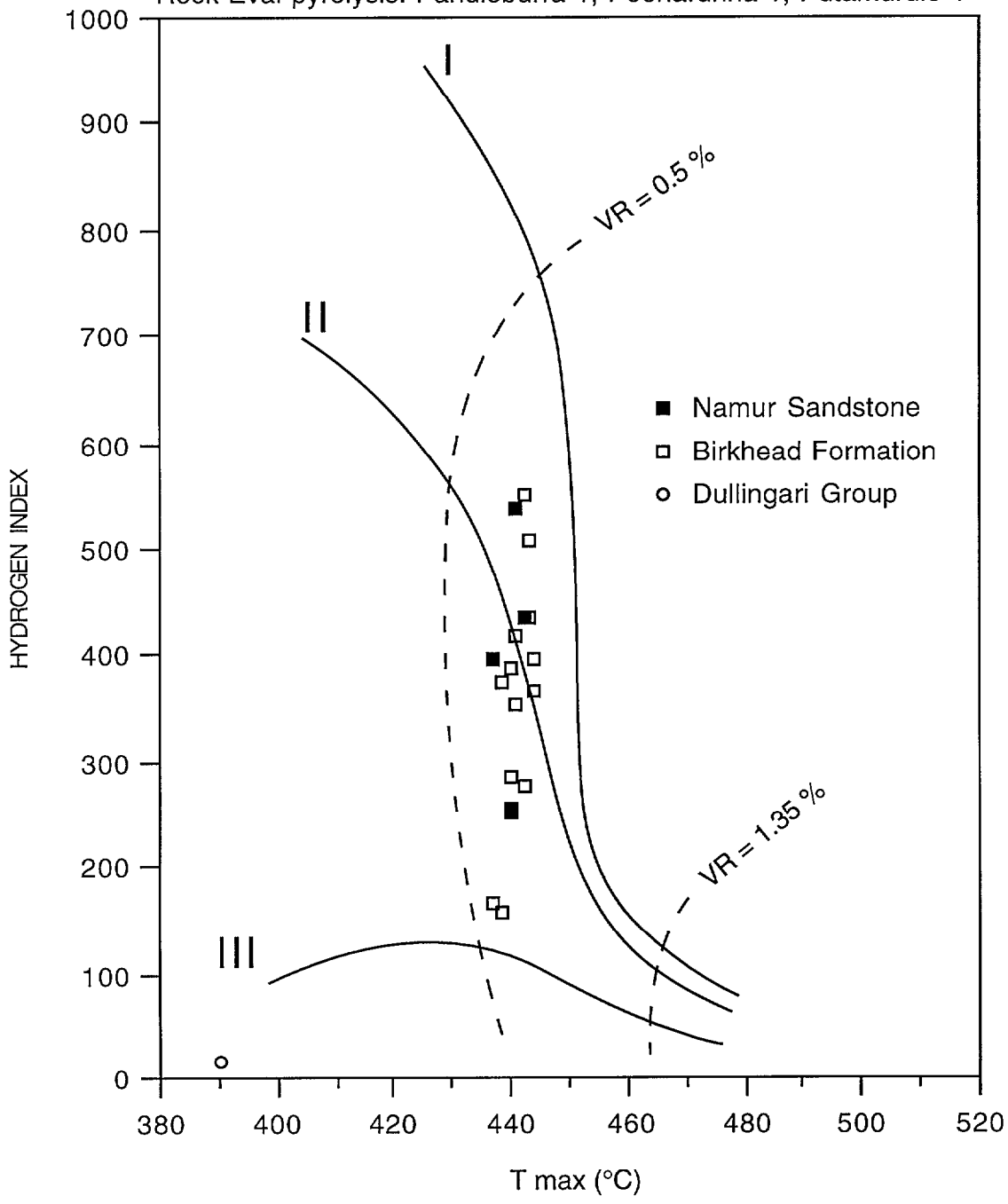


Figure 2

Rock-Eval pyrolysis: Mulapula-1 (McKirdy *et al.*, 1987)

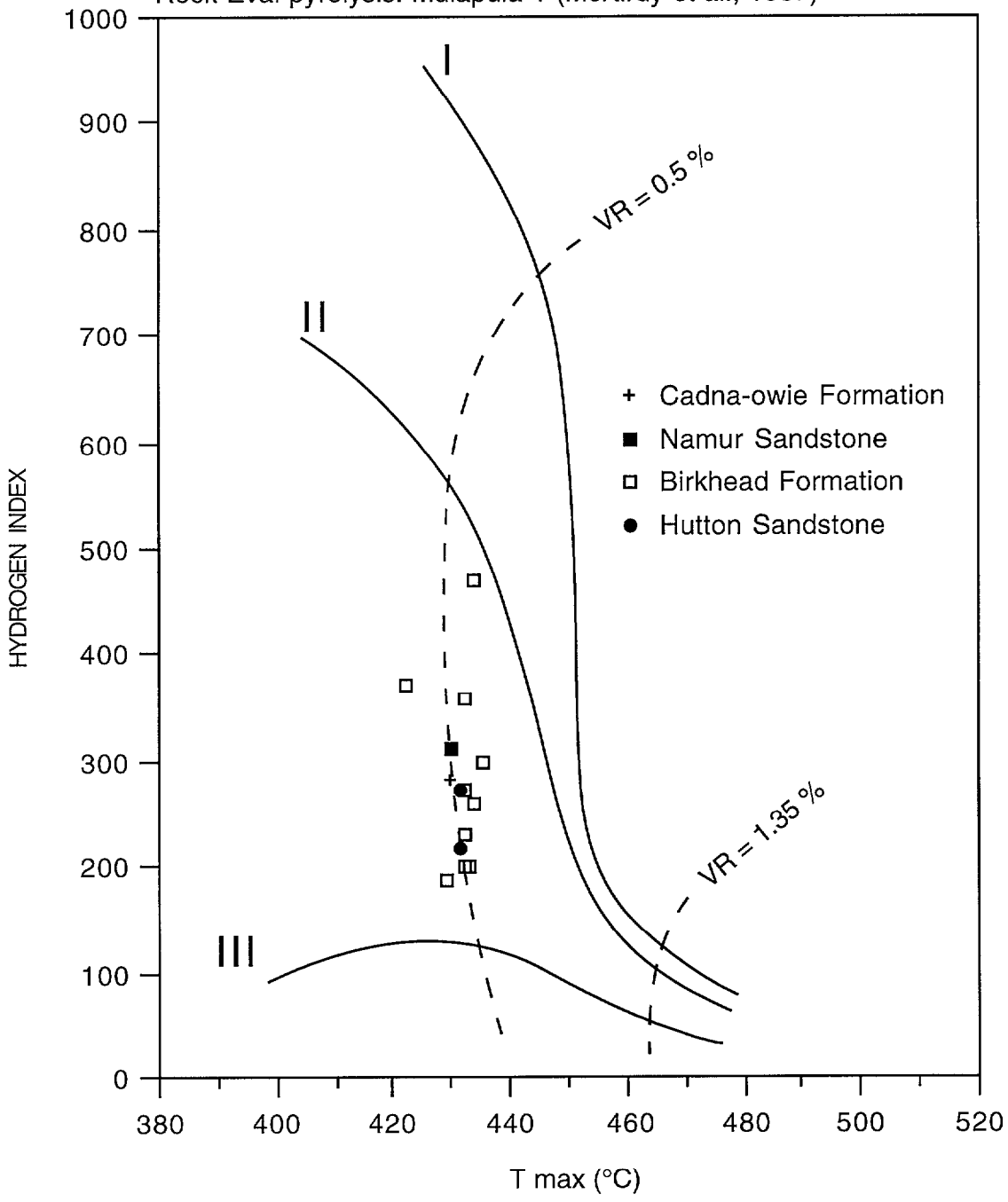


Figure 3

Rock-Eval pyrolysis: Poonarunna-1 (McKirdy and Watson, 1986)

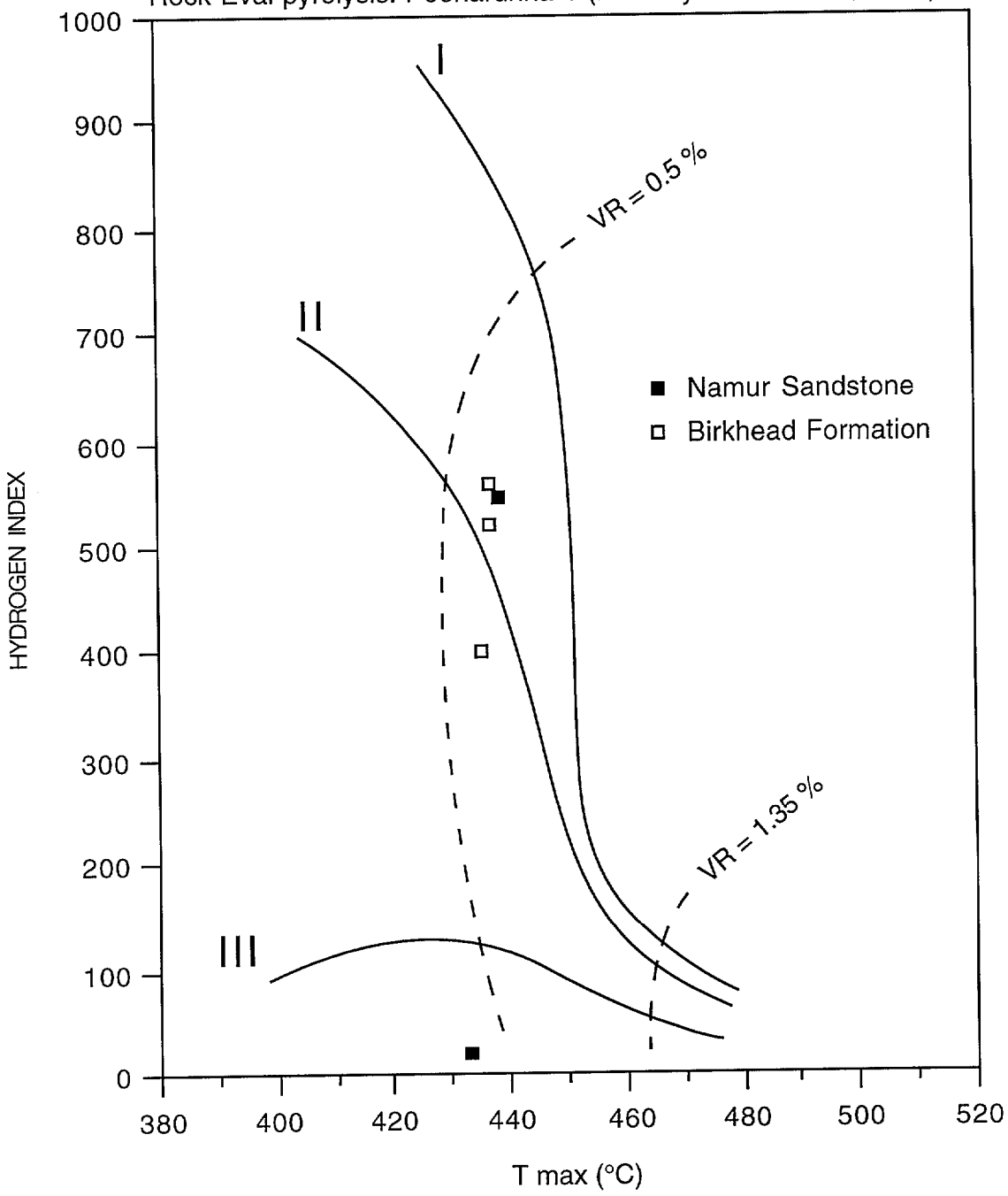


Figure 4

Total organic carbon (TOC) *versus* hydrogen index:
Pandieburra-1, Poonarunna-1, Putamurdie-1

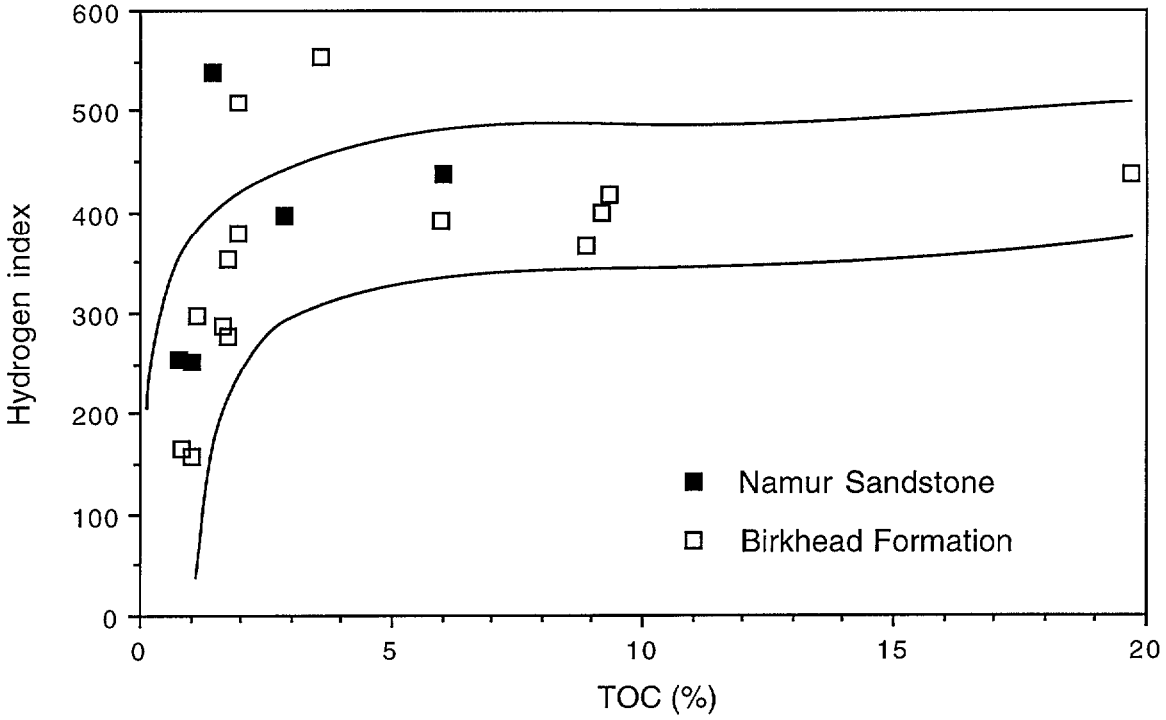


Figure 5

Aromatic hydrocarbon source cross-plots for rock extracts.

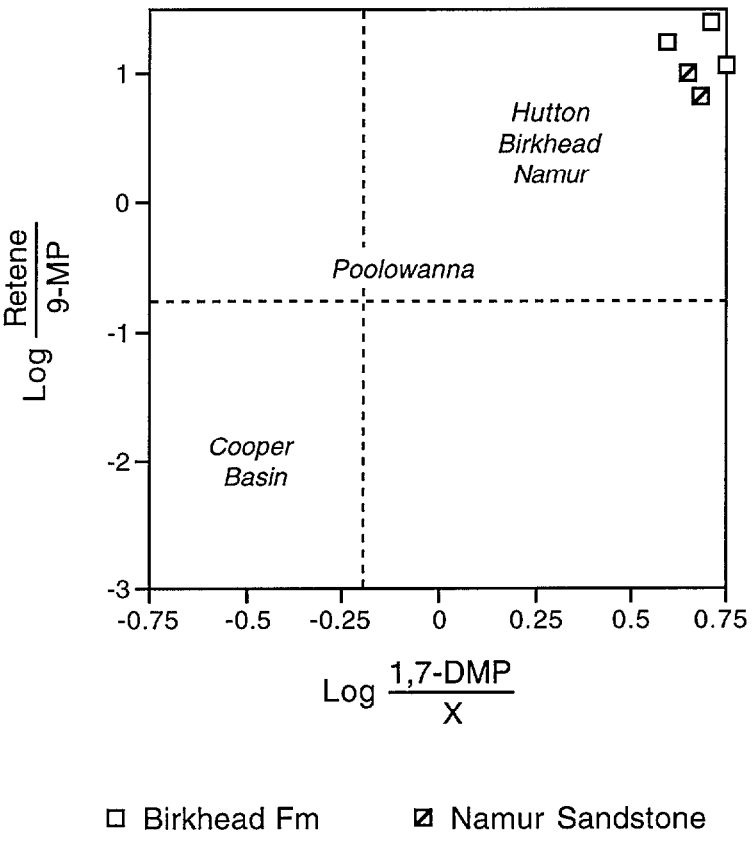
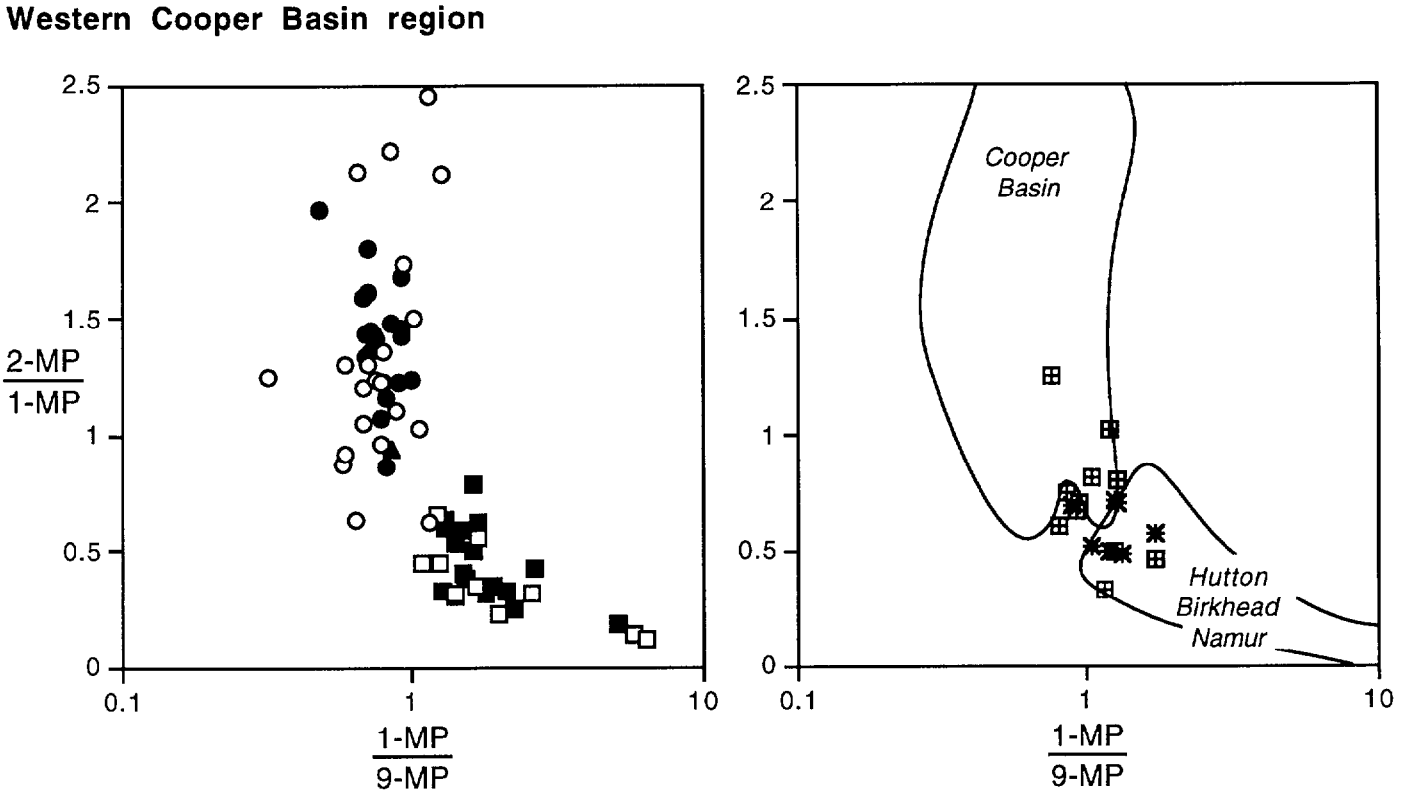


Figure 6

Cross-plots of 1-MP/9-MP *versus* 2-MP/1-MP. Comparison of data from the western Cooper Basin region (modified from Michaelsen and McKirdy, 1996) with data from the Birkhead Formation and Namur Sandstone in the western Eromanga Basin at Poonarunna-1 and Putamurdie-1.



Rock extracts
- ○ Permian
- □ Jurassic

Oils
- ● Permian
- ▲ Triassic
- ■ Jurassic

Poolowanna Fm
- ⊞ Rock extract
- ✱ Oil

1-MP = 1-methylphenanthrene
2-MP = 2-methylphenanthrene
9-MP = 9-methylphenanthrene

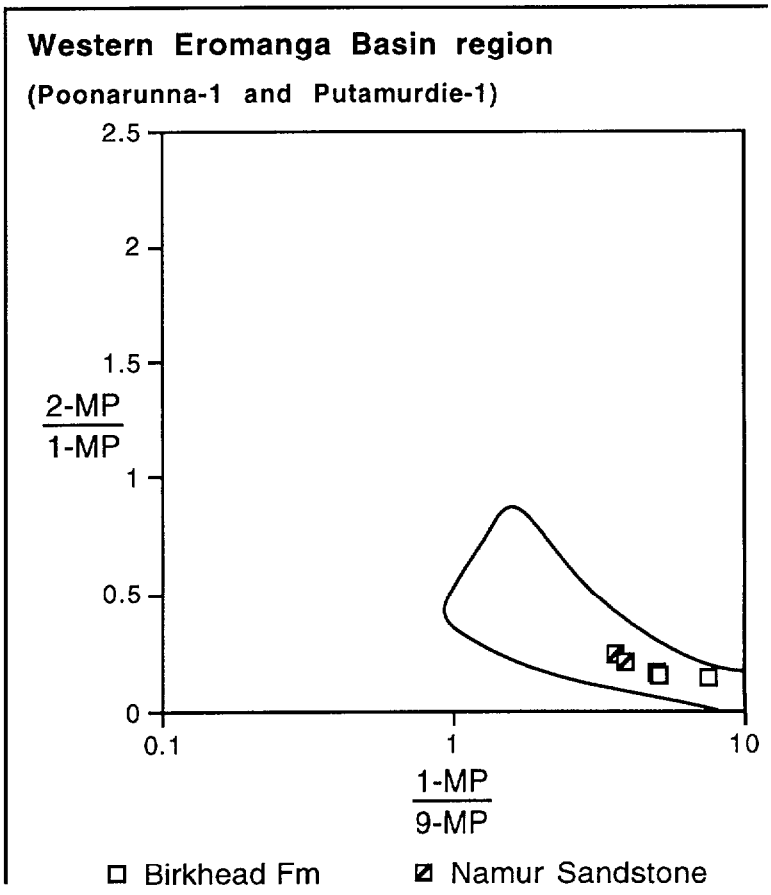
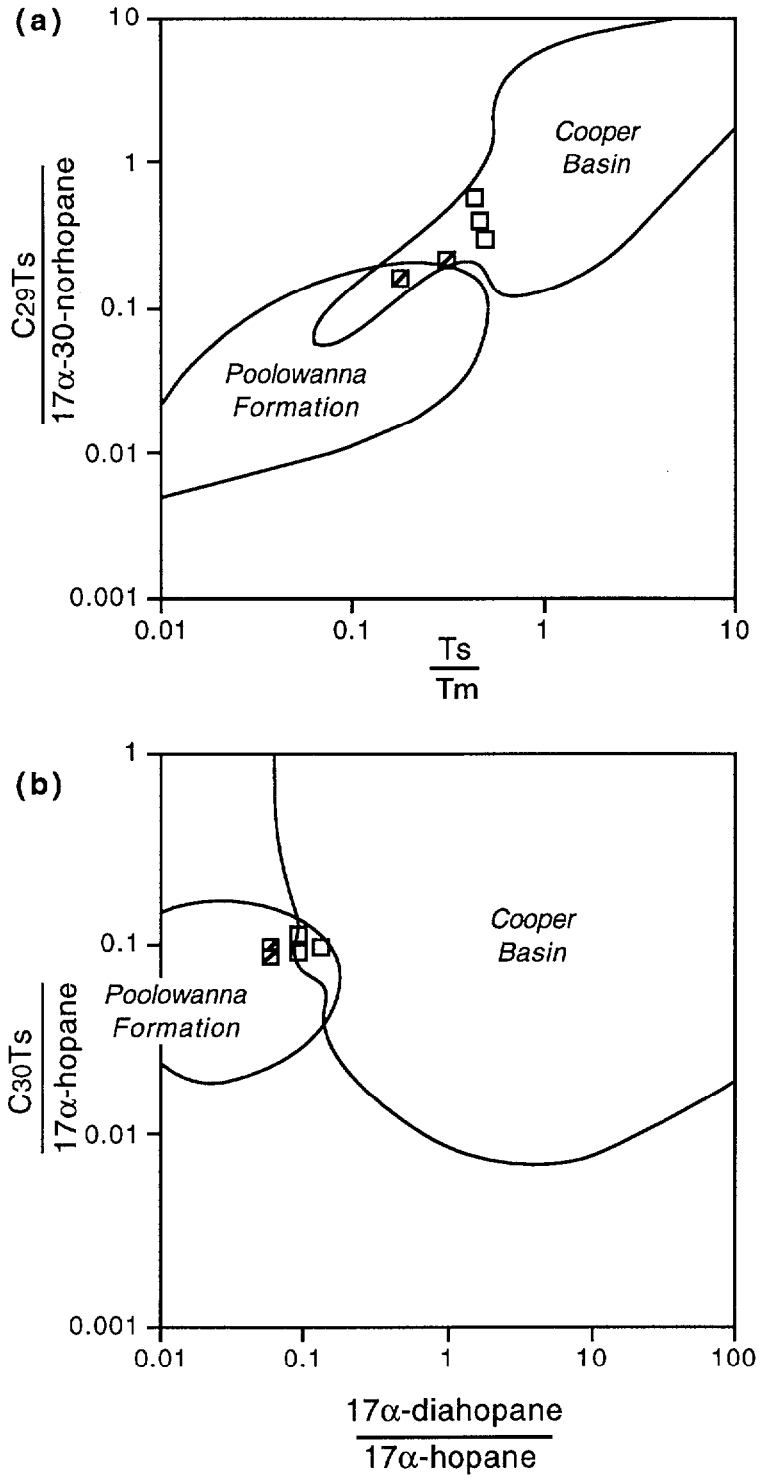


Figure 7

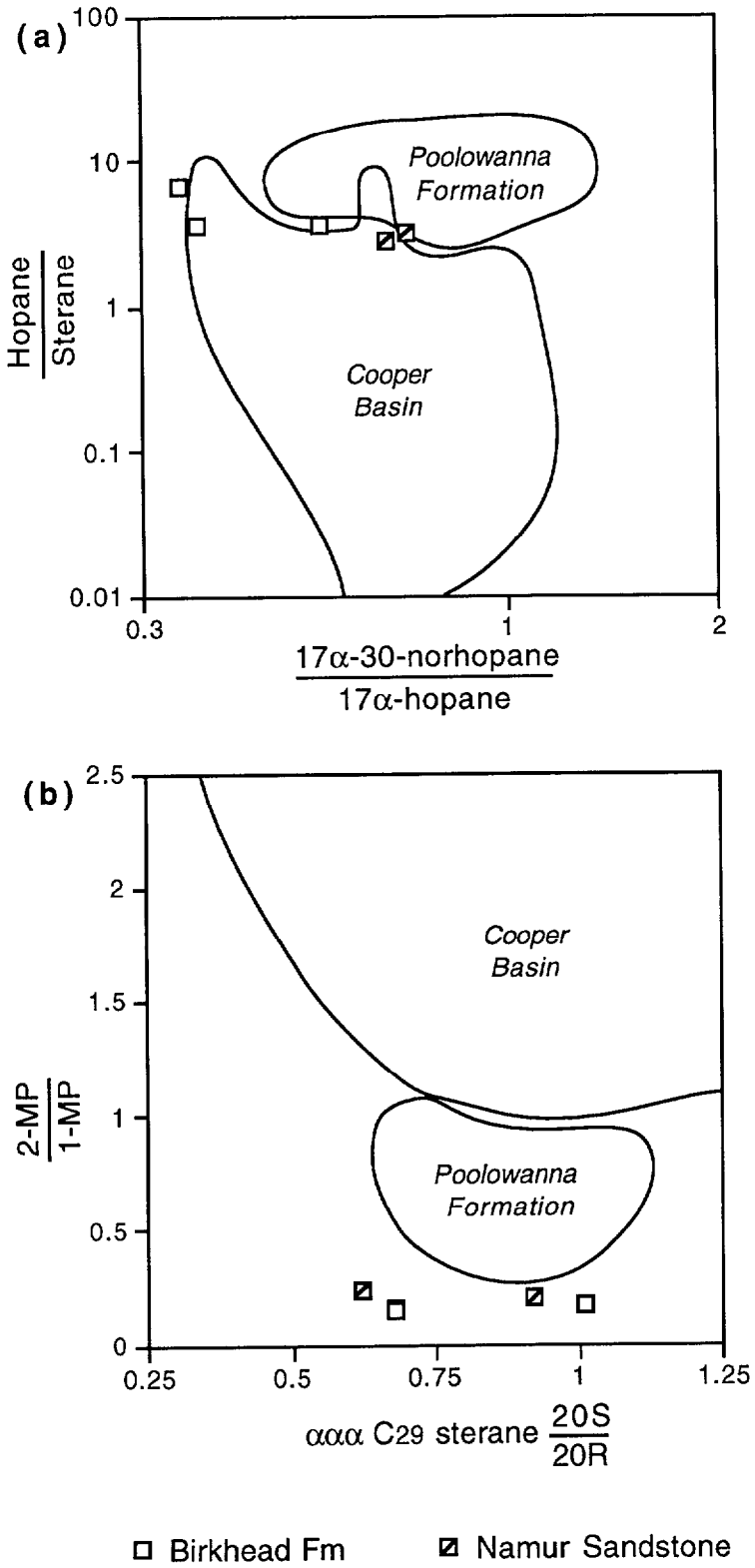
Cross-plots of various rearranged hopane parameters.



Cooper Basin and *Poolowanna Formation* fields refer to the western Cooper Basin (Michaelsen et al., 1996).

Figure 8

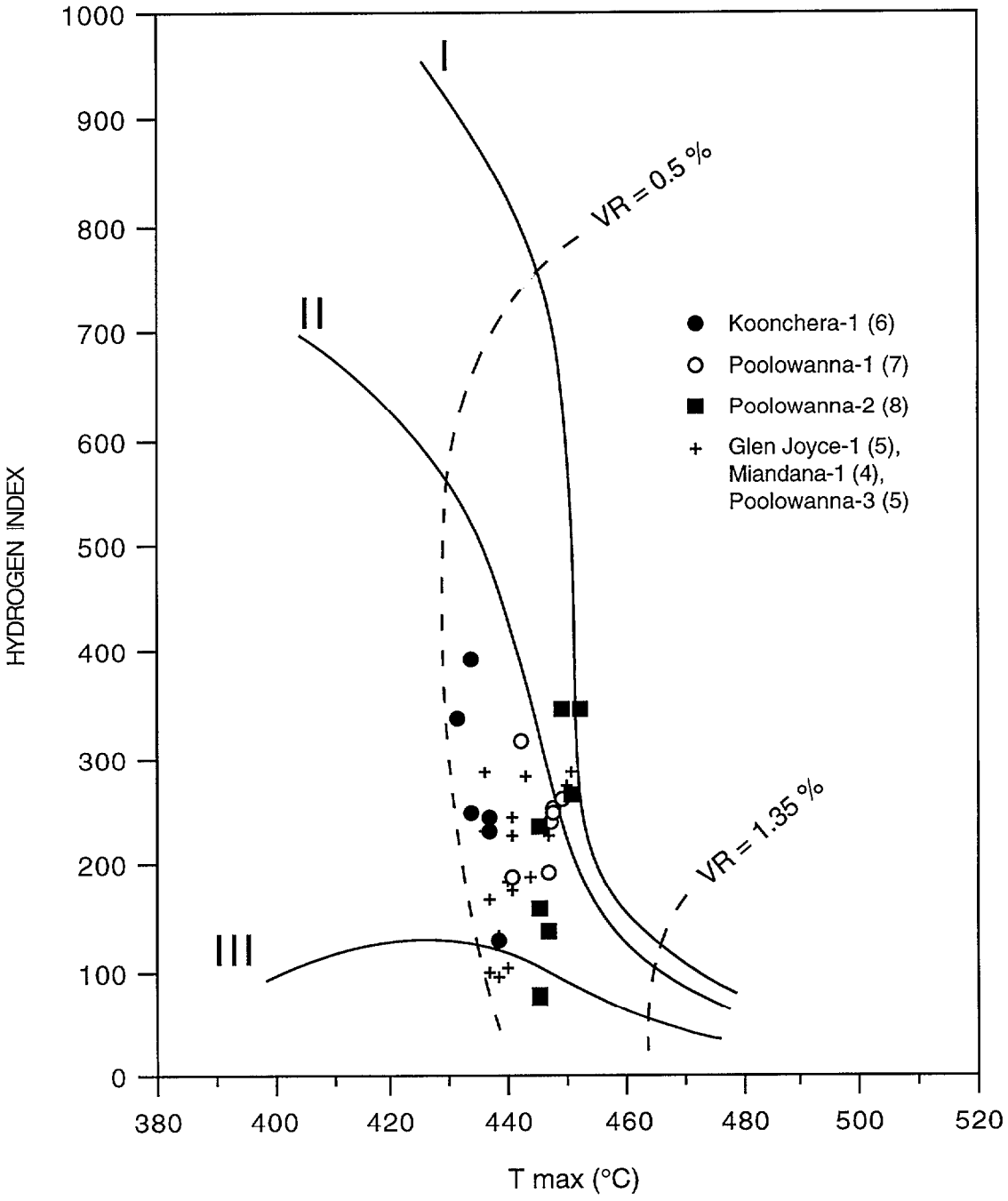
Cross-plots of various source and maturity-related biomarker parameters.



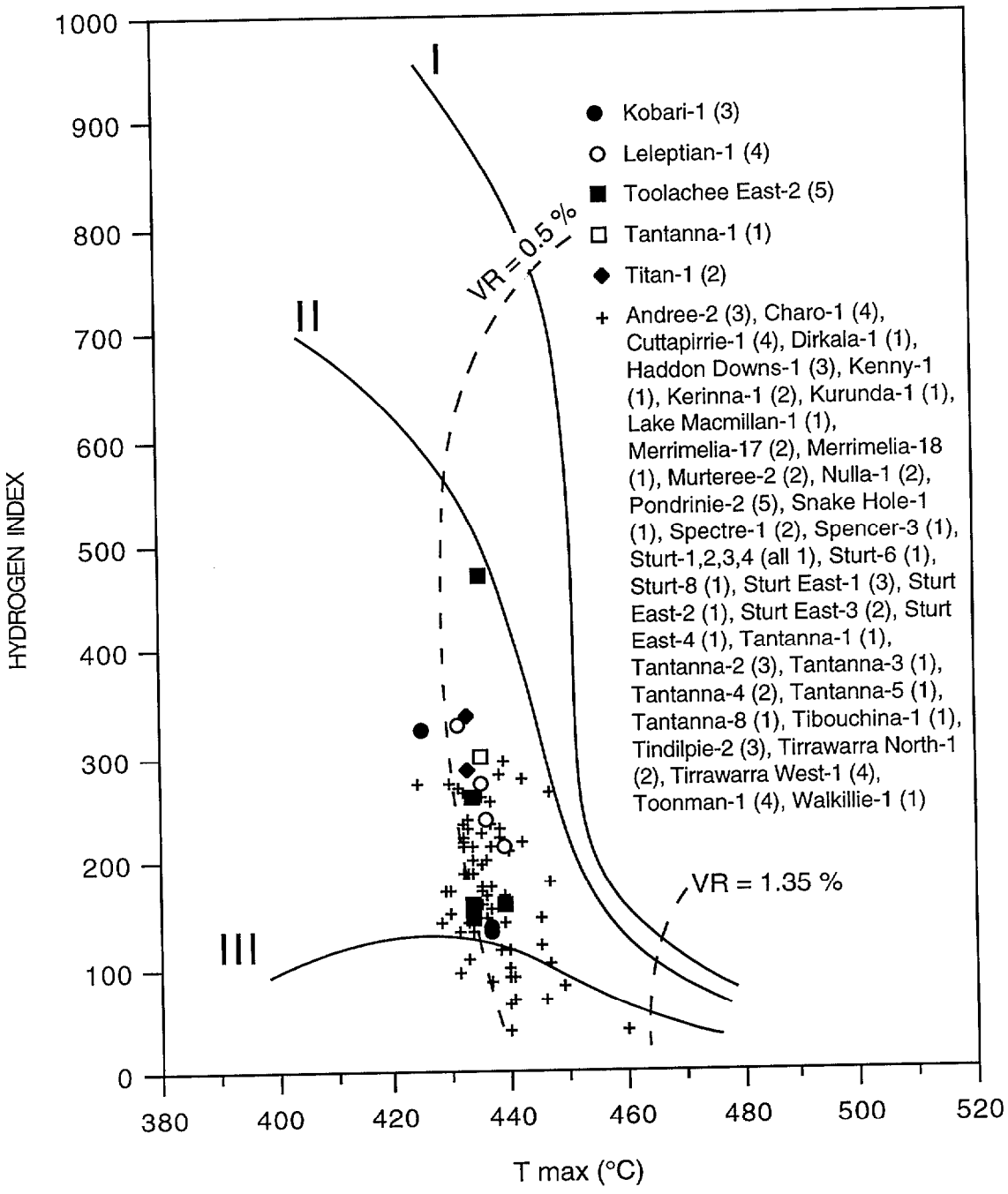
Cooper Basin and *Poolowanna Formation* fields refer to the western Cooper Basin (Michaelsen et al., 1996).

Appendix A

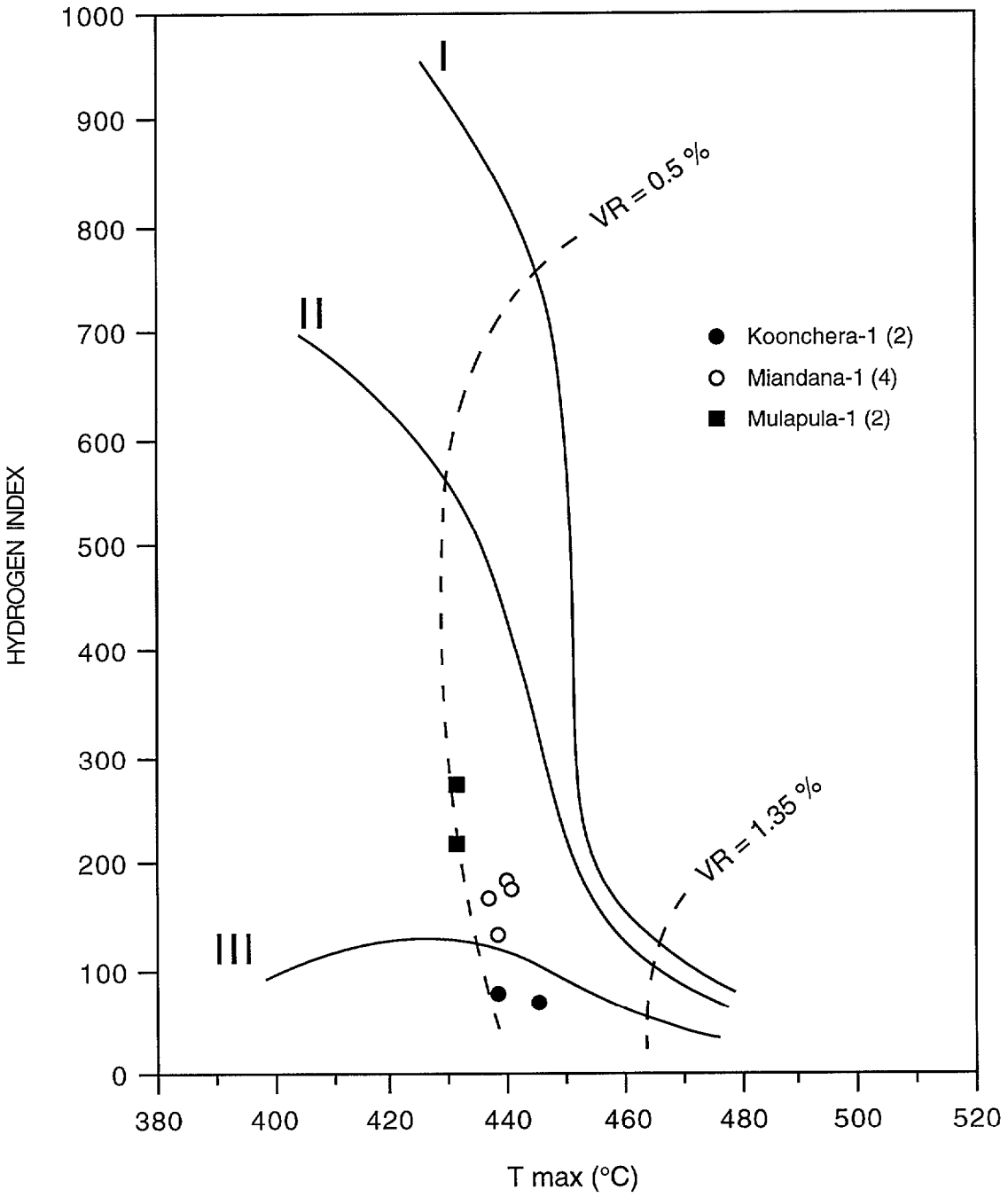
Published (open file) Rock-Eval pyrolysis data: T_{max} *versus* HI cross-plots



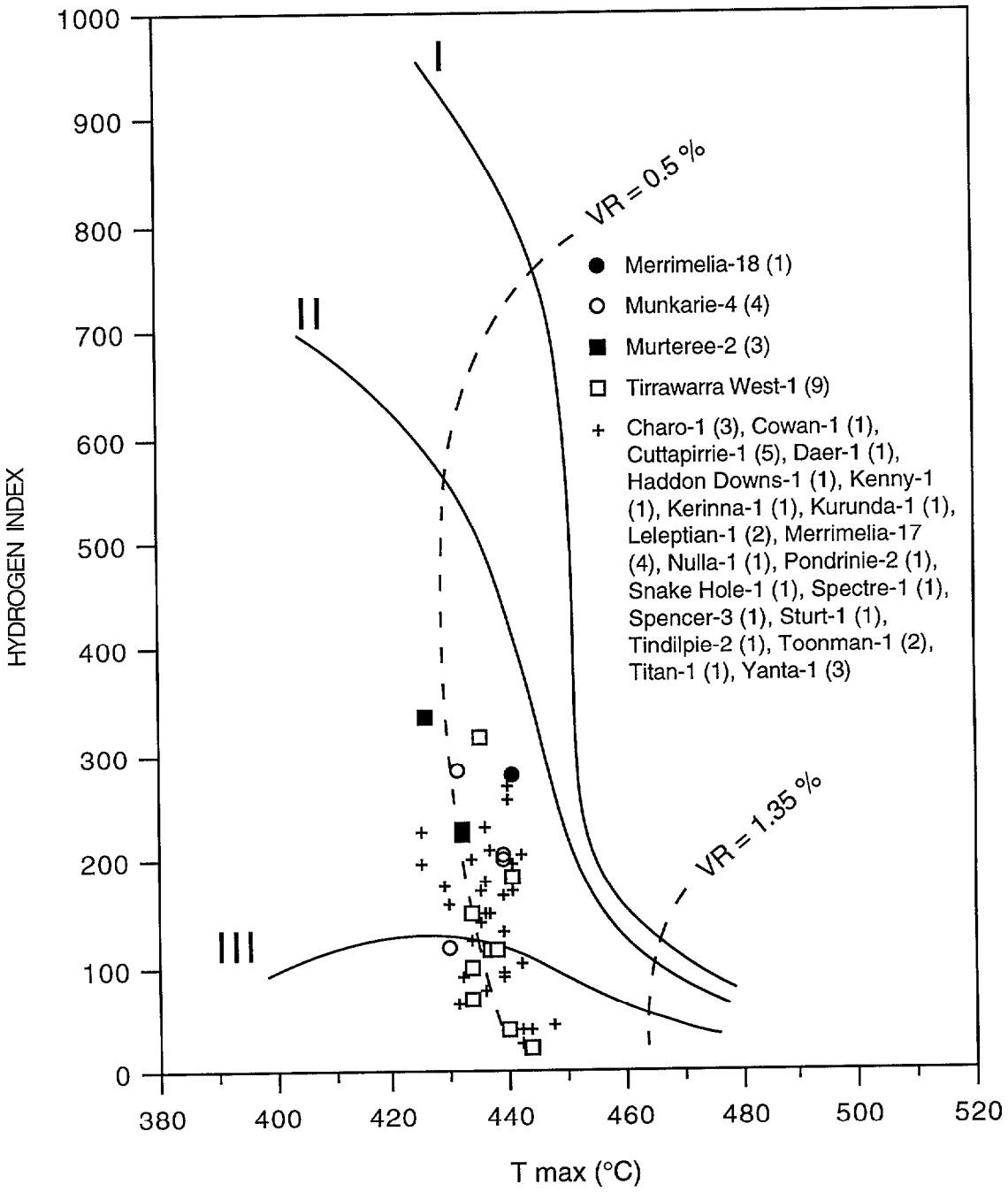
Tmax *versus* HI plot, Poolowanna Formation, Eromanga Basin, South Australia (western sector).



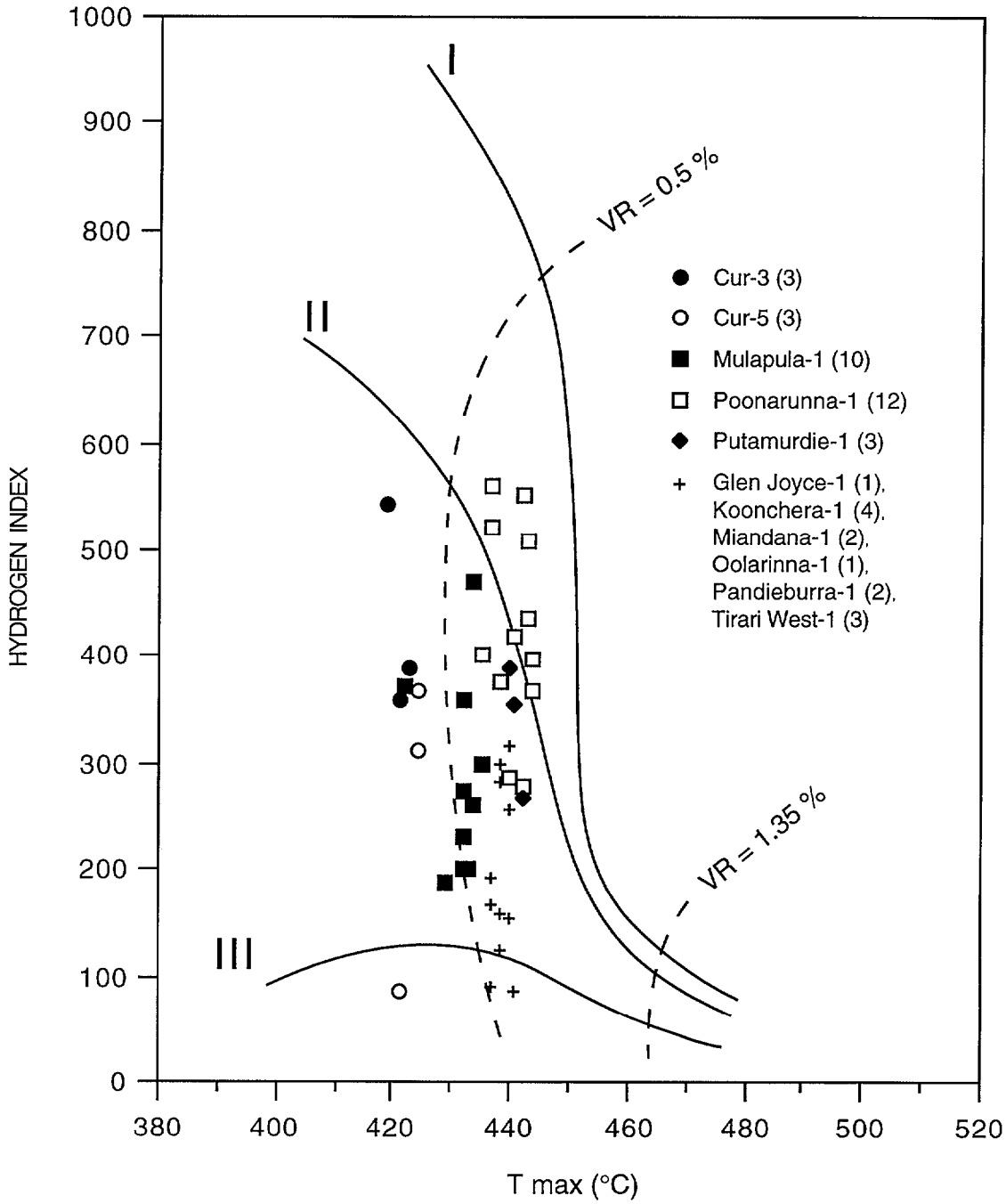
Tmax *versus* HI plot, Poolowanna Formation, Eromanga Basin, South Australia (eastern sector).



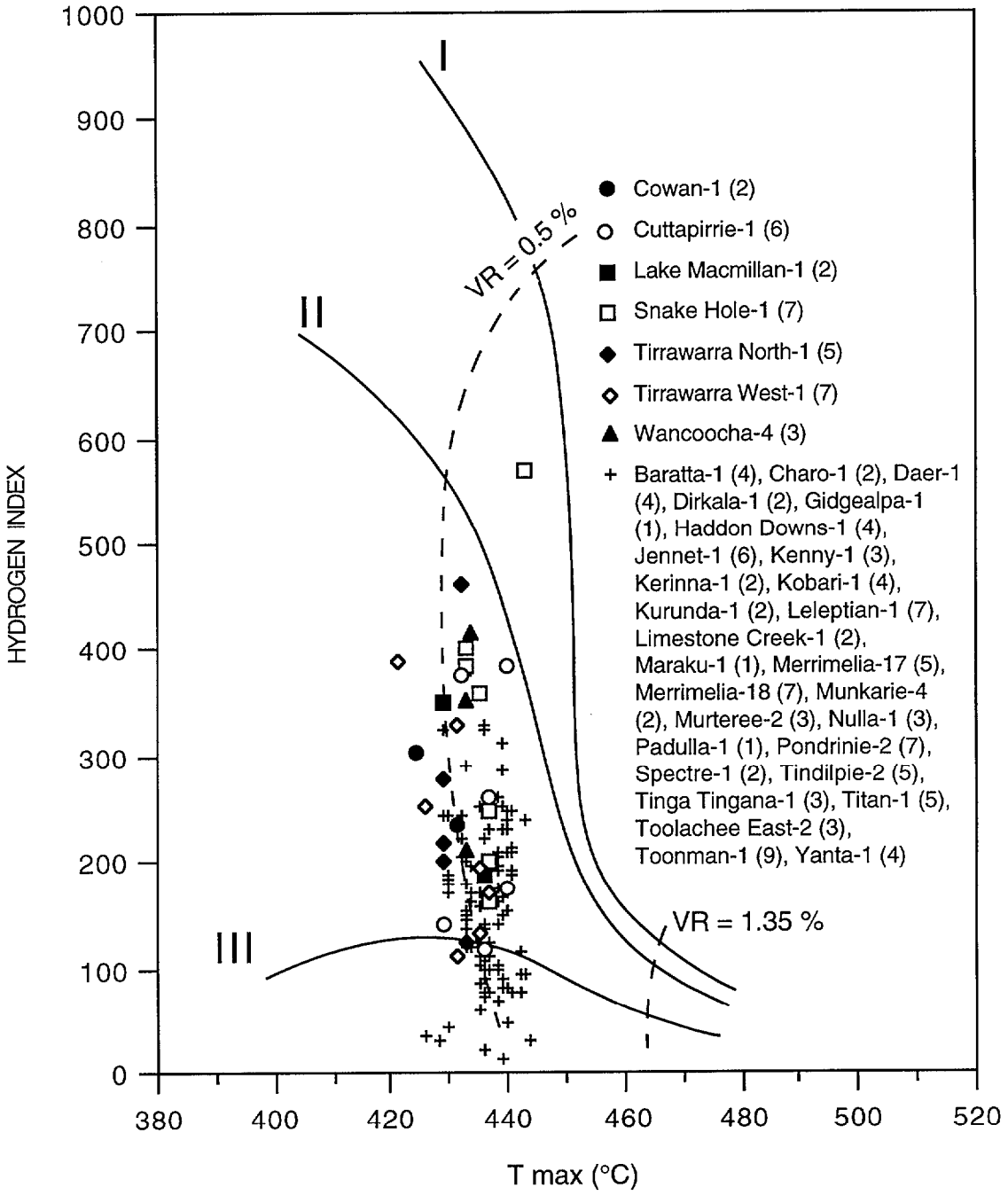
Tmax *versus* HI plot, Hutton Sandstone, Eromanga Basin, South Australia (western sector).



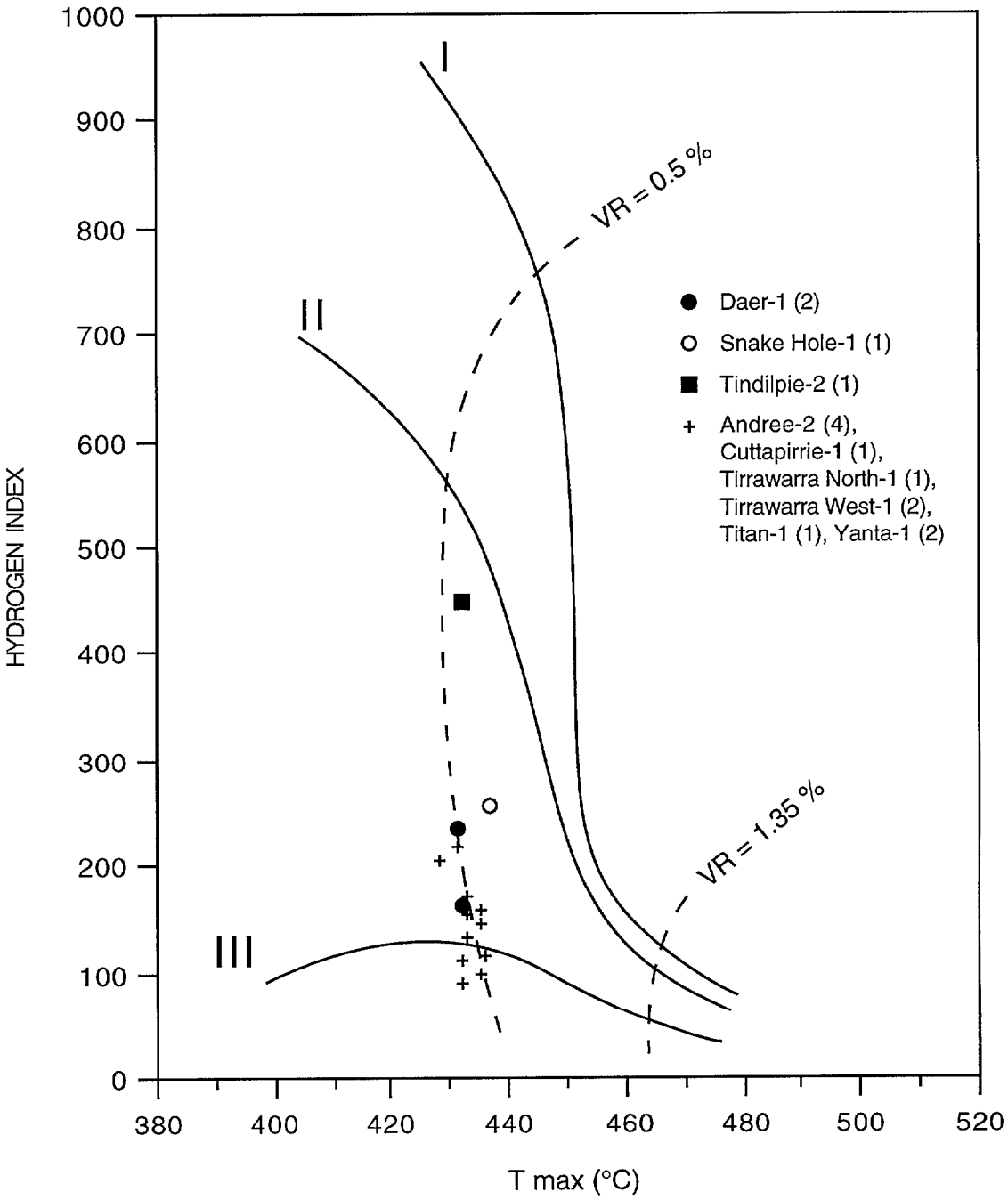
Tmax *versus* HI plot, Hutton Sandstone, Eromanga Basin, South Australia (eastern sector).



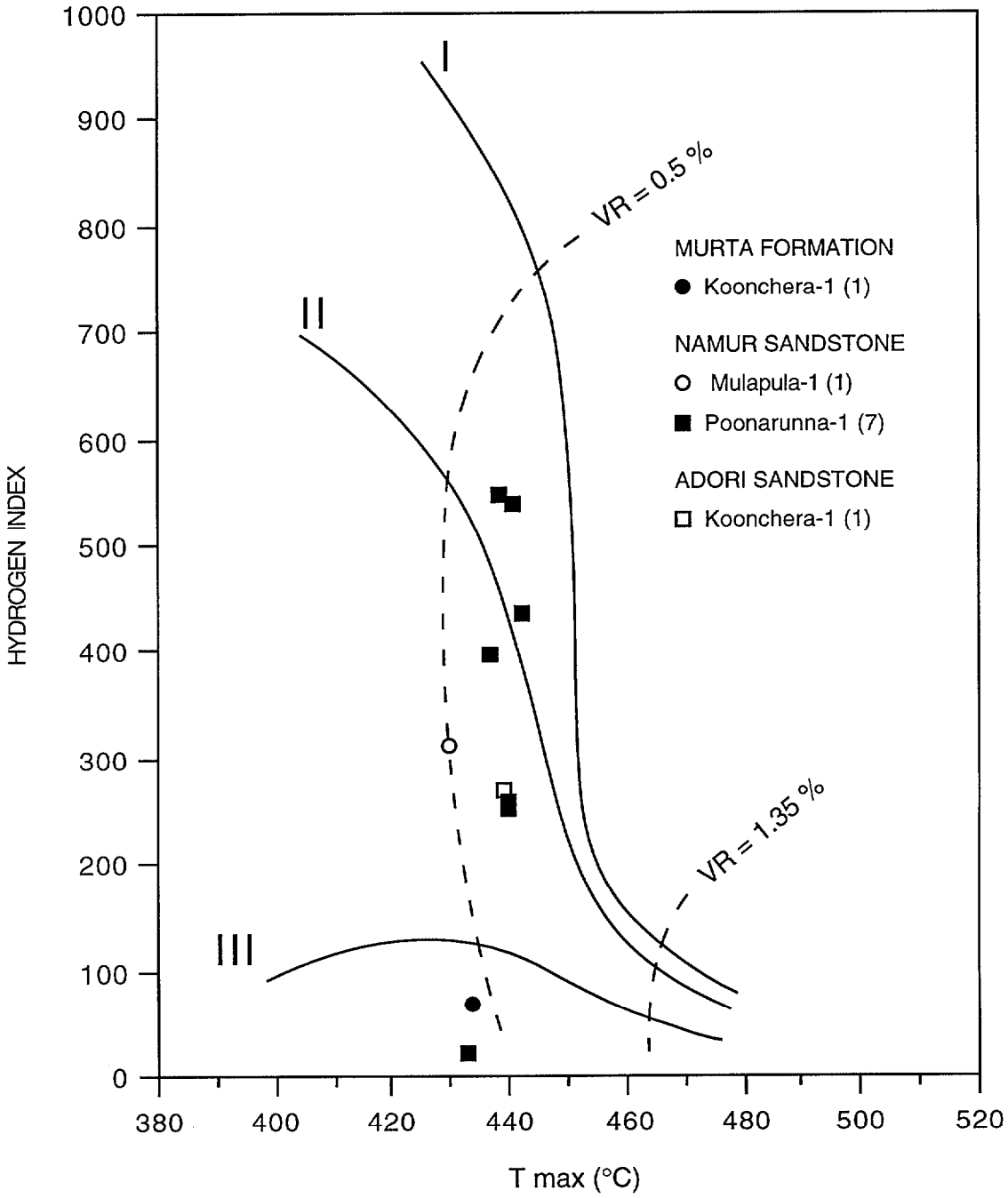
Tmax *versus* HI plot, Birkhead Formation, Eromanga Basin, South Australia (western sector).



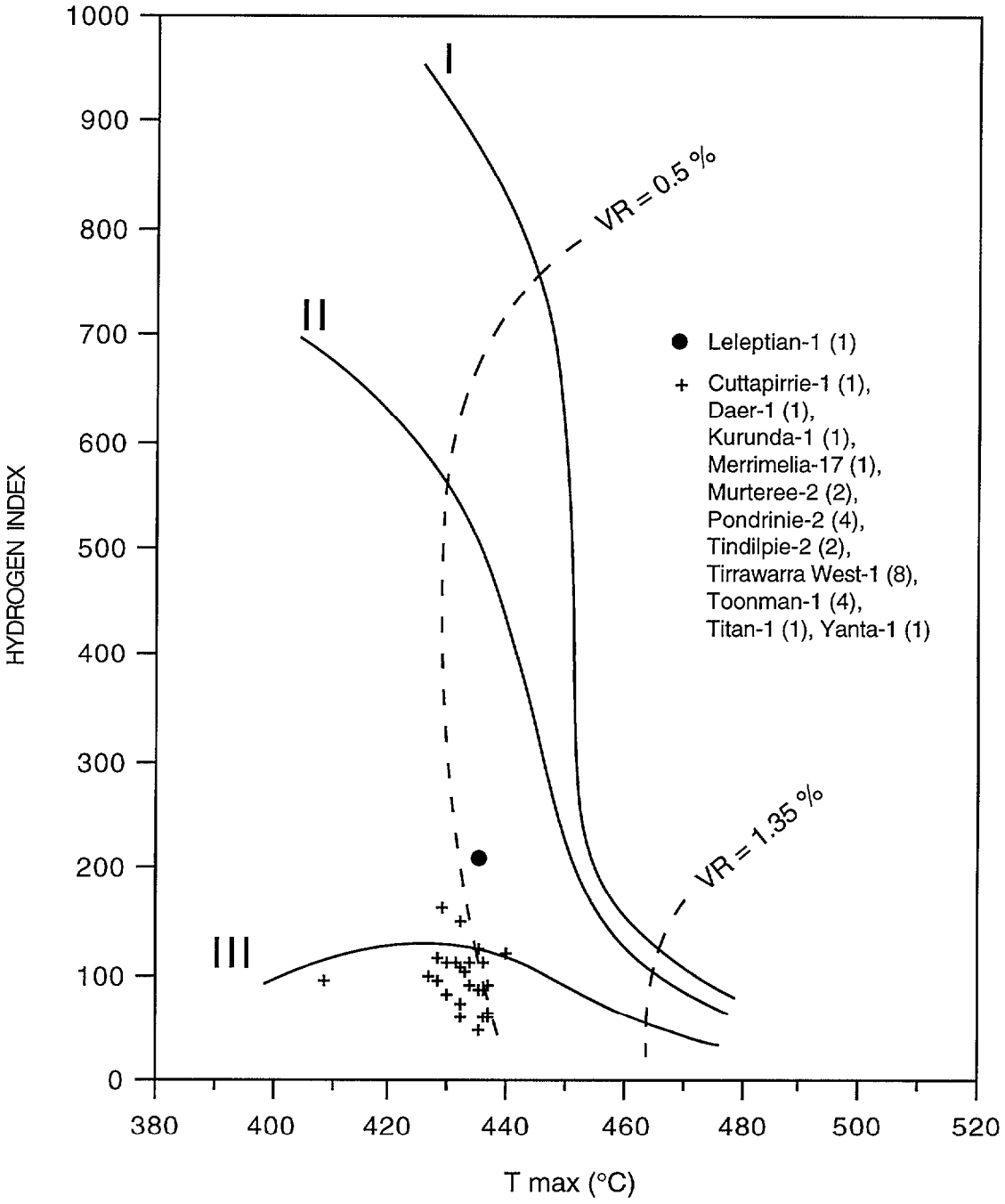
Tmax *versus* HI plot, Birkhead Formation, Eromanga Basin, South Australia (eastern sector).



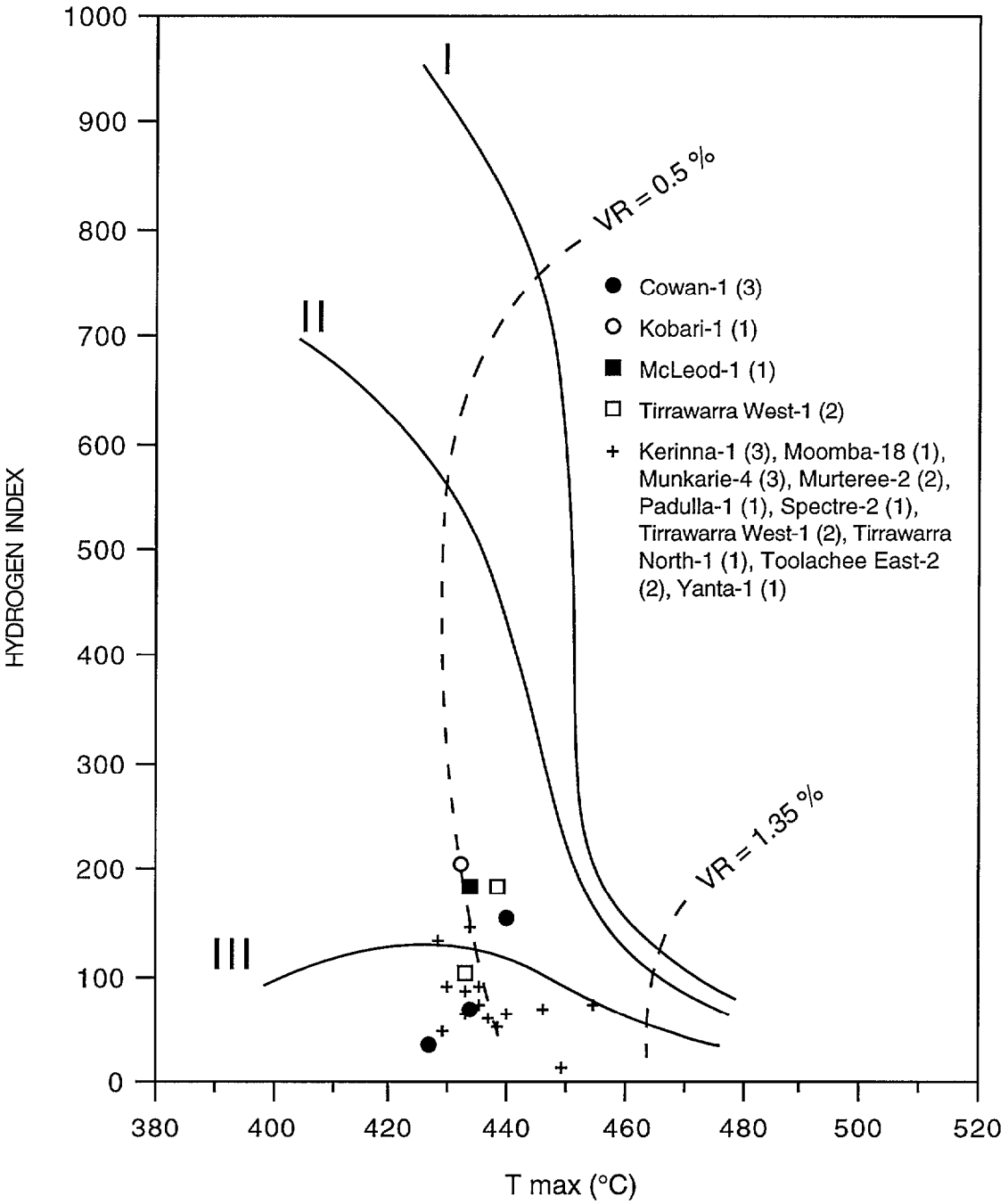
Tmax *versus* HI plot, Adori Sandstone, Eromanga Basin, South Australia (eastern sector).



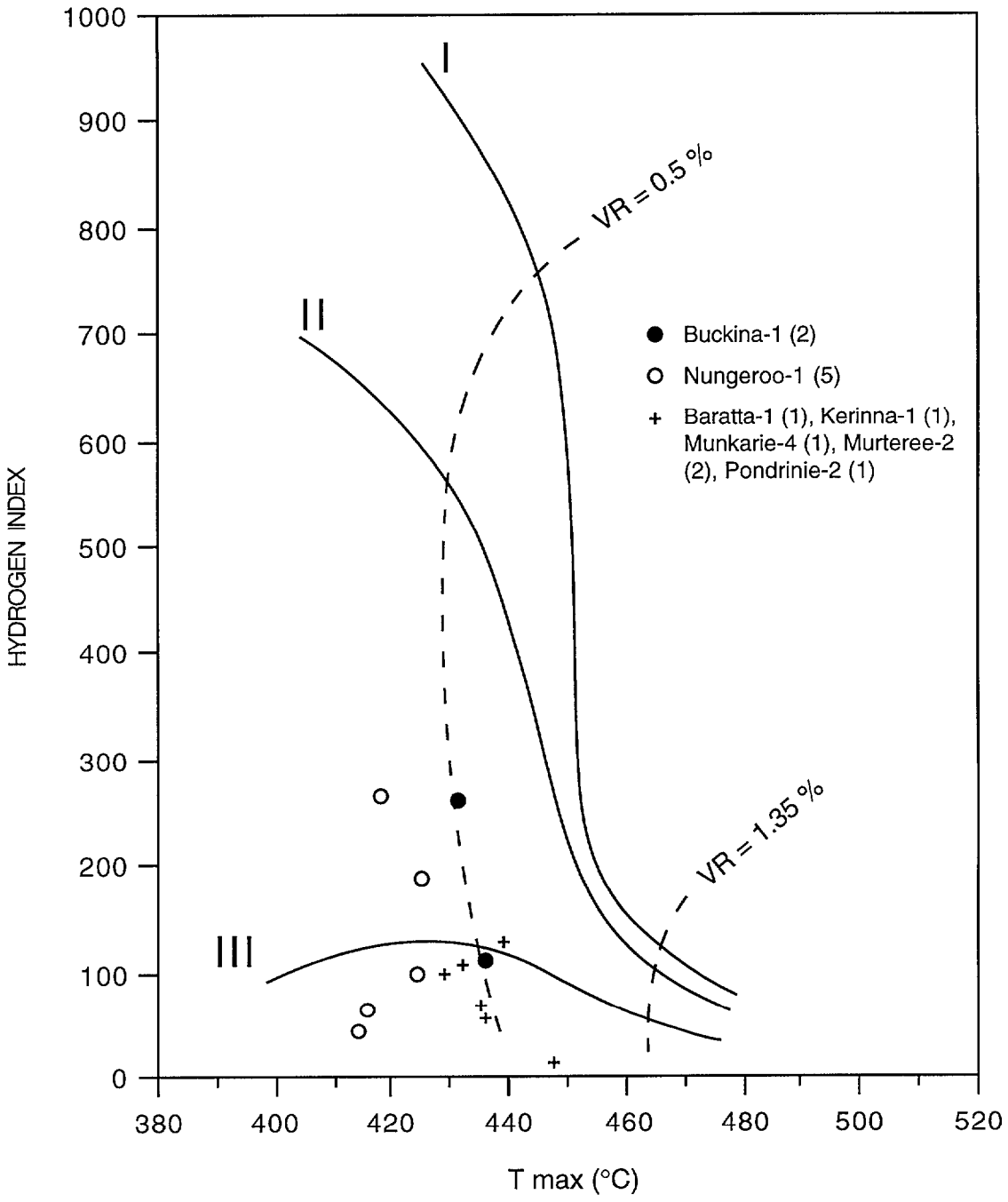
Tmax *versus* HI plot, Murta Formation, Namur Sandstone and Adori Sandstone, Eromanga Basin, South Australia (western sector).



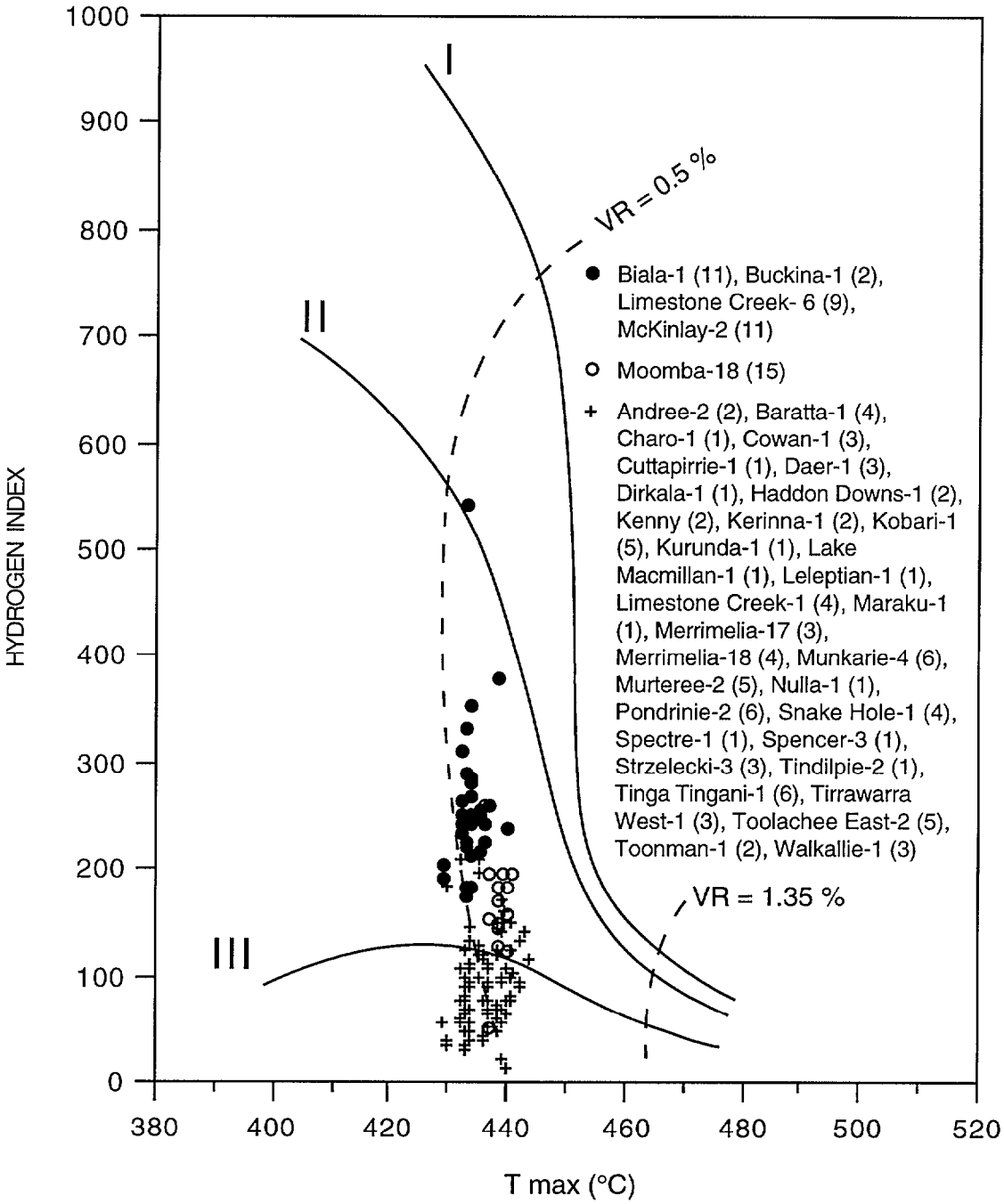
Tmax *versus* HI plot, Westbourne Formation, Eromanga Basin, South Australia (eastern sector).



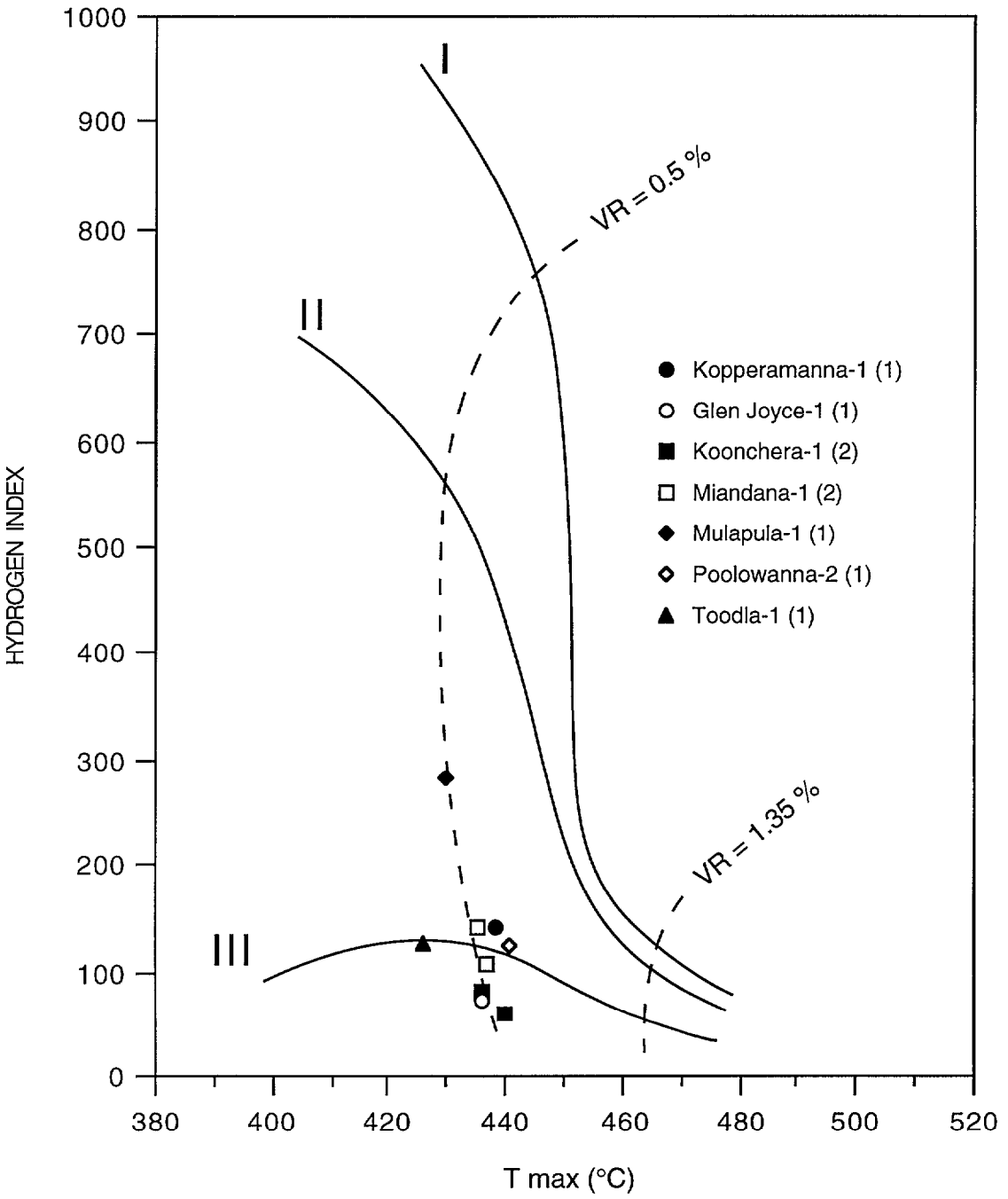
Tmax *versus* HI plot, Namur Sandstone, Eromanga Basin, South Australia (eastern sector).



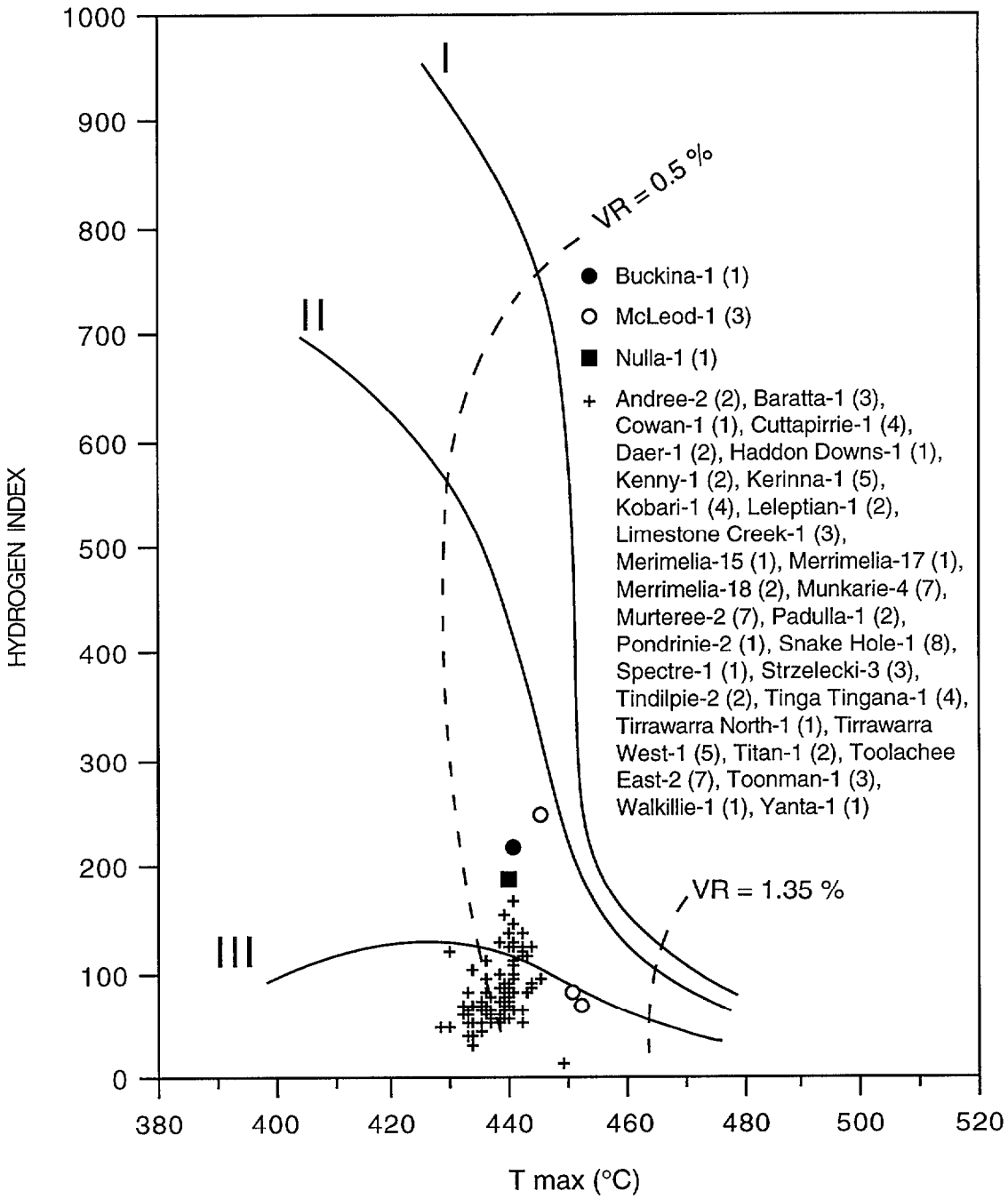
Tmax *versus* HI plot, McKinlay Member, Eromanga Basin, South Australia (eastern sector).



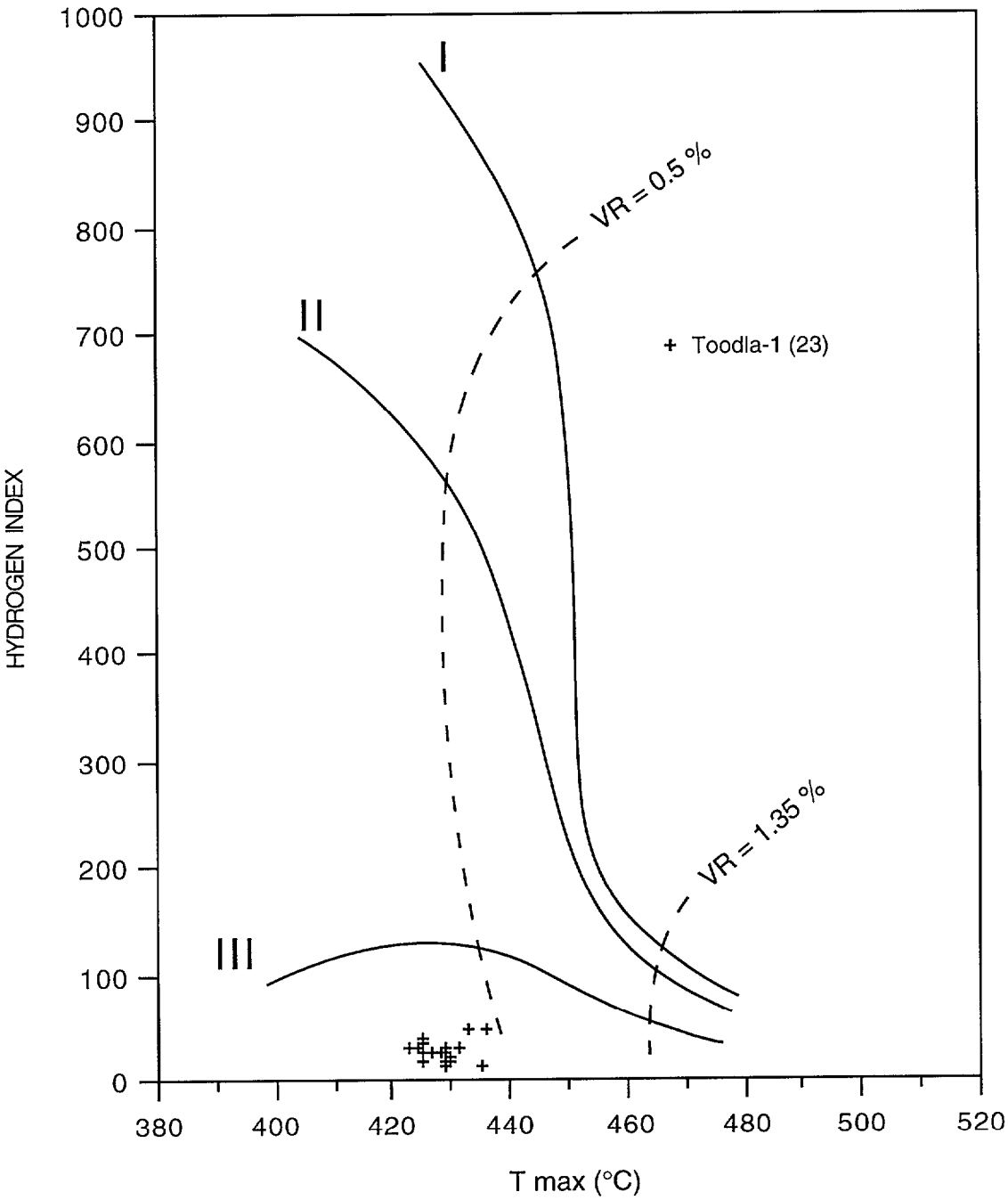
Tmax *versus* HI plot, Murta Formation, Eromanga Basin, South Australia (eastern sector).



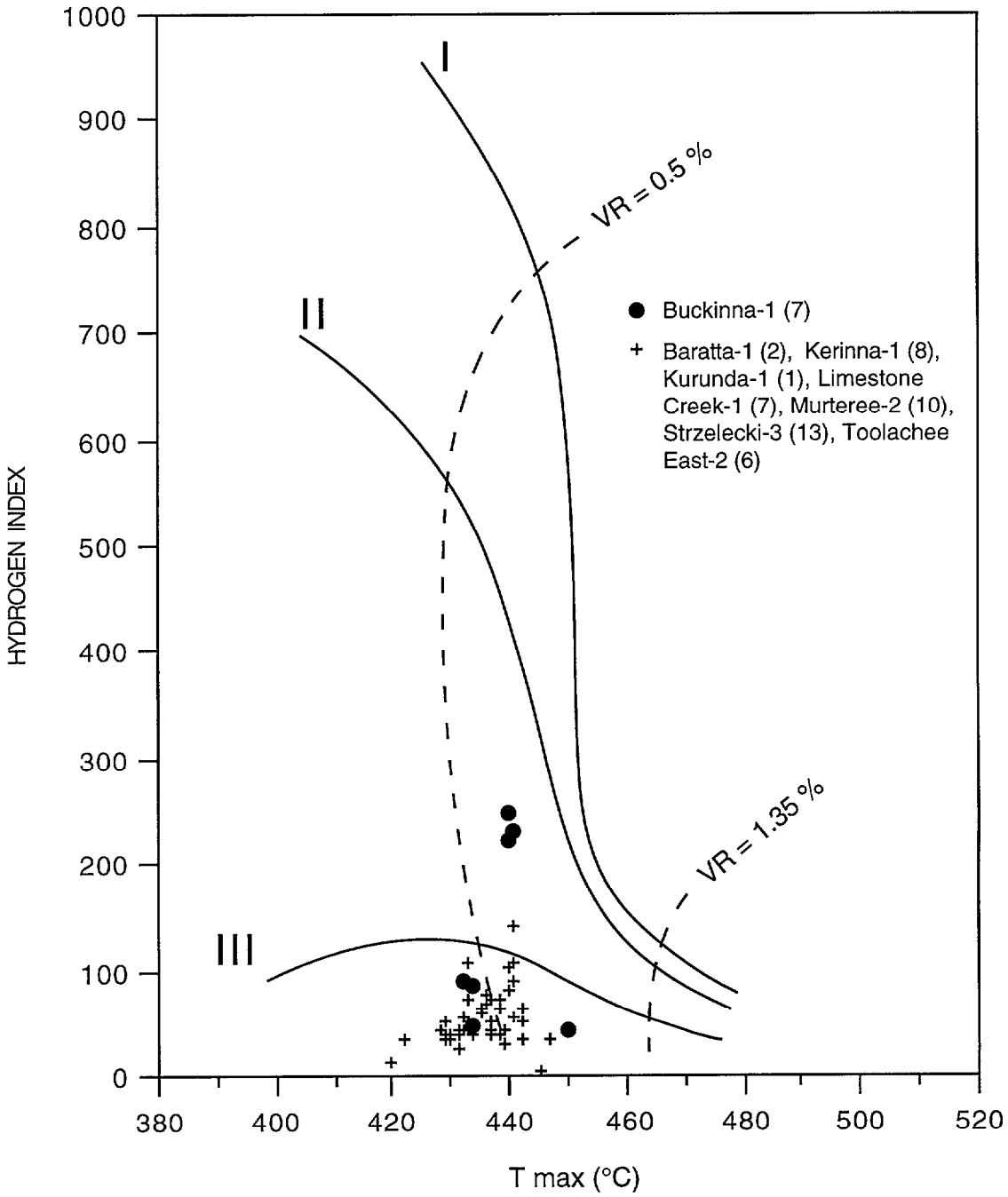
Tmax *versus* HI plot, Cadna-owie Formation, Eromanga Basin, South Australia (western sector).



Tmax *versus* HI plot, Cadna-owie Formation, Eromanga Basin, South Australia (eastern sector).



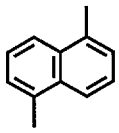
Tmax *versus* HI plot, Bulldog Shale, Eromanga Basin, South Australia (western sector).



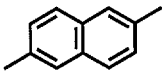
Tmax *versus* HI plot, Bulldog Shale, Eromanga Basin, South Australia (eastern sector).

Appendix B: Aromatic Hydrocarbons

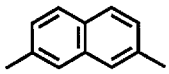
Bicyclic aromatics



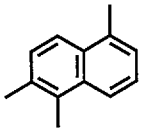
1,5-Dimethynaphthalene



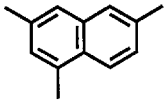
2,6-Dimethynaphthalene



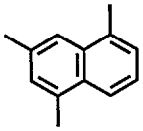
2,7-Dimethynaphthalene



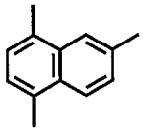
1,2,5-Trimethynaphthalene
Araucariacean marker



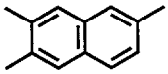
1,3,6-Trimethylnaphthalene



1,3,5-Trimethynaphthalene

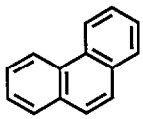


1,4,6-Trimethynaphthalene

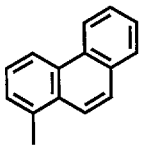


2,3,6-Trimethynaphthalene

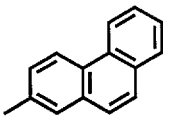
Tricyclic aromatics



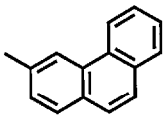
Phenanthrene



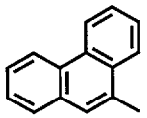
1-Methylphenanthrene
Araucariacean marker



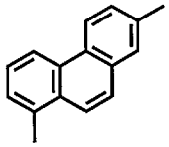
2-Methylphenanthrene



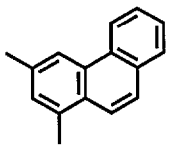
3-Methylphenanthrene



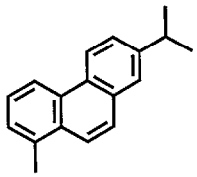
9-Methylphenanthrene



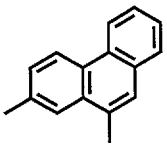
1,7-Dimethylphenanthrene
Araucariacean marker



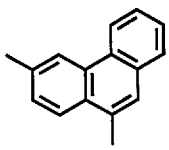
1,3-Dimethylphenanthrene



Retene
Araucariacean marker



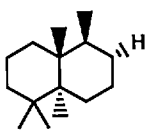
2,10-Dimethylphenanthrene



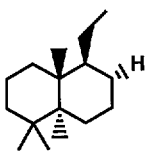
3,10-Dimethylphenanthrene

BICYCLIC SESQUITERPENOIDS

Drimanes

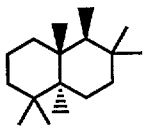


8β-drimane

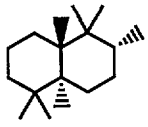


8β-homodrimane

Rearranged drimanes



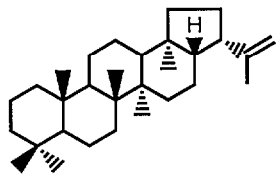
Structure 1



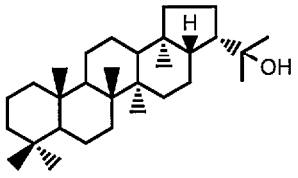
Structure 2

Appendix C: Triterpenoid Biomarkers

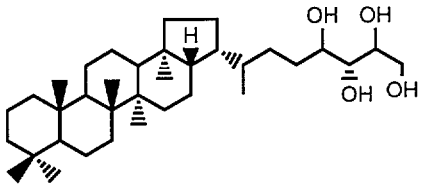
Hopanoids in bacterial membranes



Diploptene

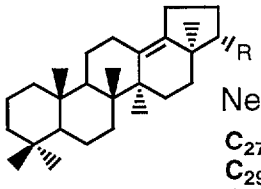


Diplopterol



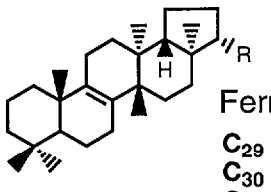
Bacteriohopanetetrol

Other compounds in bacteria and ferns



Neohop-13(18)-enes

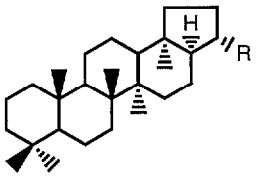
- C_{27} 22,29,30-trisnorneohop-13(18)-ene
- C_{29} 30-norneohop-13(18)-ene
- C_{30} neohop-13(13)-ene
- C_{31} homoneohop-13(18)-ene



Fern-8(9)-enes

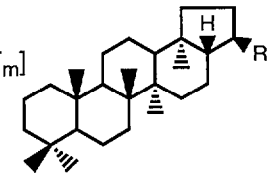
- C_{29} 30-norfernene
- C_{30} fernene
- C_{31} homofernene

Major hopanes in sediments and petroleum



17α-Hopanes

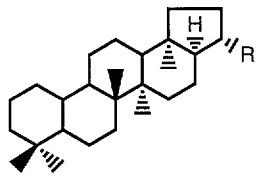
- C_{27} 22,29,30-trisnorhopane [T_m]
- C_{29} 30-norhopane
- C_{30} hopane
- C_{31} homohopane



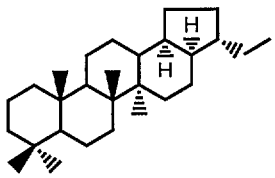
17β-Hopanes [moretanes]

- C_{27} 22,29,30-trisnormoretane
- C_{29} 30-normoretane
- C_{30} moretane
- C_{31} homomoretane

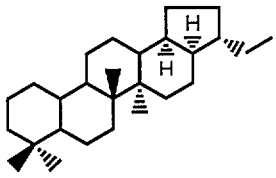
Demethylated hopanes



17α-25-Norhopanes

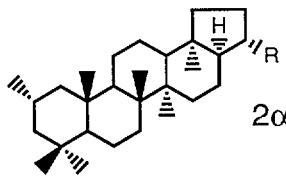


17α-28,30-Bisnorhopane [28,30-BNH]

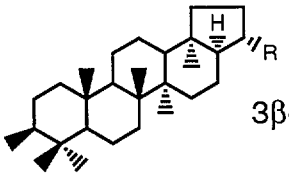


17α-25,28,30-Trisnorhopane [25,28,30-TNH]

Methylhopanes

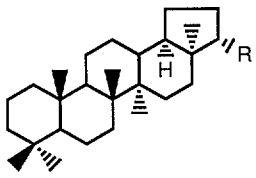


2α-Methylhopanes



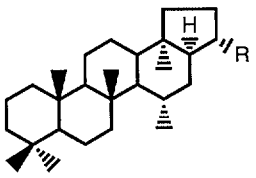
3β-Methylhopanes

Rearranged hopanes and fernanes



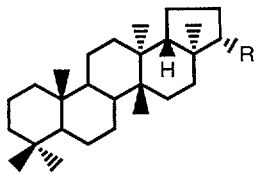
18α-Neohopanes

- C_{27} 22,29,30-trisnorneohopane [T_s]
- C_{29} 30-norneohopane [$C_{29}T_s$]
- C_{30} neohopane [$C_{30}T_s$]



17α-Diahopanes

- C_{29} 30-nordiahopane
- C_{30} diahopane
- C_{31} homodiahopane



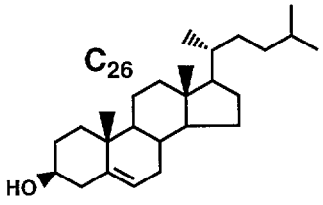
Fernanes

- C_{29} 30-norfernane
- C_{30} fernane
- C_{31} homofernane

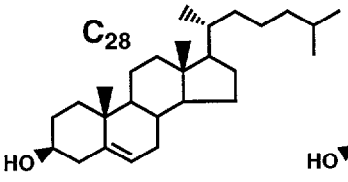
For C_{27}, C_{29}, C_{30}, and C_{31} compounds R = H, C_2H_5, *i*-C_3H_7, and *s*-C_4H_9, respectively.

Appendix D: Steroid Biomarkers

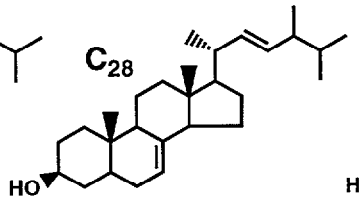
Steroids in eukaryotic cell membranes



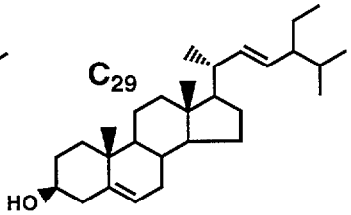
24-Norcholesterol
marine algae



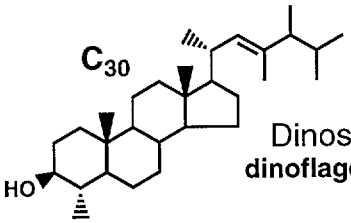
Cholesterol
animals, plants



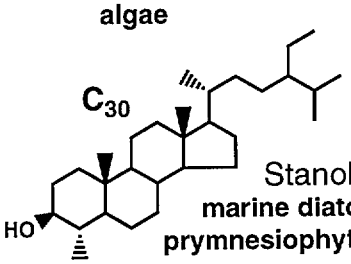
Dihydroergosterol
algae



Stigmasterol
plants

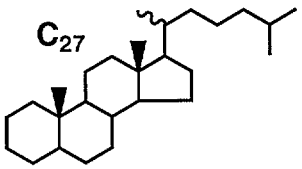


Dinosterol
dinoflagellates

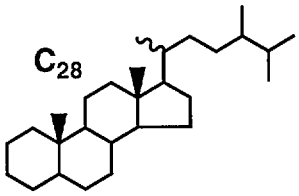


Stanol
marine diatoms, prymnesiophyte algae

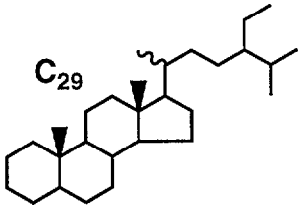
Major steranes in sediments and petroleum



Cholestane
marine algae

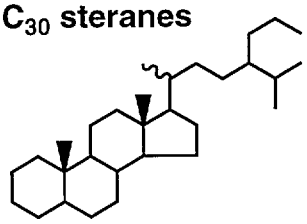


Methylcholestane
(? lacustrine) algae

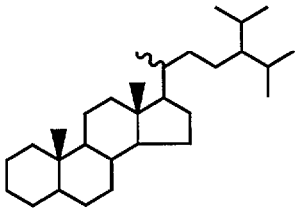


Ethylcholestane
land plants

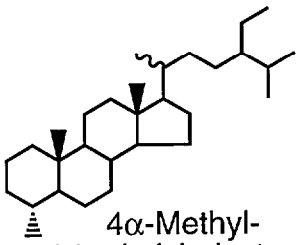
C_{30} steranes



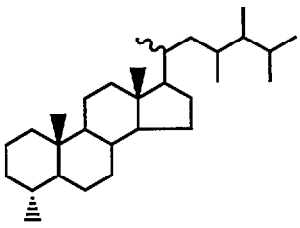
24-*n*-Propylcholestane
chrysophyte algae



24-*iso*-Propylcholestane
sponges, archaeocyatha

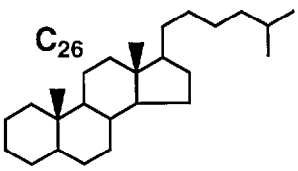


4α-Methyl-
24-ethylcholestane
prymnesiophyte algae, dinoflagelates

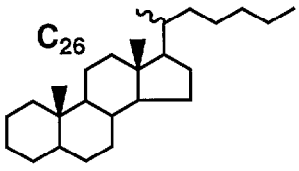


Dinosterane
dinoflagelates

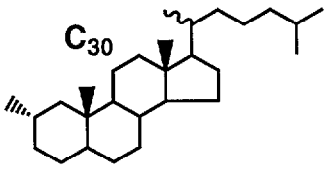
Steranes of bacterial affinity



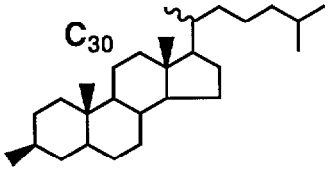
21-Norcholestane



27-Norcholestane

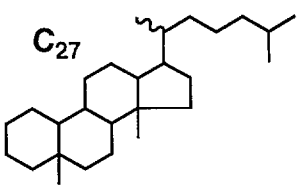


2α-Methylcholestane

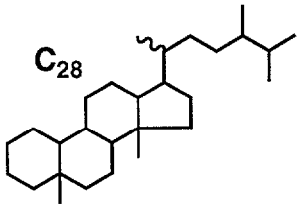


3β-Methylcholestane

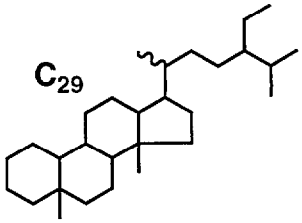
Rearranged steranes



Diacholestane



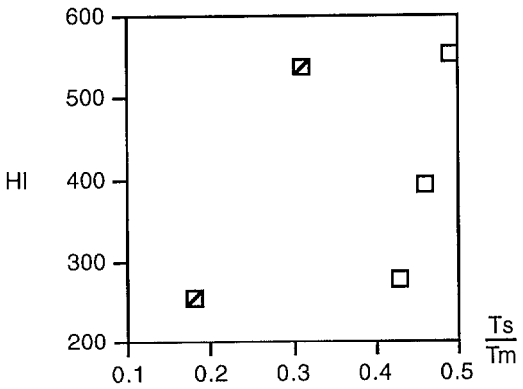
Methyldiacholestane

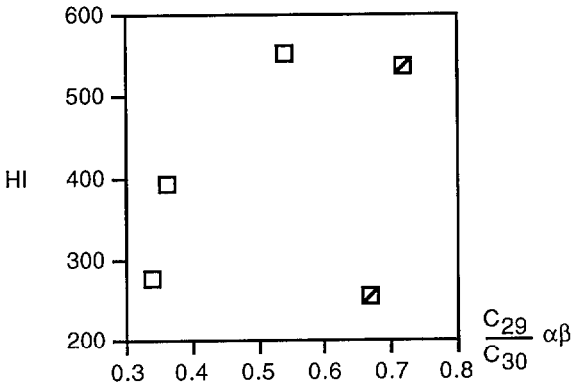


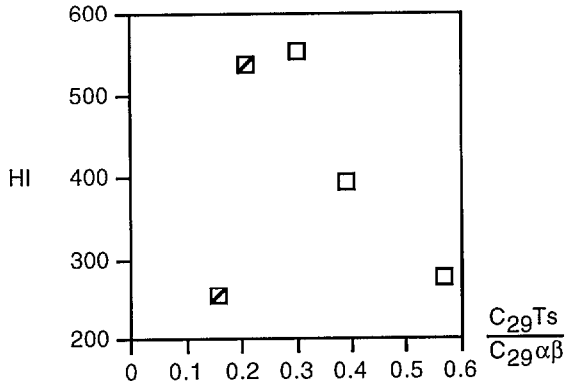
Ethyldiacholestane

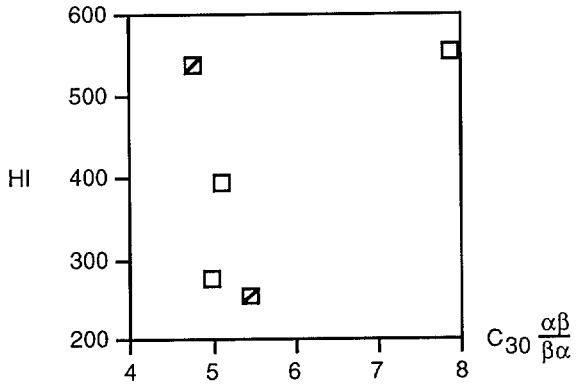
Appendix E

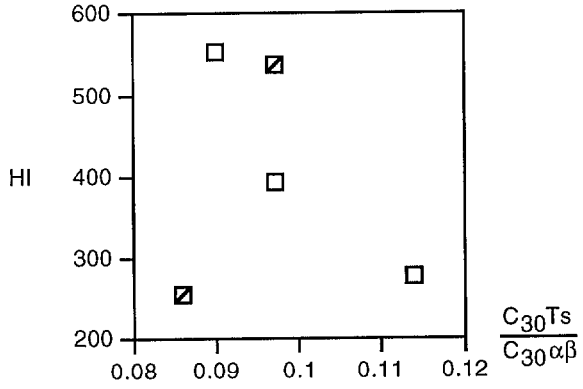
Various hopane biomarker parameters plotted against hydrogen index.

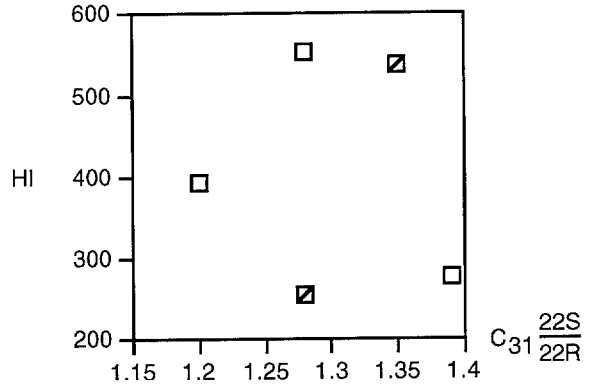


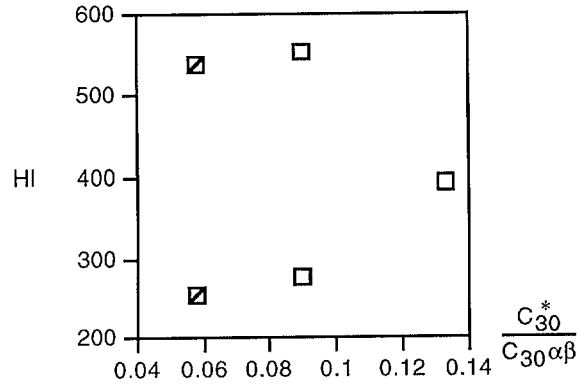


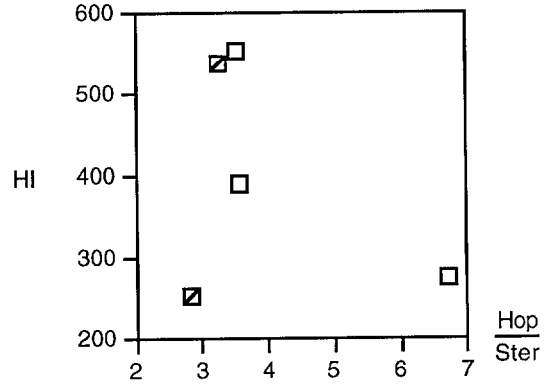








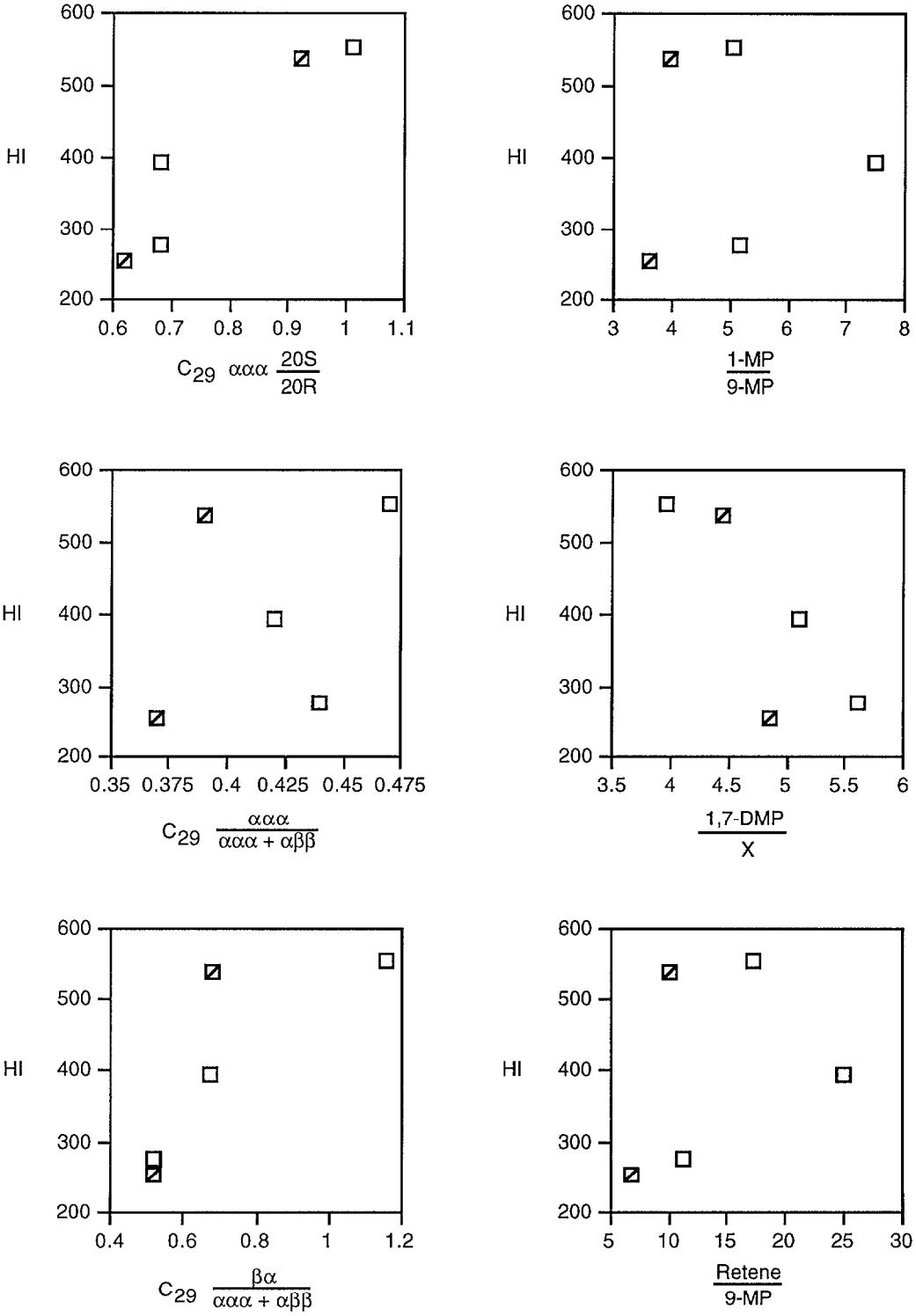




□ Birkhead Fm ▨ Namur Sandstone

Appendix F

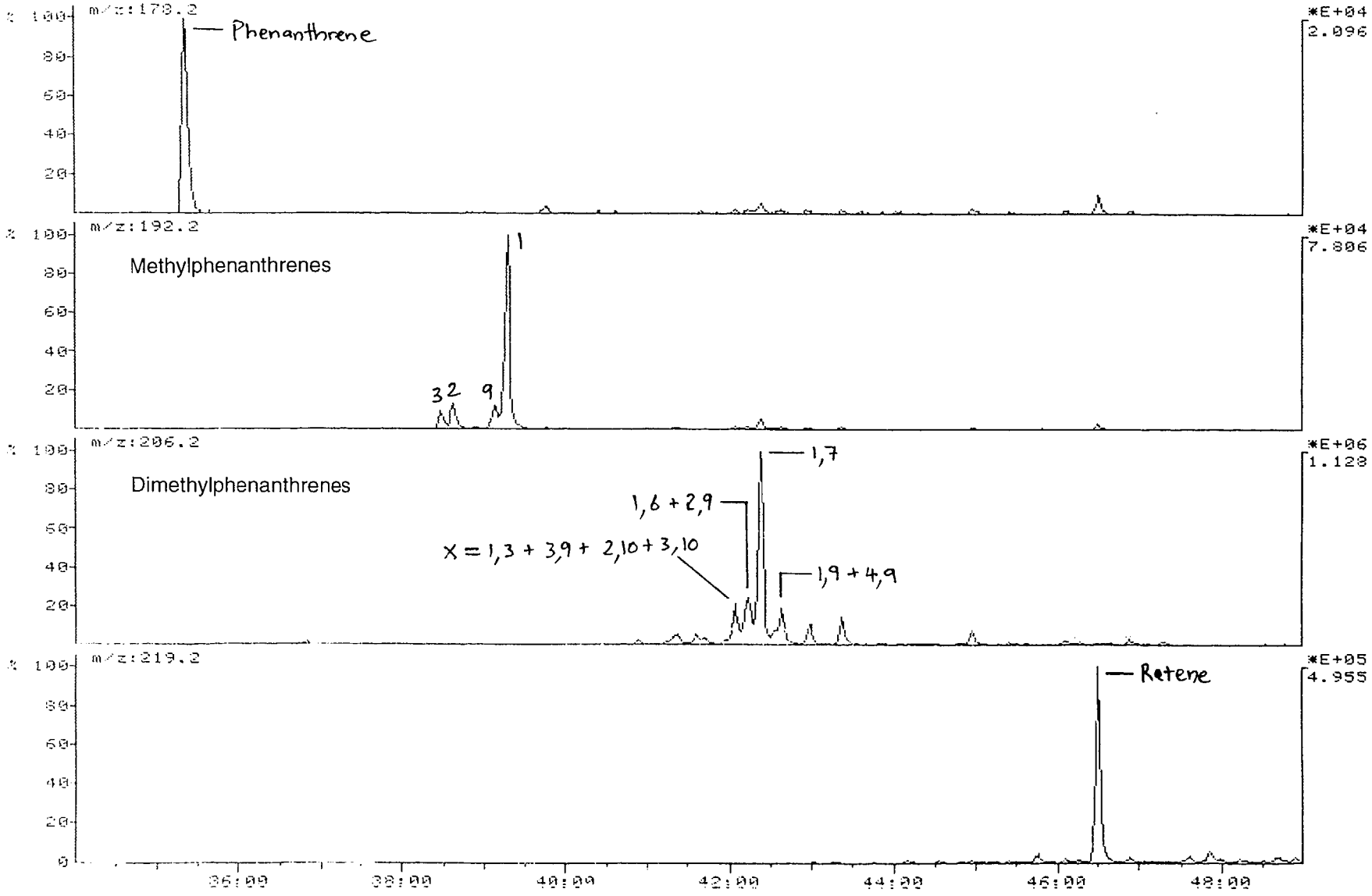
Various sterane and aromatic biomarker parameters plotted against hydrogen index.



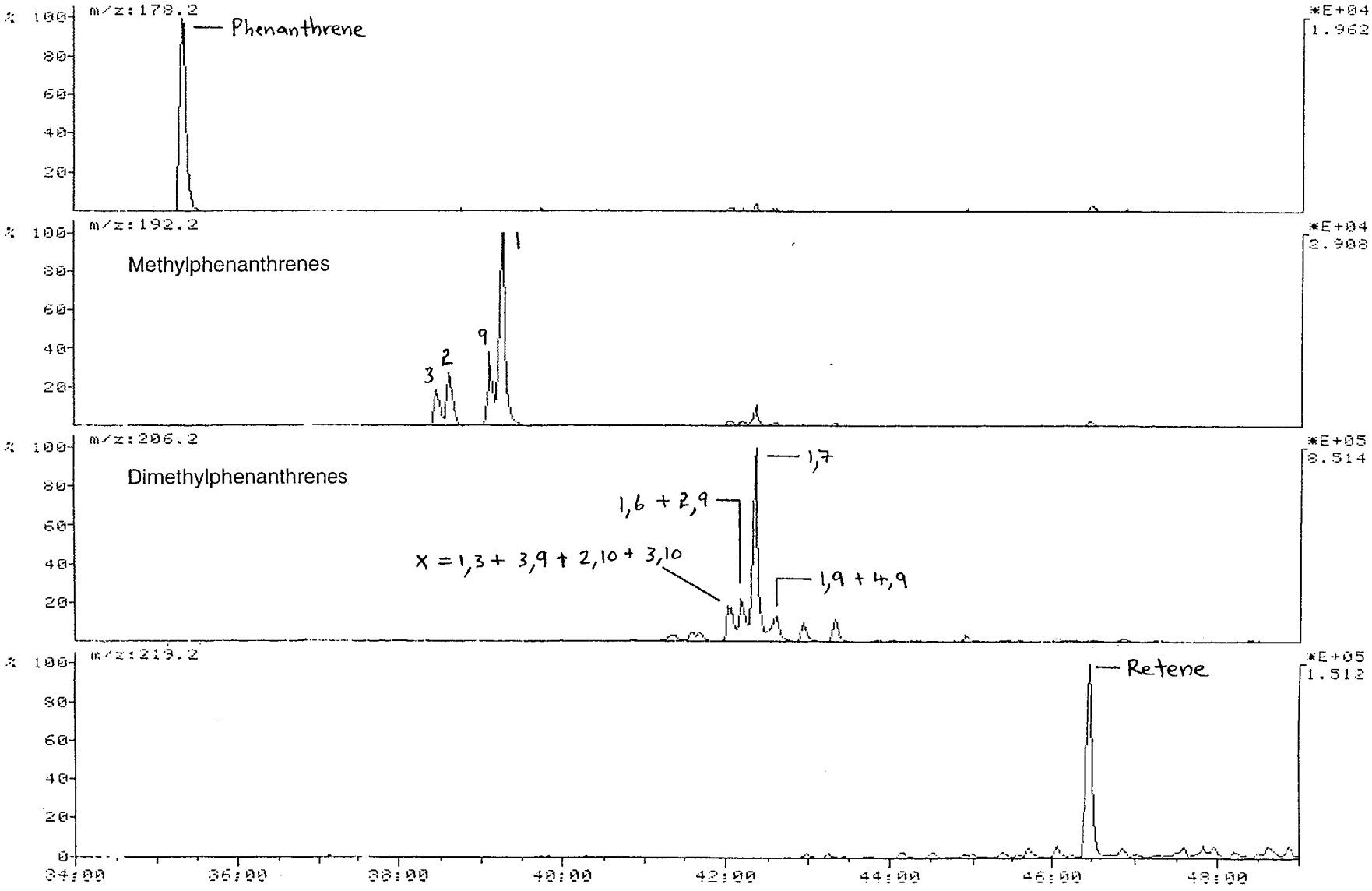
Appendix G

GC-MS mass fragmentograms of aromatic hydrocarbons

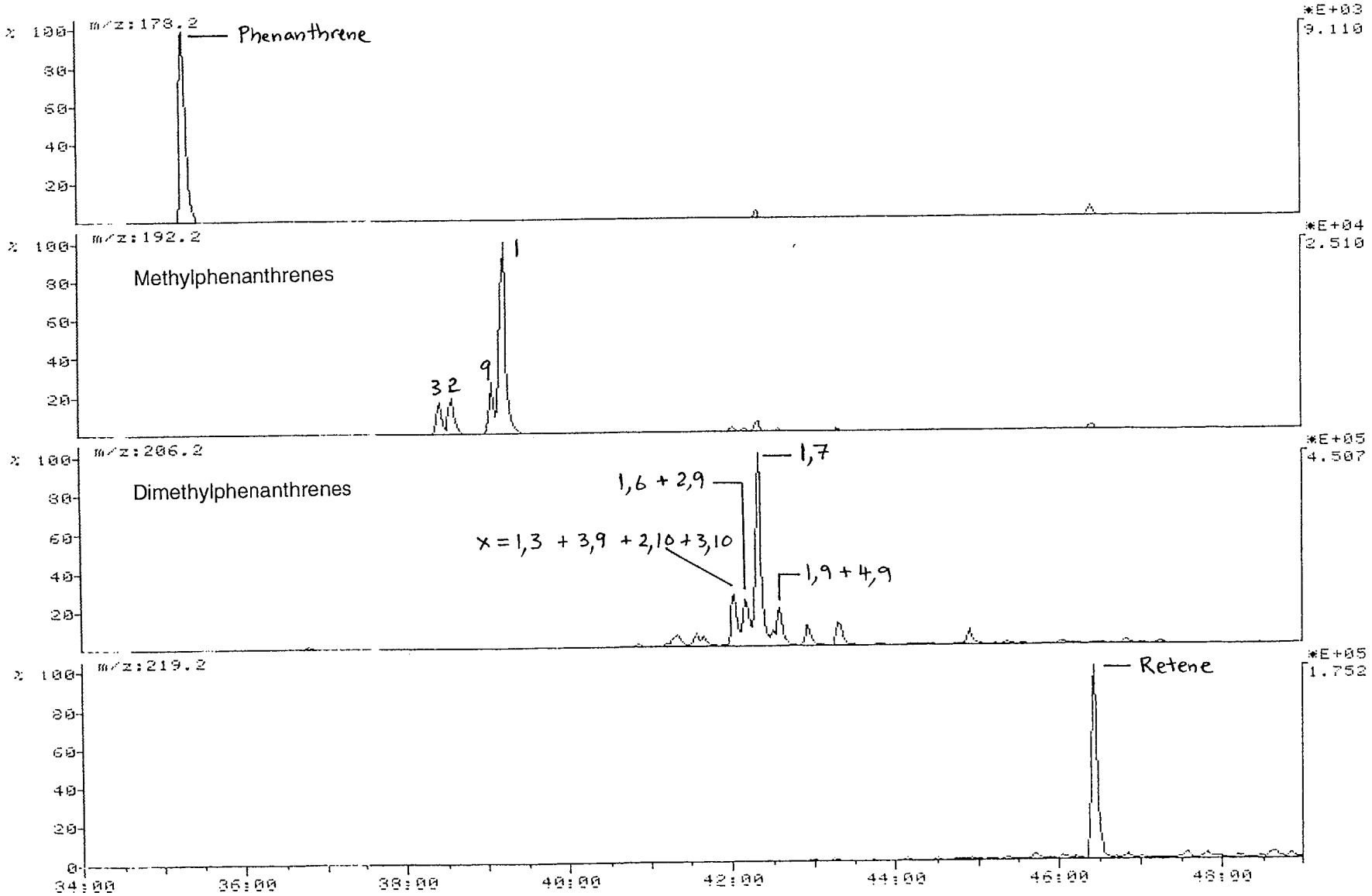
```
CHRO: BMPUT147 ver 1 on UIC 3 1        20-NOV-95 Elapse: 00:01:05.3    1
Samp: PUTAMURDIE-1 4778'9" AROM                  Start : 04:55:15  4364
Comm: DB-1 60m 23.5psi ICL:BMAROM60M 0/40/200 S180 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN                                 Inlet :
Peak: 1000.00 mmu     Label wndw: 1713 > 2492    Masses: 128 > 254
Area: 0, 4.00         Baseline  : 0, 3           Label : 0, 40.00
```



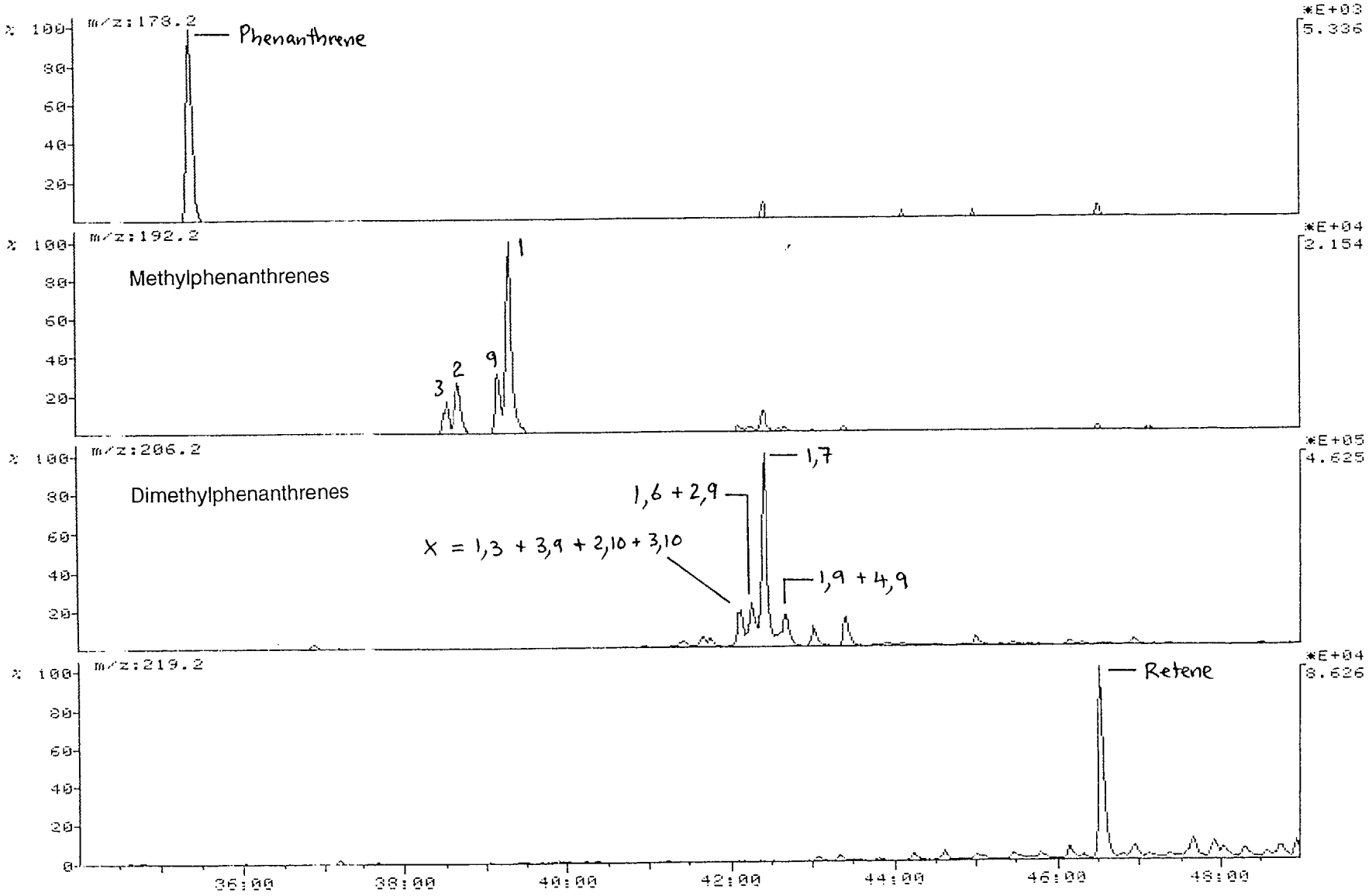
```
CHRO: BMPOON101 ver 1 on UIC 3 1      20-NOV-95 Elapse: 00:01:05.0    1
Samp: POONARUNNA-1 5001' AROM                   Start : 02:10:24  4364
Comm: DB-1 60m 23.5psi ICL:BMAROM60M 0/40/200 S180 M70
Mode: EI +Q3MS LMR UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 1713 > 2493   Masses: 128 > 254
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
```



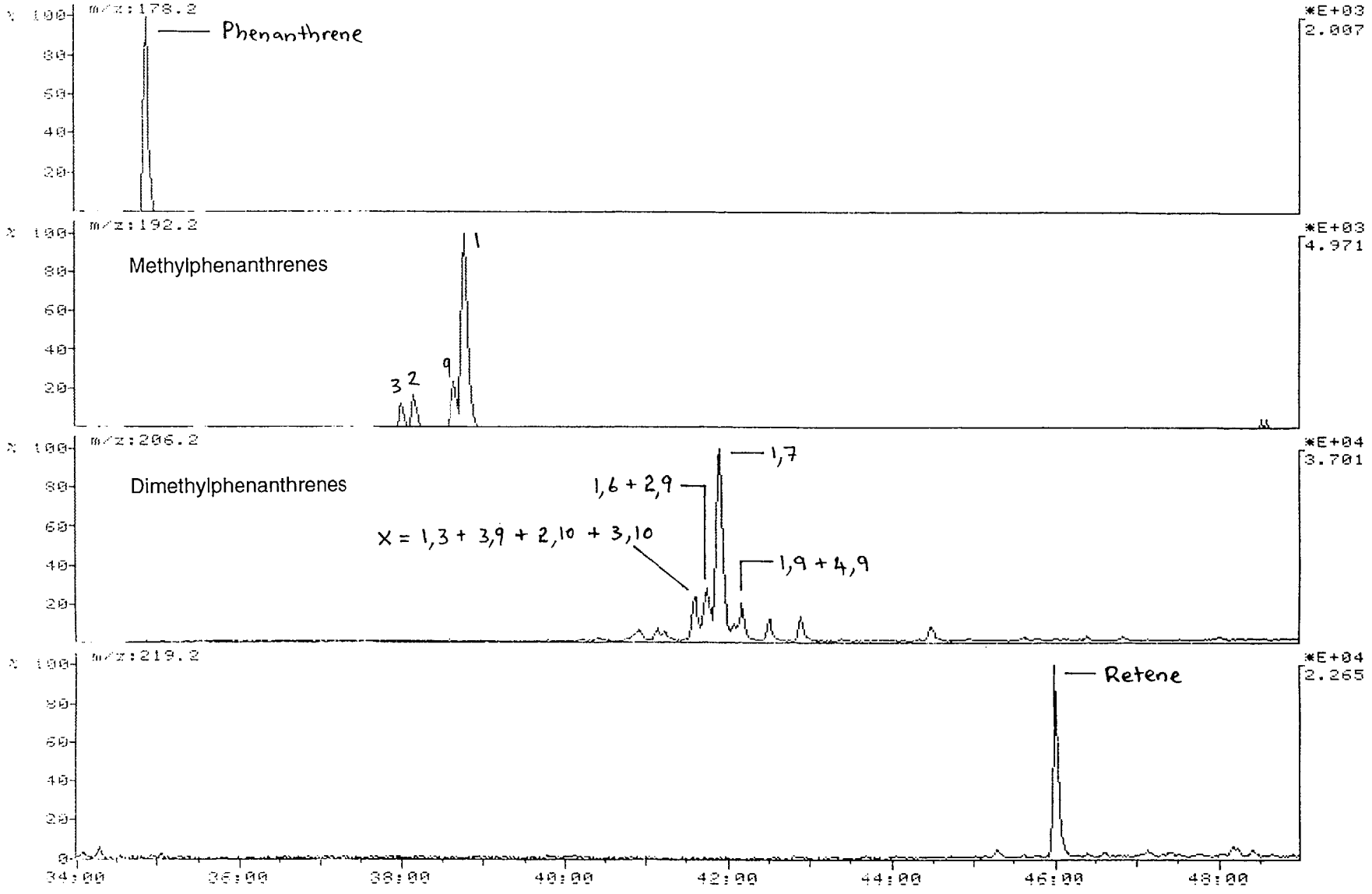
CHRO: BMPOON109 ver 1 on UIC 3 1 20-NOV-95 Elapse: 00:01:05.0 1
Samp: POONARUNNA-1 5209/3" AROM Start : 03:32:56 4365
Comm: DB-1 60m 23.5psi ICL:BMAROM60M 0/40/200 S180 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN Inlet :
Peak: 1000.00 mmu Label wndw: 1713 > 2493 Masses: 128 > 254
Area: 0, 4.00 Baseline : 0, 3 Label : 0, 40.00



```
CHRO: BMPOON150 ver 1 on UIC 3 1      19-NOV-95 Elapse: 00:01:06.7   1
Samp: POONARUNNA-1 5018'3" ARDM                 Start : 20:36:42  4363
Comm: DB-1 60m 23.5psi ICL:BMAROM60M0/40/200 S180 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 1712 > 2491   Masses: 128 > 254
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
```



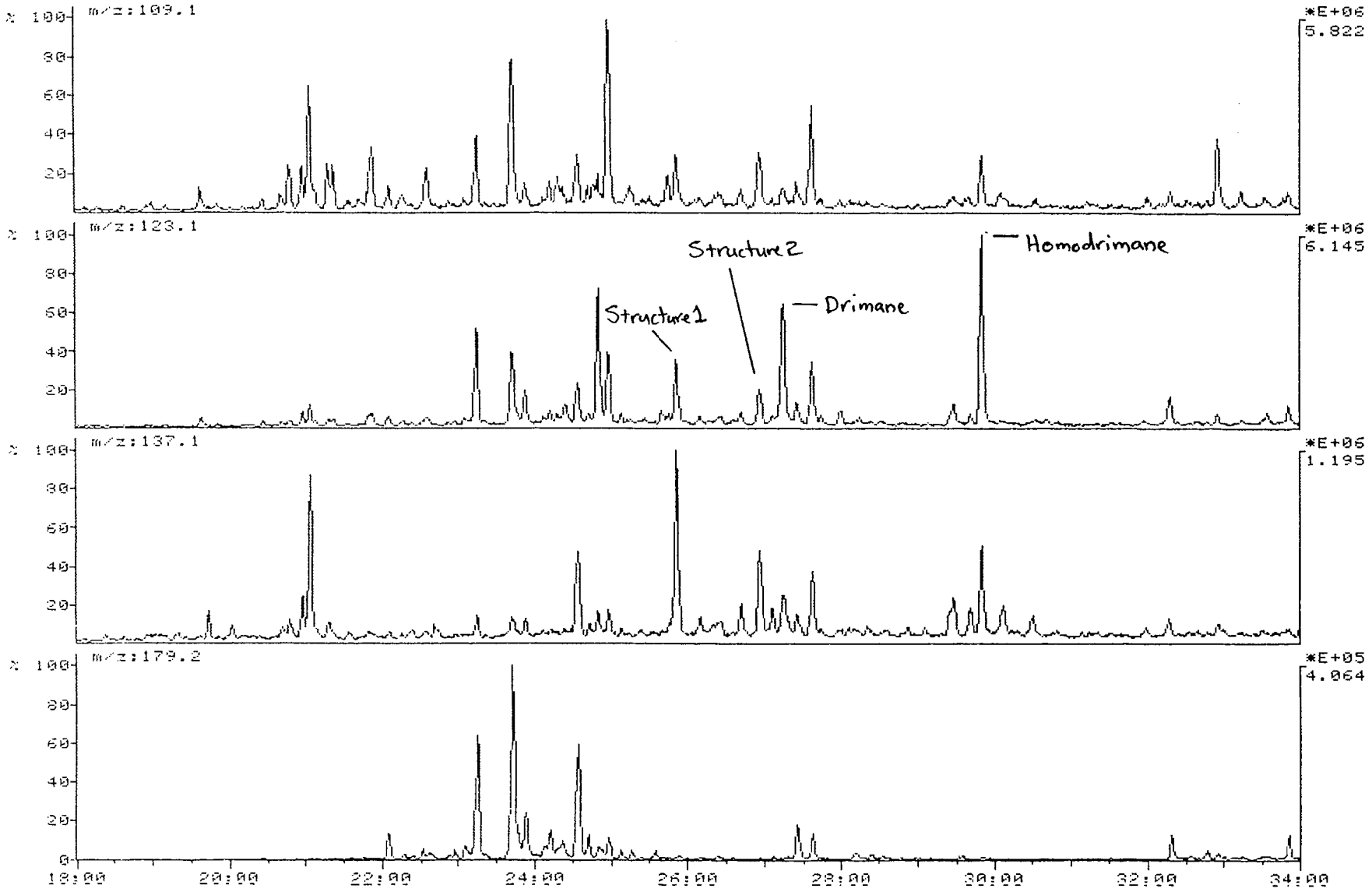
```
CHRO: BMPOON152 ver 1 on UIC 3 1      21-NOV-95 Elapse: 00:01:04.7    1
Samp: POONARUNNA-1 5253'6" AROM                 Start : 17:08:48  4365
Comm: D8-1 60m 23.5psi ICL:BMAROM60M 0/40/200 S180 M70
Mode: EI +QSMS LMR UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 1713 > 2493   Masses: 128 > 254
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
```



Appendix H

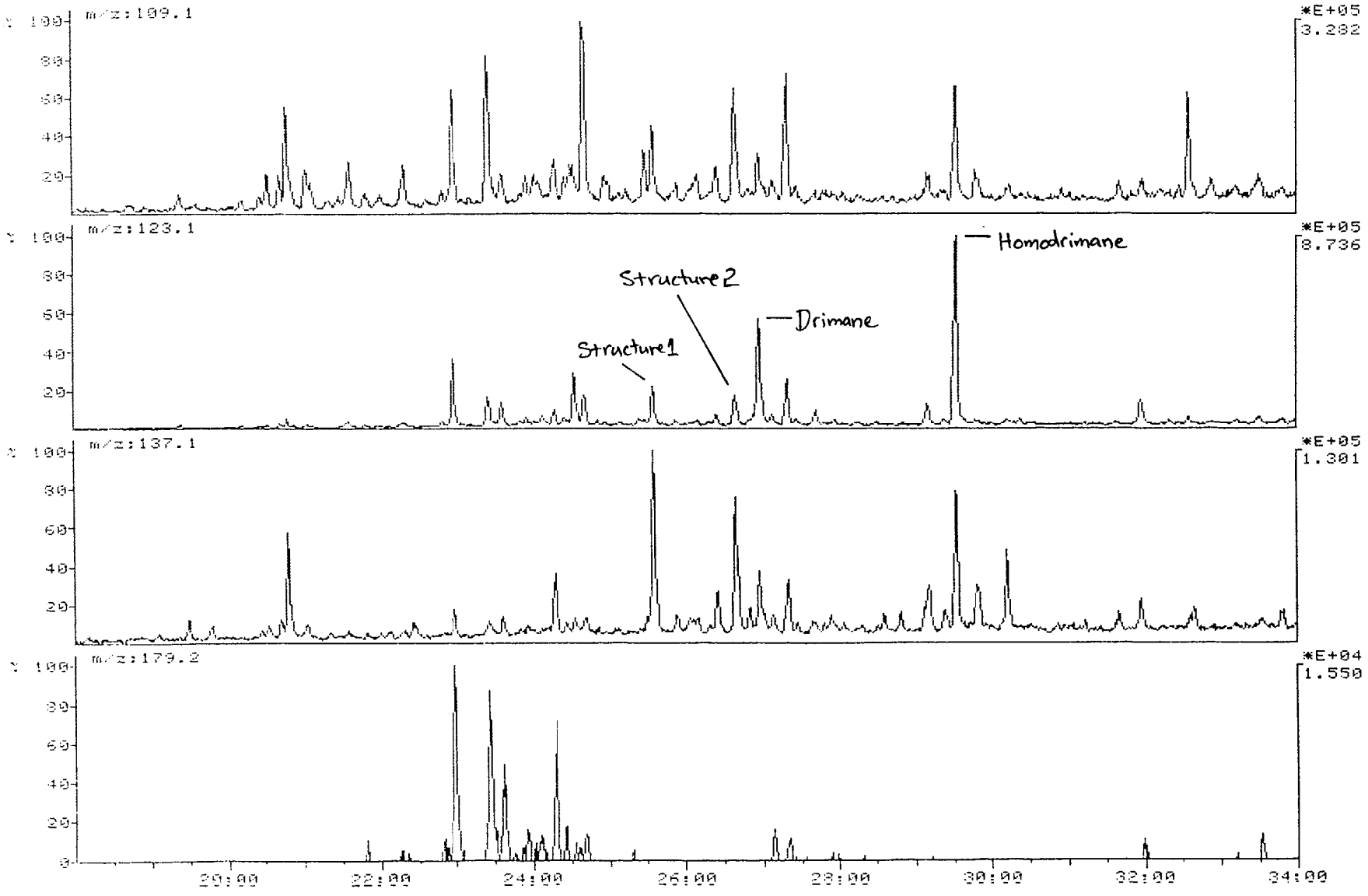
GC-MS mass fragmentograms of bicyclic sesquiterpanes (drimanes)

```
CHRO: BMSPUT11 ver 2 on UIC 3 1        19-NOV-95 Elapse: 00:15:05.1    1
Samp: PUTAMURDIE-1 4770'9"                       Start : 19:02:34  3849
Comm: DB-1 60m 23.5psi ICL:BIOMARKER 0/40/200 S1S0 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN                                 Inlet :
Peak: 1000.00 mmu     Label wndw: 227 > 1468     Masses: 82 > 305
Area: 0, 4.00         Baseline  : 0, 3           Label : 0, 40.00
```

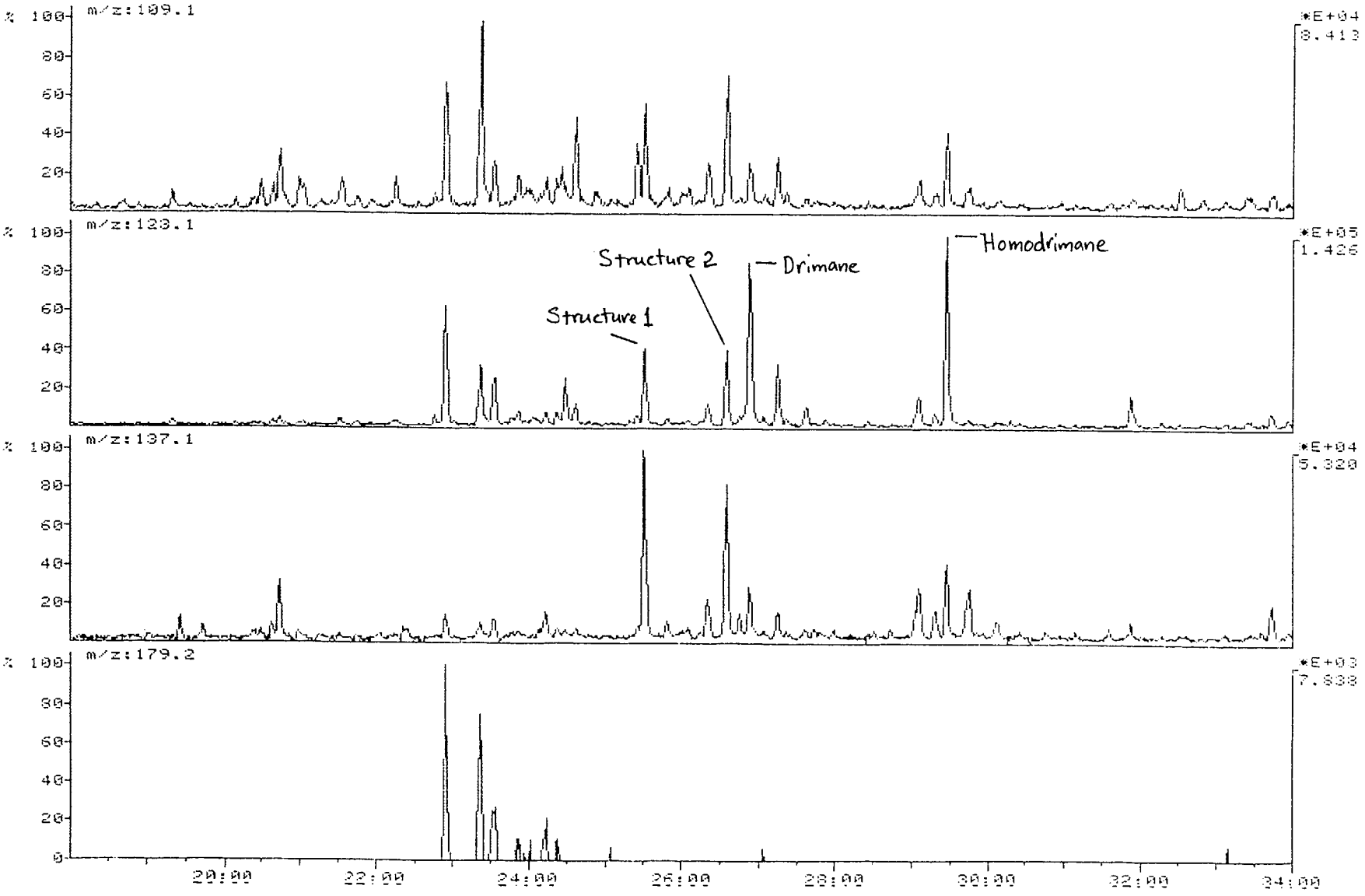


0000

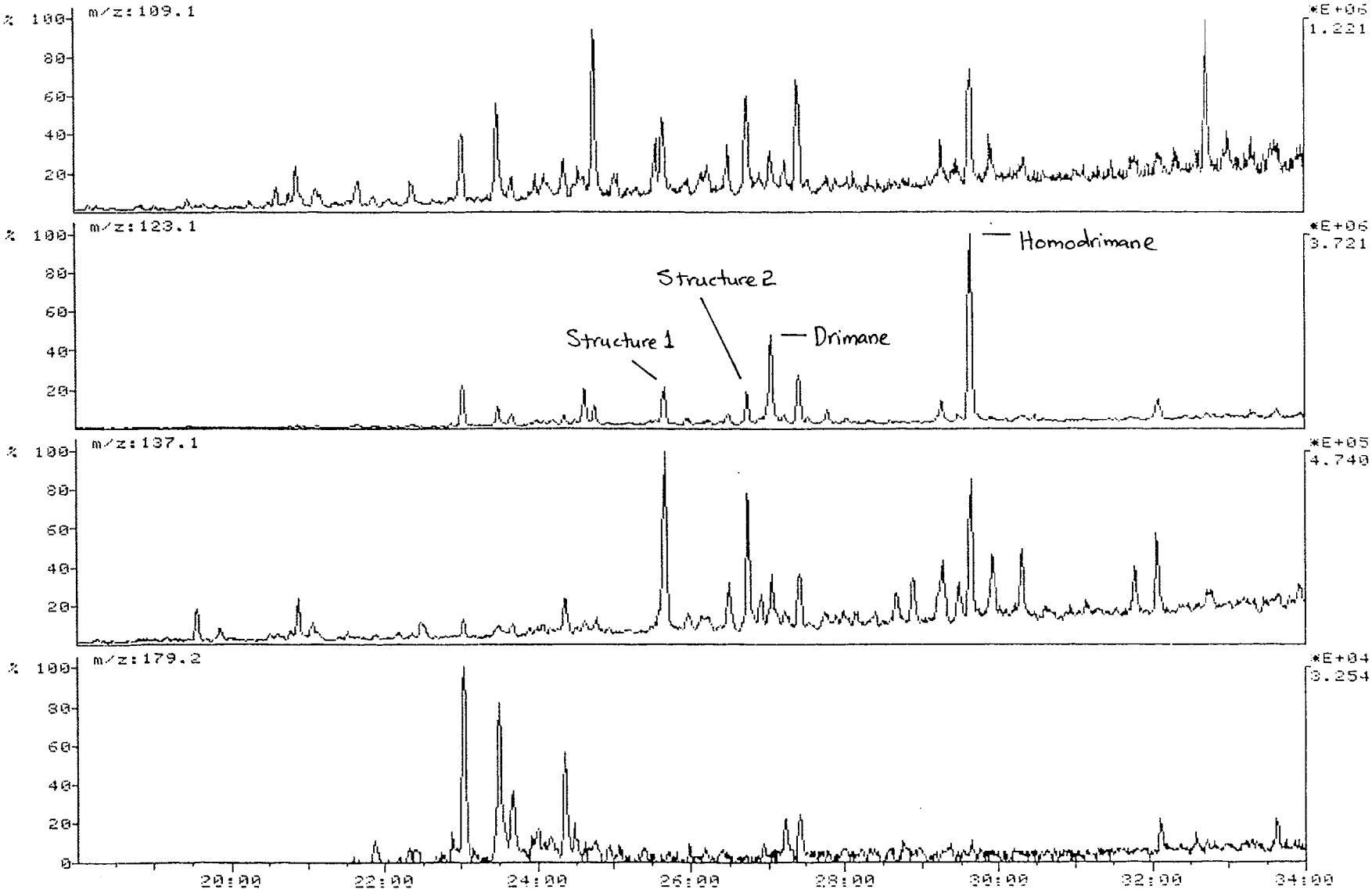
```
CNRO: BMP000101S ver 2 on UIC 3 1      20-NOV-95 Elapse: 00:15:05.4    1
Samp: PODOHARUNNA-1 5001' SAT                    Start : 15:45:47   3852
Comm: DB-1 60m 23.5psi ICL:BIOMARKER 0/40/200 S180 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN                                 Inlet :
Peak: 1000.00 mmu    Label wndw: 227 > 1469      Masses: 82 > 305
Area: 0, 4.00        Baseline  : 0, 3           Label : 0, 40.00
```



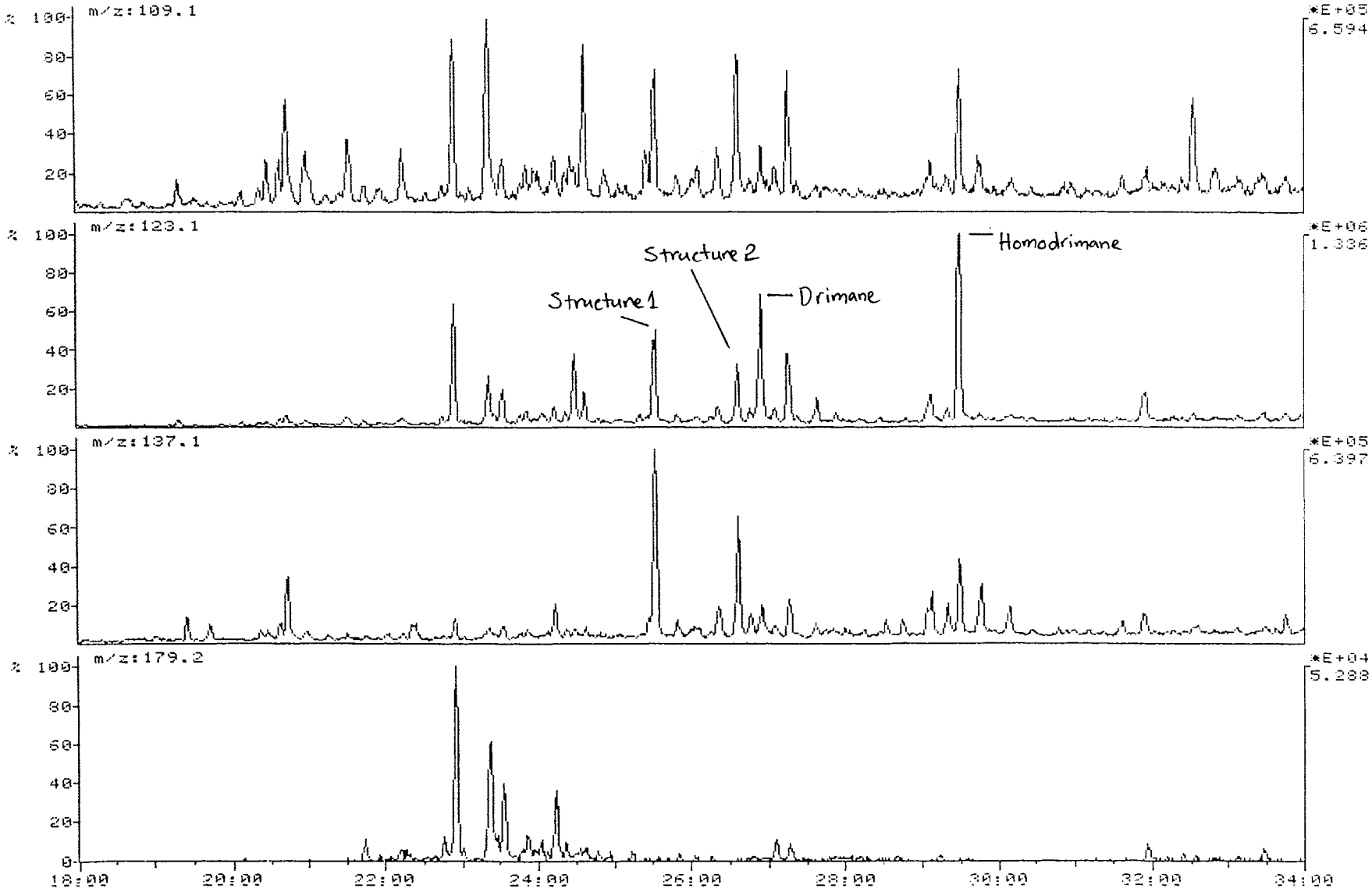
```
CHRO: BMP00109S ver 1 on UIC 3 1      20-NOV-95 Elapse: 00:15:04.0    1
Samp: POONARUNNA-1 5209'3" SAT                  Start : 18:05:25  3854
Comm: DB-1 60m 23.5psi ICL:BIOMARKER 0/40/200 S180 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 229 > 1471    Masses: 82 > 305
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
```



CHRO: BMP00150S ver 1 on UIC 3 1 21-NOV-95 Elapse: 00:15:04.8 1
Samp: POONARUNNA-1 5018'3" SAT Start : 11:41:52 3853
Comm: DB-1 60m 23.5psi ICL:BIOMARKER 0/40/200 S180 M70
Mode: EI +Q3MS LMR UP LR
Oper: MICHAELSEN Inlet :
Peak: 1000.00 mmu Label wndw: 228 > 1470 Masses: 82 > 305
Area: 0, 4.00 Baseline : 0, 3 Label : 0, 40.00



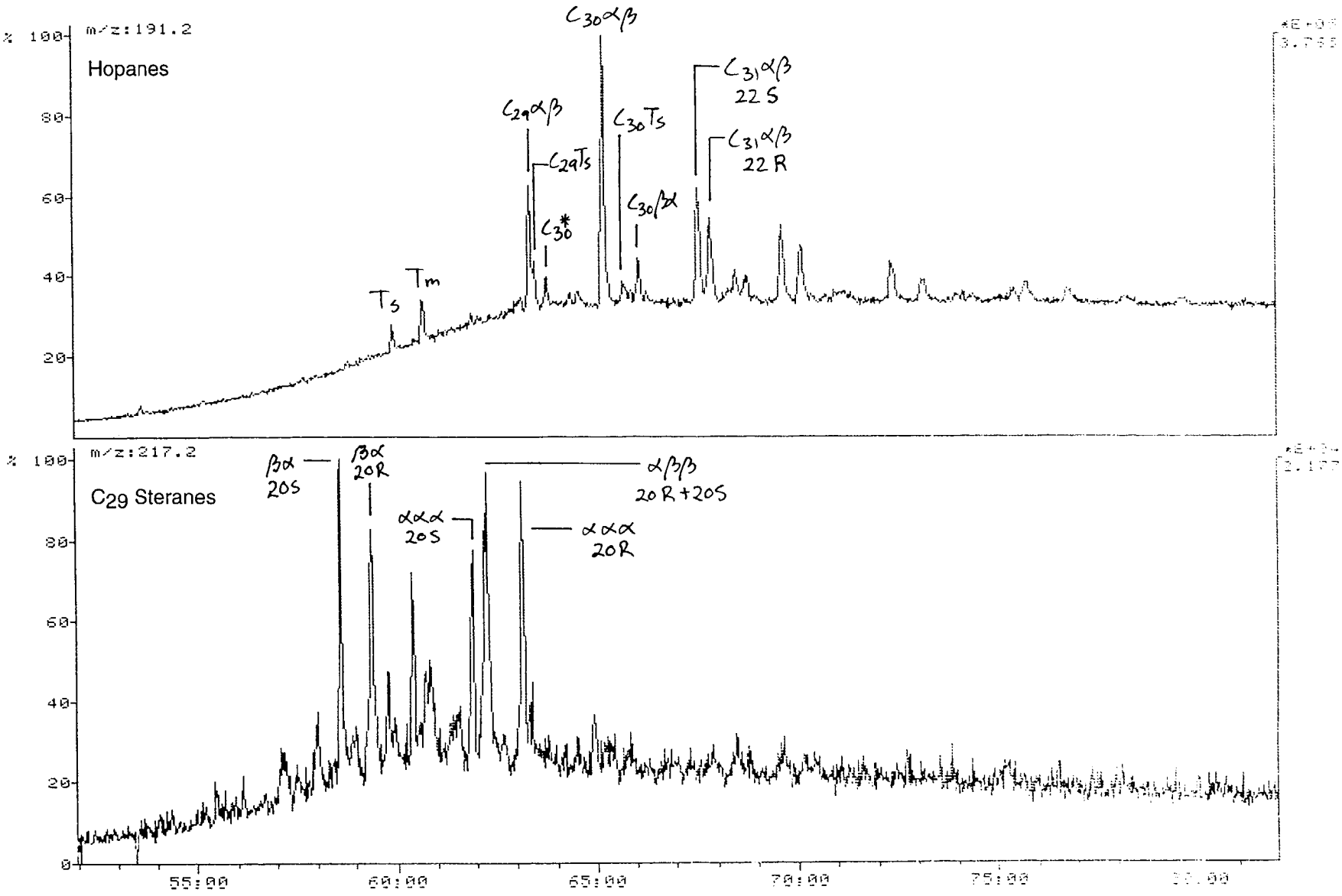
CHRO: BMP00152S ver 1 on UIC 3 1 21-NOV-95 Elapse: 00:15:05.1 1
Samp: POONARUNNA-1 5253'6" SAT Start : 06:52:39 3852
Comm: DB-1 60m 23.5psi ICL:BIOMARKER 0/40/200 S180 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN Inlet :
Peak: 1000.00 mmu Label wndw: 227 > 1469 Masses: 82 > 305
Area: 0, 4.00 Baseline : 0, 3 Label : 0, 40.00



Appendix I

GC-MS mass fragmentograms of hopanes and steranes

```
CHRO: BMPUT1478 ver 1 on UIC 3 1      24-NOV-95 Elapse: 00:15:05.1    1
Samp: PUTAMURDIE-1 4778'9" SAT                  Start : 11:40:35  3854
Comm: DB-1 60m 23.5psi ICL:BIOMARKER 0/40/200 S180 M70
Mode: EI +03MS LMR UP LR
Oper: MICHAELSEN                                Inlet :
Peak: 1000.00 mmu     Label wndw: 2546 > 3734   Masses: 82 > 305
Area: 0, 4.00         Baseline  : 0, 3          Label : 0, 40.00
```



CHRO: BMP00101S ver 1 on UIC 3 1 24-NOV-95 Elapse: 00:15:03.9 1
Samp: POONARUNNA-1 5001' SAT Start : 03:22:55 3855
Comm: DB-1 60m 23.5psi ICL:BIOMARKER 0/40/200 S180 M70
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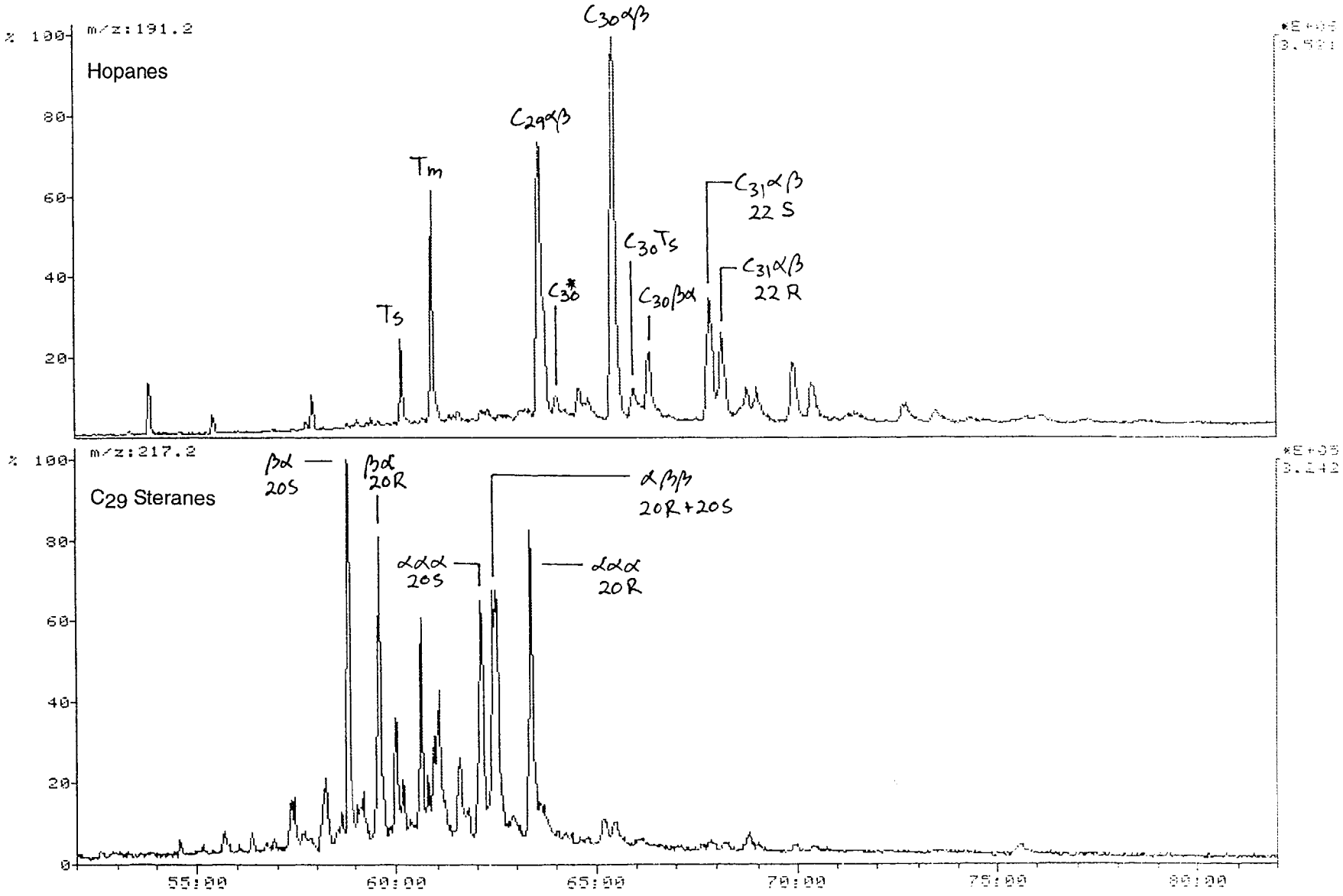

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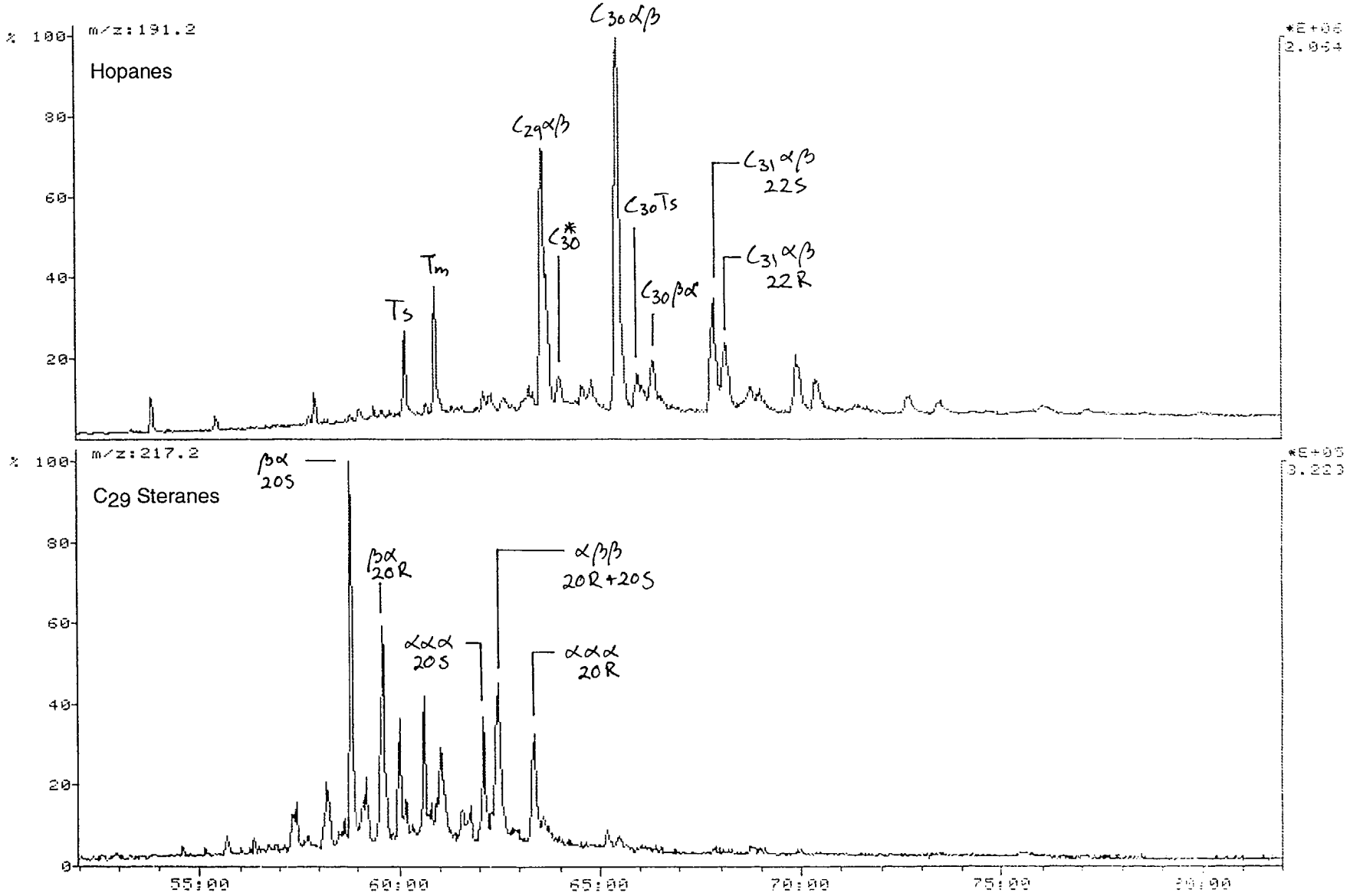

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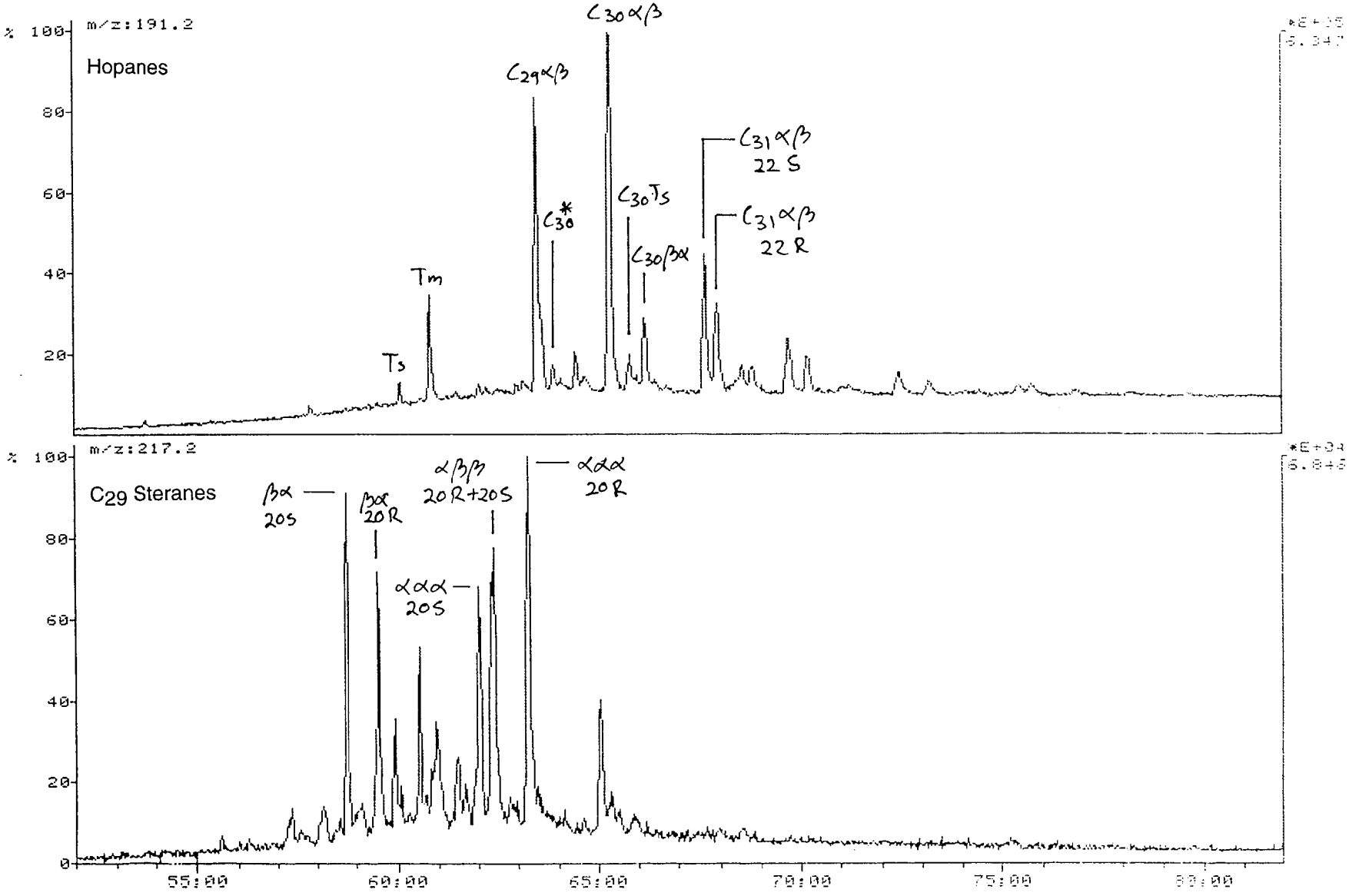

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Mode: EI +03MS LMR UP LR
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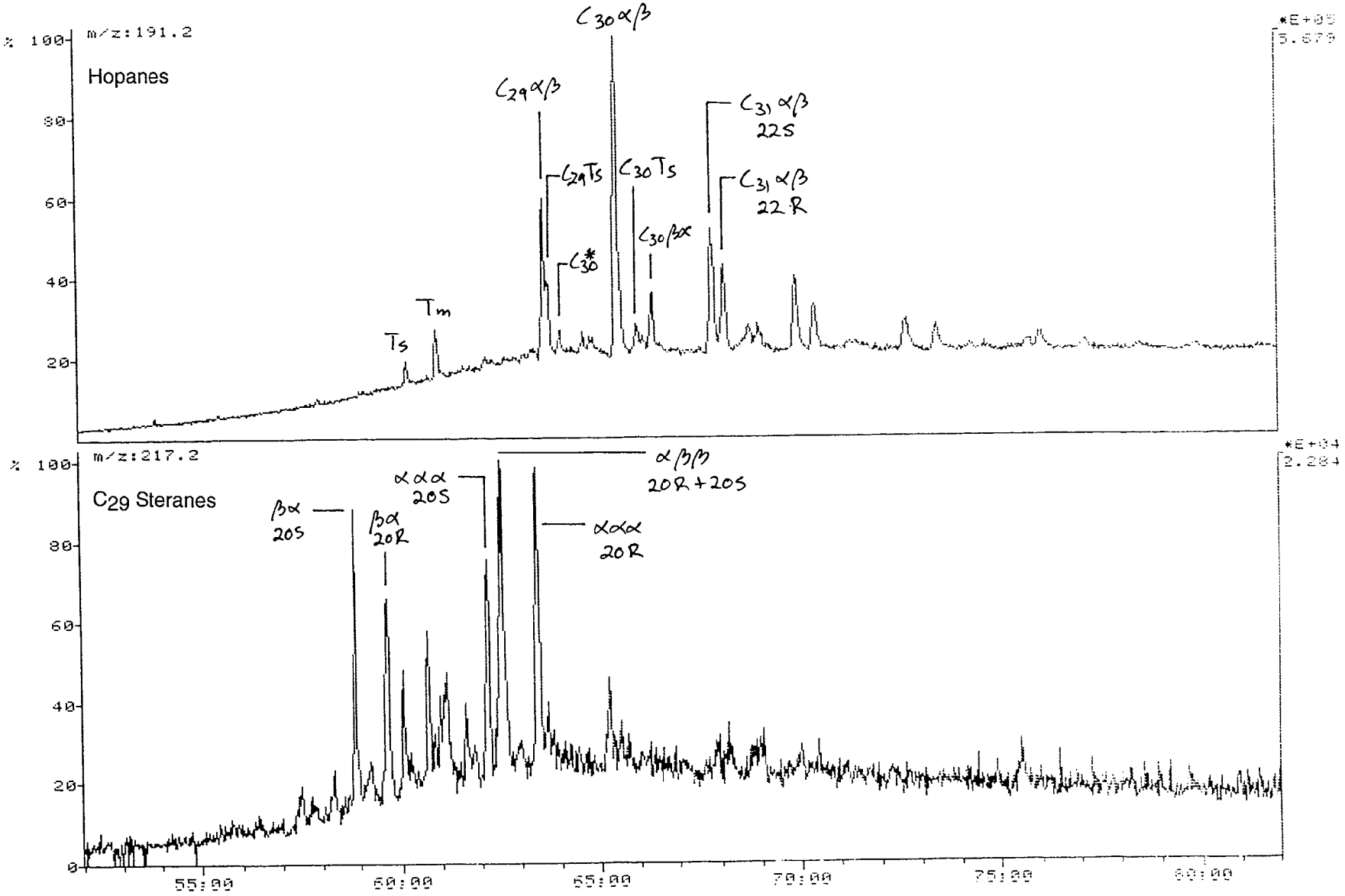

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SOURCE ROCK POTENTIAL AND PETROLEUM GEOCHEMISTRY OF THE ERINGA TROUGH AREA, PEDIRKA BASIN

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ABSTRACT

An organic geochemical and petrographic investigation of coals and carbonaceous sediments from the margins of the Eringa Trough, Pedirka Basin was undertaken to determine the source potential, degree of maturation and hydrocarbon composition of these Permian and Jurassic sediments. Analyses show that the terrestrial organic matter, is variously enriched in bacterial and algal remains, and was deposited in environments ranging from glacio-lacustrine to paludal.

A shift from a slightly heavy (-22.7‰) to lighter (-24.1‰) kerogen $\delta^{13}C$ signature during the Early Pemian suggests an increased contribution by C3-type plants.

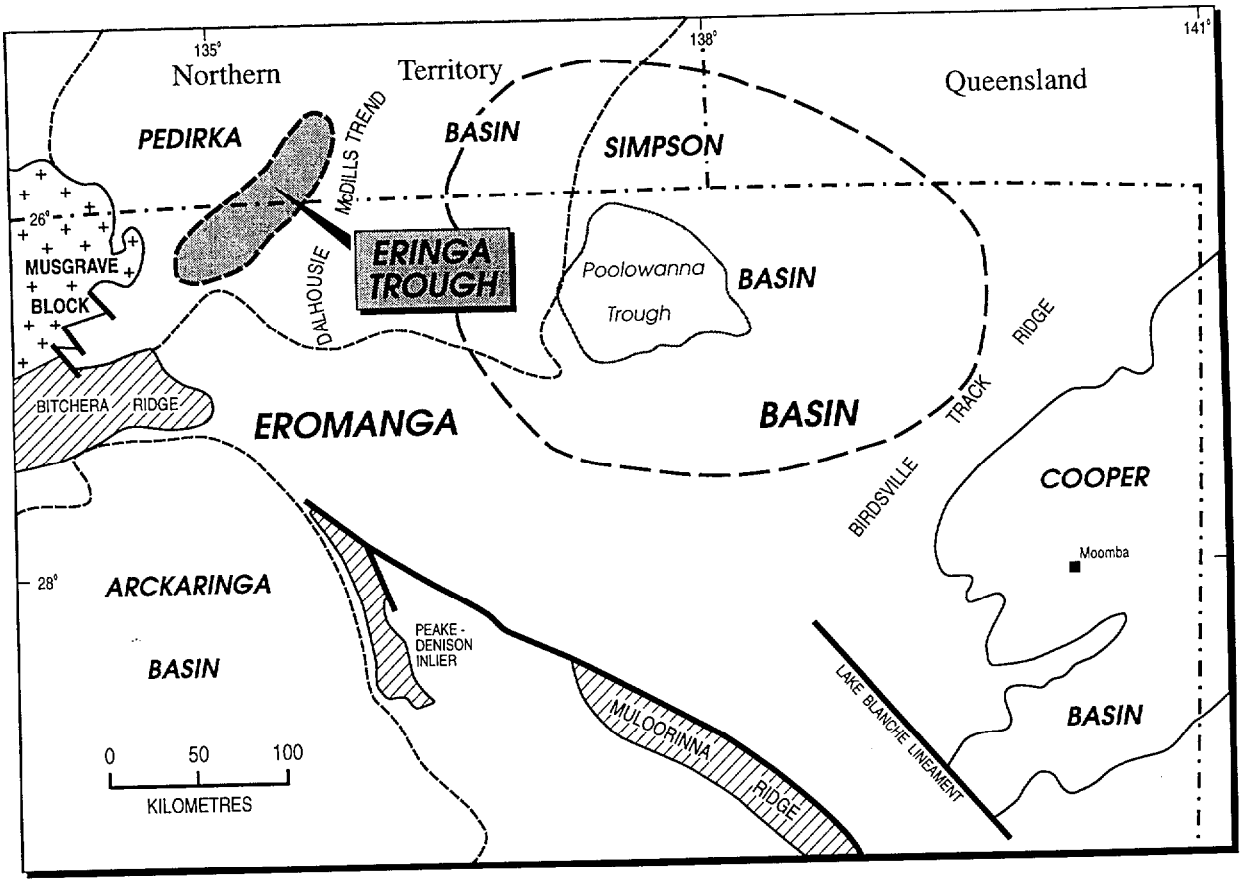
Petrographic and Rock-Eval pyrolysis data indicate that the terrestrially derived organic matter from all of these samples is thermally immature for hydrocarbon generation. The organically-lean siltstones of the Crown Point Formation and the Stuart Range Formation equivalent (both of Early Permian age) contain Type III kerogen and have very poor source potential. The samples from the Early Permian Purni Formation contain organic matter (Type III - Type II/III kerogen) of considerably better source potential. In contrast, the sediments from the Algebuckina Sandstone contain Type II to Type II/III kerogens and have good to excellent source potential based on Rock-Eval pyrolysis data.

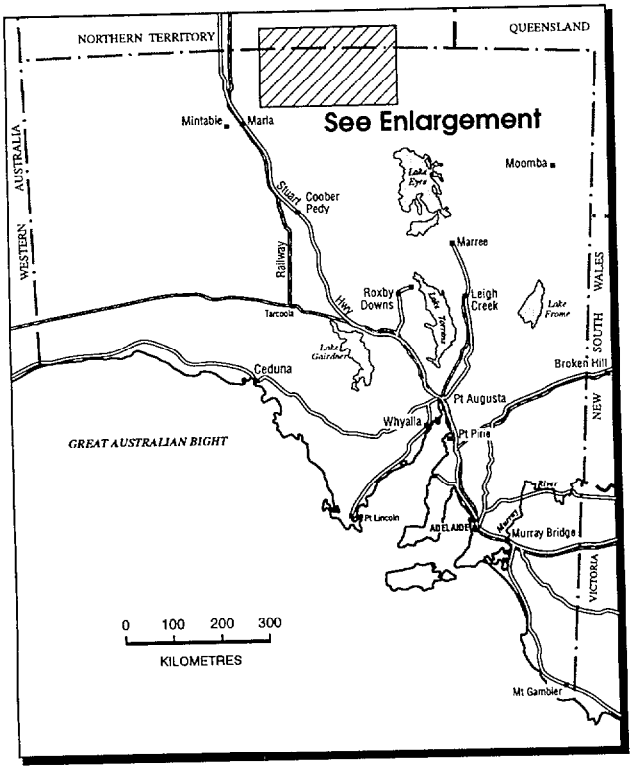
Source biomarker parameters reflect an increasing contribution by *Araucariaceae* flora to the Jurassic sediments. The standard maturation-sensitive hopane and sterane ratios give values typical of thermally immature sediments. The relative abundance of 1,2,5-trimethylnapthalene, 1,7-dimethylnapthalene, retene, 1-methylphenanthrene, 28,30-bisnorhopane (BNH), 3-methylhopanes and 3-methylsteranes appear to be age-dependent and have the potential to discriminate between Permian and Jurassic source rocks and hydrocarbons in the Pedirka Basin and adjacent Cooper/Eromanga Basins.

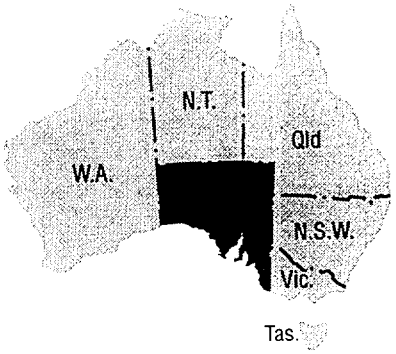
Chapter 1: Introduction

1.1 *Preamble*

Exploration for hydrocarbons in the far north of South Australia began early this century following the discovery of natural gas at Roma, Queensland. However, since the discovery of gas (Gidgealpa-2) in 1963 and oil (Tirrawarra-1) in 1970, exploration focused around the Cooper and Eromanga Basins in the north-east region of the state (Figure 1.1). These discoveries prompted exploration of similarly aged Permian/Jurassic basins, and the Pedirka Basin was one of those targeted. Exploration of the Pedirka Basin began in 1963 and a total of nine wells were drilled. However, no hydrocarbon discoveries were made. This thesis investigates the source rock potential of the Eringa Trough, which following recent acreage release and seismic exploration has renewed interest in the region as a potential oil and gas province.







Eringa Trough

LOCALITY PLAN and GEOLOGICAL SETTING

MINES AND ENERGY
SOUTH AUSTRALIA

Figure 1.1
95-965

1.2 *Aims of the study*

Mines and Energy South Australia commissioned this study as part of a reappraisal of the source rock potential of the Eringa Trough, Pedirka Basin.

The purpose of this study was to carry out an organic geochemical and petrographic investigation of coals and carbonaceous sediments from the margins of the Eringa Trough. The aims were to;

- determine the generative potential of the organic rich sediments
- assess the degree of maturation of the source rocks
- identify specific input biota
- derive age–discriminator biomarker parameters
- establish a biomarker database for potential source rocks to assist in future oil-source correlations.

Previous geochemical investigations into the source potential of the region used techniques that yielded little or no information on the biomarker character of the source rocks. Therefore, this study provides a detailed organic geochemical database for coals and carbonaceous sediments adjacent to the Eringa Trough.

1.3 *Regional Geology*

The Pedirka Basin is located in the central north of South Australia. It is a Carboniferous-Permian intracratonic basin, unconformably overlying the Amadeus Basin in the west and the Warburton Basin in the east. The following is a brief summary of a comprehensive review and study of the Pedirka Basin compiled by Giuliano (1988).

The Eringa Trough lies in the south-western region of the Pedirka Basin and is overlain by sediments of the Jurassic-Cretaceous Eromanga Basin and the Tertiary-Quaternary Lake Eyre Basin. It is an arcuate depression which is believed to contain approximately 5000 metres of Late Carboniferous to Early Permian sediments. Deformation of Amadeus Basin sediments during the Alice Springs and Delamerian Orogenies resulted in a north–east trending synclinal feature to the east of the Musgrave Block. Subsequent deposition of sediments in this depression formed the Eringa Trough.

Deposition of sediments in the Pedirka Basin began in the Carboniferous following initiation of regional down-warping. During the Late Carboniferous-Early Permian the Crown Point Formation, Stuart Range Formation equivalent and the Purni Formation were deposited unconformably over the Amadeus Basin sediments. Associated with this episode of sediment accumulation was the development of half graben structures and hinged troughs. Structural reactivation during the late Early Permian to Late Permian resulted in uplift, erosion, regional tilting and subsidence to the east. This caused an easterly migration of the depocentres and initiation of the Poolowanna Trough during the Early Triassic. Uplift continued along the western margin until the Late Triassic and resulted in a hiatus of sedimentation.

Infill of the Eromanga Basin began with the deposition of the Algebuckina Sandstone during the Early Jurassic and was complete by the Late Cretaceous.

Unconformably overlying the Eromanga Basin are the Tertiary-Quaternary sediments of the Lake Eyre Basin.

Chapter 2: Materials and Methods

The material analysed comprised 68 cuttings samples from the wells Dalmatia-1 and Mt Hammersley-1, and 9 core samples from AFMECO Cur-3 and Cur-5, Purni-1 and Witcherrie-1. The cuttings samples were washed to remove drilling mud and contaminates and then consolidated into 13 composite samples (Table 2.1). Core samples were scraped and brushed clean to remove superficial mud.

Well/Depth	Formation	Sample type
AFMECO Cur-3		
251.6 m	Algebuckina Sandstone	core
251.9 m	Algebuckina Sandstone	core
259.5 m	Algebuckina Sandstone	core
AFMECO Cur-5		
209.2 m	Algebuckina Sandstone	core
210.1 m	Algebuckina Sandstone	core
249.4 m	Algebuckina Sandstone	core
Dalmatia-1		
591.3 - 606.0 m	Purni Formation	cuttings
612.6 - 624.8 m	Purni Formation	cuttings
634.0 - 646.2 m	Purni Formation	cuttings
713.2 - 722.4 m	Purni Formation	cuttings
792.5 - 810.8 m	Purni Formation	cuttings
Mt Hammersley-1		
615.7 - 630.9 m	Purni Formation	cuttings
658.4 - 673.6 m	Purni Formation	cuttings
704.1 - 719.3 m	Purni Formation	cuttings
762.0 - 774.2 m	Purni Formation	cuttings
838.2 - 853.4 m	Purni Formation	cuttings
871.7 - 887.0 m	Purni Formation	cuttings
1219.2 - 1237.5 m	Sturt Range equivalent	cuttings
1408.2 - 1423.4 m	Crown Point	cuttings
Purni-1		
1445.8 m	Purni Formation	core
1772.1 m	Crown Point	core
Witcherrie-1		
556.2 m	Crown Point	core

Table 2.1: Wells sampled, formations, and type of sample collected.

Petrographic analyses used in this study included the analysis of macerals as dispersed organic matter (DOM) and the determination of vitrinite reflectance. Geochemical analyses included Rock-Eval pyrolysis and total organic carbon (TOC). These results were used to select samples for more detailed analysis, including capillary gas chromatography (GC) of the saturate (total alkane) fractions, gas chromatography-mass spectrometry (GC-MS) of the aromatic hydrocarbon fraction and gas chromatography-mass spectrometry-mass spectrometry (GC-MS-MS) of saturates. Mass spectrometry was employed to determine the carbon isotope values of selected kerogen concentrates. A detailed description of the conditions and analytical methods used in this study can be found in Appendix 1. A summary flow chart of the analytical procedures is shown in Figure 2.1.

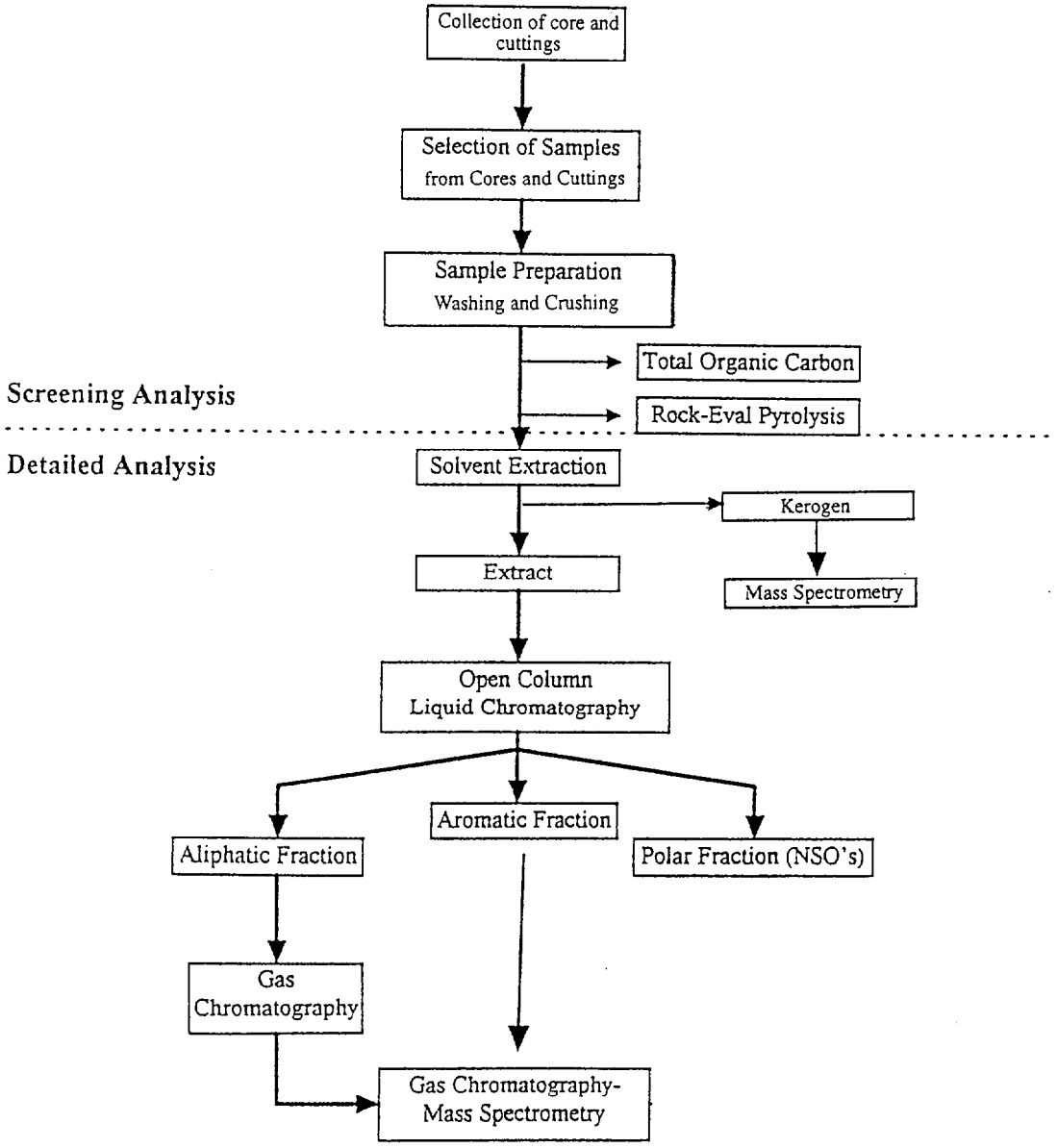


Figure 2.1 Flow diagram showing the basic steps involved in organic geochemical analysis (after Padley et al., 1991).

Chapter 3: Stratigraphy and Carbon Isotopes

3.1 *Introduction*

Only those formations sampled will be discussed. They are the Late Carboniferous - Early Permian Crown Point Formation, the Early Permian Stuart Range Formation equivalent and Purni Formation, and the Middle Jurassic Algebuckina Sandstone. The stratigraphy of the Eringa Trough has been determined from recent seismic exploration and from exploration wells located along the margins of the trough (Figure 3.1). The stratigraphic sequence of the Eringa Trough is shown in Figure 3.2. Alexander and Jensen-Schmidt (1995) and Giulano (1988) have compiled comprehensive reviews of the geology of the Eringa Trough. The following brief summary draws heavily on their papers.

The Permian-Carboniferous sequence of the Eringa Trough has been divided into three formations: the Crown Point Formation (glacigenic); the Stuart Range Formation equivalent (glacigenic) and the Purni Formation (lacustrine).

3.1.1 *Crown Point Formation*

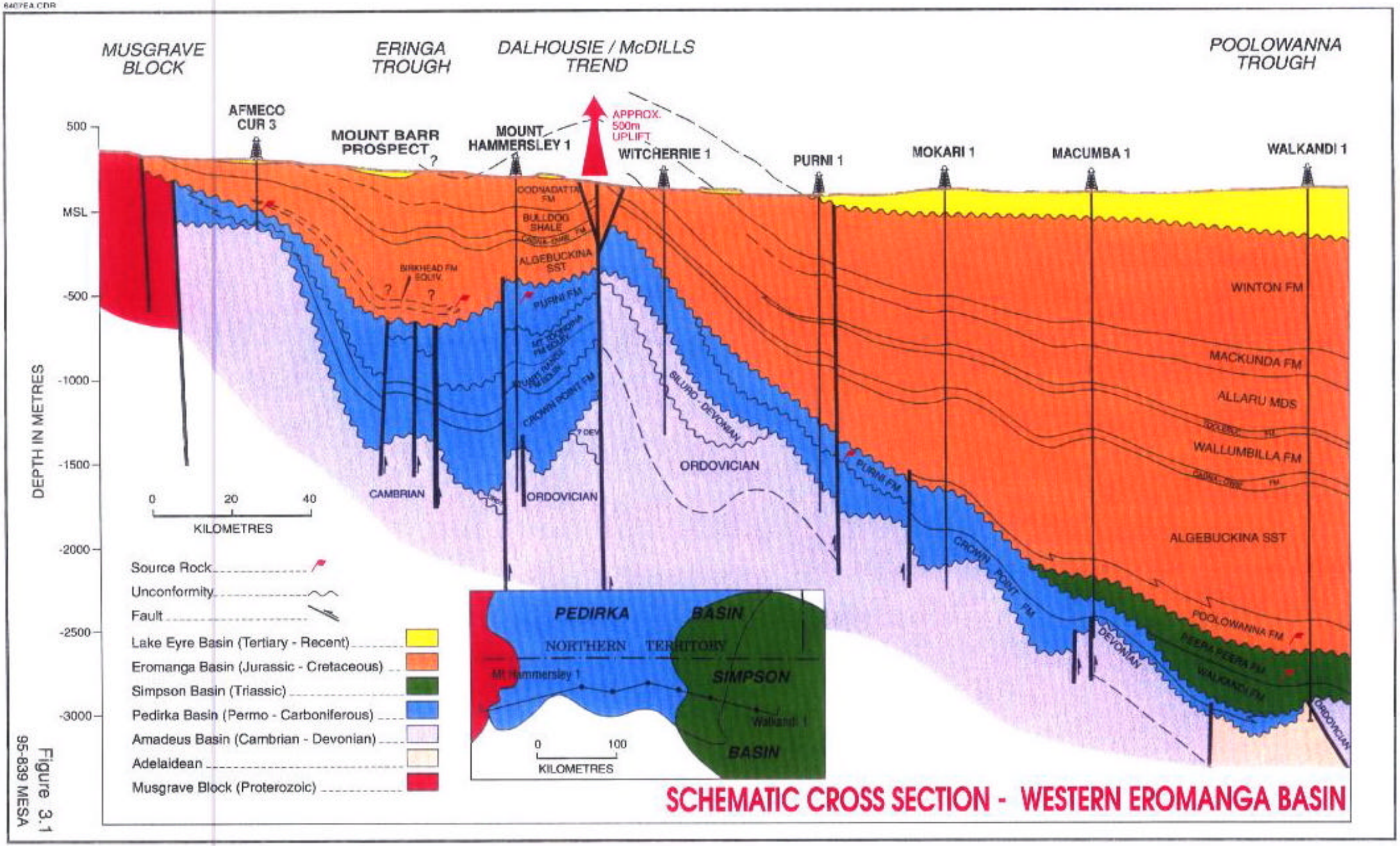
The Crown Point Formation consists of sandstones, thick clay-dominant siliciclastics and cobbly diamictites that were deposited in fluvioglacial, deep water glaciolacustrine, interglacial to periglacial environments, respectively. This formation unconformably overlies the sediments of the Amadeus Basin, and is unconformably overlain by the Stuart Range Formation equivalent and the Purni Formation.

The Crown Point Formation thickens into the Eringa Trough from the eastern margin, with 347m intersected in Mount Hammersley-1, it then shallows and thins westward to 15m in AFMECO Cur-3.

The white to buff, fine to coarse sandstones sampled in the upper part of the Crown Point Formation in Mt Hammersley-1 exhibit crossbedding, horizontal laminations, stratified beds and microfaults. These features suggest that deposition was in a high energy, proglacial, fluvial environment. The Crown Point Formation sampled in Purni-1 consists of conglomerates, diamictites and coarser sandstones that were deposited as proximal, proglacial outwash.

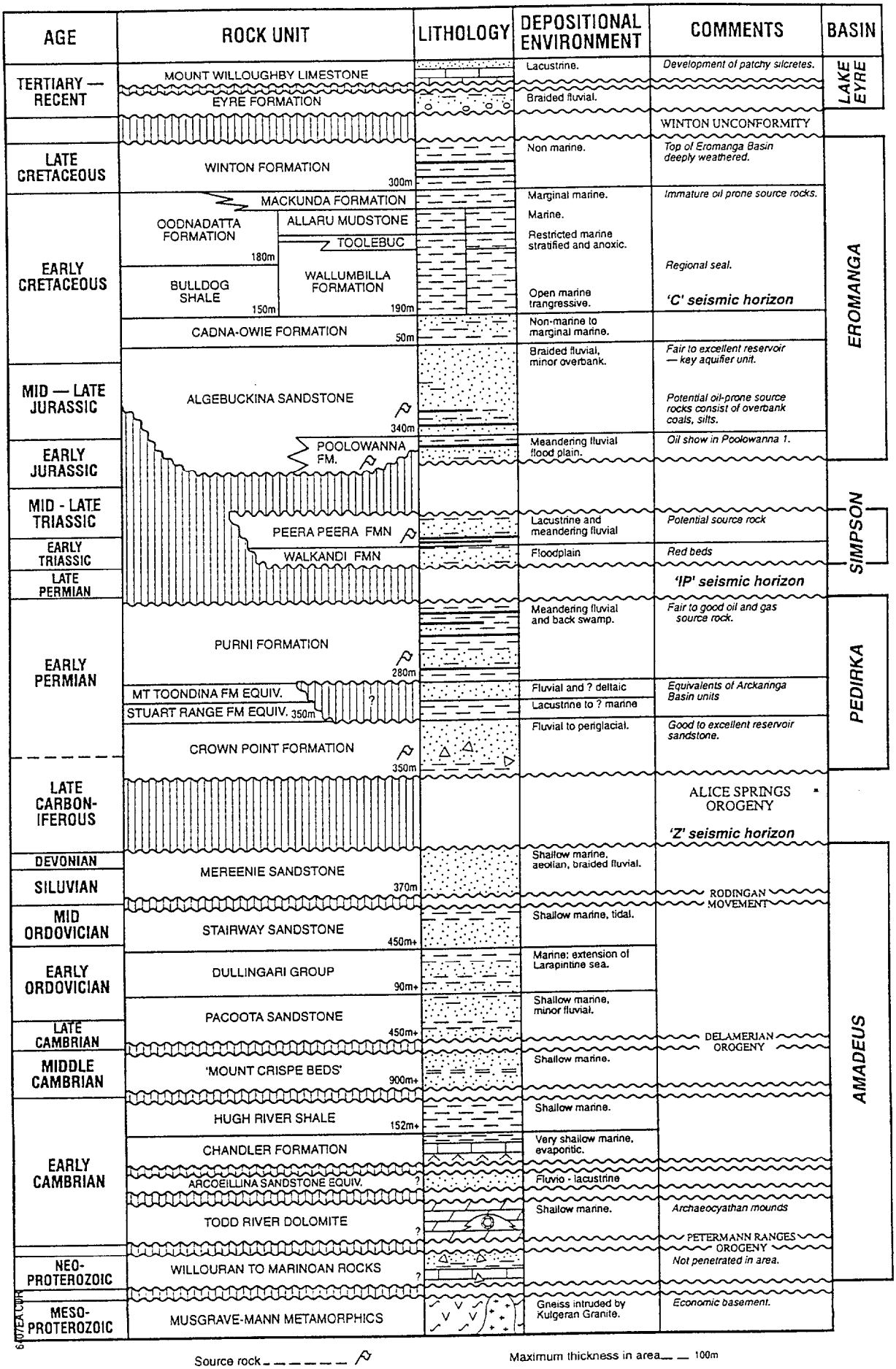
3.1.2 *Stuart Range Formation*

The Stuart Range Formation equivalent unconformably overlies the Crown Point Formation and is intersected only in Mount Hammersley-1. These light grey-green, varvite siltstones and claystones were deposited in relatively deep water in a glaciolacustrine environment or possibly marine environment .



SCHEMATIC CROSS SECTION - WESTERN EROMANGA BASIN

Figure 3.1
95-839 MESA



Eringa Trough

GEOLOGICAL SUMMARY

Figure 3.2

3.1.3 *Purni Formation*

The Purni Formation unconformably overlies the Crown Point Formation and the Stuart Range Formation equivalent. The type section in Purni-1 consists of three members. The basal member occurs as interbedded sands and silts, with shales and carbonaceous laminae at the top of the section. The middle member consists of fine to medium, fining upwards packages of kaolinitic sandstone, interbedded with thin coals and carbonaceous shales. The upper member consists of very fine to fine grained sandstones with increasingly abundant coals and carbonaceous shales towards the top of the section.

Deposition of the Purni Formation began in high to moderate energy fluvial channels (such as highly sinuous meandering streams). The middle and upper members were deposited in a flood plain and coal swamp environment.

3.1.4 *Algebuckina Sandstone*

The Middle Jurassic Algebuckina Sandstone (Birkhead Formation equivalent) unconformably overlies the Purni Formation. The Algebuckina Sandstone varies in thickness from 75 m (AFMECO Cur–2, western margin) to 270 m thick (Dalmatia–1, eastern margin). The Algebuckina Sandstone in the Eringa Trough consists of pale to dark grey carbonaceous siltstones interbedded with minor coals and sandstones. Thick sequences of carbonaceous mudstones and coals throughout this formation are of particular interest as possible source rocks for hydrocarbons.

Deposition of the coals in the Algebuckina Sandstone occurred in paludal environments that favoured the preservation of terrestrial (higher plant) organic matter.

3.2 *Carbon Isotopic Composition of Kerogen*

Carbon has two stable isotopes, ^{12}C and ^{13}C. Organisms preferentially utilise ^{12}C in equilibrium exchange and kinetic fractionation processes which result in the concentration of the light ^{12}C isotope (Degens, 1969). Therefore, biologically–derived carbon is isotopically light, that is depleted in ^{13}C. The natural variations of carbon isotopes observed in organic carbon are controlled by the different carbon pathways used by living organisms. Therefore isotopic ratios can be used to identify the source(s) of organic matter found in sedimentary rocks. The carbon isotopic data on kerogen in selected samples from the Eringa Trough are presented in Table 3.1 and plotted against depth in Figure 3.2.

Well/Depth	Formation	$\delta^{13}C$ ‰
AFMECO Cur-5		
210.1 m	Algebuckina Sandstone	-23.6
249.4 m	Algebuckina Sandstone	-23.6
Mt Hammersley-1		
704.1-719.3 m	Purni Formation	-24.1
838.2-853.4 m	Purni Formation	-23.7
871.7-887.0 m	Purni Formation	-24.1
1219.2-1237.5 m	Sturt Range equivalent	-22.9
1408.2-1423.4 m	Crown Point	-22.7

Table 3.1: $\delta^{13}C$ values of kerogens from Permian and Jurassic sediments.

The isotopic compositions of the Crown Point Formation (-22.7‰) and Stuart Range Formation equivalent (-22.9‰) are relatively heavy and fall within the range suggested by Stahl (1979) for non-marine organic matter. Contributors to this organic matter may have included one or both of the following; eukaryotic algae (-22‰) or plants with equivalent C3 pathways (-11‰ to -33‰) [Freeman *et al.*, 1991; Derenn *et al.*, 1992; Boreham *et al.*, 1994; Jones, 1994].

A shift from a cold lacustrine environment to a warmer coal swamp environment is reflected in depleted ^{13}C values as C3 plants become the dominant organic matter contributing to the sediments of the Purni Formation. Isotopic values of -23.7 to -24.1‰ fall within the range for coals (Degens, 1969) and C3 plants (Schidlowski in Jones, 1994).

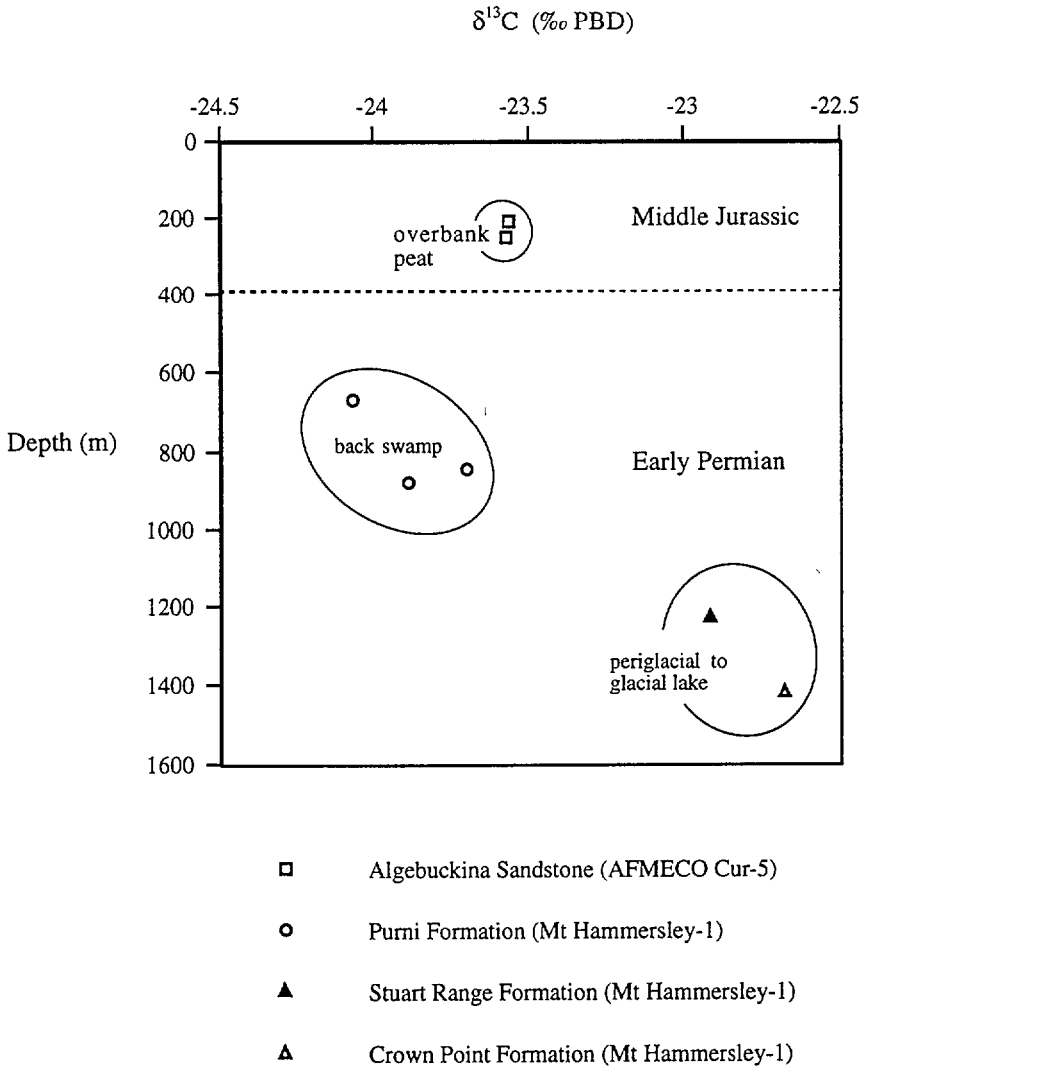


Figure 3.3: $\delta^{13}C$ values of kerogens from selected Permian and Jurassic sediments.

The ^{13}C values of the Algebuckina Sandstone samples are within the range -23 to -25‰ determined by Boreham (1995) and Summons *et al.* (1995) for Jurassic kerogens dominated by C3 plants.

The trend of upward lightening isotopic signatures through the Permian may reflect decreasing maturity. This may be due to kinetic fractionation proceses, that is as ^{12}C passes preferentially into a gaseous phase, the residue becomes enriched in ^{13}C (Clayton and Bjoroy, 1994). However, maturation only affects kerogen $\delta^{13}C$ signatures at much higher ranks than are observed here.

The heavier isotopic signature of the Crown Point Formation and the Stuart Range Formation equivalent may be explained by the preferential preservation of algal debris. For example, *Botryococcus* algal remains are enriched in ^{13}C and produces a heavy isotopic signature if present in the sediments (Boreham, 1994).

Petrographic observations reveal only rare algal material in these Permian sediments. However, the presence of sub-microscopic amorphous organic matter (petrographically unrecognisable remains) may account for the heavier signature (Taylor *et al.*, 1988).

Thus, the shift to a lighter signature is probably due to increased contribution of C3 type land plant material and a decrease in the relative amount of algal material. Plants using the C3 pathway are proposed, as plants employing the crassulacean acid metabolism pathway did not evolve until the Mesozoic.

The isotope stratigraphy illustrated in Figure 3.3 presents researchers with a potentially useful tool for future oil-source rock correlations in the Eringa Trough and wider Pedirka Basin.

Chapter 4: Source Potential: Petrography and Total Organic Carbon and Rock Eval Pyrolysis

4.1 *Petrography*

Coals and dispersed organic matter (DOM) in carbonaceous sediments contain a mixture of phytoclasts (macerals). Macerals belong to one of three groups (vitrinite, liptinite, inertinite), and are distinguishable on the basis of their morphology and physical properties (Stach *et al.*, 1982). Vitrinite and inertinite derive mainly from the structural components of plants. Spores, cutin, resin, suberin and algae make up the liptinites. The relative abundance and degree of degradation of each maceral group, are a function of the precursor flora, the provenance of the organic matter (allochthonous or autochthonous) and the redox conditions prevailing at the time of deposition.

The relative proportions of hydrogen-rich and hydrogen-poor components largely determine the hydrocarbon potential of source rocks. Vitrinites are hydrogen-poor and are precursors for gas and minor oil. Inertinites are usually inert, very hydrogen-poor, and will only produce gas at high maturity. By contrast, liptinites are hydrogen-rich and if abundant will produce a higher volume of oil and/or gas at lower maturities (Cook, 1982).

Vitrinite reflectance (R_O) is a measure of the thermal maturity of kerogen in source rocks. A range of $R_O$values has been estimated to cover the beginning and end of hydrocarbon generation, 0.6 and 1.4%R_O, respectively (Peters and Moldowan, 1993).

Vitrinite reflectance data and maceral abundances for the Eringa Trough are presented in Tables 4.1 and 4.2 and Figure 4.1.

4.1.1 *Crown Point Formation*

In Mt Hammersley-1 and Purni-1, the Early Permian Crown Point Formation is represented by organically-lean siltstones (macerals account for < 4% by volume). By contrast, the sample from Witcherrie-1 contains a significantly higher percentage of macerals (37% by volume). The main macerals present are vitrinite (85.6% of macerals) and liptinite (10% of macerals; Figure 4.1). The highly oxidised and comminuted nature of the macerals suggests substantial degradation and reworking prior to and during deposition (Plate 1a-b). Consequently, the measured vitrinite reflectance is anomalously high (0.89% R_O) and is not corroborated by other evidence (T_{max}, see below).

Well / Depth	Formation	R_o %	Vitrinite % of total	Vitrinite % of mac	Inertinite % of total	Inertinite % of mac	Liptinite % of total	Liptinite % of mac	Mineral % of total
AFMECO Cur-3									
251.60 m	Algebuckina	0.43	50.2	52.9	13.5	14.2	31.3	32.9	5.0
251.90 m	Algebuckina	0.43	46.3	49.1	4.3	4.5	43.7	46.4	5.7
259.50 m	Algebuckina	0.44	72.6	73.9	1.2	1.3	24.4	24.8	1.8
AFMECO Cur-5									
209.20 m	Algebuckina	0.62	7.9	41.9	9.0	47.6	2.0	10.7	81.0
210.10 m	Algebuckina	0.41	66.2	67.9	11.7	12.0	19.6	20.1	2.5
249.40 m	Algebuckina	0.45	66.5	67.7	1.1	1.8	30.6	31.2	1.8
Dalmatia-1									
591.3 - 606.0 m	Purni	0.44	42.7	43.3	15.3	15.6	40.4	41.1	1.6
713.2 - 722.4 m	Purni	0.34	33.3	33.9	31.6	32.3	33.2	33.8	0.9
Mt Hammersley-1									
615.7 - 630.9 m	Purni	0.43	57.0	57.6	30.4	30.7	11.6	11.7	1.0
658.4 - 673.6 m	Purni	0.37	51.2	51.6	41.2	41.4	6.9	7.0	0.7
704.1 - 719.3 m	Purni	0.45	50.3	51.0	41.5	41.7	7.3	7.3	0.9
762.0 - 774.2 m	Purni	0.39	64.7	65.5	17.3	17.6	16.7	16.9	1.3
838.2 - 853.4 m	Purni	0.33	81.3	82.4	4.3	4.4	13.1	13.2	1.4
871.7 - 887.0 m	Purni	0.36	27.4	28.3	53.4	55.5	16.2	16.7	3.0
1219.2 - 1237.5 m	Stuart Range		0.2		1.9		1.4		96.5
1408.2 - 1423.4 m	Crown Point		0.8		1.0		1.0		96.1
Purni-1									
1445.8 m	Purni	0.89	45.3	72.0	9.6	14.9	8.5	13.1	36.6
1772.1m	Crown Point		0.0		0.1		3.0		96.9
Witcherie–1									
556.2 m	Crown Point	0.51	31.3	85.6	3.7	10.1	1.6	4.3	63.4

% of Total = volume per cent of total rock; % of mac = volume per cent of total macerals

Table 4.1: Maceral and mineral abundances.

Well / Depth	Formation	Vitrinite telo %	Vitrinite detro %	Vitrinite gelo %	Inertinite indet %	Inertinite fus %	Inertinite semi %	Liptinite lipdet %	Liptinite spor %	Liptinite cut %	Liptinite res %	Liptinite bit %	Liptinite fluor %
AFMECO Cur-3													
251.60 m	Algebuckina	70.3	29.0	0.7	56.0	37.3	6.7	31.3	17.0	30.7	20.5		0.6
251.90 m	Algebuckina	52.9	16.79	0.7	13.86	77.8		26.5	8.7	42.0	21.0		0.3
259.50 m	Algebuckina	22.3	23.65	5.7	17.50	12.5	37.5	53.4	13.7	2.5	28.6		1.8
AFMECO Cur-5													
209.20 m	Algebuckina	87.2	3.51	1.2	24.97	16.8	78.9	4.6	13.6		81.8		0.2
210.10 m	Algebuckina	30.7	18.27	5.1	19.72	64.0	9.7	27.2	19.4	27.2	25.7		0.5
249.40 m	Algebuckina	56.3	42.52	6.8	27.19	25.0		47.9	28.2	13.2	10.3		0.4
Dalmatia-1													
591.3 - 606.0 m	Purni	61.3	37.3	1.4	26.6	41.4	32.0	5.2	5.5	16.2	4.9	68.2	
713.2 - 722.4 m	Purni	62.0	37.3	0.7	8.45	17.1	78.0	11.3	20.9		36.0	31.8	
Mt Hammersley-1													
615.7 - 630.9 m	Purni	63.8	20.3	15.9	3.8	24.4	71.8	21.4	32.9		45.7		
658.4 - 673.6 m	Purni	53.5	32.9	13.6	10.7	25.0	64.3	36.8	18.4		44.8		
704.1 - 719.3 m	Purni	74.2	11.6	14.2	11.0	20.1	68.9	40.4			59.6		
762.0 - 774.2 m	Purni	61.4	37.4	1.2	6.9	24.4	68.7	10.6	12.1		71.2	6.1	
838.2 - 853.4 m	Purni	26.7	72.3	1.0	32.3	38.7	29.0	26.3	29.5		2.1	42.1	
871.7 - 887.0 m	Purni	95.9	3.1	1.0	1.1	11.1	87.8	87.8	7.8	0.9	3.5		
1219.2 - 1237.5 m	Stuart Range		100		100			52.9	35.3		11.8		
1408.2 - 1423.4 m	Crown Point		100		100			63.6	27.2		63.6		
Purni-1													
1445.8 m	Purni	19.1	67.2	13.7	25.4	10.4	64.2	42.1	32.9	1.3	23.7		
1772.1 m	Crown Point		100		100			100					
Witcherie–1													
556.2 m	Crown Point	23.5	35.7	40.8	72.7	9.1	18.2	30.8	15.4	3.8	50.0		

telo = telovitrinite; detro = detrovitrinite; gelo = gelovitrinite
indet = inertodetrinite; fus = fusinite; semi = semifusinite
lipdet = liptodetrinite; spor = sporinite; cut = cutinite
res = resinite; bit = bituminite; fluor = fluorinite

Table 4.2: Relative abundance of each maceral subgroup.

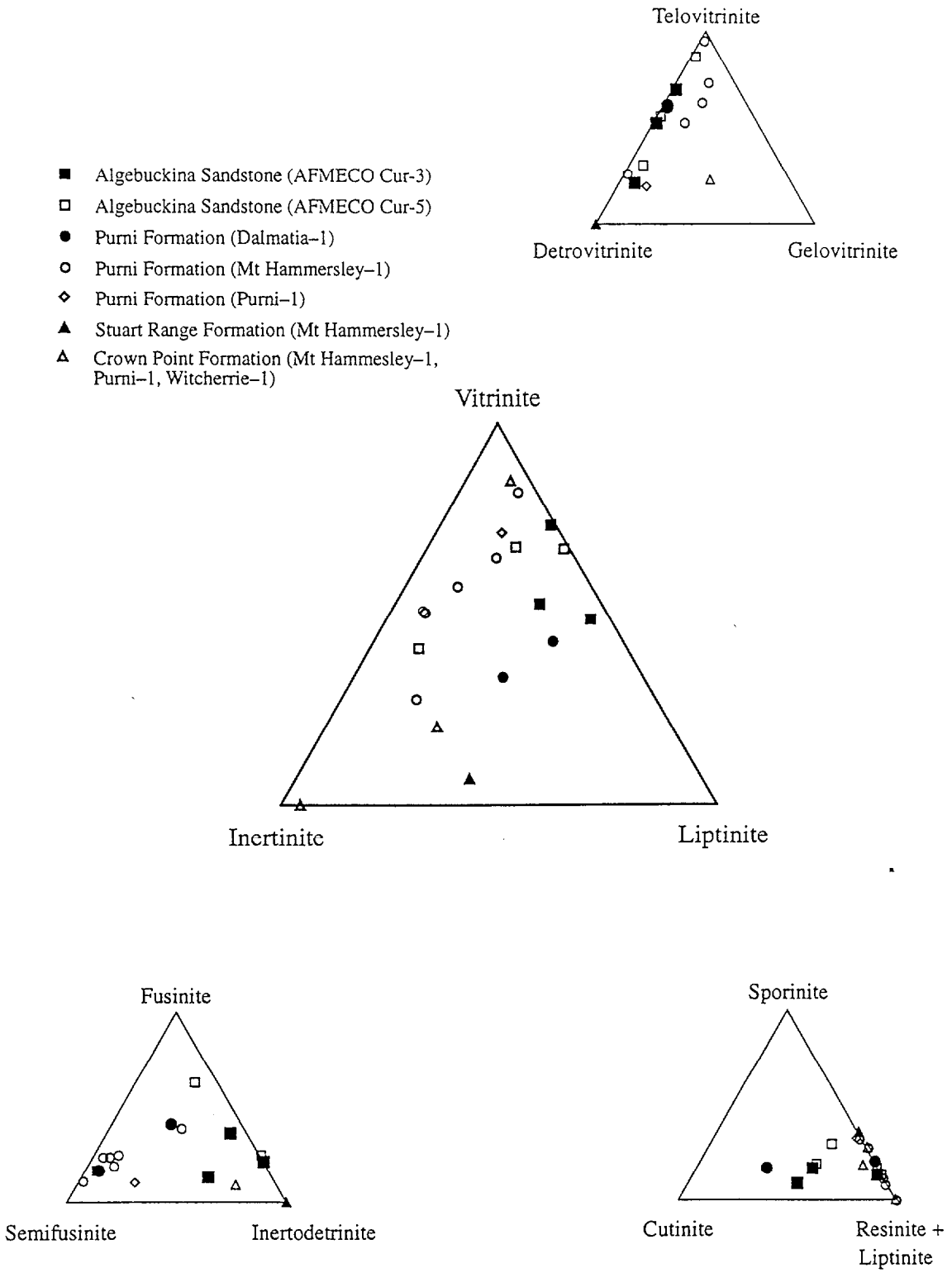


Figure 4.1: Maceral abundances in the Crown Point Fm., Stuart Range Fm. equivalent, Purni Fm. and Algebuckina Sandstone.

4.1.2 *Stuart Range Formation equivalent*

Mt Hammersley–1 intersected an organically-lean siltstone of the Stuart Range Formation equivalent (macerals < 4% by volume). This sample is similar to the siltstone of the Crown Point Formation at Mt Hammersley–1. The macerals present in decreasing abundance are inertinite > liptinite >> vitrinite which indicates that its hydrocarbon source potential is likely to be very poor.

4.1.3 *Purni Formation*

The two samples of the Early Permian Purni Formation at Dalmatia-1 have similar abundances of vitrinite (33.9 and 43.3 % of total macerals; Table 4.1). The dominant vitrinite is telovitrinite, comprising abundant eu-ulminite and texto-ulminite. Detrovitinite (densinite) is the next most abundant maceral present. In contrast, a wide range of vitrinite distribution and abundances were found in samples from Mt Hammersley–1 (Table 4.2). However, in all but one sample (838.2 – 853.4 m) from the latter well, the predominant vitrinite subgroup is similar, with telovitrinite comprising in order of abundance eu-ulminite > texto-ulminite > telocollinite. Detrovitrinite (densinite) was the predominant vitrinite in Mt Hammersley–1: 838.2 – 853.4 m and in the sample from Purni–1: 1445.8 m. The latter sample contained severely degraded vitrinites intimately associated with mineral matter to form a ground mass. In other samples, the vitrinites displayed varying degrees of degradation and oxidation and many were dissected by desiccation fractures (Plate 1c-f).

Liptinite macerals comprise 33.8 to 41.1 % by volume of the total macerals in the Dalmatia–1 samples and consist mainly of bituminite, resinite, cutinite and sporinite. In the Mt Hammersley–1 and Purni–1 samples, liptinites form the subordinate maceral group (7.0 to 16.9% of the macerals), with resinite, liptodetrinite and sporinite the most abundant liptinite macerals (Plate 1 c-j). The bituminite in Mt Hammersley–1 at 704.1-719.3 m and 838.2 – 853.4 m is intimately interlayered with degraded densinite, eu-ulminite and semifusinite (Plate 1 c-d).

Inertinite macerals are the least abundant macerals and make up 4.4 to 55.5% by volume of the total macerals. The major macerals present in order of decreasing abundance are semifusinite < fusinite < inertodetrinite.

Vitrinite refelectance ranges from 0.33 to 0.45% R_o indicating that these sediments are immature to marginally mature for hydrocarbon generation.

4.1.4 *Middle Jurassic Algeuckina Sandstone*

Five samples from the Algebuckina Sandstone are coals. The sixth sample comprises a reworked coal and will be discussed separately.

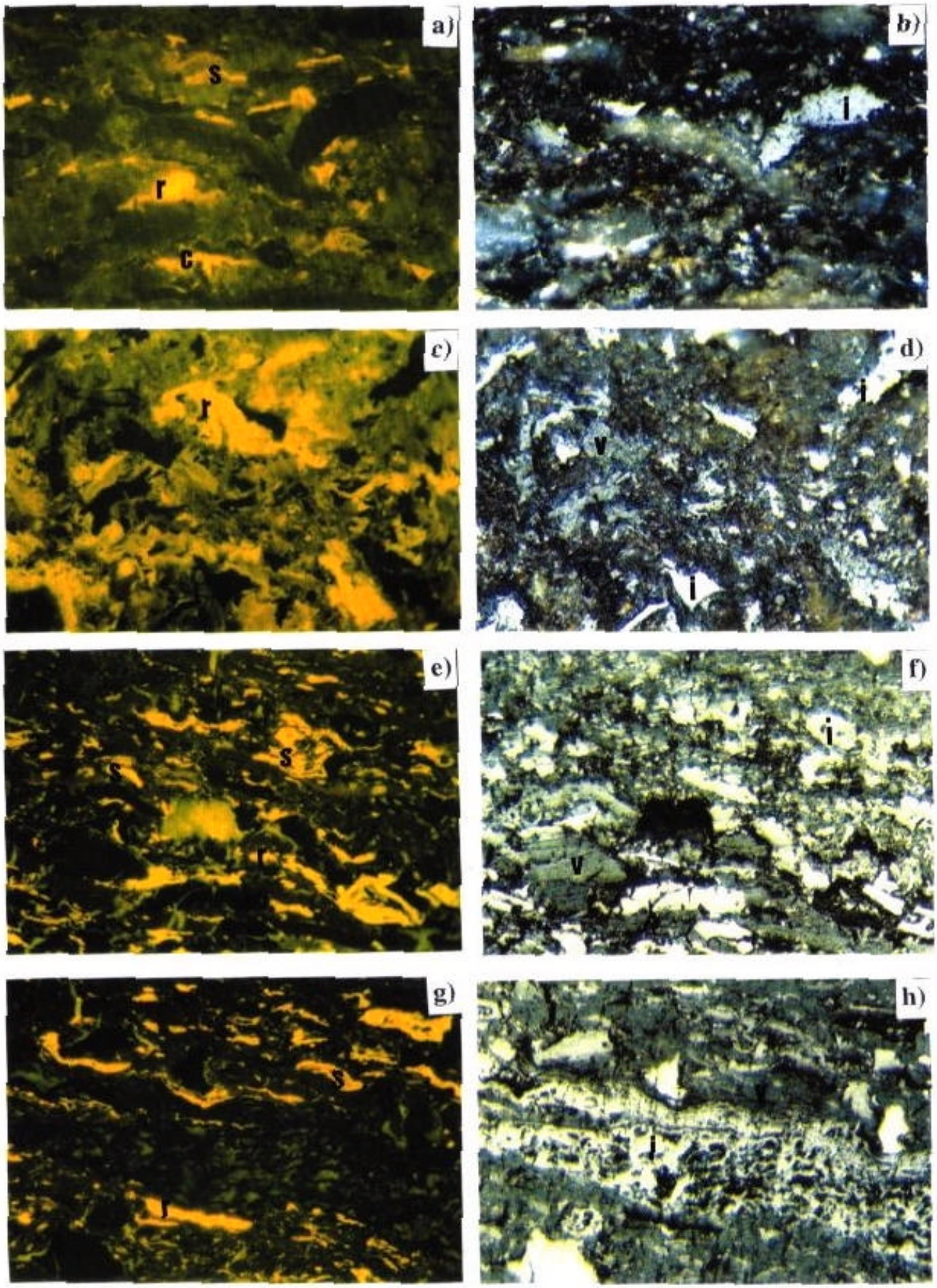


Plate 1: Plates show fluorescence-mode on the left and reflected white light on the right. Field of view 205µm for plates a-b) Crown Point Formation facies. Sample shows minor liptinites in (a) and highly oxidised vitrinites (b) from Witcherrie-1 (556.2m) c-j) Purni Formation facies. Fluorescence-mode show layering defined by sporinites, cutinites, resinites and liptodetrinites. Vitrinites show varying degrees of degradation and layering becomes more distinct (Purni-1 1445.8m; Mt Hammesley-1 615.7 - 853.4m; Dalmatia-1 612.6 - 624.8m respectively). k-p) Algebuckina facies. Fluorescence-mode samples comprising interlayered cutinites, resinites and sporinites (AFMECO Cur-3 259.5m; Cur-5 249.4m, respectively).

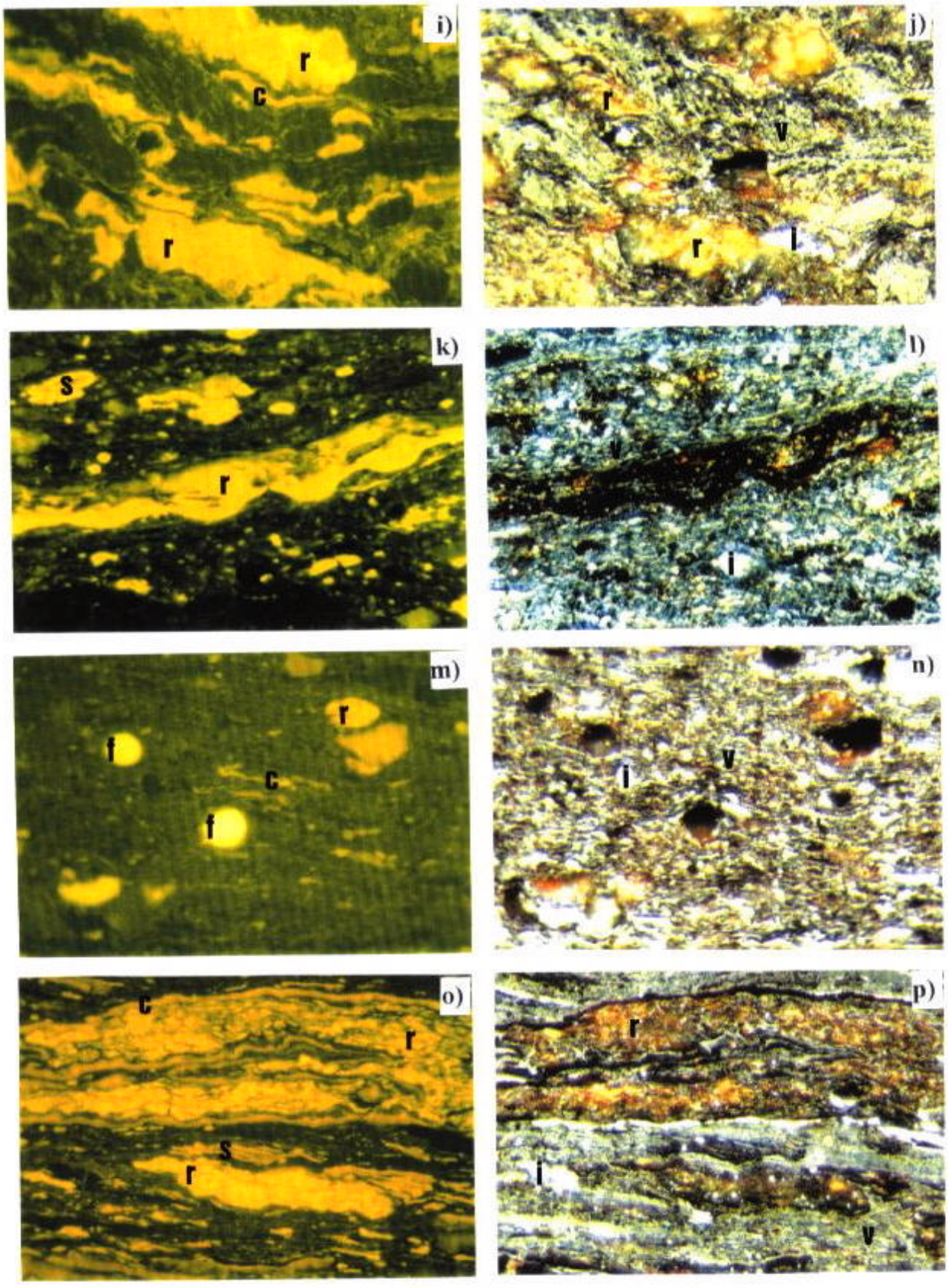


Plate 1: continued.

Legend: i = inertinites; v = vitrinites; c = cutinite; r = resinite; s = sporinite; f = fluorinite.

The five coals are rich in both vitrinite and liptinite (Table 4.1). Vitrinite abundance ranges from 74% to 49 % of total maceral abundance (Table 4.1). The most abundant vitrinites are telovitrinite (eu-ulminite) and detrovitrinite (densinite).

The liptinite macerals present in decreasing abundance are liptodetrinite > cutinite ≥ resinite > sporinite. Resinite and cutinite commonly occur as intimately associated layers (Plate 1 k-p). Fluorinite occurs as globules (< 10 μm to 200 μm) and as elongate phytoclasts 15 to 40 μm in length. (Plate 1 m-n).

Inertodetrinite and fusinite dominate the inertinite macerals and comprise 1.3 to 14.2% of the total maceral abundance.

Vitrinite reflectance ranges from 0.41% to 0.45% R_o. These sediments are therefore immature for hydrocarbon generation.

The sample from AFMECO Cur.5 (209.2m) comprises a reworked coal. Large phytoclasts of eu-ulminite and semifusinite exhibiting bogen-structure are abundant. The high vitrinite reflectance value (0.62% R_O) is of little value as a maturity measurement because the coal is reworked.

4.2 Total Organic Carbon (TOC) and Rock–Eval Pyrolysis

Rock–Eval pyrolysis was used to determine the generative potential and thermal maturity of the source rocks following the guidelines established by Peters (1986). Total organic carbon (TOC) quantifies the amount (weight %) of organic carbon in a source rock. Hydrogen index (HI) is a measure of source rock quality and the higher the HI the greater the oil generative potential. The potential yield is calculated using the sum of the volatile (S_1) and pyrolyzate (S_2) hydrocarbons expressed as mg hydrocarbon/g rock (mg HC/g rock). Plotting HI versus T_{max} enables identification of the type of organic matter present. The modal evolution pathways of the different kerogen types, Type I (very oil prone), Type II (oil and gas prone) and Type III (gas prone) are marked on the diagram (Figure 4.2). Vitrinite reflectance and T_{max} values indicate the thermal maturity of the source rocks.

Figure 4.2 is a cross–plot of HI against T_{max} of the coals and carbonaceous sediments sampled in this study. Selected Rock-Eval data from Appendix 2 are summarised in Table 4.3.

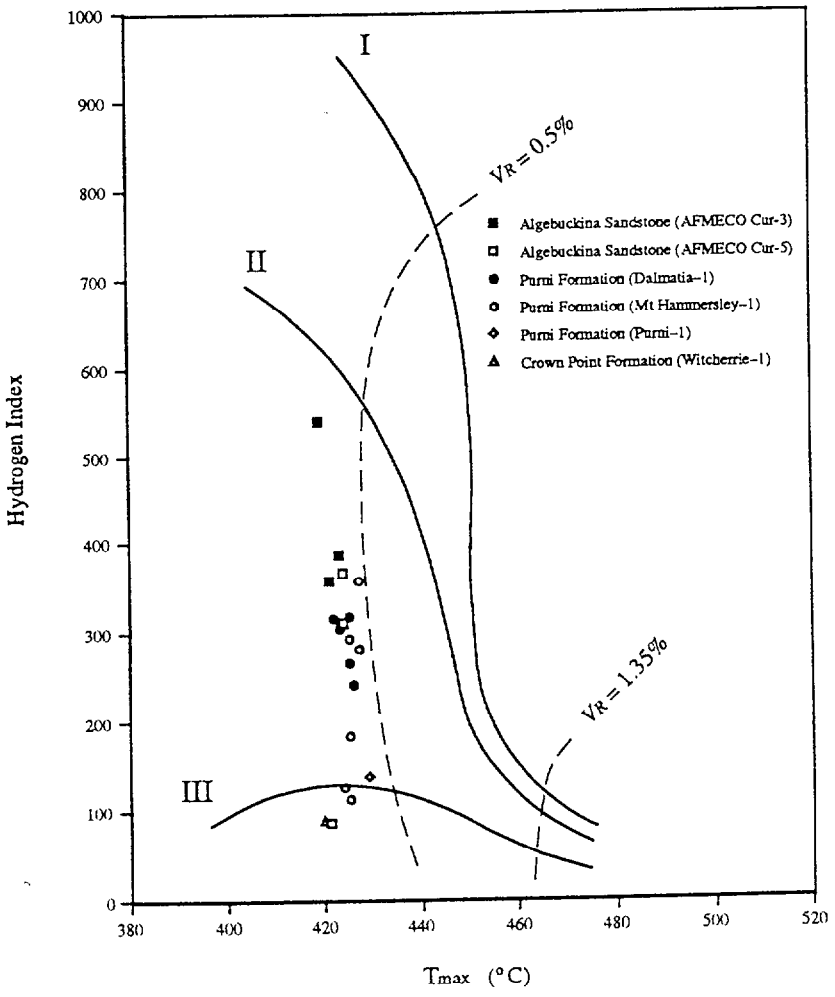


Figure 4.2: Plot of hydrogen index vs Tmax, showing kerogen type and maturity.

Well/Depth	Formation	T_{max}	S1+S2	PI	TOC	HI	R_o (%)
AFMECO Cur-3							
251.60 m	Algebuckina	421	135.08	0.09	34.30	359	0.43
251.90 m	Algebuckina	423	168.29	0.10	39.00	388	0.43
259.50 m	Algebuckina	419	279.41	0.08	47.20	542	0.44
AFMECO Cur-5							
209.20 m	Algebuckina	421	49.41	0.07	52.90	87	0.62
210.10 m	Algebuckina	424	175.72	0.10	50.50	312	0.41
249.40 m	Algebuckina	424	248.59	0.13	58.70	368	0.45
Dalmatia-1							
591.3 - 606.0 m	Purni	423	155.41	0.03	49.20	305	0.44
612.6 - 624.8 m	Purni	425	122.83	0.03	44.30	268	
634.0 - 646.2 m	Purni	426	92.96	0.02	37.70	242	
713.2 - 722.4 m	Purni	425	126.26	0.03	38.50	318	0.34
792.5 - 810.8 m	Purni	422	129.32	0.03	39.40	317	
Mt Hammersley-1							
615.7 - 630.9 m	Purni	424	82.30	0.03	63.10	127	0.43
658.4 - 673.6 m	Purni	425	72.79	0.02	62.80	113	0.37
704.1 - 719.3 m	Purni	425	98.97	0.03	58.70	164	0.45
762.0 - 774.2 m	Purni	425	179.31	0.04	59.10	293	0.39
838.2 - 853.4 m	Purni	427	206.72	0.03	55.80	359	0.33
871.7 - 887.0 m	Purni	427	144.51	0.04	52.80	264	0.36
1219.2 - 1237.5 m	Stuart Range	nd	0.19	0.16	0.41	39	
1408.2 - 1423.4 m	Crown Point	nd	0.19	0.02	0.35	34	
Purni-1							
1445.8 m	Purni	429	10.43	0.86	7.48	137	0.89
1772.1 m	Crown Point	429	0.00	0.00	0.22	0	0.00
Witcherie–1							
556.2 m	Crown Point	420	3.11	0.25	3.38	90	0.51

T_{max} = temperature of maximum generation of S2 hydrocarbons S1 = mg hydrocarbons/g rock;

S2 = mg hydrocarbons/g rock; PI = S1/(S1+S2); TOC = total organic carbon; HI = S2/g TOC;

Table 4.3: Summary of Rock-Eval pyrolysis and TOC data.

4.2.1 *Crown Point Formation*

The three samples from the Crown Point Formation have very poor to poor source potential (TOC = 0.22 - 3.38%; HI = 34 - 90). The T_{max} (420°C) and HI (90) data from Witcherrie-1 suggest that these sediments contain immature Type III kerogen with a vitrinite reflectance less than 0.45% R_o (Figure 4.2). The higher measured reflectance value (0.51% R_o) is possibly due to the presence of reworked and/or oxidised vitrinite (Peters and Moldowan, 1993).

4.2.2 *Stuart Range Formation equivalent*

The one sample from the Stuart Range Formation equivalent in Mt Hammersley–1 displays very poor source potential ($S_1 + S_2 < 1$ mg HC/g; HI = 39).

4.2.3 *Purni Formation*

The source potential of the Early Permian Purni Formation in Dalmatia-1, Mt Hammersley-1 and Purni-1 ranges from fair to good (TOC = 7.5 - 63.1%; S1+S2 = 10.4 - 206.7 mg HC/g; Table 4.3). Hydrogen index ranges from 113 to 359 and T_{max} values (422 to 429°C) suggests that these sediments contain immature (R_o = 0.40 to 0.45%) Type II/III or Type II kerogen (Figure 4.2).

4.2.4 *Algebuckina Sandstone*

All but one of the samples of the Algebuckina Sandstone from AFMECO Cur–3 and Cur–5 have good to excellent source potential (TOC = 34.3 - 58.7%; S1+S2 = 135.1 - 279.4 mg HC/g; Table 4.3). In the main, these samples contain kerogen of Type II/III composition (HI = 312 - 388; Figure 4.2). However, one sample (AFMECO Cur–3, 259.5 m) contains Type II kerogen (HI = 542) and is an excellent potential source rock. Its high resinite and liptodetrinite contents make this sample oil-prone. The sixth sample is a reworked coal and has very poor source potential (HI = 87; Table 4.3). Vitrinite reflectance ranges from 0.41% to 0.45% R_o confirming the maturity estimated from Rock-Eval pyrolysis (Figure 4.2). Cook (1986) suggested that hydrocarbon generation is possible from resinite-rich source rocks at 0.40% to 0.45% R_o. Powell (1985) proposed a model for hydrocarbon generation whereby resinite-enriched and bacterially-modified source rocks (containing mainly vitrinite and inertinite) could generate hydrocarbons at 0.45% R_o Therefore, the Algebuckina coals may be on the threshold of liquid hydrocarbon generation.

4.3 *Summary*

Crown Point Formation

The organically-lean siltstones of the Crown Point Formation display very poor source potential. Rock-Eval analysis indicates that these immature source rocks (T_{max} = 420 - 429°C; R_O = < 0.45%) contain very lean Type III kerogens (TOC = 0.2 - 3.4%; $S_1 + S_2$ = 0.02 - 1 mg HC/g). Although, a change of facies is apparent in Witcherrie-1 where macerals (Type III kerogen) account for 37 per cent of the total rock. This facies is immature and has poor generative potential (HI = 90) due to the highly reworked and oxidised nature of the macerals.

Stuart Range Formation equivalent

Very poor source potential is displayed by the Type III kerogen in the one sample from the Stuart Range Formation equivalent (TOC = 0.4%; $S_1 + S_2$ =1.1mg HC/g; HI = 39).

Purni Formation

Coals and carbonaceous sediments from the Early Permian Purni Formation in Dalmatia-1, Mt Hammersley-1 and Purni-1 (eastern margin of the Eringa Trough), have poor to good source potential for liquid hydrocarbons. The present maturity of these sediments (0.40% - 0.45% R_O) precludes them from generating hydrocarbons. Rock-Eval pyrolysis data (HI = 113 to 359; TOC = 7.5 - 63%; S_1+S_2 = 10 - 207 mg HC/g) indicate fair to good source richness. The maceral assemblages indicate floral changes and fluctuating water levels associated with the transition from a glacio-lacustrine environment to a swamp environment. Dessication cracks in the vitrinite macerals and increased abundance of inertinite support this theory. Rock-Eval pyrolysis corroborated these findings and indicate a change from Type III kerogen to Type II/III.

Algebuckina Sandstone

The coals of the Middle Jurassic Algebuckina Sandstone from the western margin of the Eringa Trough in AFMECO Cur–3 and Cur–5 have good to excellent oil-generative potential. They are marginally mature for liquid hydrocarbon generation (R_O = 0.41% - 0.45%). Their source richness is relected in their TOC (34 - 59%) and S_1+S_2 (135 - 279 mg HC/g) values. These liptinite rich coals contain Type II to Type II/III kerogens that have high hydrogen indices (HI = 312 to 542).

Chapter 5: Gas Chromatography of Saturates

5.1 *Introduction*

The distribution and abundance of alkanes in the saturated hydrocarbon fraction of the rock extracts were determined using gas chromatography. This distribution is indicative of the type of precursor organic matter and the thermal maturity of the host rock (Peters and Moldowan 1993). The saturates chromatogram also reveals the hydrocarbon generative-potential of the source rock. Abundant low-molecular-weight cyclic and acyclic alkanes are characteristic of gas-prone source beds, whereas high-molecular-weight alkanes indicate a propensity to generate liquid hydrocarbons.

Selected extractable organic matter data, *n*-alkane maturity-sensitve ratios and source parameters are presented in Table 5.1. Chromatograms of representative saturates fraction from the formations sampled are presented in Figure 5.1.

Well/Depth	Sample Formation	EOM ppm	Yield mg/g	EOM Sat (%)	EOM Aro (%)	EOM Pol (%)	*n*-alkane Pr/Ph	*n*-alkane Pr/n-C_{17}	*n*-alkane Ph/n-C_{18}	*n*-alkane range	*n*-alkane max
AFMECO Cur-3											
251.6m	Algebuckina	46519	432	20.6	4.7	74.7	2.3	0.16	0.06	13-33	27
251.9m	Algebuckina	69412	178	4.3	3.8	91.9	2.0	0.23	0.11	13-33	25
259.5m	Algebuckina	76429	162	4.8	3.0	92.2				13-33	25
AFMECO Cur-5											
210.1m	Algebuckina	71317	141	2.4	5.5	92.1				19-33	27
249.4m	Algebuckina	80691	137	1.9	2.9	95.2				19-33	27
Dalmatia-1											
591.3 - 606.0 m	Purni	26427	54	6.3	7.0	86.7	4.0	0.91	0.16	13-33	16 & 27
612.6 - 624.8 m	Purni	21482	48	6.8	8.6	84.6	3.0	1.27	0.28	13-33	16 & 27
713.2 - 722.4 m	Purni	30298	79	6.3	4.9	88.8	4.2	1.50	0.23	13-33	16 & 25
Mt Hammersley-1											
615.7 - 630.9 m	Purni	18267	29	4.7	7.1	88.2	3.4	0.81	0.33	11-33	14 & 31
658.4 - 673.6 m	Purni	16985	27	5.5	8.5	86.0	2.3	1.00	0.50	11-33	14 & 31
704.1 - 719.3 m	Purni	19704	34	4.7	9.0	86.3	3.8	1.25	0.38	12-33	16 & 31
762.0 - 774.2 m	Purni	31962	54	6.4	10.2	83.4	3.5				
838.2 - 853.4 m	Purni	31680	57	7.1	7.9	85.0	3.8	2.37	0.75	10-33	16 & 27
871.7 - 887.0 m	Purni	26155	50	11.2	8.3	80.5	3.3	1.33	0.33	10-33	16 & 27
1219.2 - 1237.5 m	Stuart Range	367	89	25.8	6.6	67.6		0.87	0.22	9-33	16 & 25
1408.2 - 1423.4 m	Crown Point										
Purni–1											
1445.8 m	Purni	3119	42	5.4	14.2	80.4					
1772.1 m	Crown Point	116	52	4.7	2.3	93.0					
Witcherie–1											
556.2 m	Crown Point	3.38									

Sat = Saturates; Aro = Aromatics; Pol = Resins + Asphaltenes; Pr = Pristane; Ph = Phytane.

Table 5.1 Relative abundances of extractable organic matter and n-alkane maturity-sensitive and source parameters from the Crown Point Fm., the Stuart Range Fm., Purni Fm. and Algebuckina Sandstone.

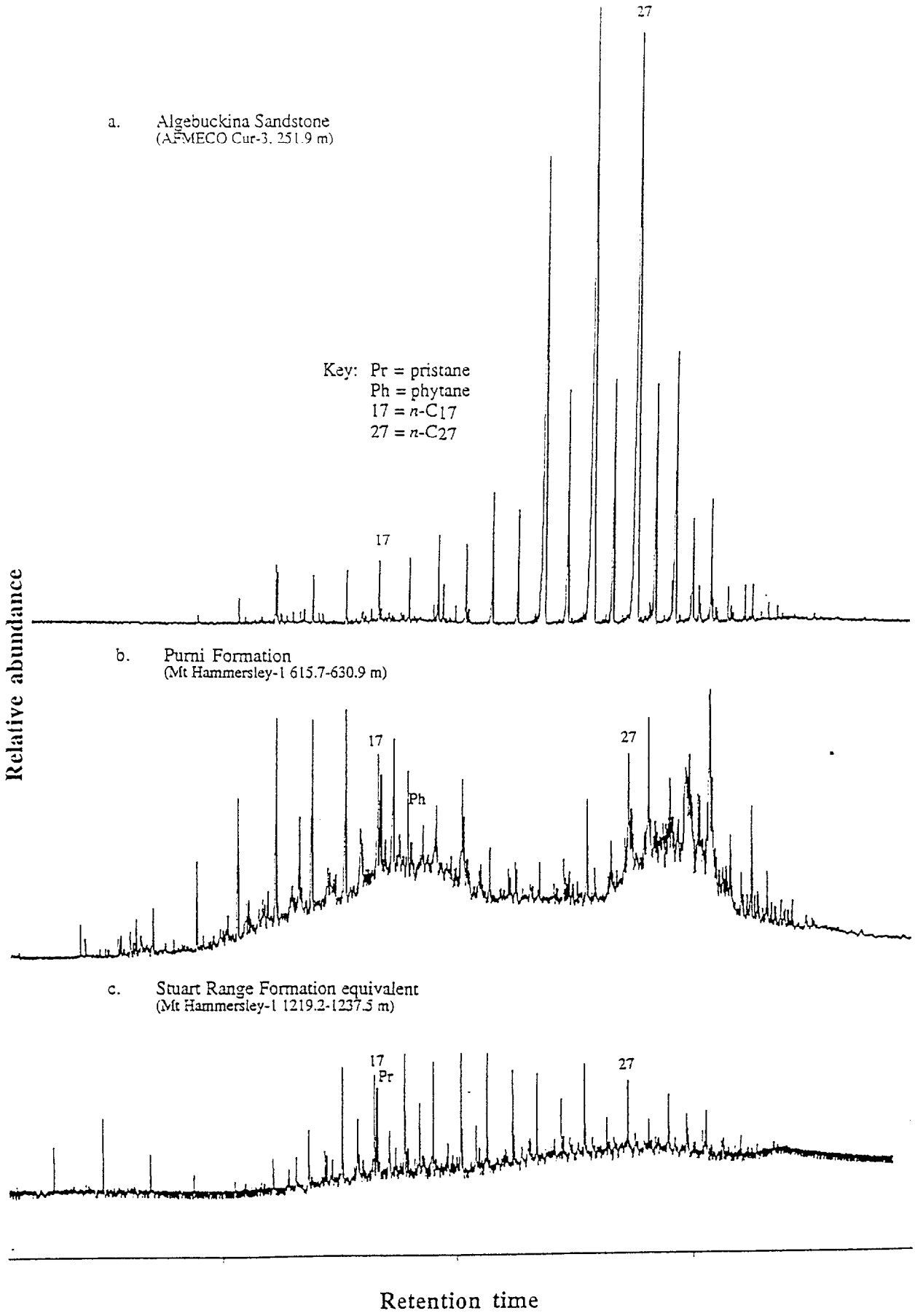


Figure 5.1 Representative saturates chormatograms of the formations sampled.

5.1.2 *Stuart Range Formation equivalent*

A representative saturates chromatogram from the Stuart Range Formation equivalent has been given in Figure 5.1c. This chromatogram shows a possible (albeit faint) bimodal distribution with an unusual dominance of low molecular weight *n*-alkanes. A slight even-carbon-number predominance among the < C_{20} *n*-alkanes and a predominance of odd-carbon-numbered *n*-alkanes in the > C_{23} range indicate both the thermal immaturity and a mixed algal, bacterial and land-plant source. Further, the isoprenoid/n-alkane parameters indicate the thermal immaturity of the source rocks (Pr/*n*-C_{17} = 0.88: Ph/*n*-C_{18} = 0.24). The moderately high pristane/phytane ratio (Pr/Ph = 3.3) suggests that deposition occurred in an oxic environment.

5.1.3 *Purni Formation*

GC analyses of the Purni Formation samples reveal a complex distribution of alkanes (Figure 5.1b). This chromatogram shows a distinct bimodal *n*-alkane distribution with a maximum at C_{14} - C_{16} and C_{27}. A broad trimodal naphthene hump is another characteristic feature of these chromatograms. The three humps represent cyclic sesquiterpanes (C_{15}), diterpanes (C_{20}) and triterpanes (C_{30}). An even carbon-numbered predominance in the *n*-alkanes < C_{20} may be attributed to a mixed algal and bacterial source. By contrast, an odd-carbon predominance in the > C_{23} *n*-alkanes suggests an input from land plants. The odd-carbon predominance and isoprenoid/n-alkane ratios (Pr/*n*-C_{17} = 0.81 - 2.37: Ph/*n*-C_{18} = 0.16 - 0.75) are characteristic of immature sediments. Pr/Ph values range from 2.3 to 4.2 indicating deposition in a sub-oxic to oxic environment.

5.1.4 *Algebuckina Sandstone*

The chromatograms of the Jurassic coals show a uniform distribution of alkanes dominated by waxy *n*-alkanes (Figure 5a). These high-molecular weight *n*-alkanes display a pronounced odd-carbon number-predominance. This predominance indicates both the oil-prone nature and the thermal immaturity of these sediments. The isoprenoid/n-alkane ratios (Pr/*n*-C_{17} = 0.16 - 0.23: Ph/*n*-C_{18} = 0.06 - 0.11) further support this finding. The high abundance of waxy *n*-alkanes indicates a source dominated by land plants. Pr/Ph ratios (2.0 - 2.3) indicate that deposition occurred in a sub-oxic environment.

5.2 *Summary*

GC analyses of the saturated hydrocarbon fraction of the Stuart Range Formation equivalent and Purni Formation samples suggest that these sediments had a mixed algal, bacterial and land plant source. The thermal immaturity of these sediments is indicated by a marked odd carbon-number predominance in the *n*–alkane > C_{23} distribution, and isoprenoid/n-alkane ratios. The abundance of lower molecular weight alkanes suggests that these sediments would be gas-prone if their maturity was sufficient to generate hydrocarbons. However, samples of the Purni Formation from Dalmatia-1 contain a significant proportion of long chain components. Therefore, if these coals and carbonaceous sediments extend towards the middle of the Eringa Trough, they have the potential to be effective source rocks for oil and gas.

By contrast, the Algebuckina saturated hydrocarbon distributions indicate that land plants were the primary source of organic matter for these source rocks. A dominance of high-molecular weight odd-carbon-numbered *n*–alkanes indicates that these thermally immature sediments have good to excellent oil-generative potential. However, given the labile nature of some of the oil-prone liptinites in these Jurassic sediments, they may be effective sources of liquid hydrocarbons at their present level of thermal maturity.

Chapter 6: Gas Chromatography-Mass Spectrometry of Di- and Tri-aromatic Hydrocarbons

6.1 *Introduction*

Gas chromatography coupled with mass spectrometry was employed to separate and identify compounds in the aromatic hydrocarbon fraction. The mass chromatogram shows the relative abundances of the molecular and fragment ions produced, using their mass to charge (*m/z*) ratios (Figure 6.1). The different compounds fragment into characteristic patterns that depend on their molecular structure. Individual peaks are species specific and are compared to published data for identification.

The aromatic hydrocarbons were analysed because of their potential to provide information on the thermal maturity of the source rocks (Radke 1987; Boreham 1988) and conifer resin biomarkers (Alexander et al., 1988).

Aromatic hydrocarbon biomarker ratios and mass chromatograms of the aromatic fractions from typical Permian and Jurassic samples are presented in Table 6.1 and Figures 6.1 - 6.5.

		Maturity			Source		
Well/Depth	Formation	MPI	R_C	DNR-1	$\frac{1\text{-MP}}{9\text{-MP}}$	$\frac{1,2,5}{1,3,6}$ TMN	$\frac{\text{retene}}{\text{phen}}$
AFMECO Cur-3							
251.60 m	Algebuckina				0.74	1.26	8.7
251.90 m	Algebuckina						38.4
259.50 m	Algebuckina						37.5
AFMECO Cur-5							
210.10 m	Algebuckina				0.75	3.85	9.3
249.40 m	Algebuckina				1.08	3.24	10.8
Dalmatia-1							
591.3 - 606.0 m	Purni	0.41	0.51		0.61		0.3
612.6 - 624.8 m	Purni	0.58	0.63	3.35	0.52	0.70	2.4
713.2 - 722.4 m	Purni	0.46	0.54				
Mt Hammersley-1							
615.7 - 630.9 m	Purni	0.62	0.65	5.88	0.51	0.58	0.6
658.4 - 673.6 m	Purni	0.46	0.54	6.25	0.34	0.61	1.1
704.1 - 719.3 m	Purni	0.48	0.56		0.25	0.46	0.4
762.0 - 774.2 m	Purni	0.45	0.53		0.38	0.58	0.2
838.2 - 853.4 m	Purni	0.40	0.50	2.50	0.55	0.46	1.6
871.7 - 887.0 m	Purni	0.48	0.56		0.47	0.48	1.0
1219.2 - 1237.5 m	Stuart Range	0.82	0.80		0.71	0.71	0.3
Purni-1							
1445.8 m	Purni	0.53	0.59		0.67	0.86	0.007
1772.1 m	Crown Point	0.29	0.42	2.78	0.99	0.43	0.004

MPI = $1.5 \times \frac{\text{2-MP + 3-MP}}{\text{P + 1-MP + 9-MP}}$; Rc (%) = 0.7 MPI + 0.22 after Boreham et al. (1988)

where; P = phenanthrene, 1-MP = 1-methylphenanthrene, 2-MP = 2-methylphenanthrene, and so on.

DNR - 1 = $\frac{2,6 + 2,7}{1,5}$ DMN after Radke (1987).

where; 1,5-DMN = 1,5-dimethylnapthalene, 2,6-dimethylnapthalene, and so on.

phen = phenanthrene.

Table 6.1: Aromatic biomarker ratios for the Permian and Jurassic samples.

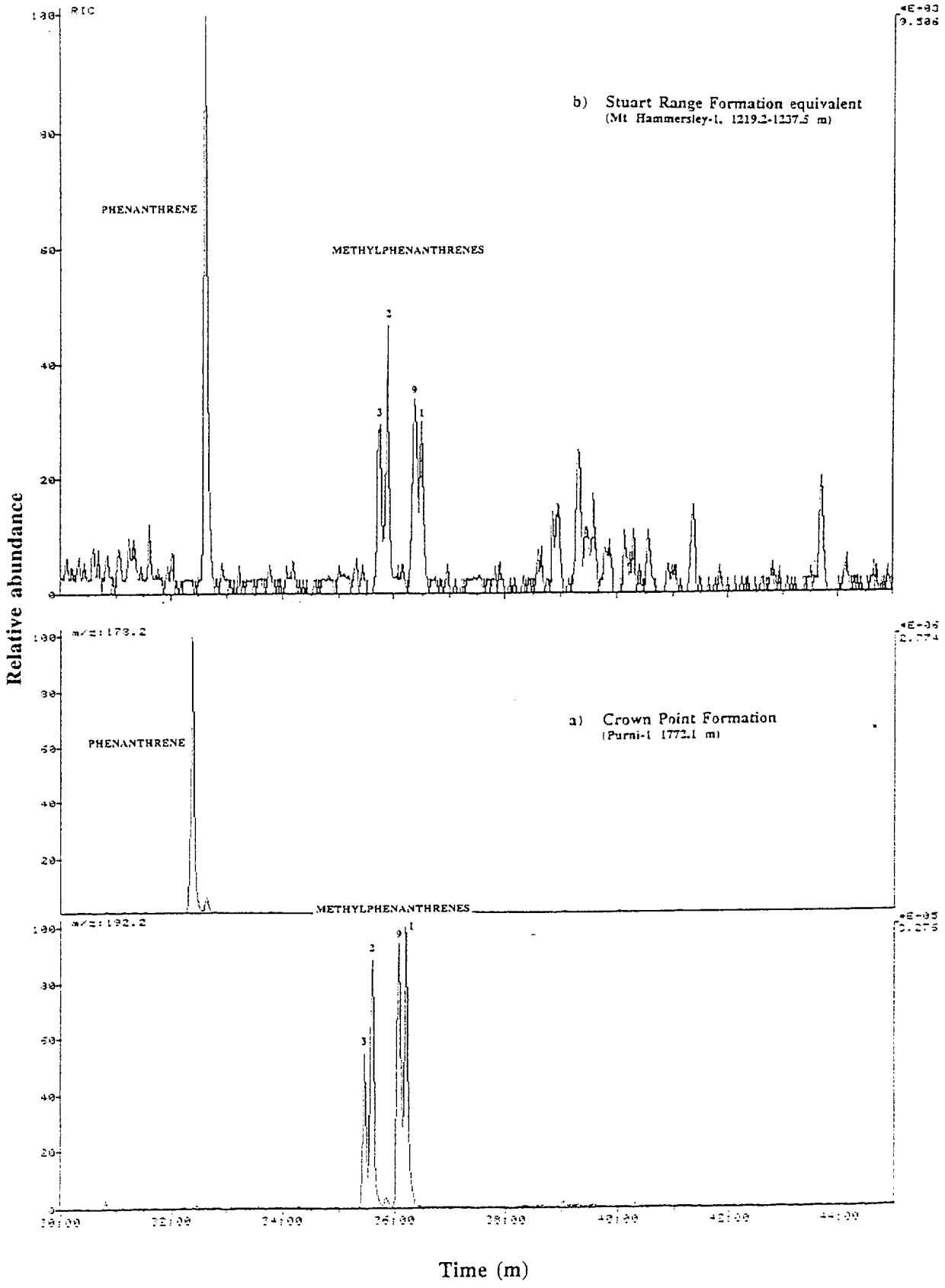


Figure 6. 1: a - h; reconstructed ion chromatograms and single ion chromatograms showing relative abundances of aromatic fractions from typical Permian and Jurassic samples.

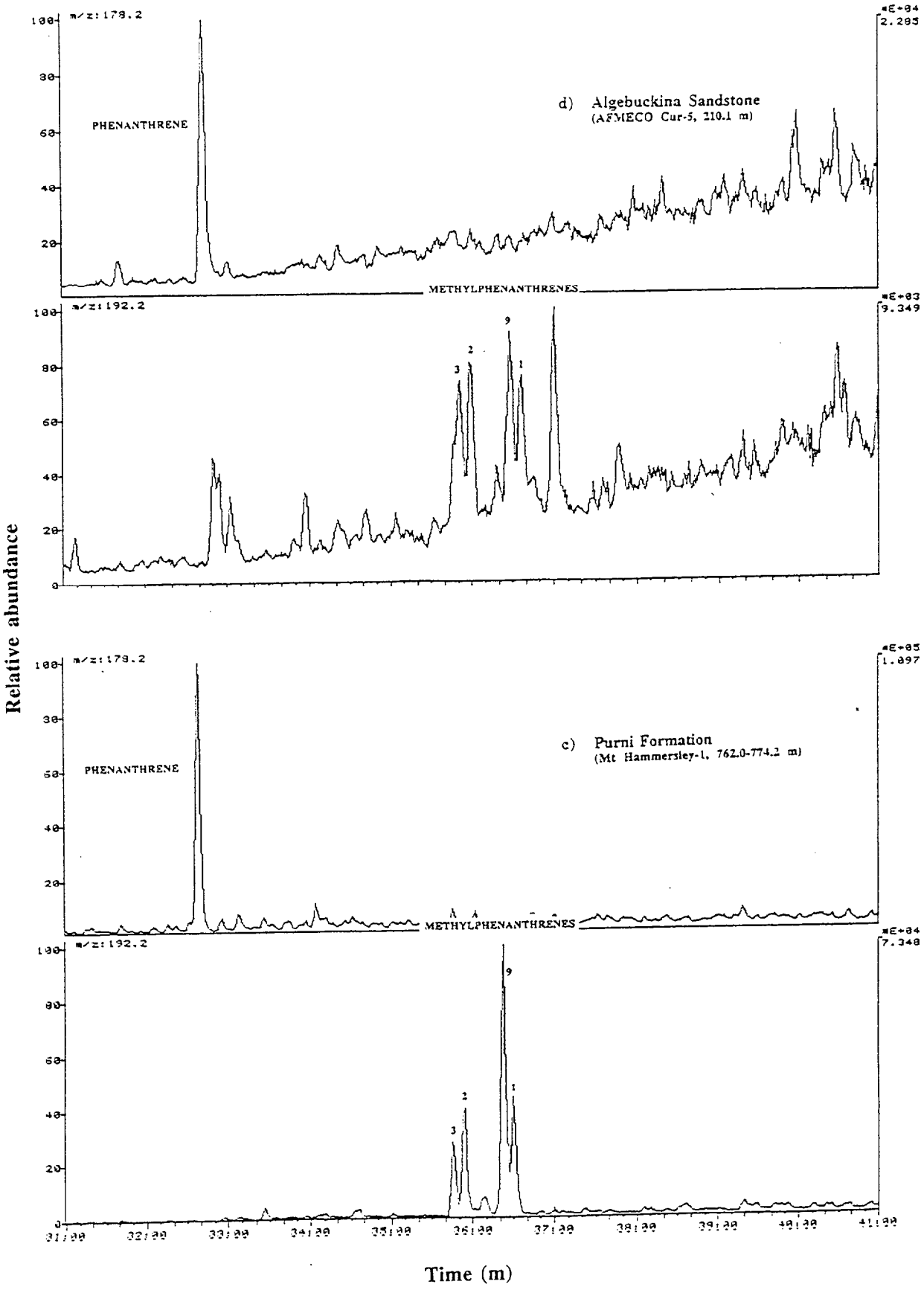


Figure 6.1: contd.

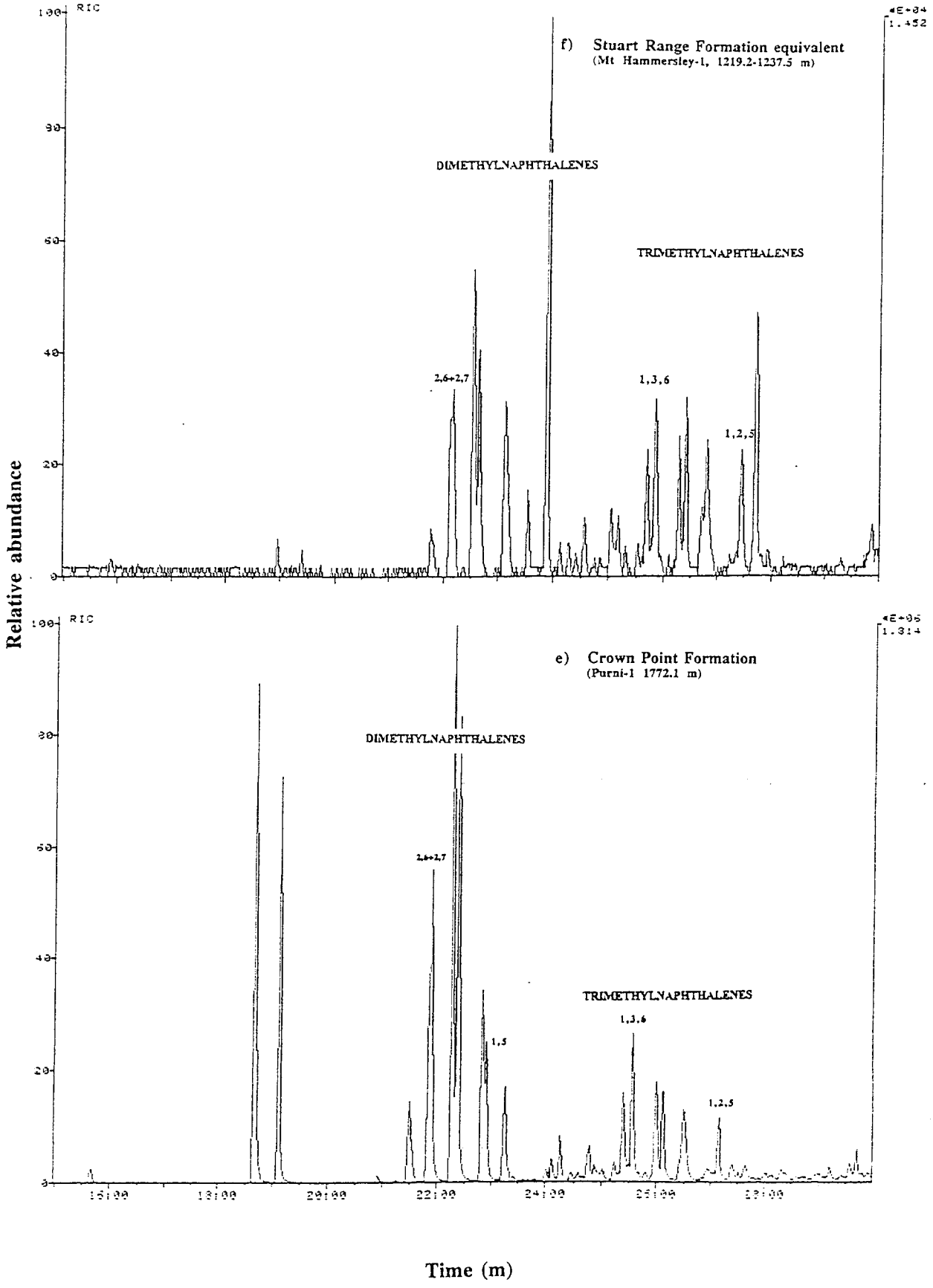


Figure 6.1: contd.

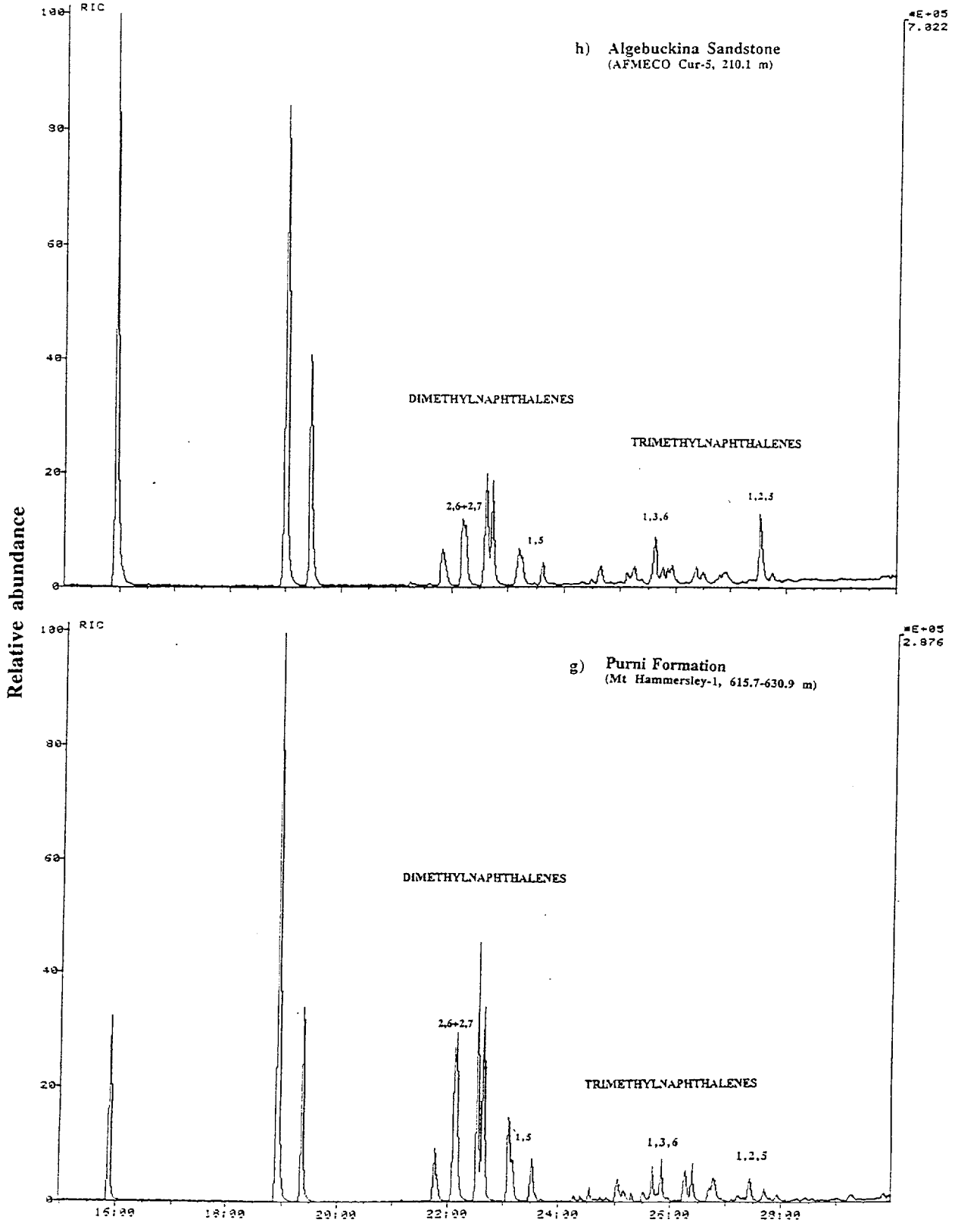


Figure 6.1: contd.

6.2 *Maturity*

Thermal maturity parameters are based on the relative abundances of various aromatic hydrocarbons. As maturity increases there is an associated increase in the thermally stable isomers. Two maturity parameters were used in this study. One is based on relative abundances of phenanthrene and methylphenanthrene isomers (R_C; Radke and Welte, 1983; Boreham 1988). The other is based on the dimethylnaphthalene isomers (DNR-1; Radke 1987).

6.2.1 *Crown Point Formation, Stuart Range Formation equivalent, Purni Formation and Algebuckina Sandstone*

The calculated vitrinite reflectance values (R_C) from the Stuart Range Formation equivalent and Purni Formation differed significantly from the measured vitrinite reflectances (R_O) and maturities inferred from Rock-Eval pyrolysis data. MPI-1 was plotted against R_O to determine if a correlation existed between the two parameters (Figure 6.2a). The plot confirms that there is no correlation between the two parameters. High mineral matter content in the Crown Point Formation samples prevented the determination of measured vitrinite reflectance values. Poorly resolved methylphenanthrene peaks precluded the determination of R_C for the Jurassic coals.

The DNR-1 ratio is based on the 2,6-, 2,7- and 1,5-dimethylnaphthalenes (DMN). The 1,5-DMN is the least thermally stable, therefore the relative abundance of this isomer decreases with increasing thermal maturity. Figure 6.2b is a graph of R_O values plotted against the DNR-1 ratios for the Purni Formation and the Algebuckina coals and shows that there is no correlation between these parameters.

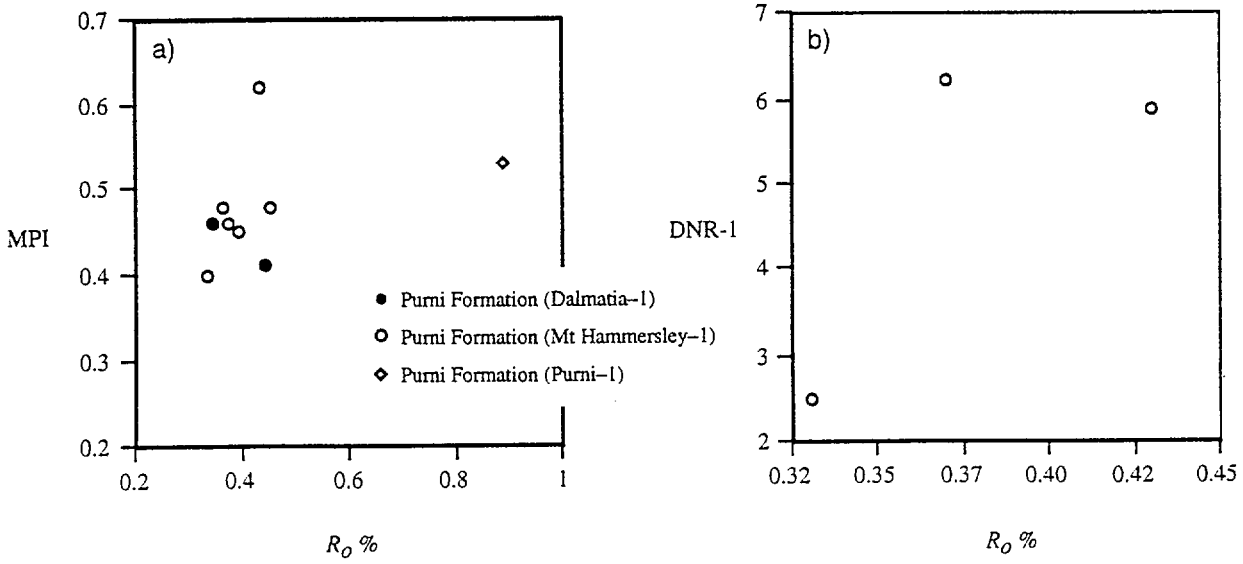


Figure 6.2: Plot of maturity parameters for Permian sediments showing lack of correlation. a) MPI *versus* R_O. b) DNR-1 *versus* R_O.

6.3 *Source*

Alexander *et al.* (1988) state that the *Araucariaceae* became a prominent feature of the Early to Middle Jurassic flora. These researchers used a suite of aromatic biomarkers derived from the resins of the *Araucariaceae* flora (trees of the kauri pine group) to differentiate between oils sourced from Permian and Jurassic sediments in the Cooper/Eromanga Basins (Figure 6.3).

Retene is known to occur in sediments of Palaeozoic to Recent age. There is no unique natural precursor of retene and it is derived from a number of sources (Alexander *et al.* 1988). For example, retene may be derived from phyllocladane or *via* the aromatisation and/or the reduction of abietic acids (Alexander *et al.*, 1987; Alexander *et al.*, 1988). These compounds originate from resins and higher plant tissues (Alexander *et al.*, 1987). However, associated with the evolution of the *Araucariaceae* flora in the Late Triassic was an increase in the concentration of retene (Alexander *et al.*, 1988). Therefore, sediments older than the Jurassic have relatively low concentrations of retene when compared to younger sediments.

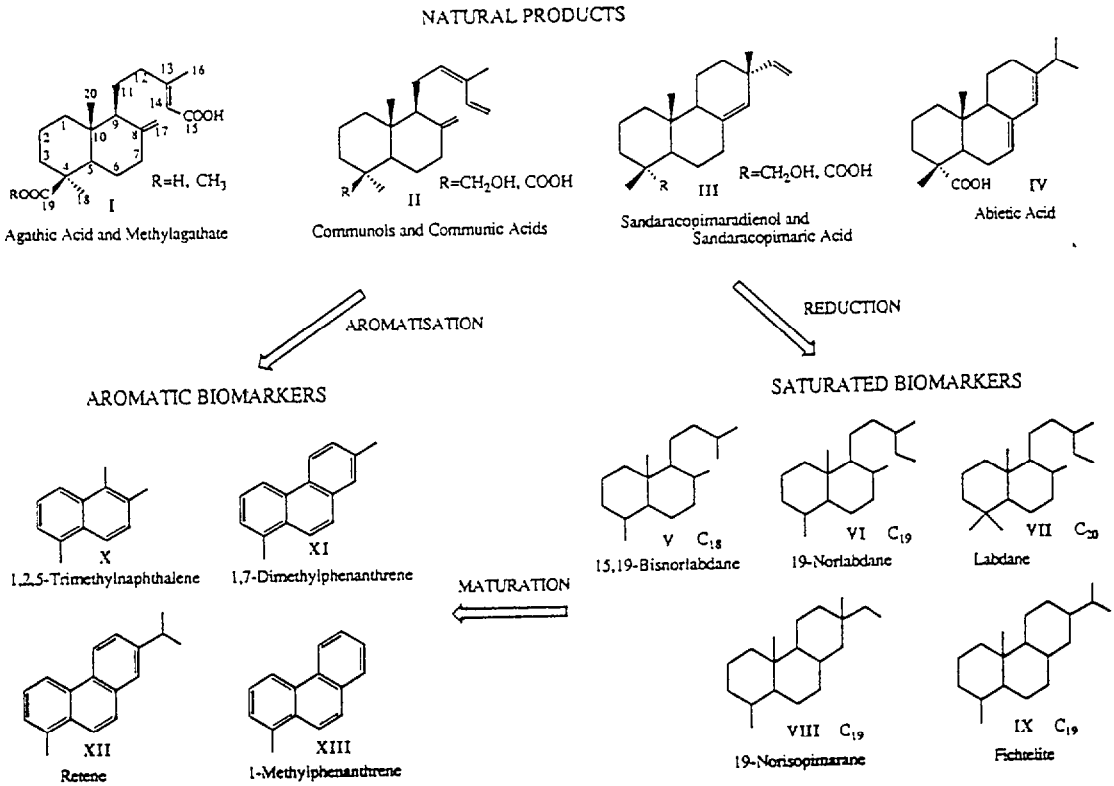


Figure 6.3 Natural precursor molecules and pathways of aromatic biomarkers (from Alexander et al., 1988).

6.3.1 *Crown Point Formation, Stuart Range Formation equivalent, Purni Formation and Algebuckina Sandstone*

Aromatisation of the araucariacean diterpanes results in the formation of 1,2,5-trimethylnaphthalene, 1,7-dimethylnaphthalene, retene and 1-methylphenanthrene (Figure 6.4; Alexander *et al.*, 1988). Poorly resolved peaks precluded the detemination of 1,7-DMN, however a plot of methylphenanthrene against trimethylnaphthalene parameters differentiates between samples of Permian and Jurassic age (Figure 6.4). Samples of Jurassic age (Algebuckina coals) have values that indicate a high input from aromatic biomarkers derived from araucariacean resins.

A plot of 1-/9-methylphenanthrenes against retene/phenanthrene ratios show that coals of Jurassic origin have high concentrations of retene derived from the resins of the *Araucariaceae* flora (Figure 6.5). Therefore, this abundance differentiates between Permian (Stuart Range Formation and Purni Formation) and Jurassic (Algebuckina) samples.

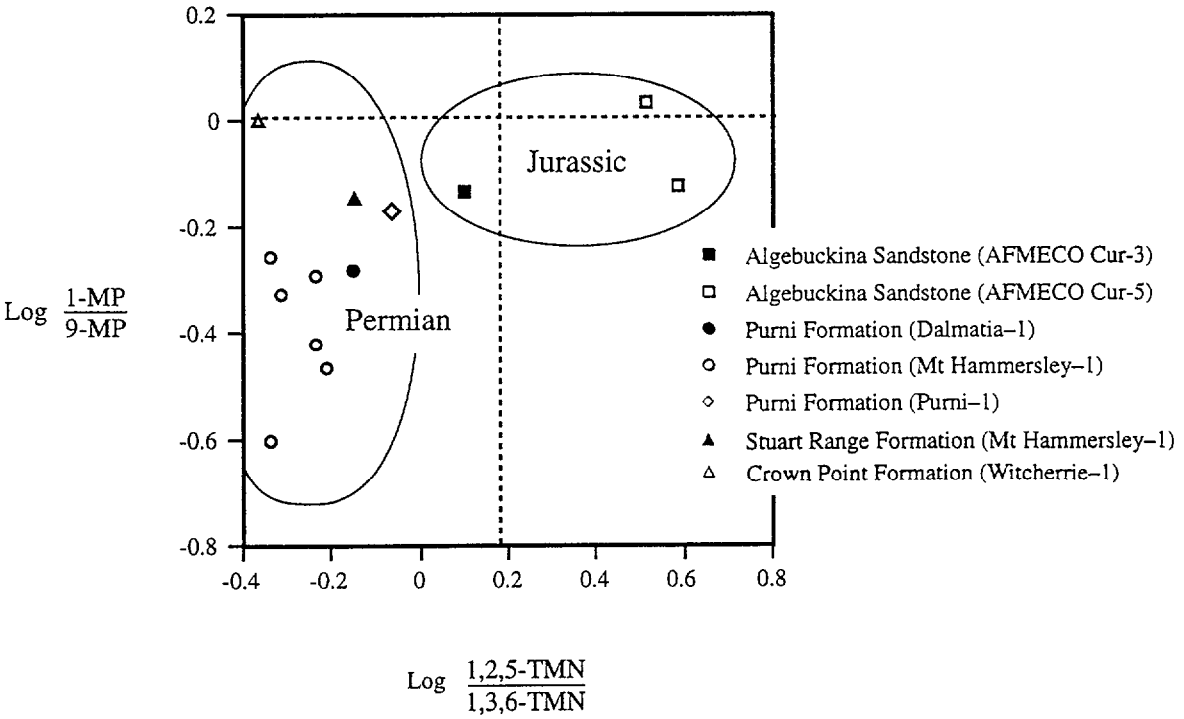


Figure 6.4: Log log plot of source parameters using methylphenanthrenes and trimethylnaphthalenes for Permian and Jurassic sediments (after Alexander *et al.*, 1988).

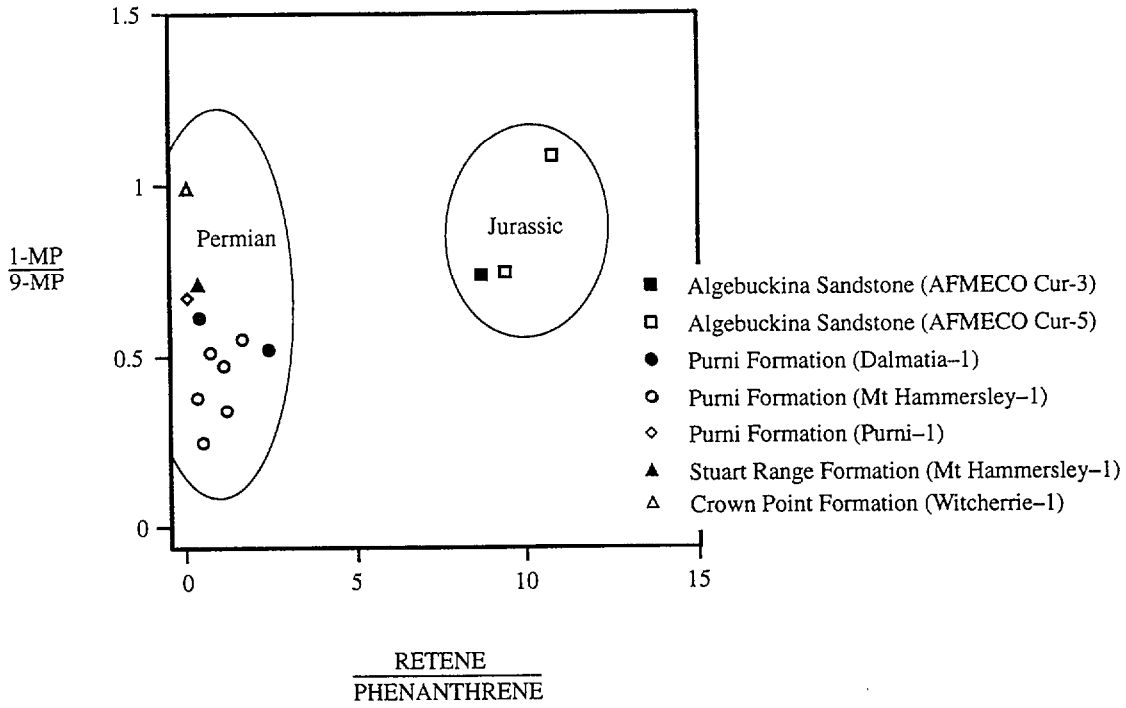


Figure 6.5: Plot of source parameters using methylphenanthrenes and retene/phenanthrene ratios for Permian and Jurassic sediments.

6.4 *Summary*

GC–MS analysis of the aromatic hydrocarbon fraction enabled determination of maturation–sensitive and source parameters. These were based on the relative abundane of various aromatic biomarkers including phenanthrene, methylphenanthrenes, dimethylnaphthalenes, trimethylnapthalenes and retene. Calculated vitrinite reflectance values do not correlate well with measured vitrinite relectances, and maturities inferred from those derived from Rock–Eval pyrolysis data. The differences are probably source related and these effects are exacerbated due to the low thermal maturity of the samples from the Stuart Range Formation equivalent, the Purni Formation and the Algebuckina coals (that is $R_O < 0.6\%$).

A range of aromatic hydrocarbons that are derived from the resins of the *Araucariaceae* flora are found in high abundance in the Jurassic Algebuckina coals. Comparable aromatic biomarker assemblages are found in much lower abundances in Permian samples from the Crown Point Formation, Stuart Range Formation equivalent and the Purni Formation. Thus, this difference in abundance can be used as an age discriminator between Permian and Jurassic samples.

Chapter 7: Gas Chromatography-Mass Spectrometry-Mass Spectrometry of Saturates

7.1 *Introduction*

Various gas chromatography–mass spectrometry (GC-MS) techniques have been applied to the analysis of the saturated and aromatic hydrocarbons in crude oils and their source rocks. However, identifying many of these compounds using routine GC–MS is difficult because individual compounds and compound families often co-elute (Peters and Moldowan, 1993). Selective reaction monitoring (SRM) by triple quadrupole mass spectrometry (GC-MS-MS) reduces this interference and was used in this study to measure specific parent to daughter ion transitions ($M^+ \rightarrow m/z$) in the saturated hydrocarbon fraction. An example of this is the identification of a homologous series of steranes using $M^+ \rightarrow m/z$ 217 transitions (Figure 7.1). By contrast, the GC-MS of the aromatic hydrocarbon fraction was undertaken using selective ion monitoring (SIM) because of fewer co-elution problems (see Figure 6.1).

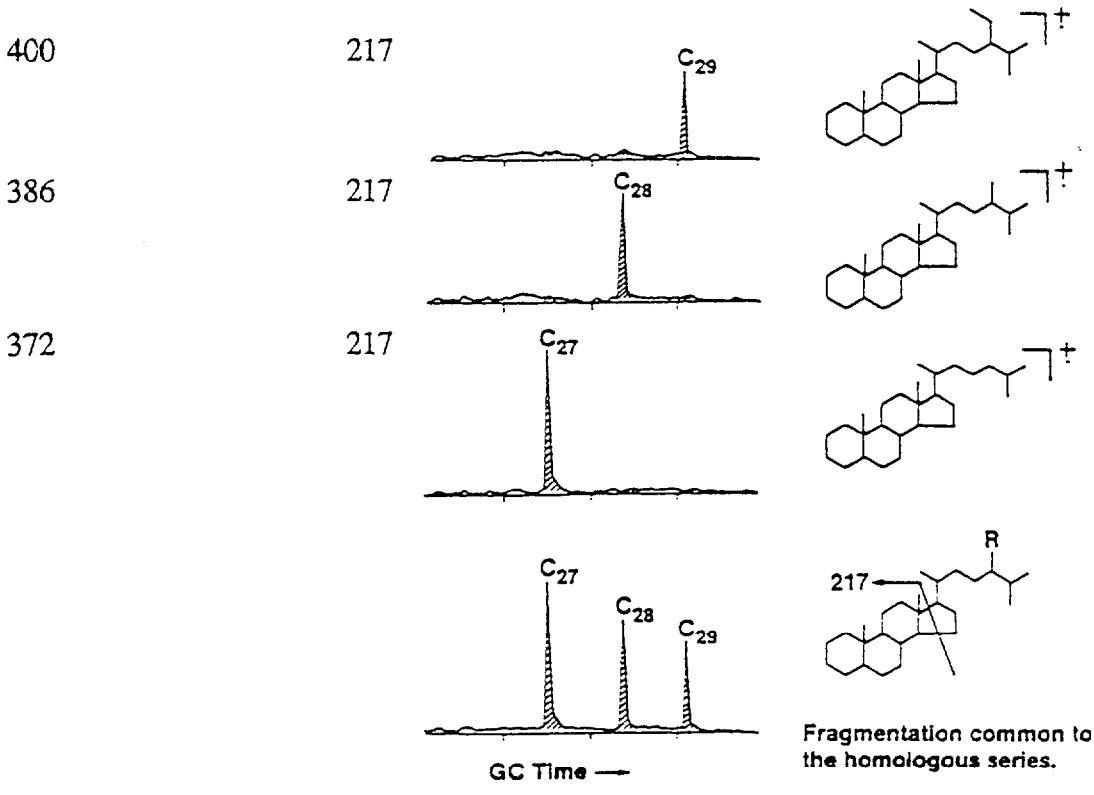


Figure 7.1: Illustration showing parent to daughter fragment ions for a series of steranes (adapted from Peters and Moldowan, 1993)

Selective reaction monitoring (SRM) GC-MS-MS was used to monitor those transitions that correspond to the steranes and hopanoids (Appendix 1).

The saturated hydrocarbon fractions contain abundant steranes and hopanes (Figure 5.1). The results of the GC-MS-MS analyses are summarised in Table 7.1 and Figures 7.2 - 7.4. Representative hopane and sterane distributions for the Stuart Range Formation equivalent, the Purni Formation and the Algebuckina Sandstone are presented in Appendix 3.

		Maturity						Source					
Well/Depth	Formation	$\frac{Ts}{Tm}$	$\frac{mor}{hop}$	$\frac{S}{S+R}$	$\frac{\alpha\beta}{\alpha\beta+\alpha\alpha}$	27:28:29	29 $\frac{dia}{ster}$	$\frac{hop}{ster}$	$\frac{hop}{X}$	$\frac{BNH}{hop}$	$\frac{retene}{phen}$	$\frac{3\beta\ st}{20\ R}$	$\frac{3\beta\ hop}{hop}$
		a	b	c	d	e	f	g	h	i	j	k	l
AFMECO Cur-3													
251.60 m	Algebuckina	0.10	0.38	0.03	0.30	2:16:82	0.05	3.1		0.04	8.7	3.2	0.23
259.50 m	Algebuckina	0.06	0.42	0.01	0.11	1:5:94	0.02	3.1		0.002	38.4	12.0	0.40
AFMECO Cur-5													
249.40 m	Algebuckina		0.41	0.01	0.59	5:14:81	0.05	4.6		0.002	9.3	0.2	1.20
Dalmatia-1													
591.3 - 606.0 m	Purni	0.40	0.20	0.28	0.59	7:20:73	0.99	1.4	0.75	0.34	0.3	1.4	0.10
612.6 - 624.8 m	Purni	0.48	0.10	0.24	0.59	7:22:71	1.11	0.7	1.02	0.02	2.4	0.3	0.09
713.2 - 722.4 m	Purni	0.45	0.15	0.02	0.45	9:13:78	0.64	0.5	1.19	0.13		0.3	0.10
Mt Hammersley-1													
615.7 - 630.9 m	Purni	0.26	0.19	0.25	0.61	3:22:75	0.55	2.2	0.45	0.28	0.6	2.1	0.07
704.1 - 719.3 m	Purni	0.17	0.15	0.11	0.36	8:15:77	0.27	4.1	0.47	0.97	0.4	3.9	0.80
838.2 - 853.4 m	Purni	0.20	0.30	0.09	0.31	11:13:76	0.27	19.8	1.35	0.14	1.6	8.9	0.17
1219.2 - 1237.5 m	Stuart Range	0.36	0.08	0.15	0.42	6:56:38	0.23	0.5	4.52	0.07	0.3	0.3	0.09
Purni-1													
1445.8 m	Purni	0.09	0.26	0.15	0.47	9:21:70	1.48	12.4		0.35	0.007		
1772.1 m	Crown Point		0.29										

	derivation	specificity;
a	C_{27} 18α-22,29,30-trisnorneohopane (Ts)/	maturity.
	C27 17α-22,29,30-trisnorhopane (Tm)	
b	C_{30} 17β,21α-moretane/17α,21b-hopane	maturity
c	C_{29} 5α,14α,17α-ethylcholestane 20S/	
	C_{29} 5α,14α,17α-ethylcholestane 20S + 20R	maturity
d	C_{29} 5α,14β,17β-ethlycholestane 20R/C_{29} 5α,14β,17β-ethlycholestane 20R	
	+ C_{29} 5α,14α,17α-ethylcholestane 20R	maturity
e	C_{27}:C_{28}:C_{29} 5α,14α,17α-ethylcholestane 20R	C_{27} marine algae; C_{28} lacustrine algae; C_{29} land plants
f	C_{29} 13β,17α-diaethylcholestane (20R+ 20S)/	as above - modified carbon skeleton indicates environment of
	C_{29} 5α,14α,17α-ethylcholestane	deposition
g	C_{30} hopanes/C_{29} steranes	bacterial versus algal input
h	C_{29} 17α,21β-30-norhopane/Compound X	maturity, ?specific bacetria
i	28,30-bisnorhopane/C_{30} 17α,21β-hopane	environment of deposition
j	retene/phenanthrene	aromatic source parameter
k	C_{30} 24-ethyl-3β-methylcholestane/C_{29} 5α,14α,17α-ethylcholestane 20R	methylotrophic algae
l	C_{31} 3β-methyl-17α,21β-hopane/C_{30} 17α,21β-hopane	methylotrophic bacteria

Table 7.1: Key maturation-sensitive parameters and source-specific ratios for Permian and Jurassic samples.

7.2 *Maturity*

Biologically-derived stereoisomers become increasingly unstable as temperature increases during diagenesis and catagenesis. The maturity-sensitive ratios in Table 7.1 reflect a progressive decrease in these thermally unstable isomers and an increase in thermally stable isomers. For example, hopanes have three characteristic stereoisomers. The thermodynamic stability of the 17α,21β configuration is greater than that of 17β,21α which in turn is greater than that of 17β,21β-hopane, the biological configuration (Peters and Moldowan, 1993).

7.2.1 *Crown Point Formation*

As stated above the most thermally stable hopane has the configuration αβ therefore, the ratio of 17β,21α-moretane to 17α,21β-hopane decreases with increasing thermal maturity (Peters and Moldowan, 1993). Thus, the C_{30} moretane/hopane ratio (0.29) indicates that these source rocks are immature. However, Peters and Moldowan (1993) state that the moretane/hopane ratio is partially dependent on source input and depositional environment may have an effect on the ratio. Vitrually no steranes were present in one sample from this formation. The results from this formation must be viewed with caution due to the limited number of identifiable isomers in the sample.

7.2.2 *Stuart Range Formation equivalent*

The C_{27} 17α-22,29,30-trisnorhopane (T_m) is thermally less stable than C_{27} 18α-22,29,30-trisnorhopane (T_s). The T_s/T_m ratio (0.36) for this sample suggests that the source rocks are thermally immature (Peters and Moldowan, 1993). The C_{30} moretane/hopane ratio (0.08) supports the notion that these source rocks are immature.

A decrease in the abundance of the biologically derived C_{29} 5α,14,α17α-ethylcholestane (20R) isomer due to isomerization at C20 results in an increase in the geologically-derived C_{29} 5α,14α,17α-ethylcholestane (20S) isomer. The thermal immaturity of these sediments is reflected by their ratios (ααα 20S/ααα (20S + 20R) = 0.15). The formation of 5α,14β,17β,-ethylcholestane (20R) following isomeration at the C14 and C17 positions increases with thermal maturity. The immaturity of these sediments is reflected in the ratio (αββ 20R/αββ 20R + ααα 20R = 0.42).

7.2.3 *Purni Formation*

Maturity-sensitive ratios for the Purni Formtion indicate that these source rocks are immature for hydrocarbon generation. Both hopane ratios, the T_s/T_m ratio (0.20 - 0.48) and the moretane/hopane ratio (0.10 - 0.30), indicate that the sediments are immature for hydrocarbon generation. The sterane maturity parameters (ααα 20S/ααα (20S + 20R) = 0.09 - 0.28;. αββ 20R/αββ 20R + ααα 20R = 0.31 - 0.61) suggest that these sediments are immature for hydrocarbon gneration. However, in the uppermost samples from Mt Hammersley-1 and Dalmatia-1, one of the maturity-dependent parameters (αββ 20R/αββ 20R + ααα 20R = 0.59

- 0.61) has high values indicating a greater maturity. These values do not concur with the other maturity-sensitive ratios, suggesting that unusual biota may have contributed to the sediments during deposition, influencing the sterane ratio.

7.2.4 *Algebuckina Sandstone*

The maturity of the Algebuckina coals obtained from maturity-sensitive hopane and sterane ratios indicate that these samples are immature (T_S/T_m = 0.06 - 0.1;. moretane/hopane = 0.38 - 0.42; ααα 20S/ααα (20S + 20R) = 0.01 - 0.03; αββ 20R/αββ 20R + ααα 20R = 0.30 - 0.11).

7.3 *Source input*

Alkane biomarkers have the potential to identify input from different precursor organisms and to characterise a range of depositional environments. For example, a preponderance of the C_{29} homologue among the C_{27} - C_{29} homologue steranes indicates a significant contribution by terrestrial plants (Figure 7.2).

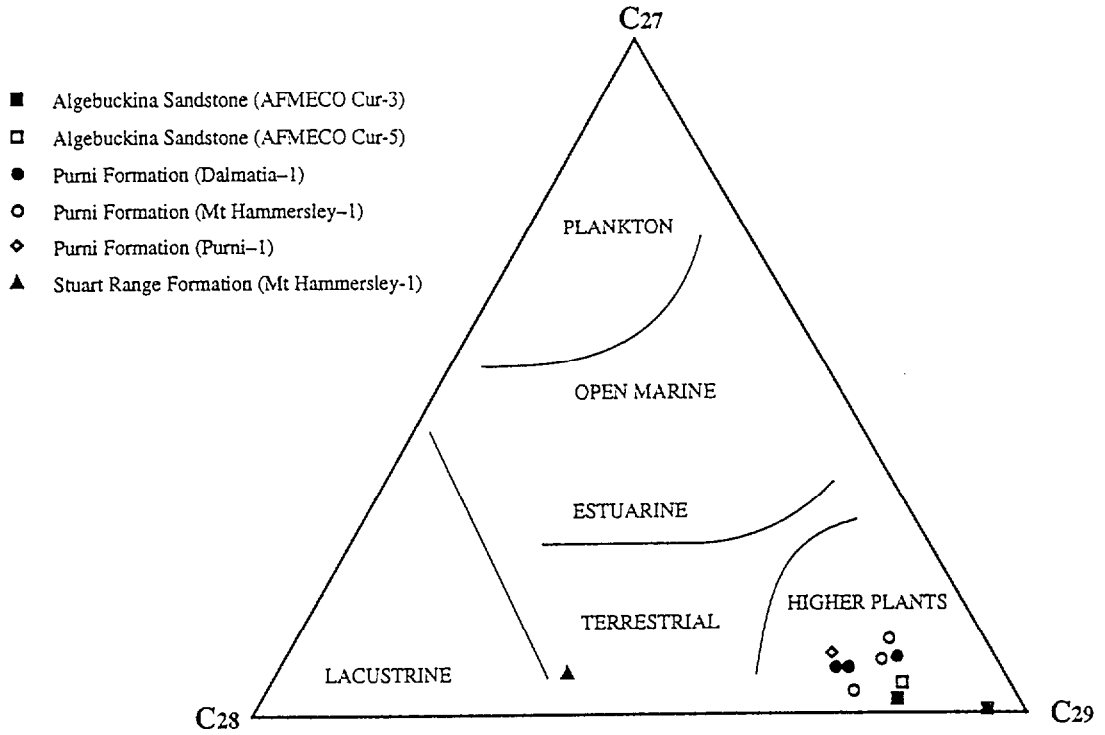


Figure 7.2: Source affinity of coals and carbonaceous sediments sampled. (after Waples and Machihara, 1991)

7.3.1 *Stuart Range Formation equivalent*

The relative proportions of C_{27}, C_{28} and C_{29} 20R 5α,14α,17α steranes (7:63:42) reflect their lacustrine terrestrial source (Figure 7.2). This distribution is consistent with a mixed algal and land plant input in a lacustrine setting. The diasterane/sterane ratios are determined by the inorganic properties of the source rock (Peters and Moldowan, 1993). A ratio of 0.23 for this sample suggests that deposition probably occurred in an anoxic, clay–free, carbonate environment (Peters and Moldowan, 1993).

The hopane/sterane ratios reflect the input by prokaryotic (bacteria) versus eukaryotic (algae and land plants) organisms. The low hopane/sterane ratio (0.5) suggests a mixed input but the algal contribution was greater than bacterial (Waples 1991).

7.3.2 *Purni Formation*

All of the samples from the Purni Formation are characterised by a dominance of the C_{29} 20R 5α,14α,17α sterane, consistent with significant contribution from land plants (Figure 7.2; Huang and Meinschein, 1979). The diasterane ratios (dia/ster = 0.27 to 1.5) suggest that deposition occurred initially in a lacustrine ?carbonate setting that gradually changed to a paludal environment. The virtual absence of the C_{30} member (24-*n*-propyl-cholestane) which is diagnostic of marine environments, further supports a terrestrial deposition.

A range of hopane/sterane ratios from 0.5 to 19.8 indicates the fluctuating dominance of prokaryotic and eukaryotic organisms. The high hopane/sterane ratios represent significant bacterial reworking during deposition and diagenesis. The lower hopane/sterane ratios are consistent with high input from algal and/or land plants (Peters and Moldowan 1993). These low ratios are typically associated with coals deposited in an anoxic swamp environment (Waples 1991 and references therein; Philip and Gilbert 1986).

7.3.3 *Algebuckina Sandstone*

The sterane fraction is dominated by the C_{29} 20R 5α,14α,17α sterane suggesting that land plants were the dominant source of organic matter (Figure 7.2).

The high hopane versus sterane ratio (34.4) in one of the samples from AFMECO Cur–5 (249.4 m) suggests intensive bacterial activity during deposition and the initial stages of diagenesis. The other two samples have ratios (hopane/sterane = 3.1 and 4.6) consistent with deposition in an environment where bacterial reworking and input were moderately low.

7.4 *Unusual Biomarkers*

7.4.1 *Compound X*

An unusual feature of the C_{29} hopane mass chromatograms from the Purni and Crown Point Formations is a compound (labelled X) that elutes just prior to 17β,21β-30-norhopane (Appendix 3). A review of the literature indicates that this compound has not been identified although it is present in studies of other immature source rocks (e.g. Boreham, 1994; George, 1995). In this study the concentration of this compound relative to 17α,21β-norhopane decreases with depth, suggesting that compound X may be the biological precursor for, or an isomer of the 17β,21β–30-norhopane (Table 7.1). By contrast, R. Paull (pers. comm., 1995) has found this compound in a study of Triassic coals but her study reveals an increasing abundance of compound X relative to 17α,21β-norhopane with depth. Together our data suggest that the presence or absence of this compound is source related. For example compound X may be derived from a similar biological precursor that inhabits a particular niche in the environment. Further, the absence of this compound in thermally mature source rocks indicates that this is a relatively unstable compound.

7.4.2 *28,30-bisnorhopane*

The desmethylhopane, 28,30–bisnorhopane (BNH) was present in higher concentrations, relative to 17α,21β-hopane, in samples from the Crown Point and Purni Formations than in samples from the Algebuckina Sandstone (Table 7.1). High concentrations of BNH typically occur in sediments deposited under suboxic and highly anoxic conditions (Summons and Walter 1990; Peters and Moldowan, 1993). The BNH/17α,21β–hopane ratios were plotted against the retene/phenanthrene ratios (Figure 7.3). The results indicate that this parameter has the potential to be used as an important age discriminator between Permian and Jurassic source rocks and hydrocarbons in the Cooper/Eromanga Basins. This finding was corroborated by unpublished data (B. Michaelsen, pers comm., 1995) which indicate that BNH is more common and occurs in higher concentration in the Mesozoic, than the Palaeozoic. However, considering the small number of samples used to determine this parameter, the author advises caution when applying it.

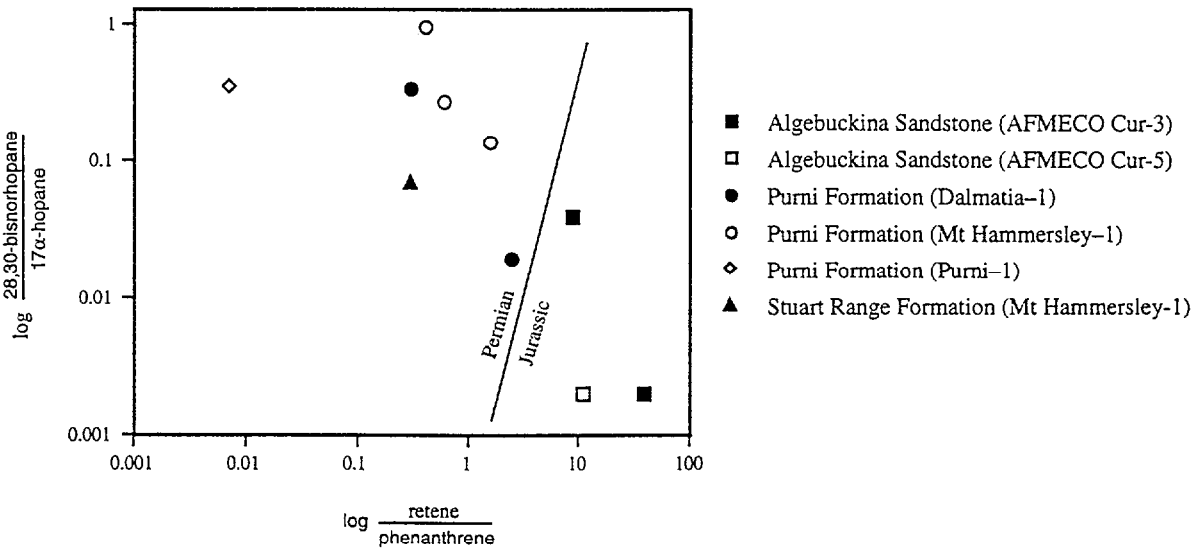


Figure 7.3: Log graph of source parameters 28,30-bisnorhopane/hopane and retene/phenanthrene for Permian and Jurassic sediments. Concept for figure courtesy of B. H. Michaelsen.

7.4.3 *Methylhopanes and Methylsteranes*

The 2α-methylhopanes are virtually ubiquitous in all sediments (Summons and Walter 1990). However, the predominance of 3β-methylhopanes over 2α-methylhopanes in samples from the Stuart Range Formation equivalent, Purni Formation and Algebuckina Sandstone are unusual. The presence of methylhopanes suggests that methylotrophic bacteria were active during deposition in an anoxic carbonate environment (Summons and Walter 1990; Summons and Jahnke 1993). The 3β-methylhopanes are more abundant than the 2α-methylhopanes (Appendix 3). Padley *et al.* (1995) suggest that a predominance of 3β-methylhopanes over 2α-methylhopanes is indicative of sedimentation in a hypersaline carbonate playa lake. However, these samples were deposited in a coal swamp. Further, the lower abundance or absence of 3β–methylhopanes in source rocks that are thermally mature suggests that these compounds are relatively unstable.

C_{30} methylsteranes are present in moderate abundances with 24-ethyl-3β-cholestane [3β(Me)] predominate over the 24-ethyl-2α-cholestane [2α(Me); Appendix 3]. According to Boreham (1994) this methylsterane distribution is characteristic of Australian coals. The 3β(Me)/ααα 20R sterane ratios were plotted against the 3β-methylhopane/17α,21β-hopane ratios (Figure 7.4). The results suggest that the formation of methylated hopanes and steranes are related and possibly a result of the same mechanism (Michaelsen pers. comm., 1995). Also, it appears that this parameter has the potential to be used as an age discriminator for Permian and Jurassic sourced oils.

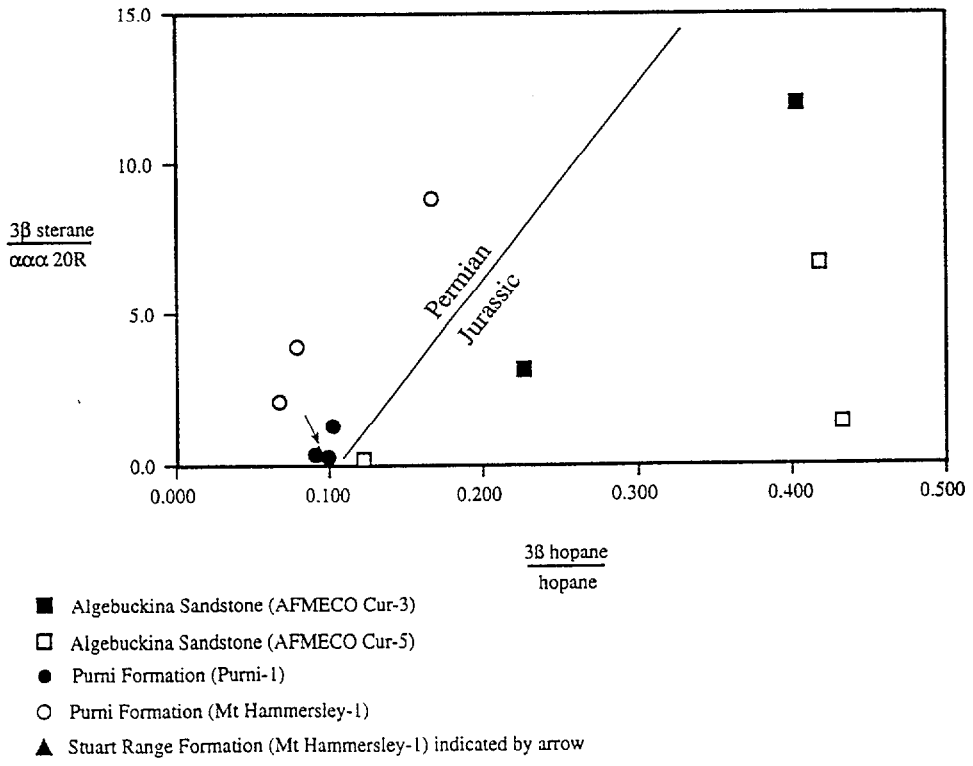


Figure 7.4: Plot of source parameters, methylsteranes and methylhopanes for Permian and Jurassic samples. Concept of figure courtesy of B. H. Michaelsen.

The mechanism that may be responsible for the synthesis of these methyl compounds could include one or more of the following processes:

1. Summons and Capon (1988, 1991) suggest that the 3β(Me) and 2α(Me) steranes are formed *via* the microbial modification (possibly methylation) of Δ^2–sterenes derived from sterols.
2. Dahl *et al.* (1992) found that 3-pentylcholestane was formed from precursor compounds synthesised by bacteria *via* the addition of a C_5 sugar to a Δ^2–sterene. Further, Dahl *et al.*, (1992) suggests that bacteria living in environments with abundant sterol debris, will have membranes with 3-alkyl steroids.
3. Summons and Walter (1990) suggest that the 3β(Me) and 2α(Me) steranes may be synthesised either from naturally occurring 4-methyl steroid precursors *via* the cleavage, migration and subsequent addition of a methyl group, or from cholest-2-ene *via* microbial methylation.
4. Dehydration and/or hydrogenation of biologically-derived methyldiplopterol and methylbacteriohopane polyols (Summons and Jahnke, 1993).

Also, specific environmental conditions that favour the proliferation of methylotrophic bacteria and algae (e.g. anoxic swamp) would result in high concentrations of hopanoids and steranes in the depositional environment. These readily available degradation products may then be synthesised onto the methylated compounds. However, further work will be required to resolve this matter.

7.4.4 *C_{26} Steranes*

C_{26} steranes are found in low concentrations in the Stuart Range Formation equivalent, the Purni Formation and the Algebuckina coals, and are almost exclusively present as 27-norcholestanes with minor 21-norcholestane (Appendix 3). Poorly resolved peaks and low abundances precluded the identification of the other member of the C_{26} series, 24-norcholestanes. Moldowan *et al.* (1991) suggested that there are no direct sterol precursors for the 27-norcholestanes and they are derived from larger steroids (> C_{26}). The same authors hypothesised that these C_{26} steranes formed *via* bacterially-mediated oxidation or were the products of thermal cleavage. However, the latter is unlikely given the thermal immaturity of the samples.

7.5 *Summary*

The saturated hydrocarbon fractions from samples of the Crown Point Formation, Stuart Range Formation equivalent, Purni Formation and Algebuckina Sandstone reveal high concentrations of hopanes and steranes. The maturation–sensitive ratios based on hopane distributions indicate that the source rocks are immature (Ts/Tm = 0.09 to 0.48; βα/αβ hopane = 0.10 to 0.41). Thermal maturity ratios based on sterane distribution concurs with those derived from hopane maturity parameters (ααα 20S/ααα (20S + 20R) = 0.03 to 0.28; αββ 20R/αββ 20R + ααα 20R = 0.3 to 0.61). The values obtained for these maturation–sensitive parameters indicate that the sediments in question are immature for hydrocarbon generation.

Ethylcholestane derived from terrestrial land plants dominates the C_{27} - C_{29} sterane distribution of all but one sample (Stuart Range Formation equivalent). A dominance of the methylcholestane in this latter sample indicates a significant algal input to a lacustrine environment.

Variable mixtures of prokaryotic and eukaryotic organisms are shown to have contributed to the organic matter of all samples. However, in the main, bacterial hopanes dominate the biomarker composition of all samples, as demonstrated by the hopane/sterane ratios (hop/ster = >1). The high hopane ratios indicate intensive bacterial activity during deposition and initial stages of diagenesis (AFMECO Cur–3, 259.5 = 34.4 and Mt Hammersley–1, 838.2 - 853.4 m = 19.8). In contrast, abundant algae and land plant material in the sediment column has lowered the hopane/sterane ratio of some samples. For example, the Stuart Range Formation equivalent sample (Mt Hammersley–1, 1219.2-1237.5 m) and Purni Formation (Dalmatia–1 713.2-722.4 m) have very low hopane/sterane ratios (hop/ster = 0.5).

R. Paull (pers. comm., 1995) found that the concentration of the C_{29} hopane, compound X, increases with depth in Triassic sediments at Leigh Creek, contrary to the finding of this study. Together our data suggest that this compound is source related and may be derived from a similar biological precursor. However, this compound is thermally unstable as indicated by its absence in mature source rocks.

High concentrations of 28,30–bisnorhopane (BNH) in Permian sediments suggest that the environment of deposition was highly anoxic. A plot of BNH/17α,21β–hopane against retene/phenanthrene indicates that the former parameter has the potential to be used as an age discriminator between Permian and Jurassic source rocks and hydrocarbons. The same concepts have been applied to a plot of 3β(Me) sterane /ααα 20R sterane against 3β-methylhopane/17α,21β-hopanes and indications are that it has potential to act as an age-specific parameter.

Methylhopanes are derived from methyltrophic bacteria (Summons and Jahnke, 1993). The relatively high concentrations of methylhopanes suggest that deposition occurred in an anoxic environment (perhaps an anoxic swamp).

The observed distribution of the C_{30} methylsteranes in the Stuart Range Formation equvialent, Purni Formation and Algebuckina samples is characteristic of Australian coals and carbonaceous sediments. The predominance of 24-ethyl–3β-cholestane [3β(Me)] over the 24-ethyl-2α-cholestane [2α(Me)] is indicative of immature sediments. A plot of 3β(Me)/ααα 20R sterane against 3β-methylhopane/17α,21β-hopane suggests that there may be a common mechanism forming these methylated compounds (Figure 7.4).

Chapter 8: Conclusions

Petrographic and geochemical analysis of a suite of coals and carbonaceous sediments from the margins of the Eringa Trough indicate that terrestrial organic matter, variously enriched in bacterial and algal remains, was deposited in environments ranging from glacio-lacustrine to paludal.

1. The shift from -22.7‰ to a lighter -24.1‰ kerogen $\delta^{13}C$ signature during the Early Permian suggests an increased contribution by C3-type land plants, as swamps began to dominant the depositional environment.

2. Organic petrography, in conjunction with Rock–Eval pyrolysis, was used to assess the source potential and thermal maturity of the formations sampled. Other petrographic observations support the theory that deposition occurred in a range of environments. The siltstones from the Crown Point Formation and the Stuart Range Formation equivalent have very poor source potential (TOC = 0.4%; $S_1 + S_2$ = 1 mg HC/g; HI = 39). However, coals and carbonaceous shales from the Early Permian Purni Formation have poor to good source potential for liquid hydrocarbon generation (TOC = 7 - 63%; S1+S2 = 10 - 207 mg HC/g; HI = 113 to 359). The present maturity of samples from the Purni Formation precludes them from generating hydrocarbons (0.40 - 0.45% R_O). In contrast, the samples from the Algebuckina Sandstone have good to excellent oil–generative potential (TOC = 34 - 59%; S1+S2 = 135 - 279 mg HC/g; HI = 312 to 542). Petrographic observations reveal high concentrations of oil–prone liptinites. Maturities estimated from vitrinite reflectance ranges 0.41 to 0.45% are supported by Rock–Eval T_{max} data. These oil–prone sediments are marginally mature for liquid hydrocarbons given their labile liptinites.

3. Gas chromatography analysis indicates a mixed algal, bacterial land plant input. The predominance of odd carbon–numbered *n*–alkanes supports the notion that these sediments are immature. Abundant cyclic and low molecular weight alkanes in the Purni Formation samples suggests that these sediments are gas-prone. By way of contrast, the Algebuckina Sandstone samples display a dominance of high odd carbon–numbered *n*–alkanes that indicate the excellent oil–generative potential of these source rocks.

4. Maturation–sensitive parameters determined from GC-MS data confirms that these sediments are immature. A range of aromatic hydrocarbons derived from the *Araucariaceae* flora are found in high abundance in the Algebuckina coals. Comparable aromatic assemblages are found in much lower abundances in Permian samples from the Crown Point Formation, Stuart Range Formation equivalent and the Purni Formation. Thus, this difference in abundance can be used as an age discriminator between Permian and Jurassic samples.

5. The maturation-sensitive ratios and source parameters based on hopane and sterane distributions confims that the sediments in question are immature with respect to hydrocarbon generation. The presence of an unidentified C_{29} hopane (Compound X) supports the latter finding. Ethylcholestane derived from terrestrial land plants dominates the C_{27} - C_{29} sterane distribution in all but one sample from the Stuart Range Formation equivlent. A dominance of methylcholestane in this latter sample indicates a significant algal input to a lacustrine environment. The relative abundance of 28,30–bisnorhopane, 3β-methylhopanes and 3β-methylsteranes have the potential to discriminate between Permian and Jurassic source rocks and hydrocarbons in the Pedirka Basin and adjacent Cooper/Eromanga Basins.

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APPENDIX 1

Materials and Methods

A.1 *Sample Selection and Preparation*

A total of 68 cuttings samples were collected from Dalmatia-1 and Mt Hammesley-1 and 9 quarter core samples from AFMECO Cur-3 and Cur-5, Purni-1 and Witcherrie-1. The darkest (organic rich) samples were preferentially selected. The 68 cuttings samples were individually washed and rinsed in distilled water using step-wise ultrasonification to remove drilling mud. Selective picking of the coaly lithologies as individual rock chips > 0.75 mm avoided contamination. Contaminants included iron-filings and minor paint in Dalmatia-1; and grass, abundant paint, iron filings and ?rubber in Mt Hammersley-1. The washed and picked cuttings were consolidated into 13 composite samples (Table 2.1). The core samples were scraped and brushed clean to remove surficial contamination.

A.2 *Petrographic analyses*

Sub-samples of two composite samples from Dalmatia-1 (713.2-722.4 m & 591.3-606.0 m), all eight composite samples from Mt Hammersley-1 and sub-samples from AFMECO Cur-3, Cur- 5, Purni-1 and Witcherrie-1 were mounted in hot-setting Araldite resin and polished for petrographic analyses. Prior to mounting, the core sub-samples were cut perpendicular to bedding.

Maceral analysis involved the point-counting of the dispersed organic matter (DOM) to determine the relative abundance of the maceral groups in each sample. A Wild Photoautomat MPS Spot camera, loaded with 200 ASA film, was mounted on a Leitz Ortholux II microscope to photograph the DOM using both reflected white light and fluorescence light. Fluorescence-mode photography required the use of a K 510 barrier filter plus a BG 12 and a BG 38 exciter filters.

Reflectance measurements were made using a Leitz Ortholux Pol BK microscope at AMDEL Petroleum Services under conditions specified in the Australian Standard 2856 (1986) for coal - maceral analysis. Random vitrinite reflectance measurements (R_r %) were converted to mean maximum reflectance values (R_o %) using Kilby's (1991) formula $R_o = 1.083 \times R_r$ %.

A3: *Geochemical analyses*

Preceding geochemical analyses, the cuttings and core samples were milled to a fine powder. A subsample of all of the samples was taken to be analysed for total organic carbon (TOC) and by Rock-Eval pyrolysis at Geotechnical Services and AMDEL Petroleum Services. These results provide information on the thermal maturity, type of organic matter and source potential of the source rocks and are interpreted using guidelines outlined by Peters (1986). Further analyses were carried out on those samples that showed the most potential.

The powdered cuttings and core samples were Soxhlet extracted using an azeotropic dichloromethane/methanol mixture (93:7). The extractable organic matter (EOM) was then

fractionated sequentially using petroleum ether, petroleum ether/dichloromethane mixture (40:60) and dichloromethane/methanol mixture (35:65) to isolate the saturated hydrocarbons, aromatic hydrocarbons and polar compounds (resins and asphaltenes) respectively, by liquid chromatography on activated silica gel.

A4: *Gas Chromatography*

The saturated hydrocarbon fractions were analysed by gas chromatography on a Varian 3400 gas chromatograph which was interfaced with a Macintosh SE computer running Chart. The instrument was fitted with a 25 m x 0.22 um i.d. fused silica column (BP-1, 0.25 um film thickness; SGE Australia). The samples, in n-hexane were injected on-column at 40°C and the oven programmed to 300°C at 4°C min-1, and then held at 300°C for 30 minutes. The carrier gas was hydrogen at a linear flow rate of 30 cm s^{-1}. The hydrocarbons were detected using a flame ionisation detector (FID). Alkane ratios determined from gas chromatograms were based on peak heights.

A5: *Gas Chromatography-Mass Spectrometry*

GC-MS analyses were carried out on a Varian 3400 gas chromatograph interfaced with a Finnigan TSQ 70 mass spectrometer. The GC was fitted with a J & W Scientific fused silica capillary DB-1 column, 0.25 um film thickness, 0.25 mm i.d. and 60 m length. Helium was used as the carrier gas at an inlet pressure of approximately 23.5 psi. The oven was held isothermal at 50°C for 2 min, then programmed to rise 50° to 120°C at 8°C min-1, then 120°C to 300°C at 4°C min-1 and held isothermal for 35 minutes. The injector was held at 50°C for 3 seconds then ramped to 300°C at 180°C min-1 and held isothermal for 5 minutes. The mass spectrometer operating conditions included an ionisation voltage of 70 eV with a filament current of 200 uA and a photomultiplier voltage of 1100 V.

A5.1: *Aromatic hydrocarbons*

The aromatic hydrocarbons were dissolved in n-hexane and injected on column. The mass spectrometer was programmed (multiple ion detector: MID) to monitor *m/z* 128 (naphthalene), *m/z* 141 and 142 (methylnaphthalenes), *m/z* 156 (dimethylnaphthalenes), *m/z* 170 (trimethylnaphthalenes), **m/z* 178 (phenanthrene), *m/z* 192 (methlyphenanthrenes), *m/z* 206 (dimethlyphenanthrenes), *m/z* 219 (retene), *m/z* 231 and 245 (monoaromatic steroids), and *m/z* 253 (triaromatic steroids). Ratios calculated were based on peak areas for aromatic compounds. *A GC-MS response factor of 0.69 was applied to the area of phenanthrene before calculating ratios using this compound. Calculated aromatic ratios were determined using peak areas.

A5.2: *Saturated hydrocarbons*

The collision gas (Argon) was set at -20 eV collision-offset voltage to induce the dissociation (CAD) in the second quadrupole (Q2MS) and the photomultiplier was at 1900 V. The first quadrupole (Q1MS) was used as a mass filter, allowing only parent ions with specific *m/z* ratios to pass into Q2MS. The third quadrupole (Q3MS), measured the molecular ions of the targeted *m/z* ratios corresponding to the daughter ions produced by CAD in Q2MS. Q1MS and

Q3MS were operated in tandem to provide the selective reaction monitoring (SRM) data presented here. The saturated hydrocarbons were dissolved in *n*-hexane and injected on-column. The decomposition reactions that were monitored are presented in Table A.1. The calculated hopane and sterane ratios were determined using peak areas.

Q1MS *m/z*	Q3 *m/z*	Target compounds
Hopanes		
370, 398	163	25-norhopanes (10-desmethylhopanes)
398, 370, 412	177	Demethylated hopanes
370	191	C_{27} hopanes (e.g. Ts, Tm)
384	191	C_{28} hopanes (e.g. 28,30-BNH)
398	191	C_{29} hopanes (e.g. C_{29}Ts)
412	191	C_{30} hopanes (e.g. diahopane)
440, 454, 468, 482	191	Homohopanes
370, 384, 398, 412, 426, 440, 454	205	Methylhopanes
Steranes		
358	217	C_{26} steranes
374	217	C_{27} steranes
386	217	C_{28} steranes
400	217	C_{29} steranes
414	217	C_{30} steranes (4-desmethylsteranes)
414	231	C_{30} steranes (A-ring methylsteranes)

Table 1: Decomposition reactions monitored by mass spectrometer

A6: *Stable Carbon Isotopes*

Selected kerogen and rock samples were treated sequentially with hydrochloric acid (HCl) and hydrofluoric acid (HF). The final treatment with HCl was heated at 60°C for 8 hours. The residue was rinsed in distilled water several times and then dried. The non-extracted samples were then washed with dichloromethane and methanol to remove EOM. The treated samples were placed into 6 mm quartz tubes with silver wire and cupric oxide, evacuated and sealed before combustion at 900°C for 8 hours. The ratio of $^{13}C/^{12}C$ in the CO_2 evolved in the combustion was determined using a Micromass V6 602E mass spectrometer. The ^{13}C values were calculated relative to the Peedee Belemnite standard (PBD).

$$\delta^{13}C\ ^{o}/_{oo} = \left[\frac{^{13}C/^{12}C\ (\text{sample}) - {}^{13}C/^{12}C\ (\text{standard})}{^{13}C/^{12}C\ (\text{standard})} \right] \times 1000$$

APPENDIX 2

Rock-Eval Pyrolysis & TOC

Well / Depth	Formation	T_{max}	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
AFMECO Cur-3												
251.60 m	Albebuckina	421	11.88	123.20	13.20	135.08	9.33	0.09	11.21	34.30	359	38
251.90 m	Algebuckina	423	16.79	151.50	13.86	168.29	10.93	0.10	13.97	39.00	388	36
259.50 m	Algebuckina	419	23.65	255.76	17.50	279.41	14.61	0.08	23.19	47.20	542	37
AFMECO Cur-5												
209.20 m	Algebuckina	421	3.51	45.90	24.97	49.41	1.84	0.07	4.10	52.90	87	47
210.10 m	Algebuckina	424	18.27	157.45	19.72	175.72	7.98	0.10	14.58	50.50	312	39
249.40 m	Algebuckina	424	32.52	216.07	27.19	248.59	7.95	0.13	20.63	58.70	368	46
Dalmatia-1												
591.3 - 606.0 m	Purni	423	5.32	150.09	11.96	155.41	12.55	0.03	12.90	49.20	305	24
612.6 - 624.8 m	Purni	425	4.11	118.72	13.03	122.83	9.11	0.03	10.19	44.30	268	29
634.0 - 646.2 m	Purni	426	1.85	91.11	12.87	92.96	7.08	0.02	7.72	37.70	242	34
704.1 - 719.3 m	Purni	425	3.90	122.36	8.45	126.26	14.48	0.03	10.48	38.50	318	22
792.5 - 810.8 m	Purni	422	4.23	125.09	11.25	129.32	11.12	0.03	10.73	39.40	317	29
Mt Hammersley-1												
615.7 - 630.9 m	Purni	424	2.12	80.18	17.96	82.30	4.46	0.03	6.83	63.10	127	28
658.4 - 673.6 m	Purni	425	1.58	71.21	17.66	72.79	4.03	0.02	6.04	62.80	113	28
704.1 - 719.3 m	Purni	425	2.77	96.20	15.74	98.97	6.11	0.03	8.21	58.70	164	27
762.0 - 774.2 m	Purni	425	6.37	172.94	9.70	179.31	17.83	0.04	14.88	59.10	293	16
838.2 - 853.4 m	Purni	427	6.34	200.38	8.17	206.72	24.53	0.03	17.16	55.80	359	15
871.7 - 887.0 m	Purni	427	5.38	139.13	9.13	144.51	15.24	0.04	11.99	52.80	264	17
1219.2 - 1237.5 m	Stuart Range	nd	0.03	0.16	0.14	0.19	1.14	0.16	0.02	0.41	39	34
1408.2 - 1423.4 m	Crown Point	nd	0.07	0.12	0.12	0.19	1.00	0.37	0.02	0.35	34	34
Purni-1												
1445.8 m	Purni	429	0.15	10.28	1.34	10.43	0.01	7.67	0.86	7.48	137	17
1772.1 m	Crown Point	429	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.22	0	68
Witcherie–1												
556.2 m	Crown Point	420	0.05	3.06	1.42	3.11	0.02	2.15	0.25	3.38	90	42

T_{max} = temperature of maximum generation of S2 hydrocarbons

S1 = mg hydrocarbons/g rock; S2 = mg hydrocarbons/g rock; S3 = mg CO_2/g rock

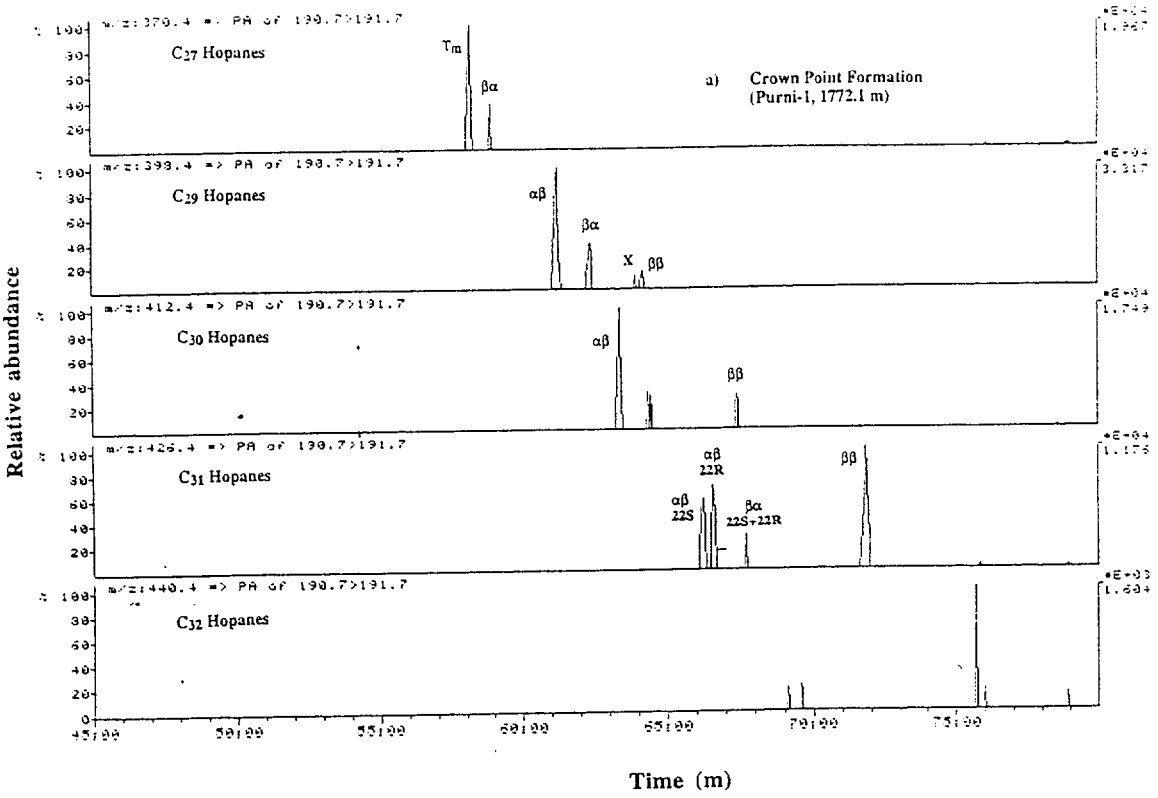
PI = S1/(S1+S2); PC = pyrolysable carbon; TOC = total organic carbon

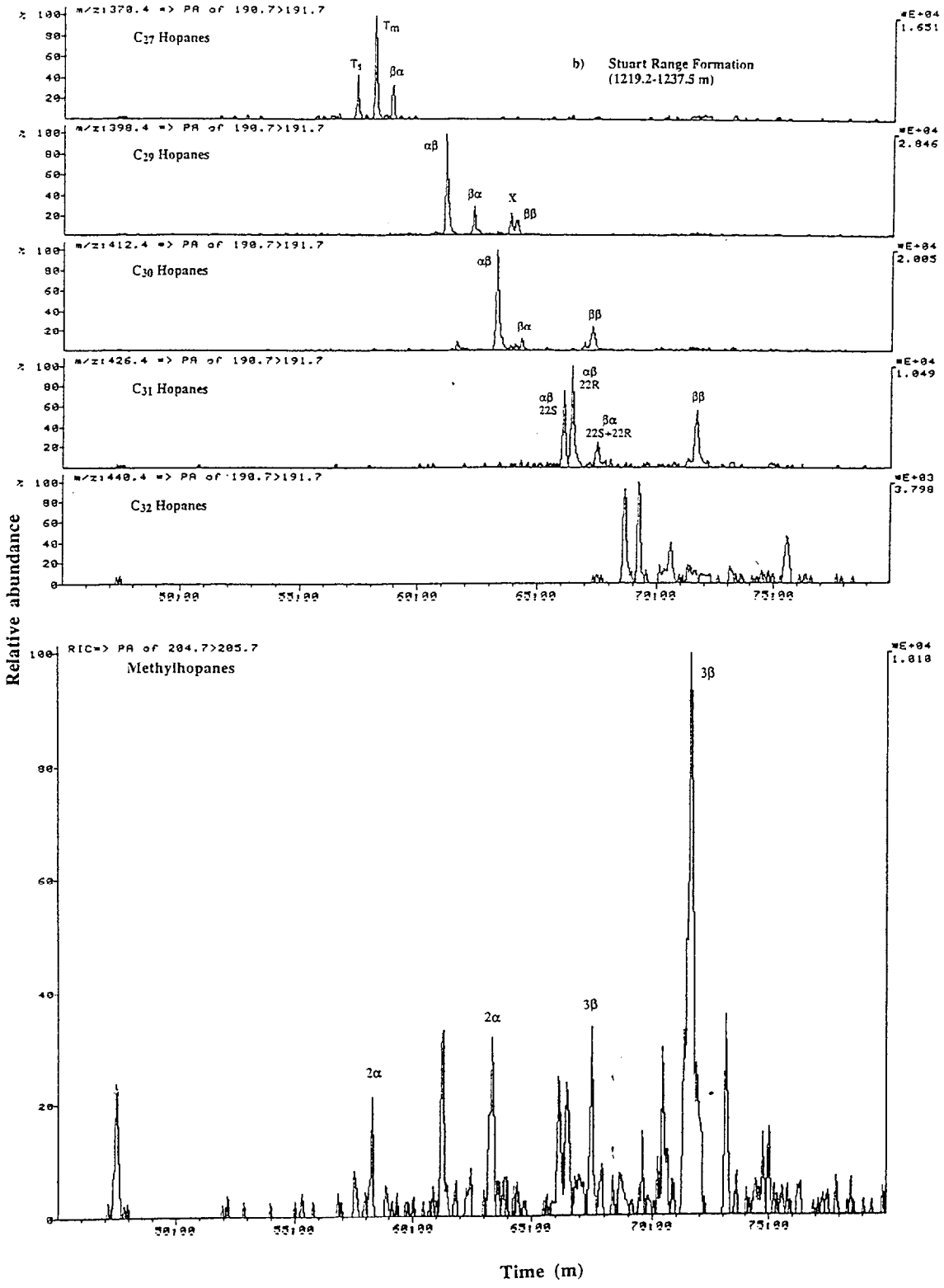
HI = S2/g TOC; OI = S3/g TOC

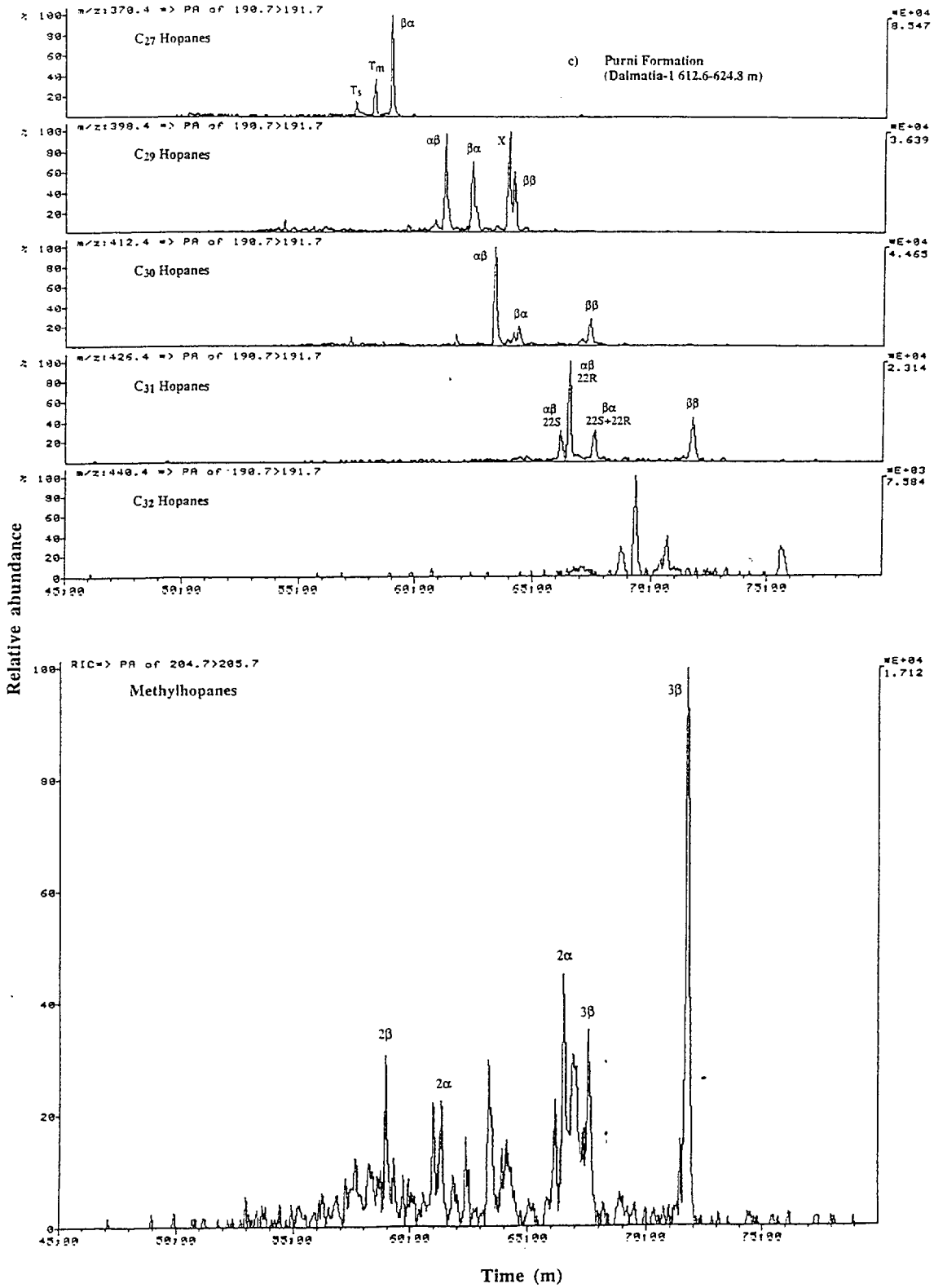
APPENDIX 3

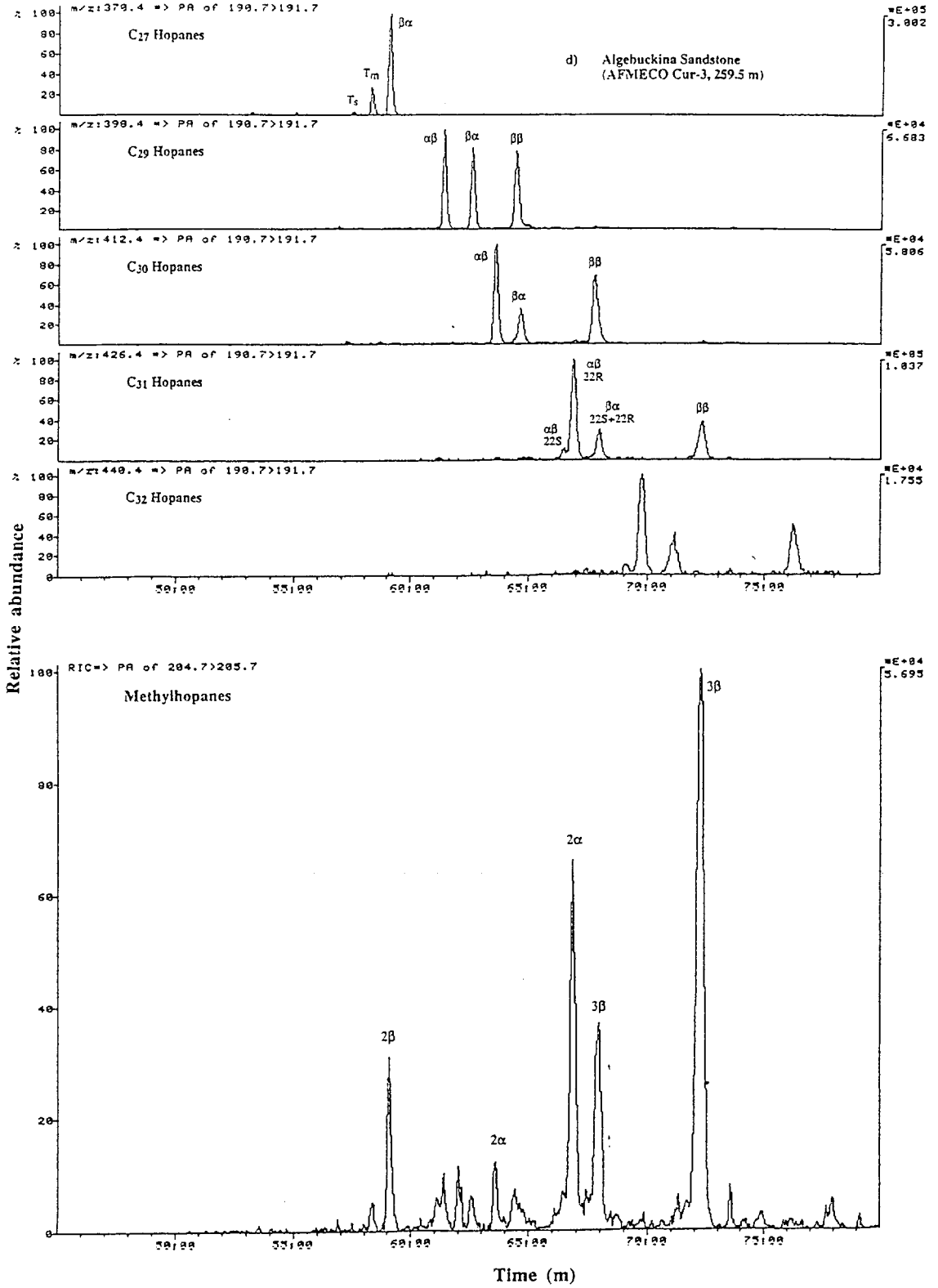
GC-MS-MS

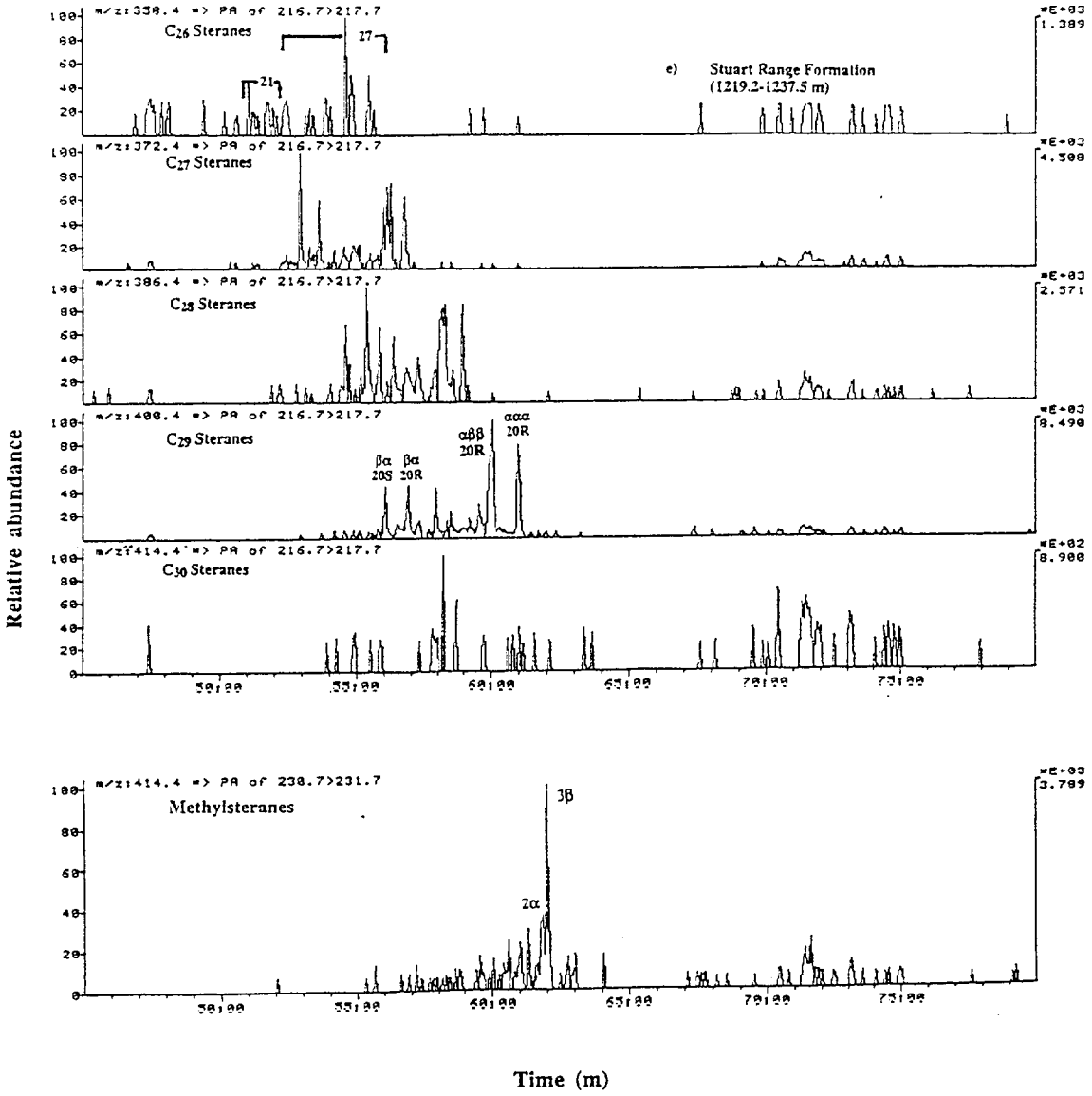
Hopane and Sterane traces

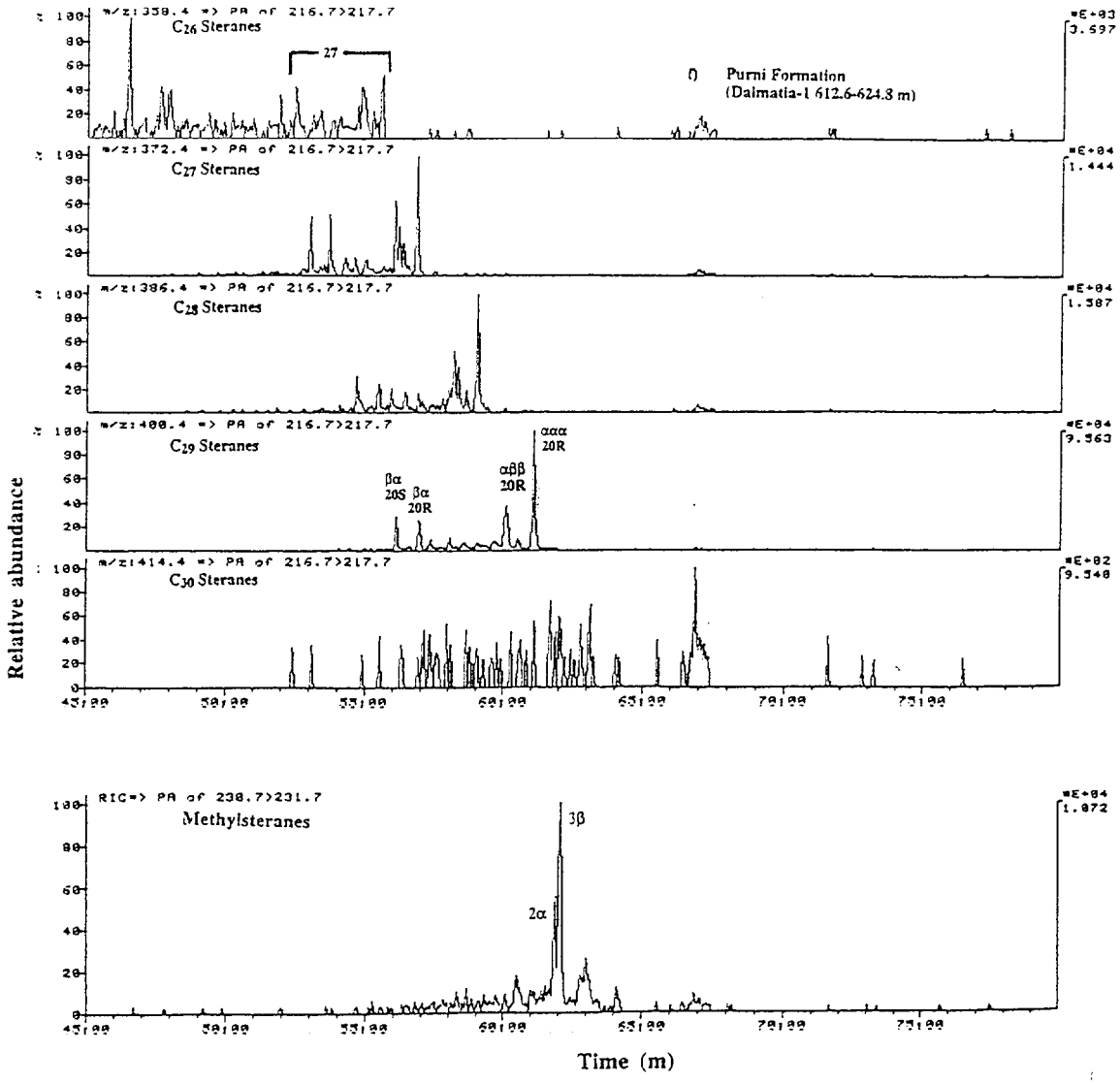

C27 Hopanes
Tm
βα
a) Crown Point Formation
(Purni-1, 1772.1 m)
C29 Hopanes
αβ
βα
X
ββ
C30 Hopanes
αβ
ββ
C31 Hopanes
αβ 22R
αβ 22S
βα 22S+22R
ββ
C32 Hopanes
Relative abundance
Time (m)

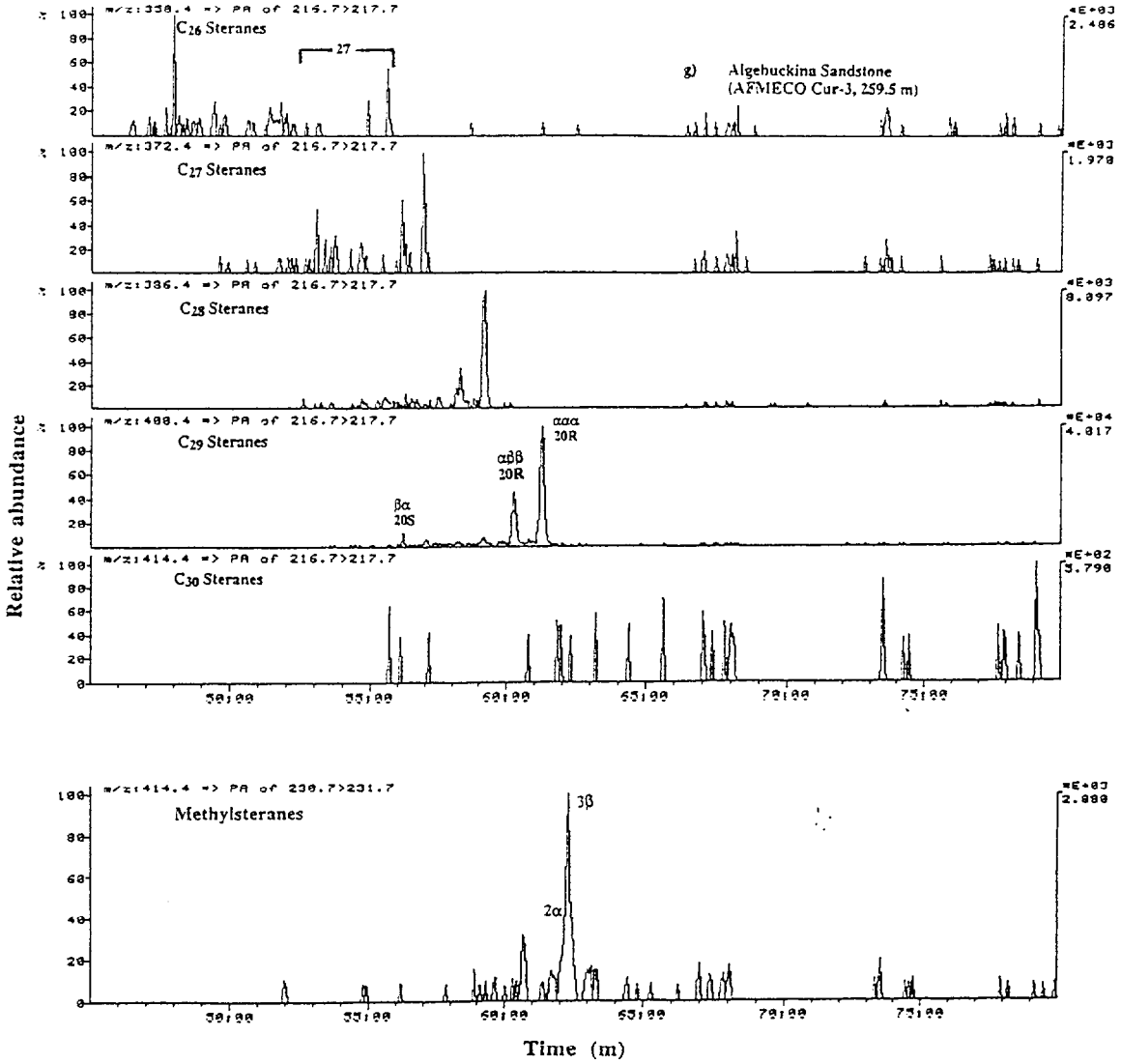

m/z:370.4 => PA of 190.7>191.7
C27 Hopanes
Ts
Tm
βα
b) Stuart Range Formation
(1219.2-1237.5 m)
m/z:398.4 => PA of 190.7>191.7
C29 Hopanes
αβ
βα
X
ββ
m/z:412.4 => PA of 190.7>191.7
C30 Hopanes
αβ
βα
ββ
m/z:426.4 => PA of 190.7>191.7
C31 Hopanes
αβ 22S
αβ 22R
βα 22S+22R
ββ
m/z:440.4 => PA of 190.7>191.7
C32 Hopanes
Relative abundance
RIC=> PA of 204.7>205.7
Methylhopanes
2α
2α
3β
3β
Time (m)


m/z:370.4 => PA of 190.7>191.7
C27 Hopanes
Ts
Tm
βα
c) Purni Formation
(Dalmatia-1 612.6-624.8 m)
m/z:398.4 => PA of 190.7>191.7
C29 Hopanes
αβ
βα
X
ββ
m/z:412.4 => PA of 190.7>191.7
C30 Hopanes
αβ
βα
ββ
m/z:426.4 => PA of 190.7>191.7
C31 Hopanes
αβ 22S
αβ 22R
βα 22S+22R
ββ
m/z:440.4 => PA of 190.7>191.7
C32 Hopanes
45:00
50:00
55:00
60:00
65:00
70:00
75:00
Relative abundance
RIC=> PA of 204.7>205.7
Methylhopanes
2β
2α
3β
2α
3β
Time (m)


m/z:370.4 => PA of 190.7>191.7
C27 Hopanes
Ts
Tm
βα
d) Algebuckina Sandstone
(AFMECO Cur-3, 259.5 m)
m/z:398.4 => PA of 190.7>191.7
C29 Hopanes
αβ
βα
ββ
m/z:412.4 => PA of 190.7>191.7
C30 Hopanes
αβ
βα
ββ
m/z:426.4 => PA of 190.7>191.7
C31 Hopanes
αβ 22S
αβ 22R
βα 22S+22R
ββ
m/z:440.4 => PA of 190.7>191.7
C32 Hopanes
Relative abundance
RIC=> PA of 204.7>205.7
Methylhopanes
2β
2α
3β
2α
3β
Time (m)

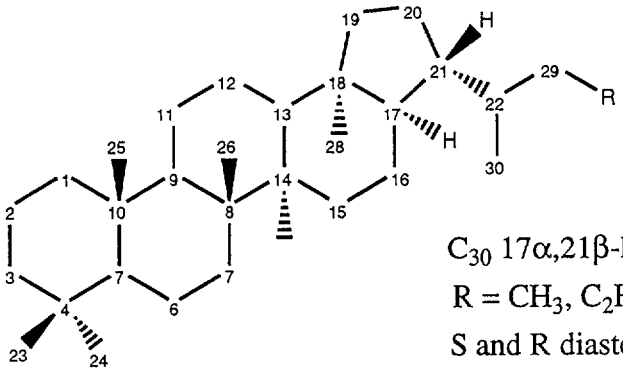

m/z:358.4 => PA of 216.7>217.7
C26 Steranes
27
21
e) Stuart Range Formation
(1219.2-1237.5 m)
m/z:372.4 => PA of 216.7>217.7
C27 Steranes
m/z:386.4 => PA of 216.7>217.7
C28 Steranes
m/z:400.4 => PA of 216.7>217.7
C29 Steranes
βα 20S
βα 20R
αββ 20R
ααα 20R
m/z:414.4 => PA of 216.7>217.7
C30 Steranes
Relative abundance
m/z:414.4 => PA of 238.7>231.7
Methylsteranes
3β
2α
Time (m)


m/z:358.4 => PA of 216.7>217.7
C26 Steranes
27
Purni Formation
(Dalmatia-1 612.6-624.8 m)
m/z:372.4 => PA of 216.7>217.7
C27 Steranes
m/z:386.4 => PA of 216.7>217.7
C28 Steranes
m/z:400.4 => PA of 216.7>217.7
C29 Steranes
βα 20S
βα 20R
αββ 20R
ααα 20R
m/z:414.4 => PA of 216.7>217.7
C30 Steranes
Relative abundance
45:00
50:00
55:00
60:00
65:00
70:00
75:00
RIC=> PA of 238.7>231.7
Methylsteranes
3β
2α
Time (m)


m/z:358.4 => PA of 216.7>217.7
C26 Steranes
27
g) Algebuckina Sandstone
(AFMECO Cur-3, 259.5 m)
m/z:372.4 => PA of 216.7>217.7
C27 Steranes
m/z:386.4 => PA of 216.7>217.7
C28 Steranes
m/z:400.4 => PA of 216.7>217.7
C29 Steranes
βα 20S
αββ 20R
ααα 20R
m/z:414.4 => PA of 216.7>217.7
C30 Steranes
Relative abundance
m/z:414.4 => PA of 230.7>231.7
Methylsteranes
3β
2α
Time (m)

Hopanes

hopane

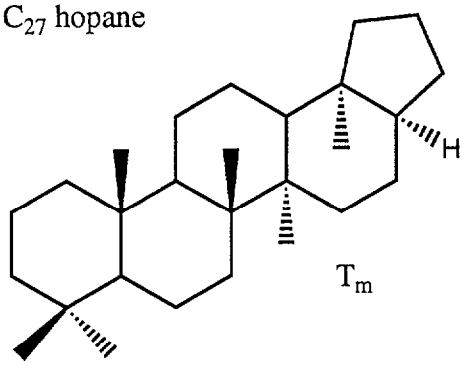


C_{30} 17α,21β-hopane shown

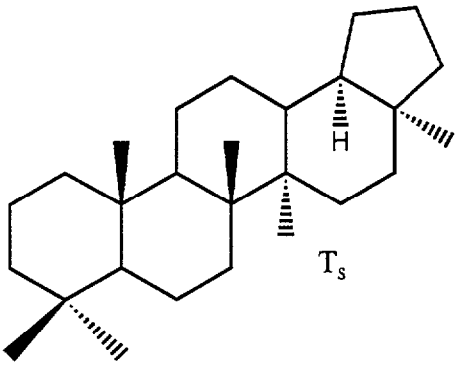
R = CH_3, C_2H_5, C_3H_7 etc.

S and R diastereoisomers at C22

C_{27} hopane

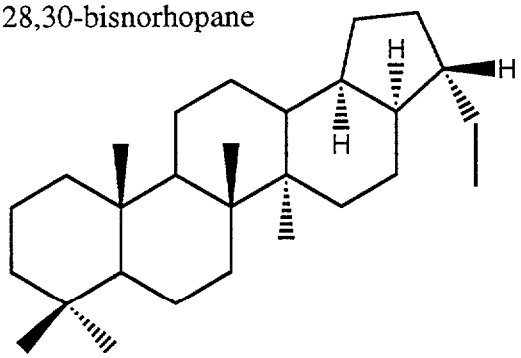


T_m

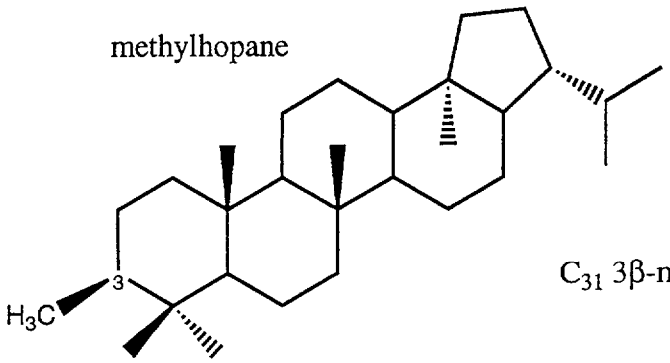


T_s

28,30-bisnorhopane



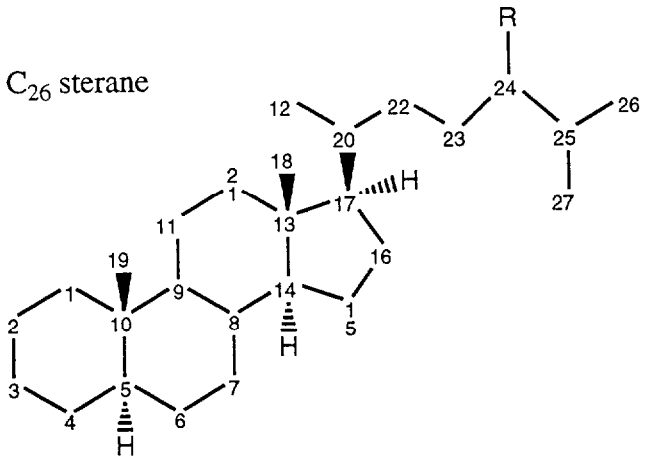
methylhopane



C_{31} 3β-methylhopane shown

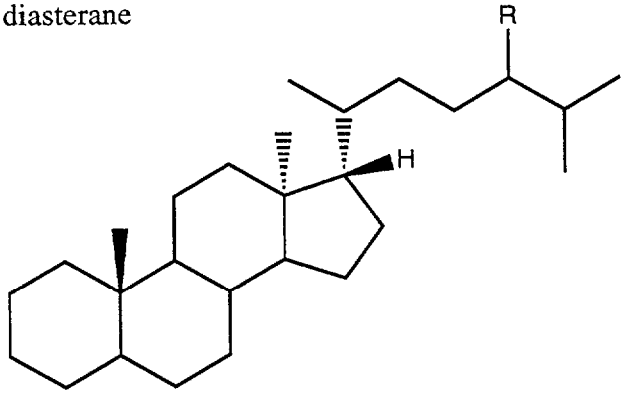
Steranes

C_{26} sterane



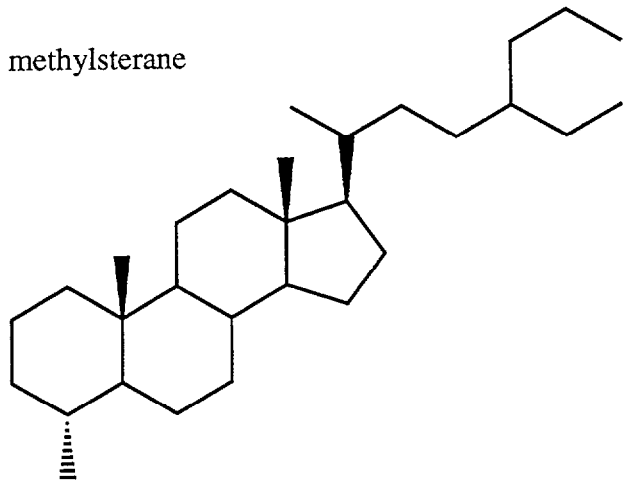
C_{27} R = H; C_{28} R = CH_3; C_{29} R = C_2H_5
S and R diastereoisomers at C20;
5α,14α,17α-norcholestane shown

diasterane



C_{27} R = H; C_{28} R = CH_3; C_{29} R = C_2H_5
S and R diastereoisomers at C20;
13a,17b-

methylsterane



C_{31} 4-methyl-24-propylcholestane

GEOTRACK

000003

APATITE FISSION TRACK ANALYSIS OF SAMPLES FROM THE WESTERN EROMANGA BASIN AND ERINGA TROUGH, AUSTRALIA

GEOTRACK REPORT #582

Data Report Only

A report prepared for Mines and Energy South Australia

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APATITE FISSION TRACK ANALYSIS OF SAMPLES FROM THE WESTERN EROMANGA BASIN AND ERINGA TROUGH, AUSTRALIA

Data Report Only

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GEOTRACK REPORT #582

1. Introduction

This report contains Apatite Fission Track Analysis (AFTA®) data obtained from a total of seventeen samples in the **Western Eromanga and Eringa Trough** region. Sixteen samples (one outcrop and 15 well samples) were supplied by Mines and Energy South Australia (MESA), but two of the well samples failed to yield sufficient apatite suitable for analysis. Well samples are from Cherri-1, Mulapula-1, Koonchera-1, Poolowanna-1 and Poonarunna-1. An additional AFTA sample (8642-54) from the Tinga Tingana-1 well which was originally part of NERDDC Project No. 720 (Gleadow et al., 1988) was re-processed for this report, as requested. Chlorine contents were measured in all grains in which AFTA parameters (ages or lengths) were determined.

Vitrinite reflectance (VR) data from the six wells covered in this study were also supplied by MESA. No interpretation of the AFTA or VR data is provided in this report, as requested.

Near the completion of this Data Report (#582), three further samples were supplied for AFTA, including one well sample from Weena-1 and two outcrop samples. Rather than delay this report, we intend to supply data from the additional samples in an addendum to this report, which should be completed in January 1996.

2. Report structure

Data at the front of this report is divided into three parts. Graphical results of thermal history modelling of the AFTA and chlorine data are supplied in the first part. Summary files relating to the results of thermal history modelling are presented next. Finally, the Default Burial Histories as derived from the preserved stratigraphy in each well are displayed along with the VR data plotted with respect to depth. (Presentation of these data are as implemented by BasinMod™ (version 3.15), a software package of Platte River Associates.)

Sample details are discussed in Appendix A together with the yields of detrital apatite obtained after mineral separation. Also shown in Appendix A are summaries of present temperature data in each well. Sample preparation and analytical details are described in Appendix B, followed by presentation of all AFTA data including raw track counts and fission track ages for individual grains. The presentation of data in the form of Tables and Figures throughout the report is discussed in detail in Appendix B.

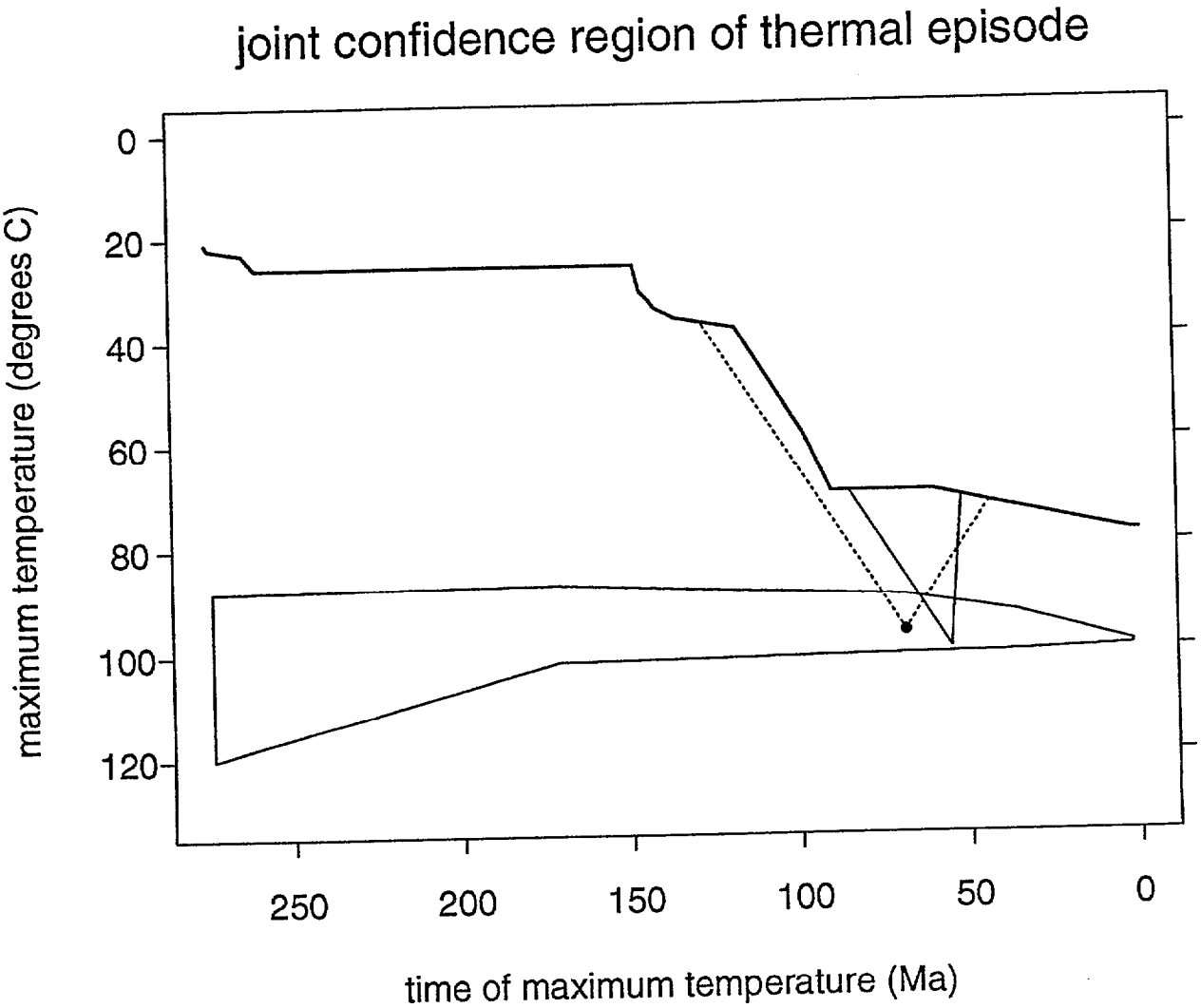
References

Gleadow, A.J.W., Duddy, I.R, Green, P.F. and Lovering, J.F. (1988). Assessment of hydrocarbon resource potential in Australian sedimentary basins: development of fission track techniques. *End of Grant Technical Report NERDDC Project No. 720.*

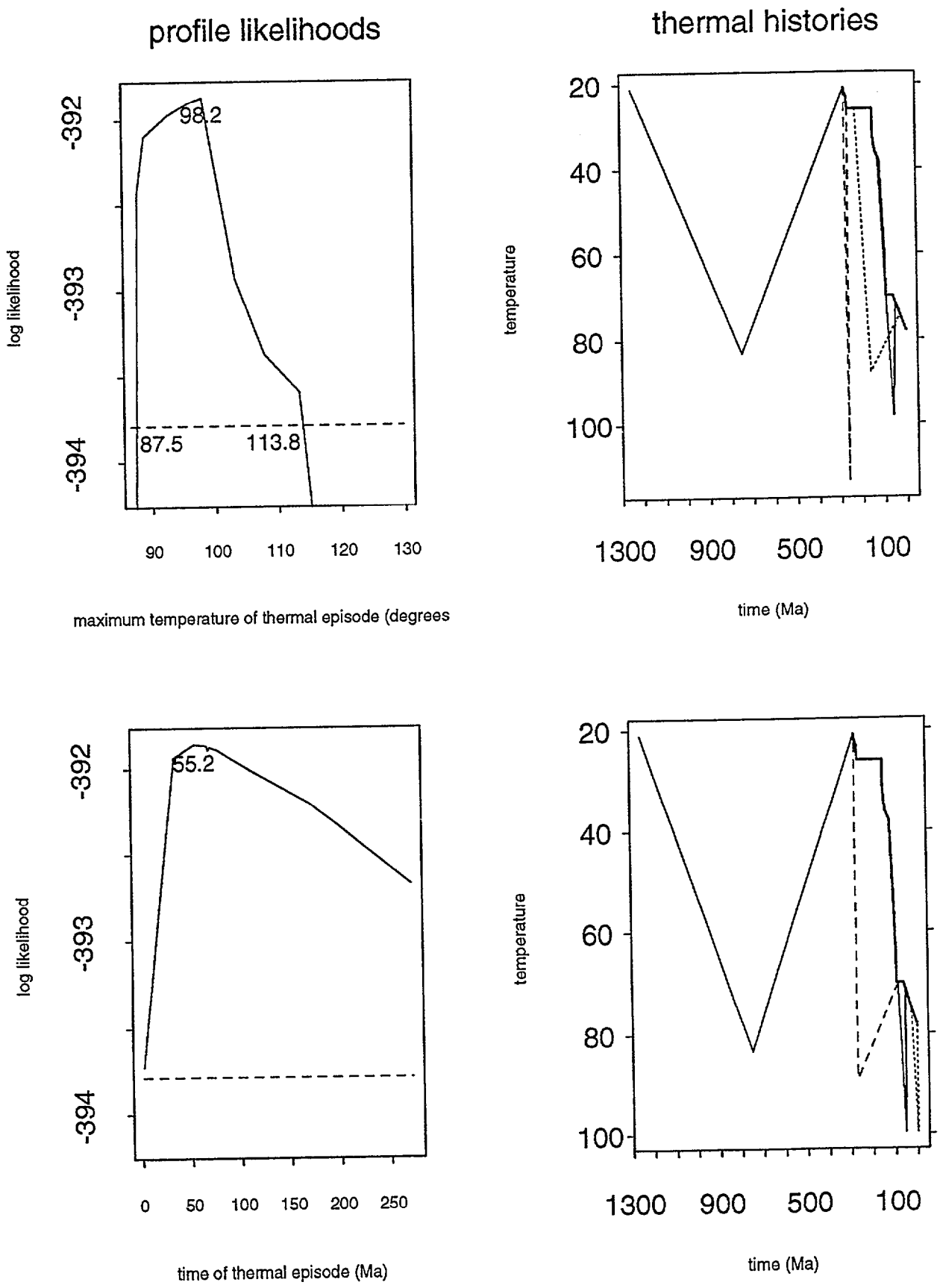
PART ONE:

Graphical results of thermal history modelling of the AFTA and chlorine data

582-1

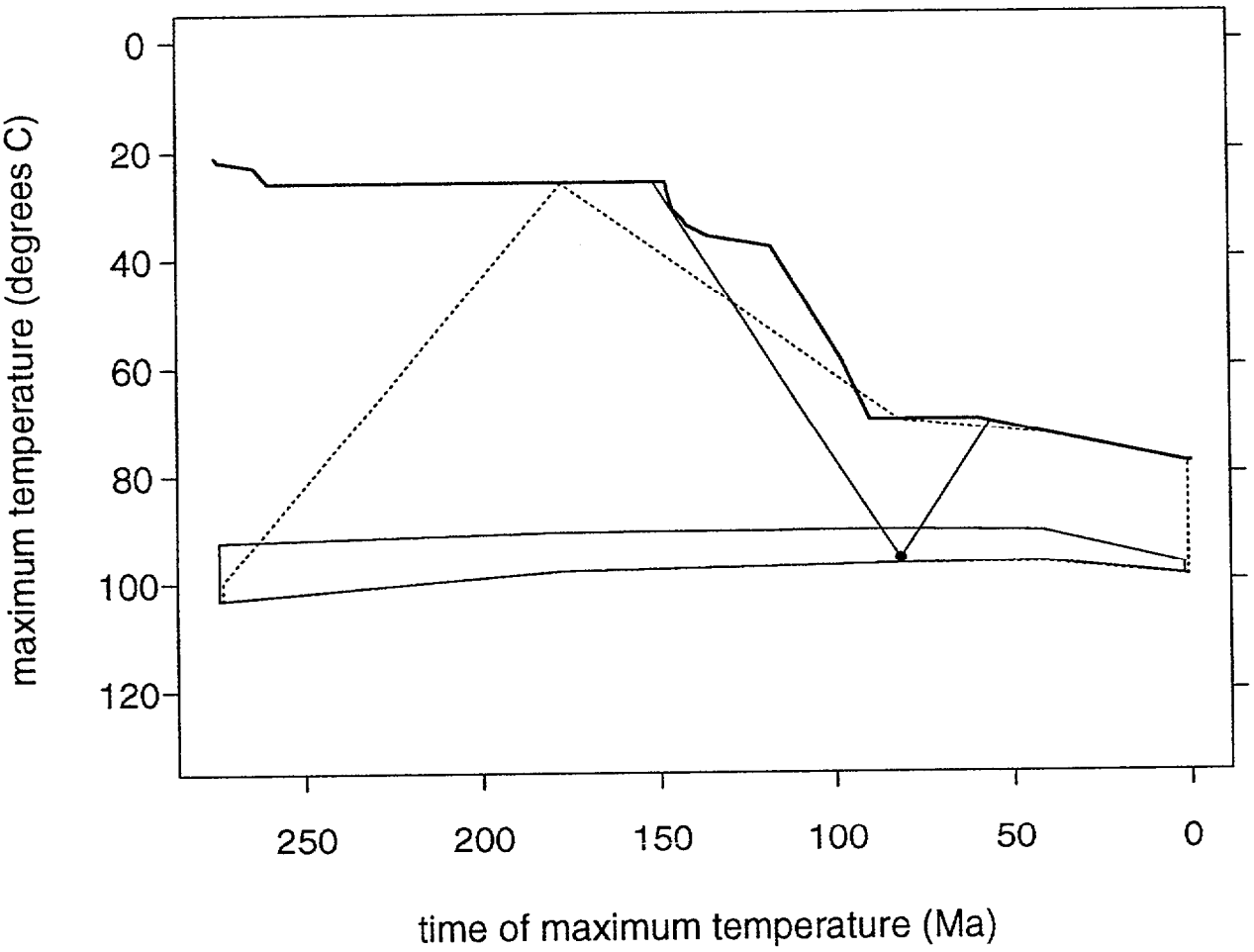

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
250
200
150
100
50
0
time of maximum temperature (Ma)

582-1


profile likelihoods
log likelihood
-392
-393
-394
98.2
87.5
113.8
90
100
110
120
130
maximum temperature of thermal episode (degrees
thermal histories
temperature
20
40
60
80
100
1300
900
500
100
time (Ma)
log likelihood
-392
-393
-394
55.2
0
50
100
150
200
250
time of thermal episode (Ma)
temperature
20
40
60
80
100
1300
900
500
100
time (Ma)

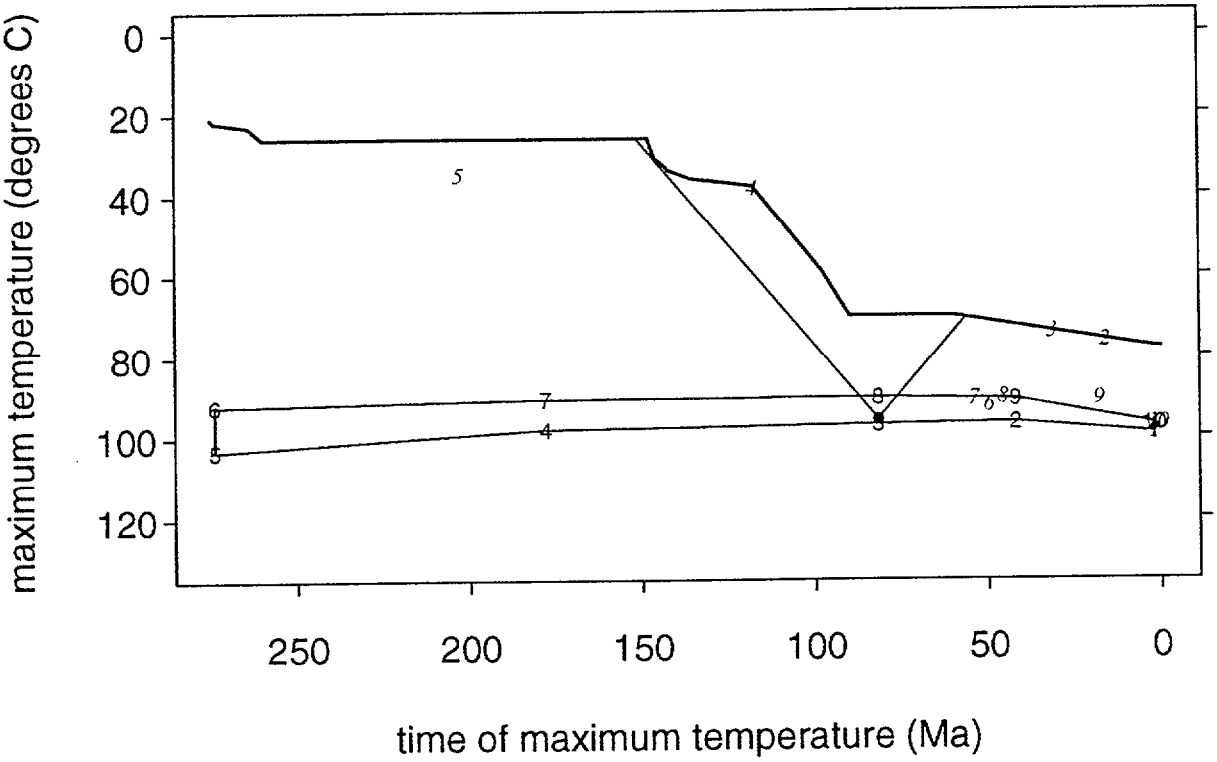
582-1

episodes 1 and 2

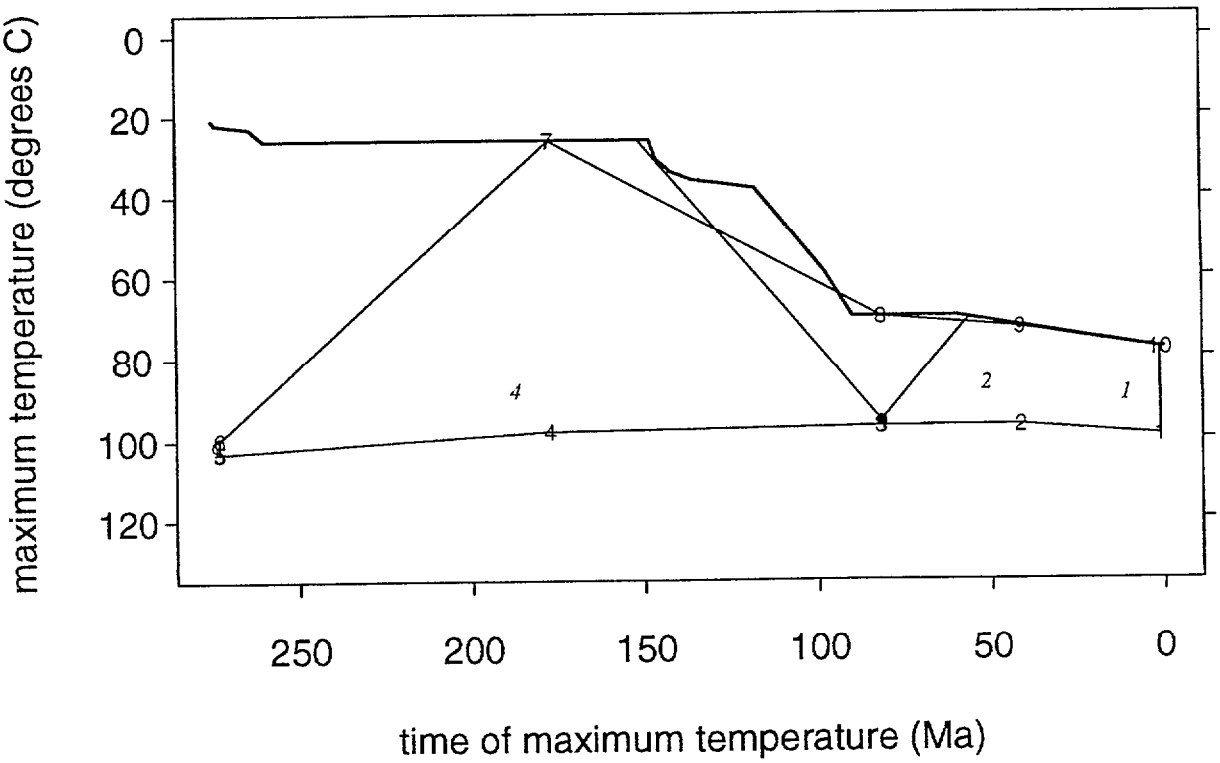


582-1

episode 1

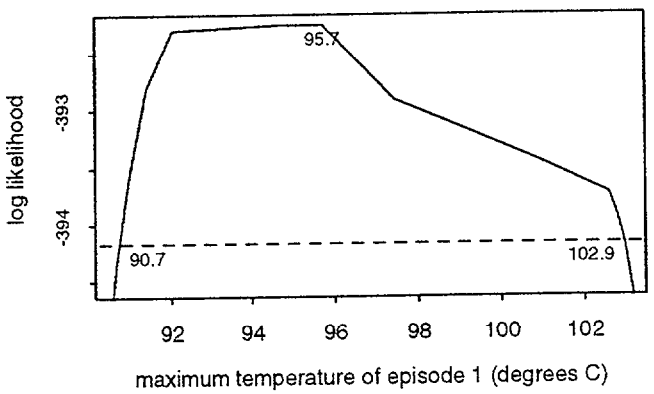


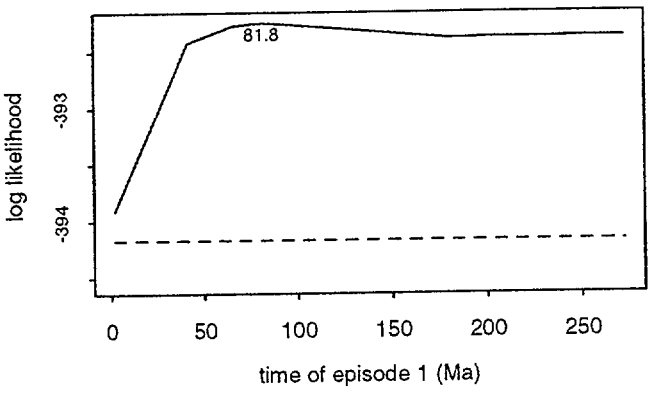
episode 2

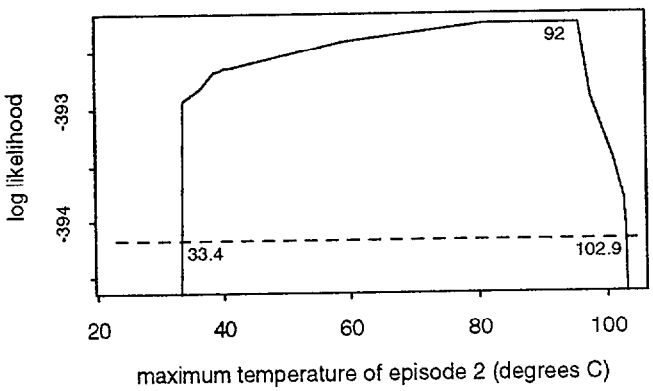


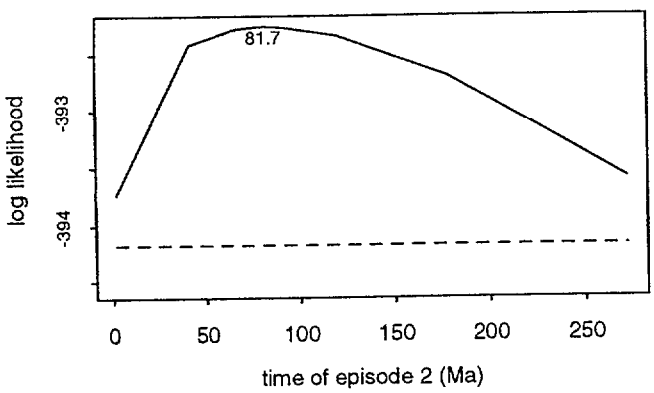
582-1

profile likelihoods

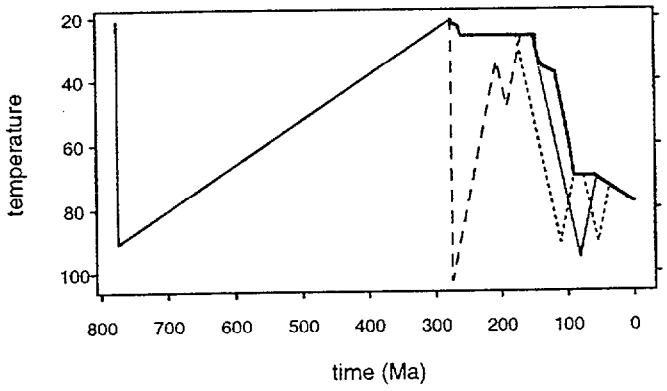


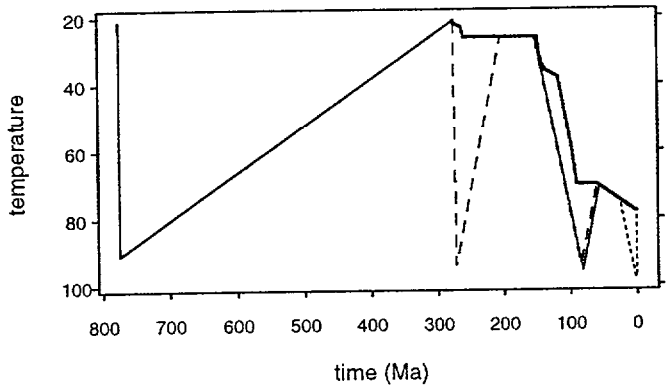


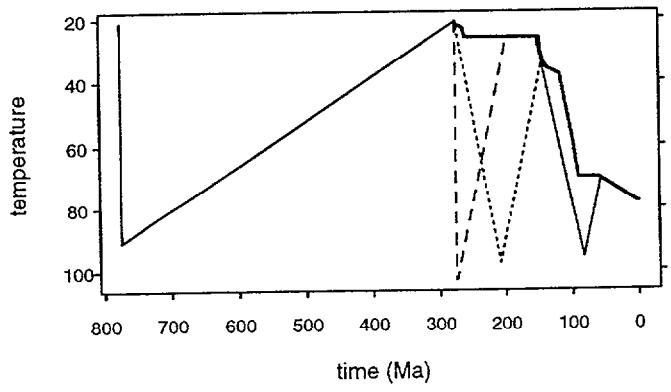


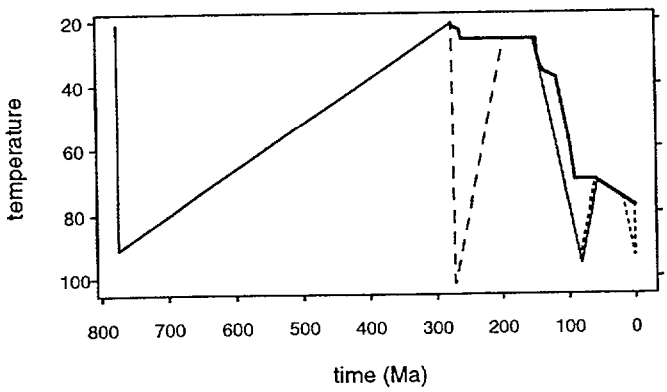


thermal histories

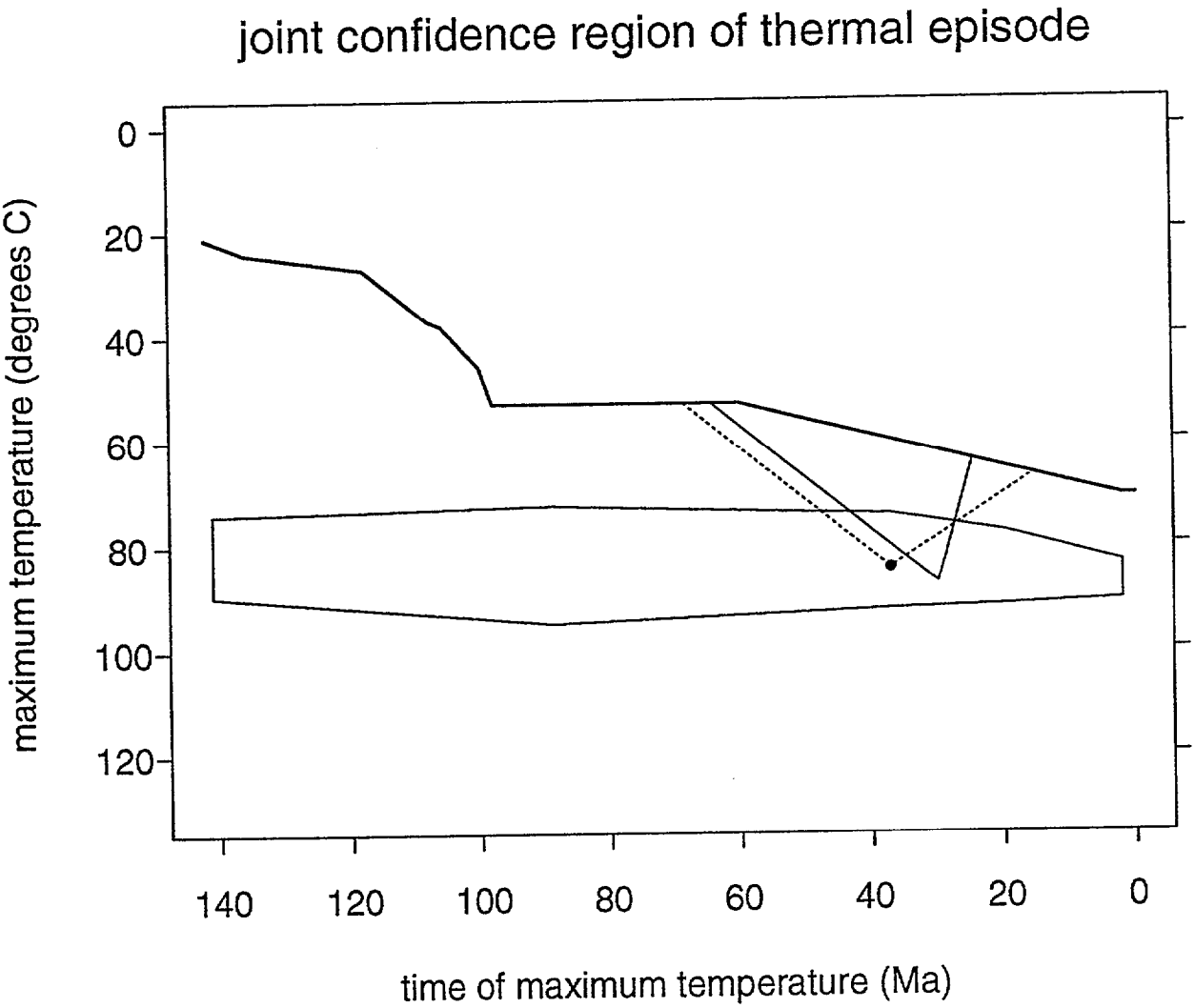




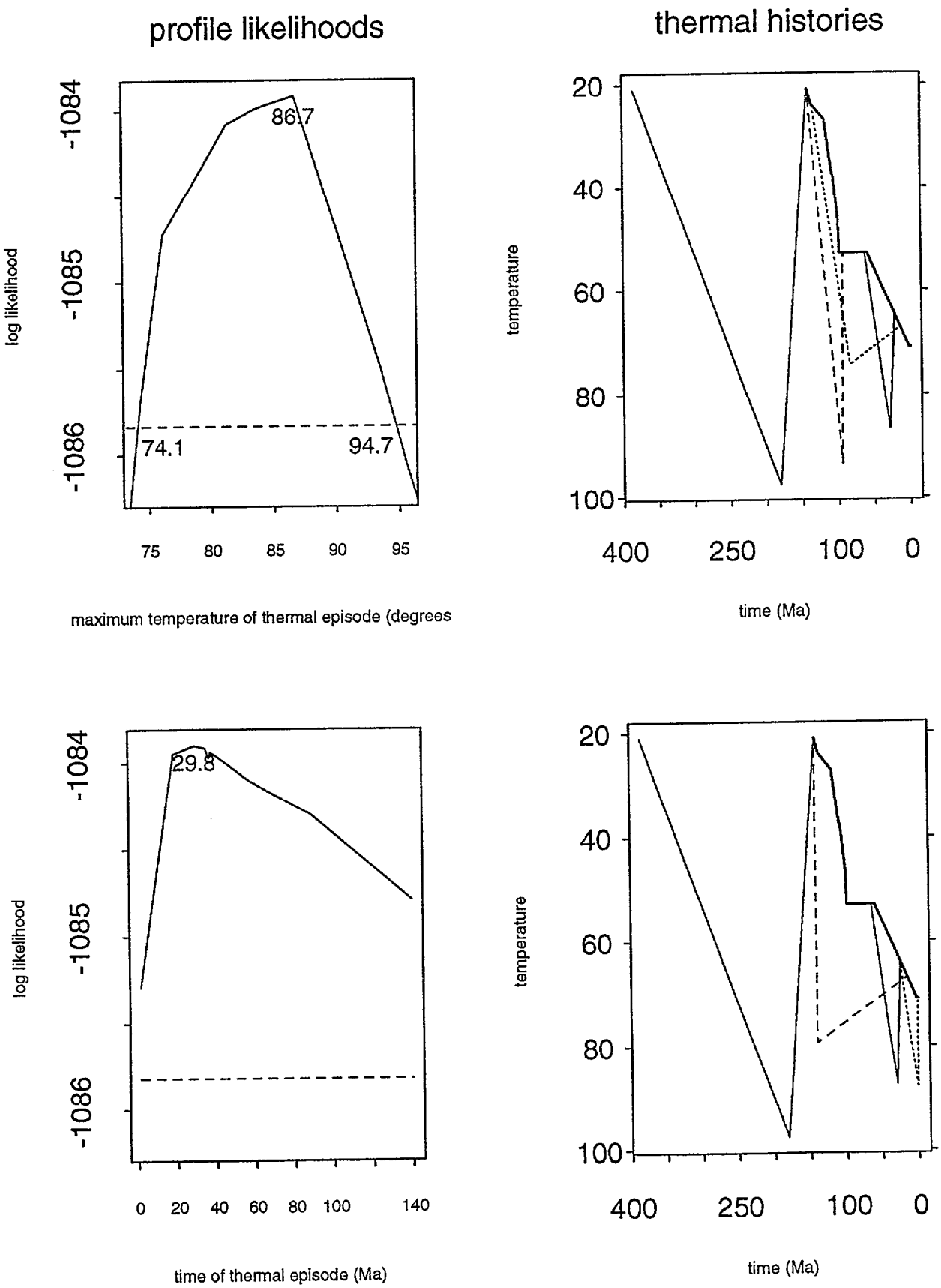




582-3

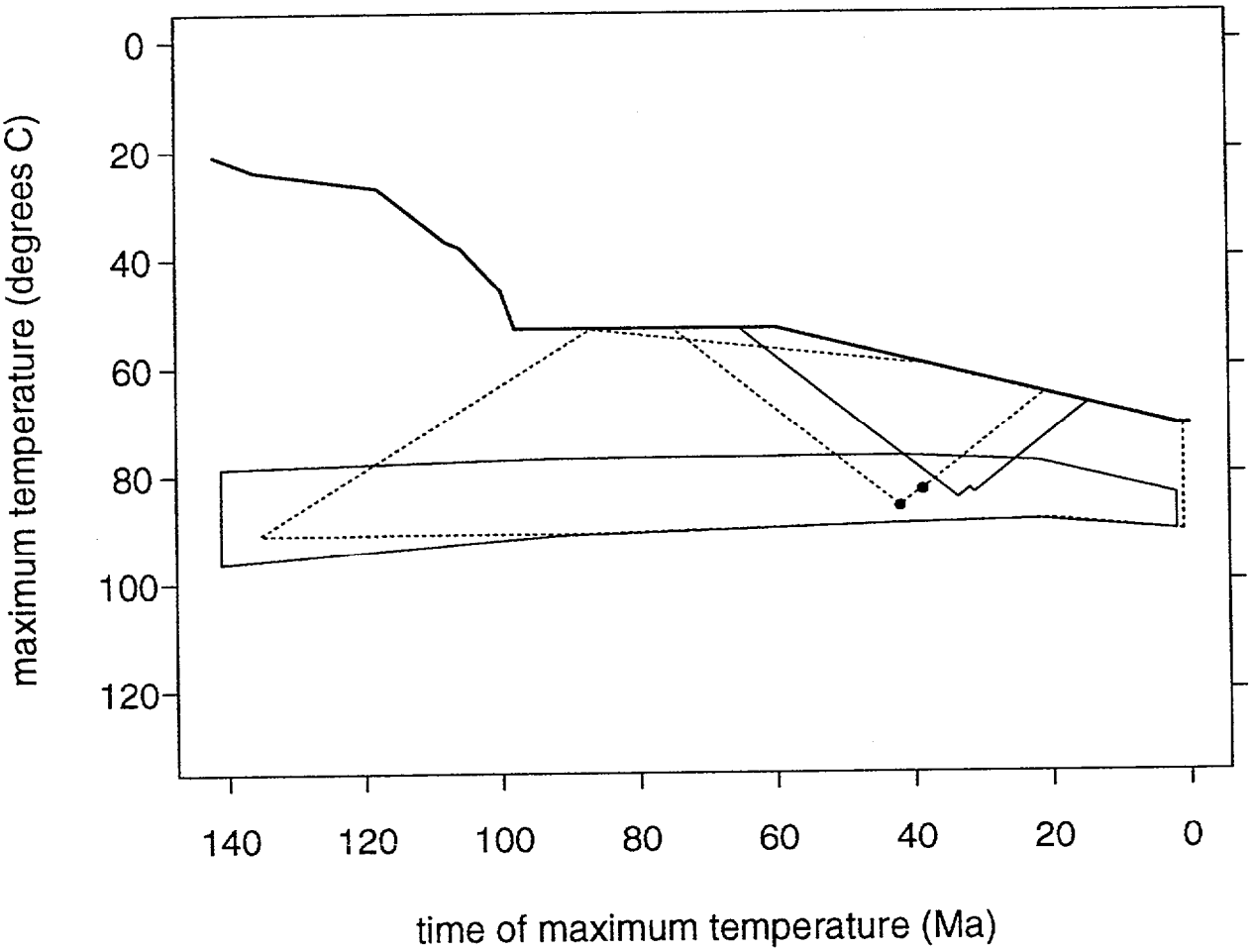

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

582-3


profile likelihoods
thermal histories
log likelihood
-1084
-1085
-1086
86.7
74.1
94.7
75
80
85
90
95
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
400
250
100
0
time (Ma)
log likelihood
-1084
-1085
-1086
29.8
0
20
40
60
80
100
140
time of thermal episode (Ma)
temperature
20
40
60
80
100
400
250
100
0
time (Ma)

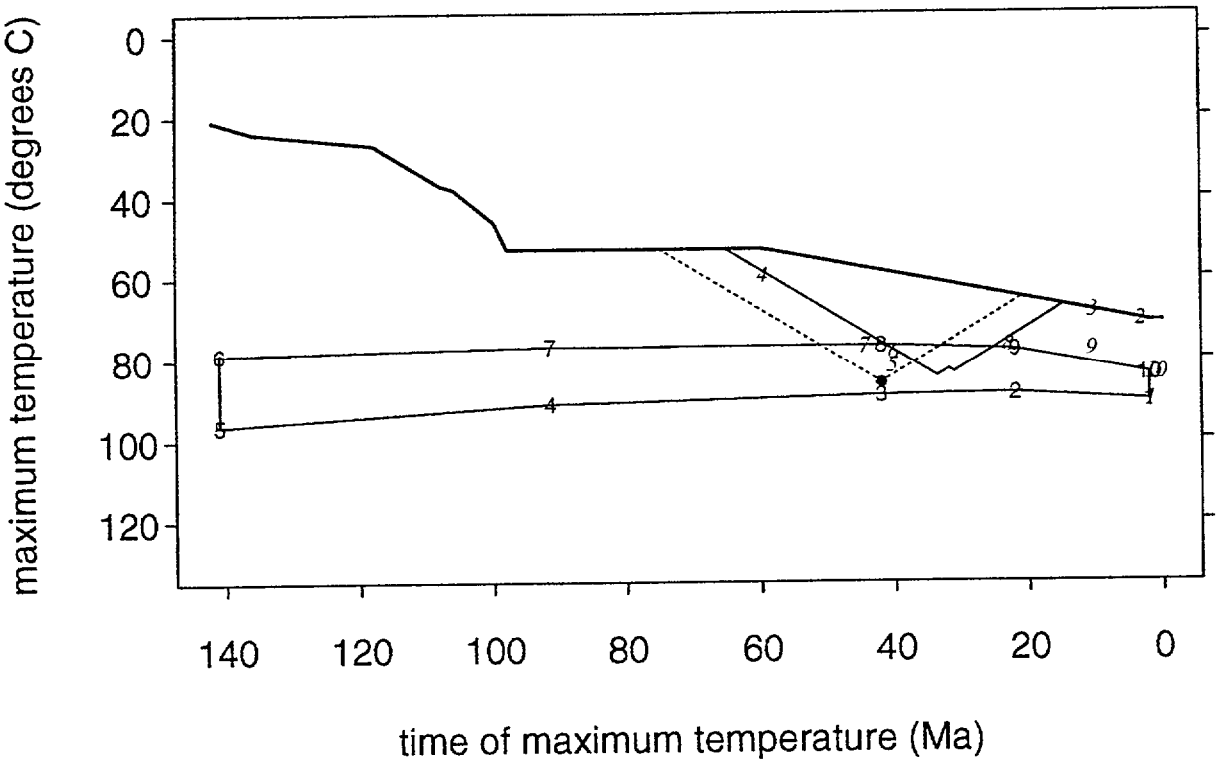
582-3

episodes 1 and 2

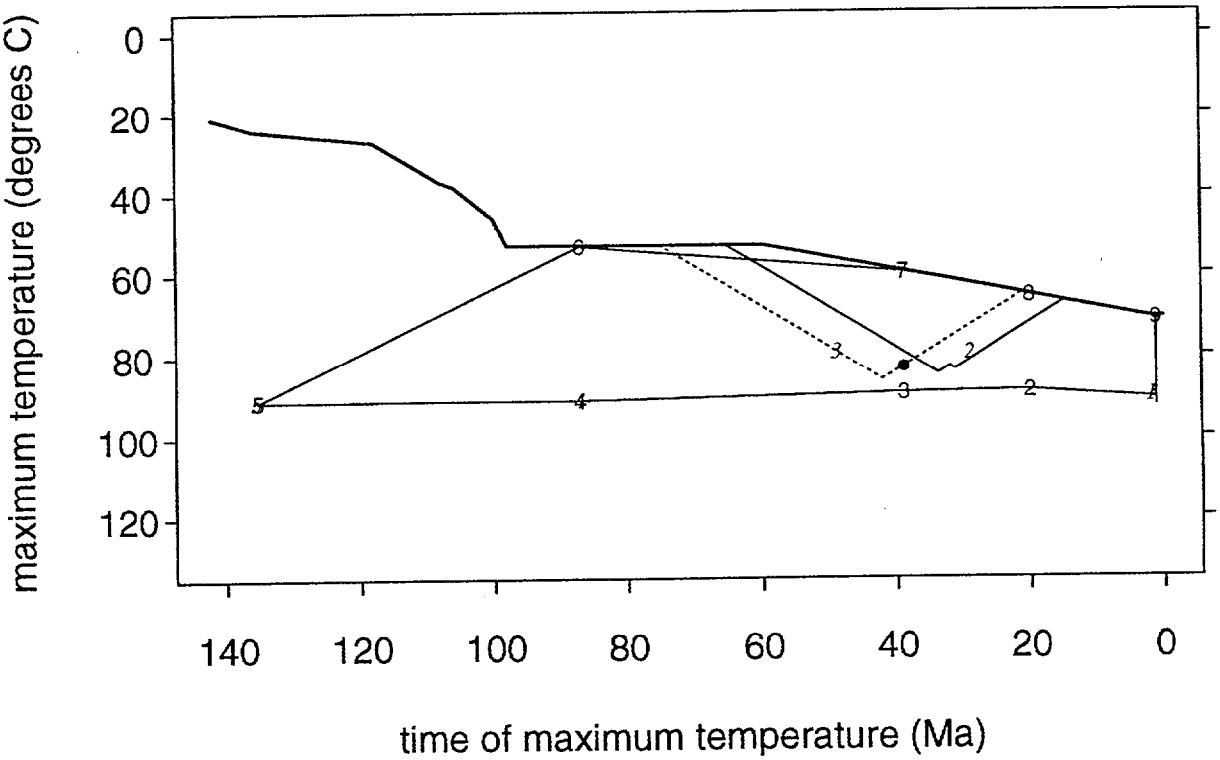


582-3

episode 1

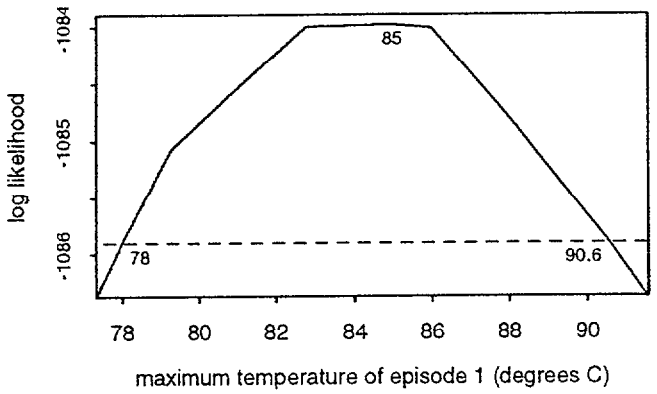


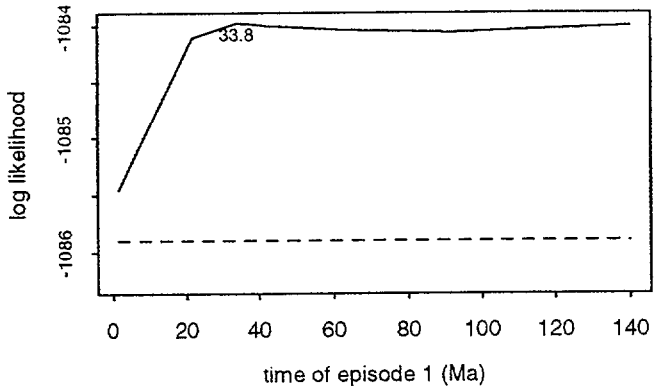
episode 2

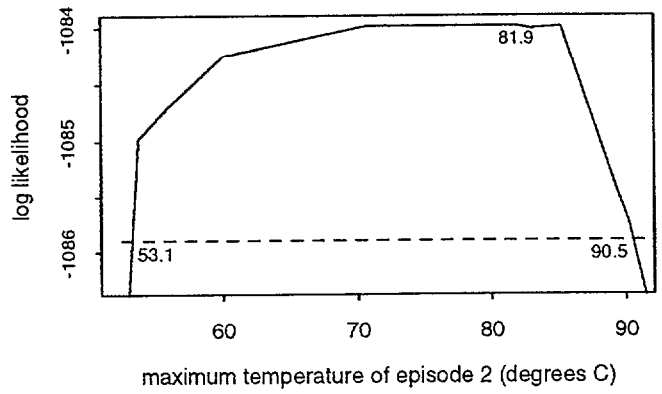


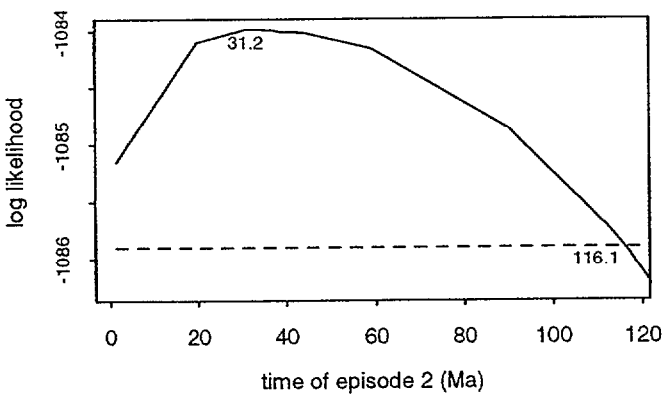
582-3

profile likelihoods

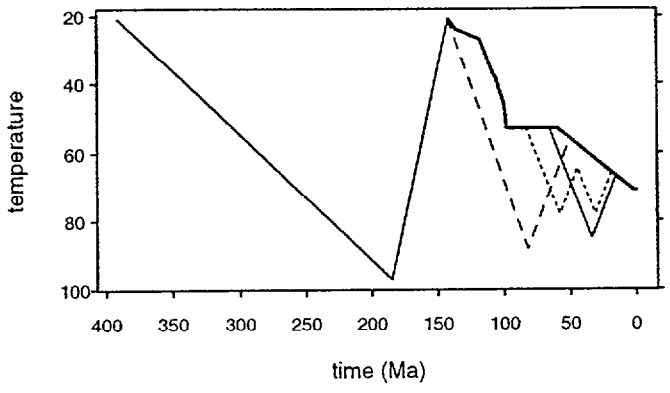


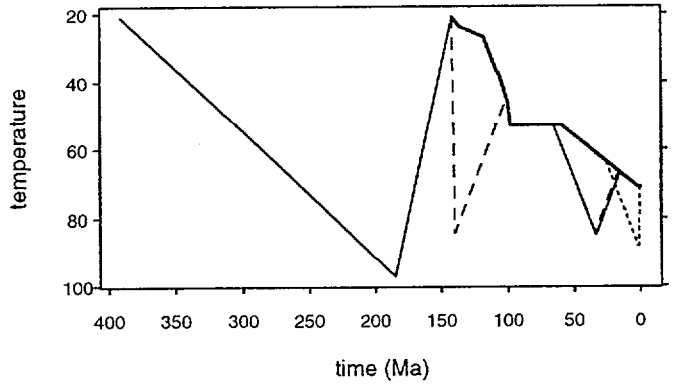


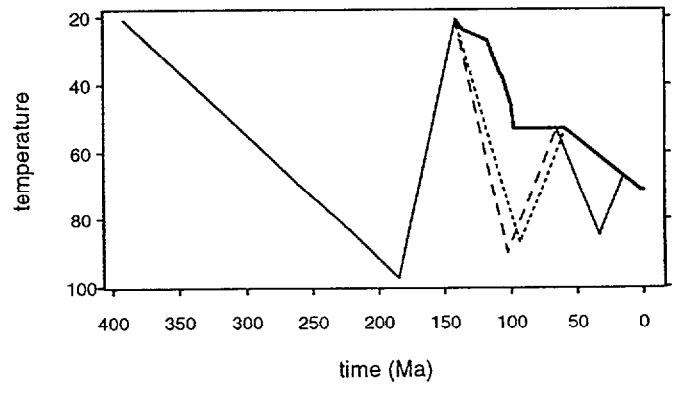


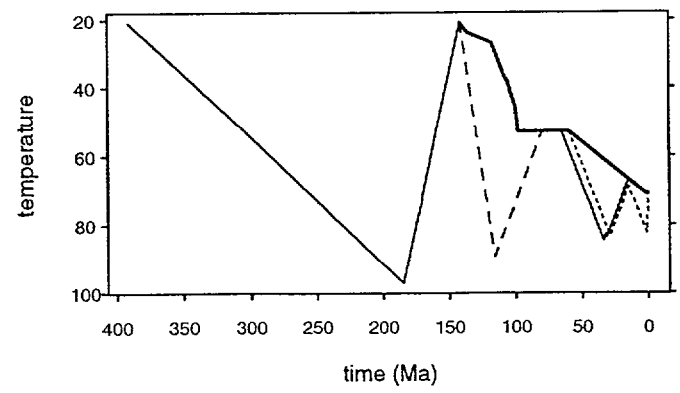


thermal histories

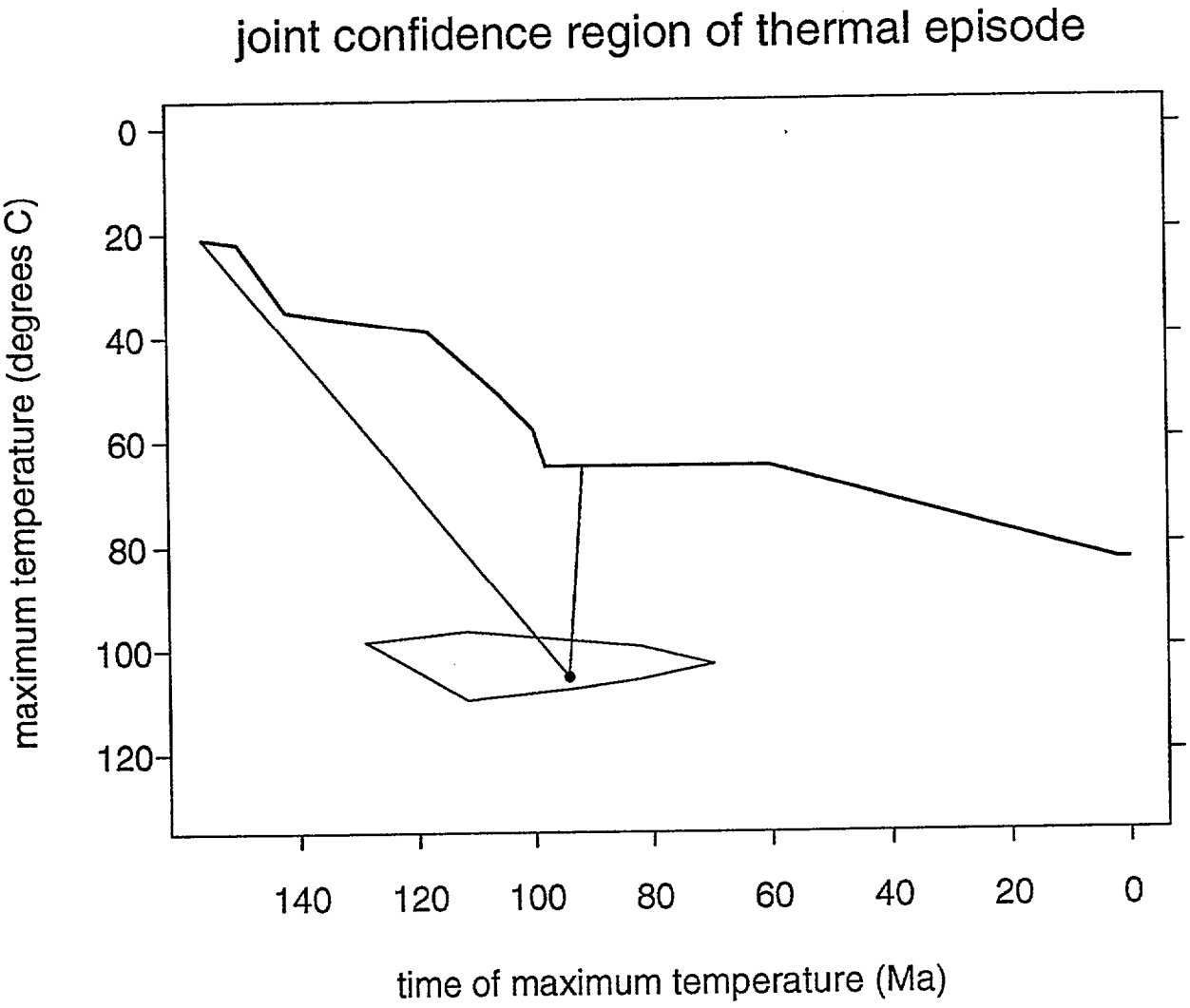




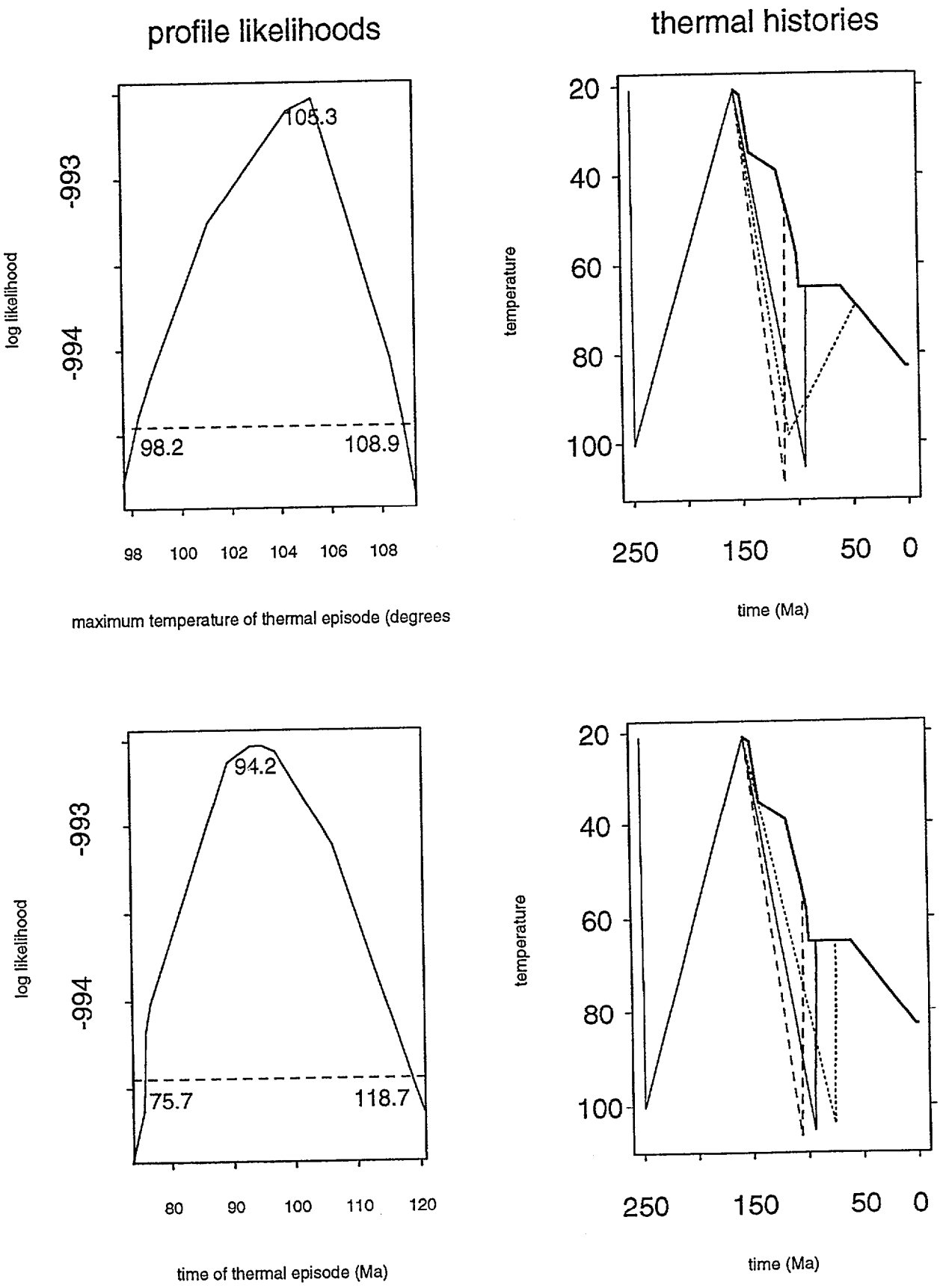




582-4

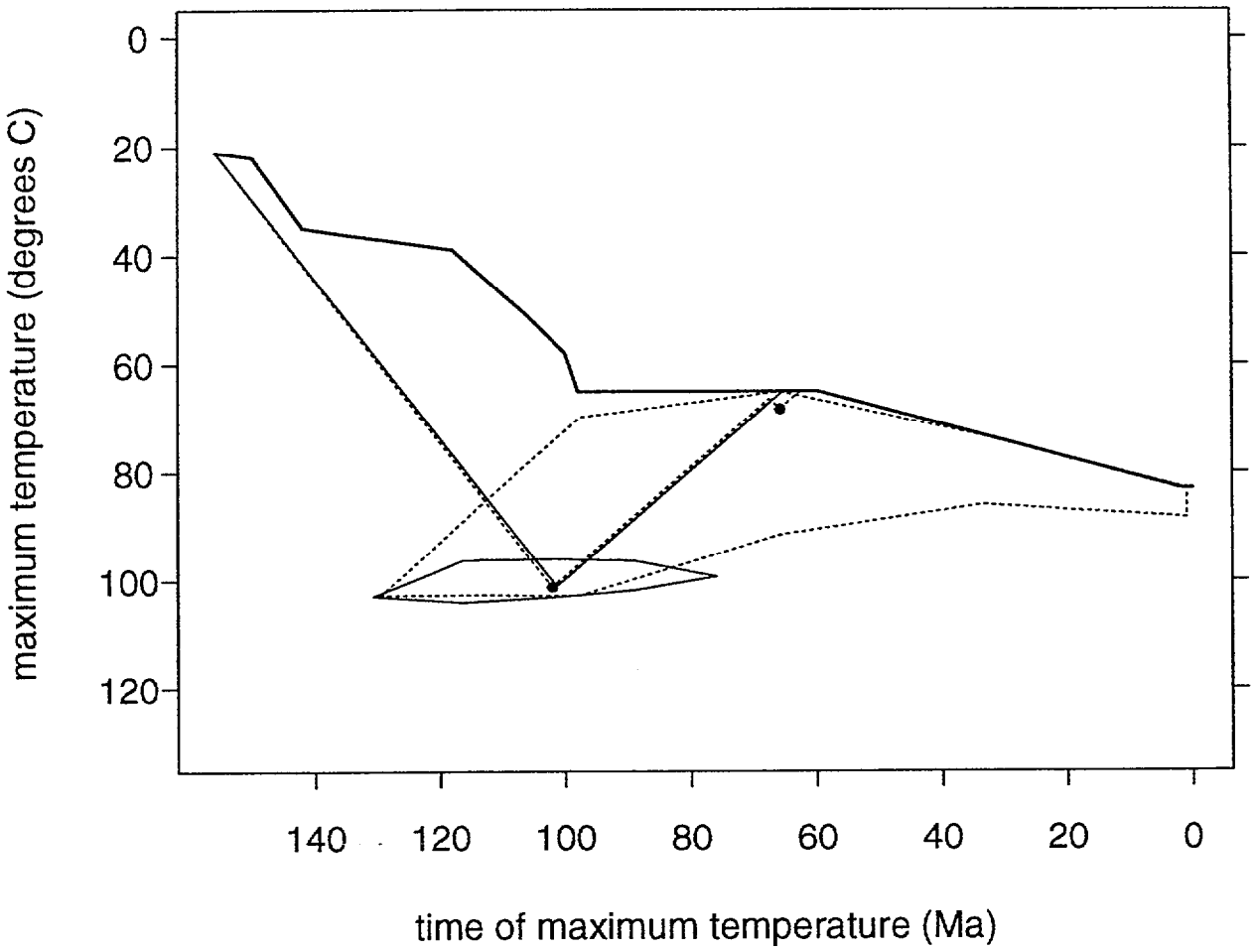

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

582-4


profile likelihoods
thermal histories
log likelihood
-993
-994
105.3
98.2
108.9
98
100
102
104
106
108
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
250
150
50
0
time (Ma)
log likelihood
-993
-994
94.2
75.7
118.7
80
90
100
110
120
time of thermal episode (Ma)
temperature
20
40
60
80
100
250
150
50
0
time (Ma)

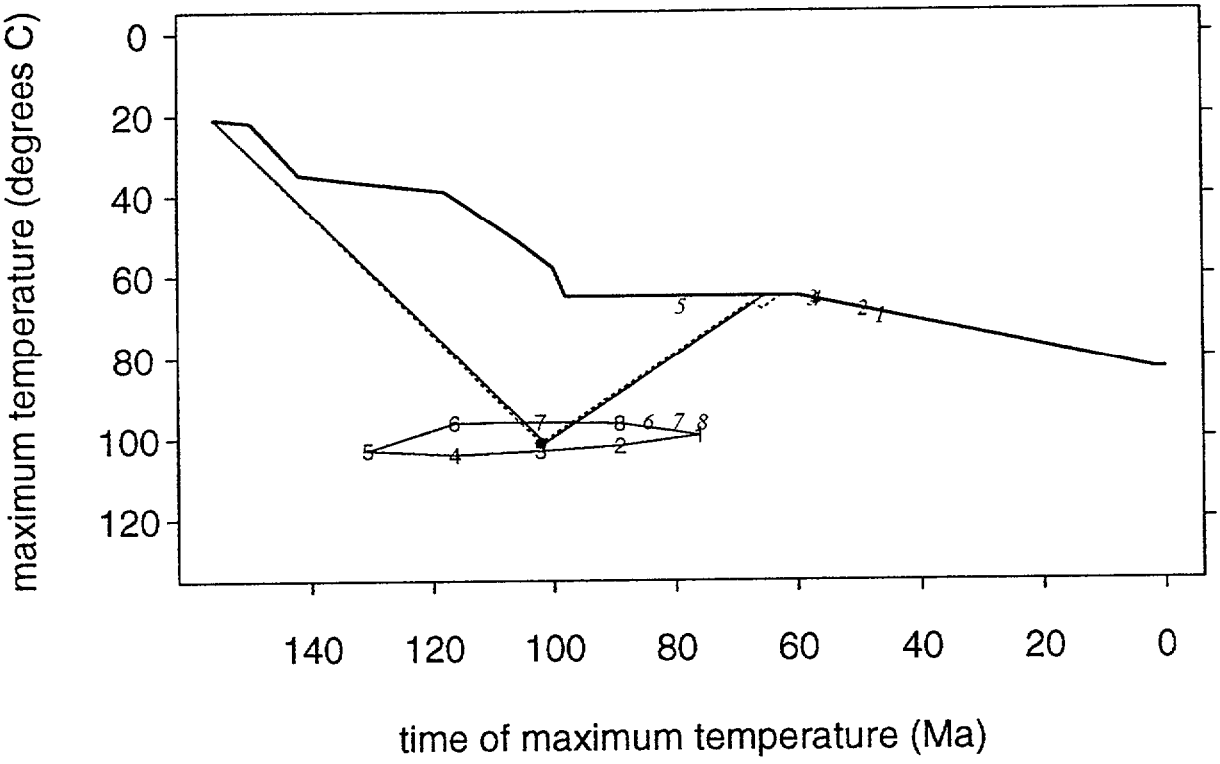
582-4

episodes 1 and 2

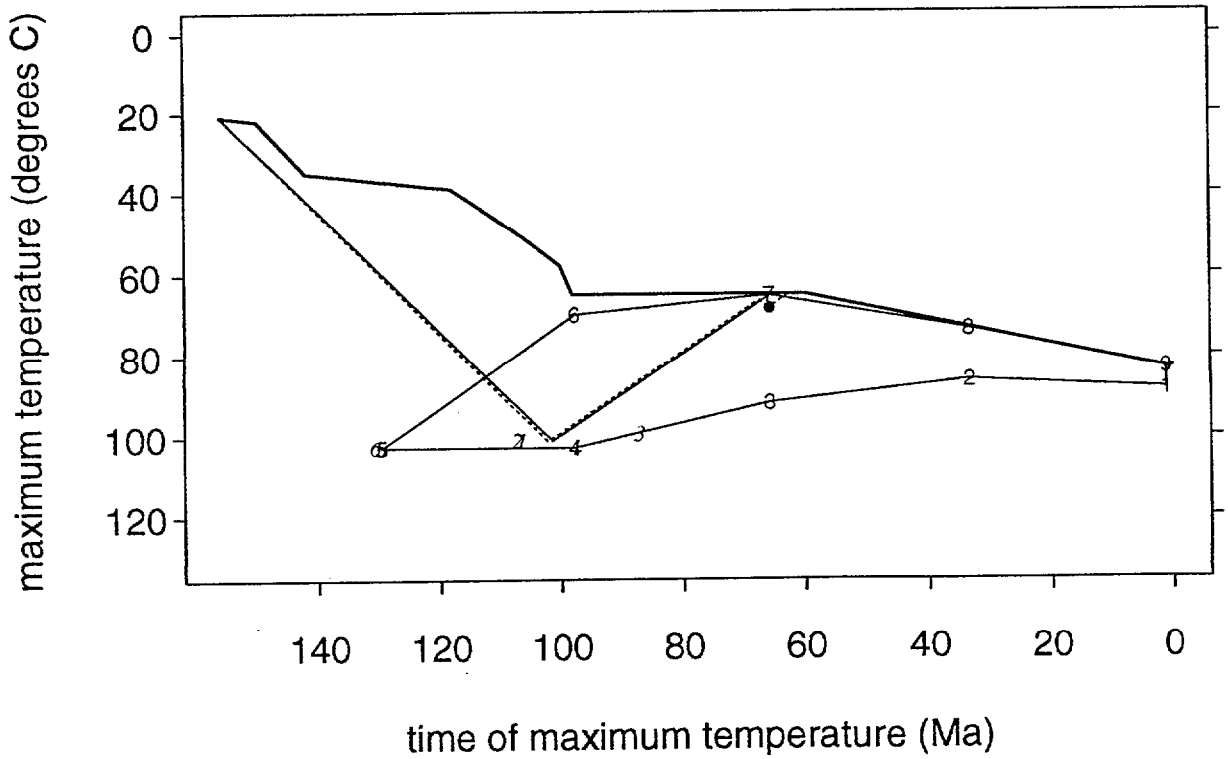


582-4

episode 1

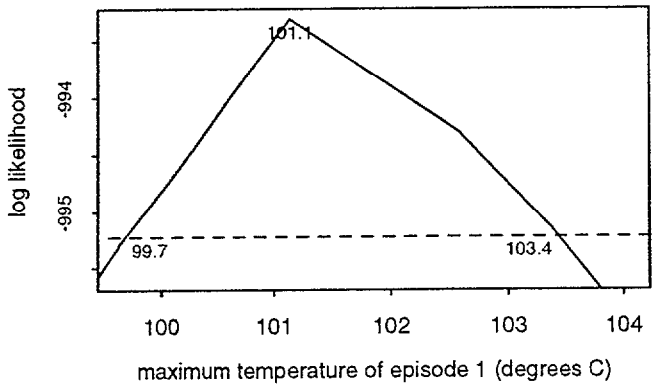


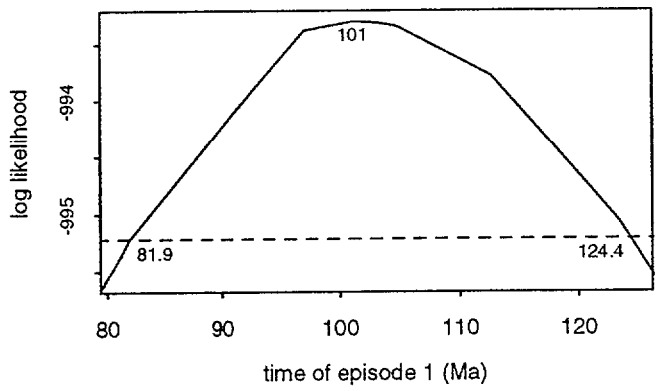
episode 2

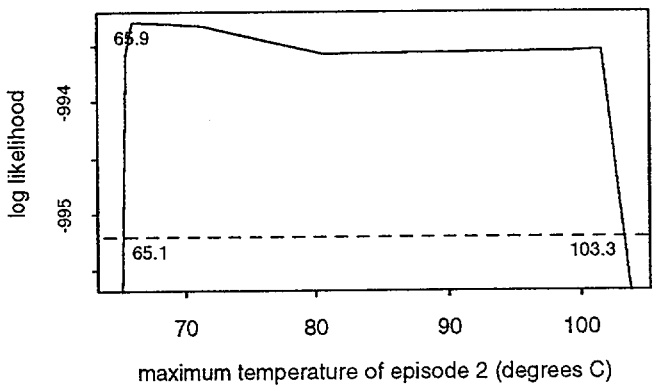


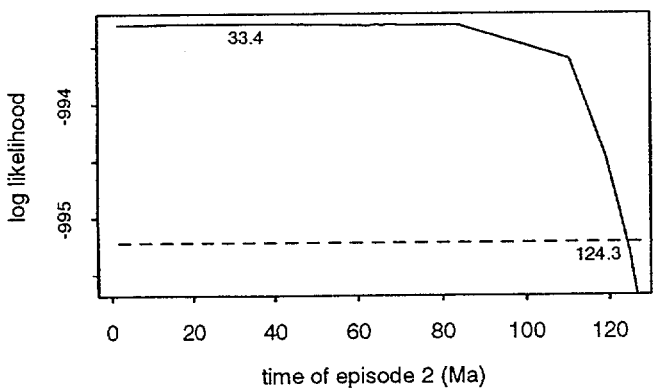
582-4

profile likelihoods

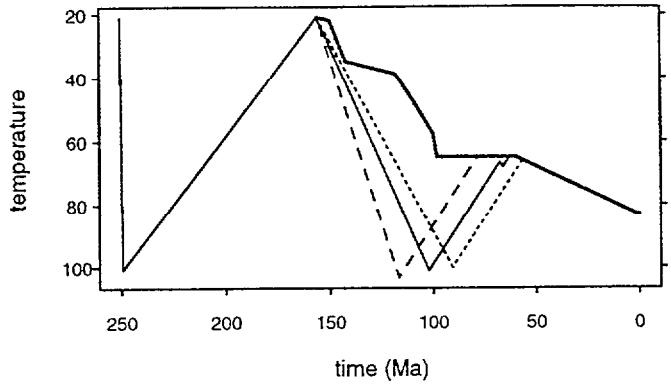


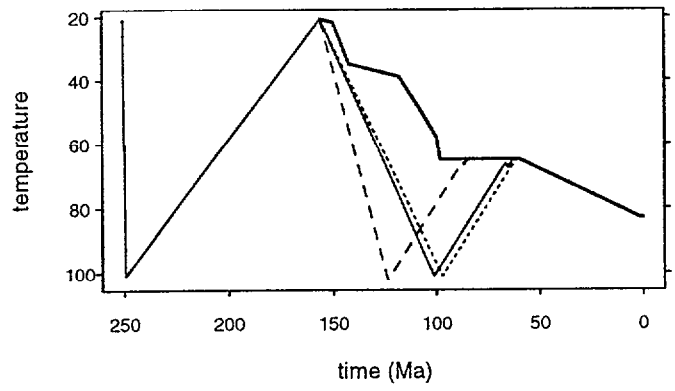


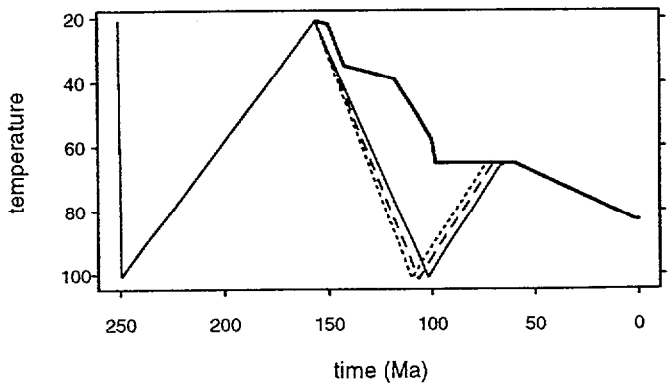


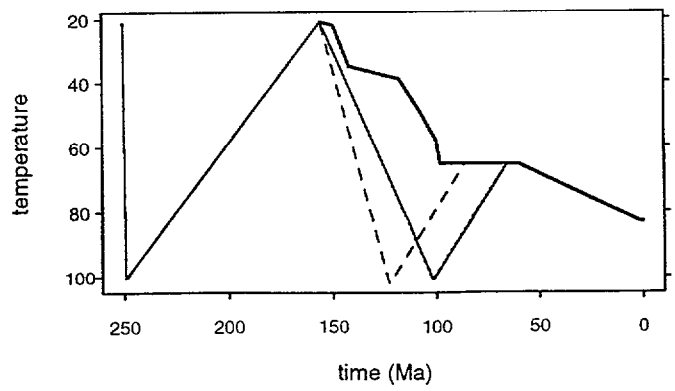


thermal histories

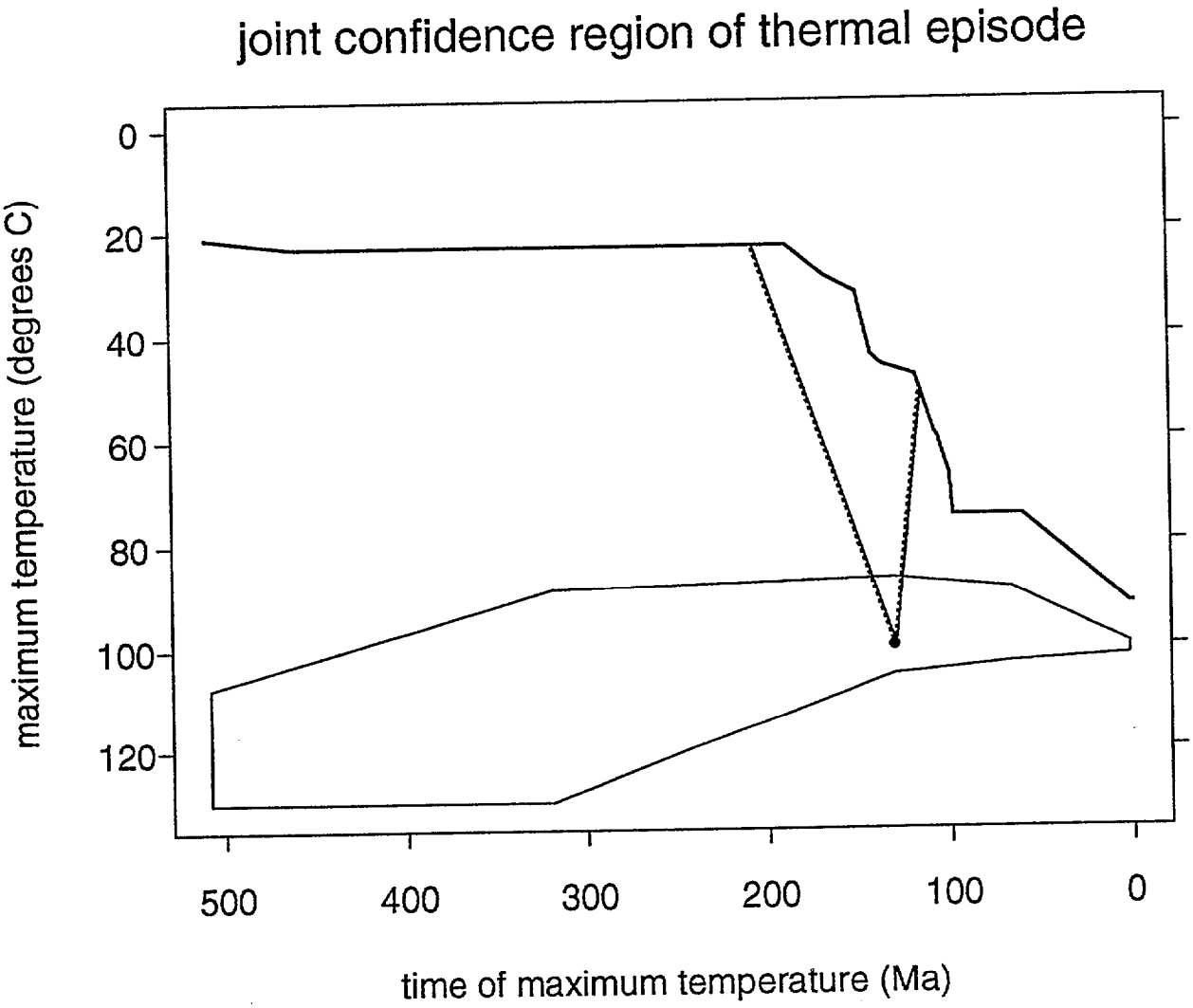






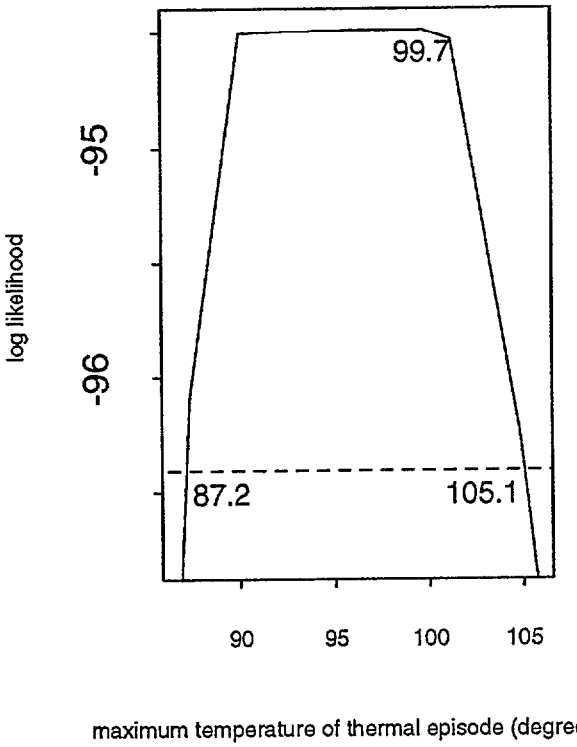


582-5

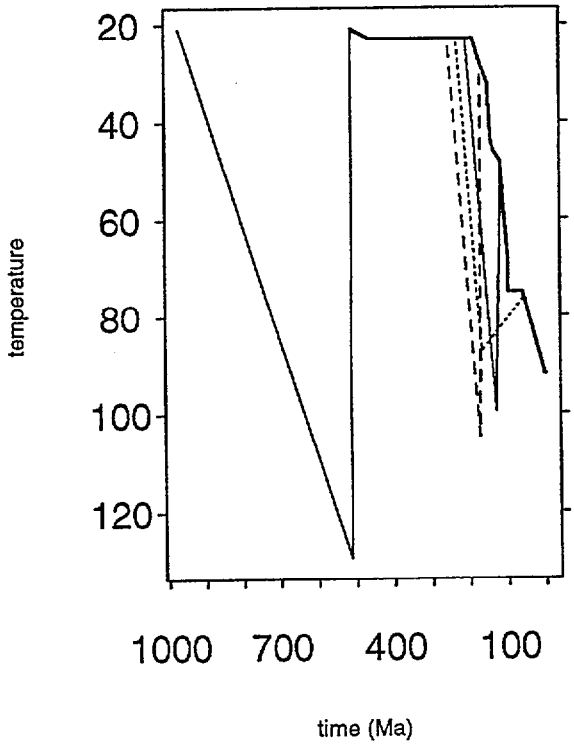

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
500
400
300
200
100
0
time of maximum temperature (Ma)

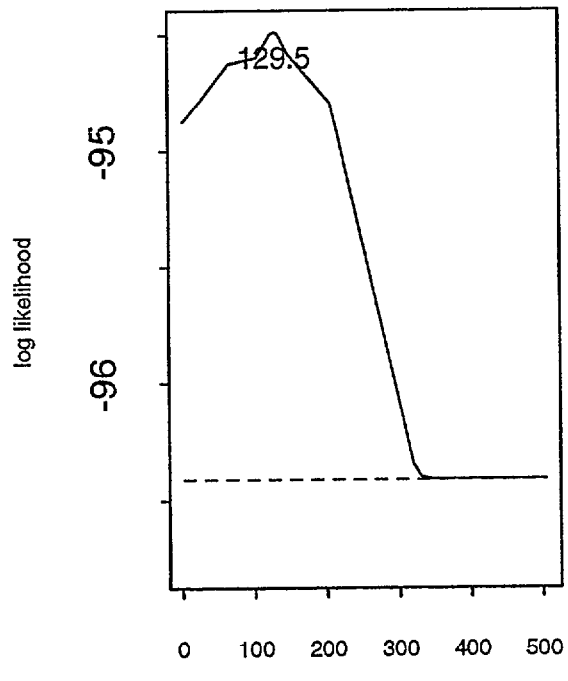
582-5

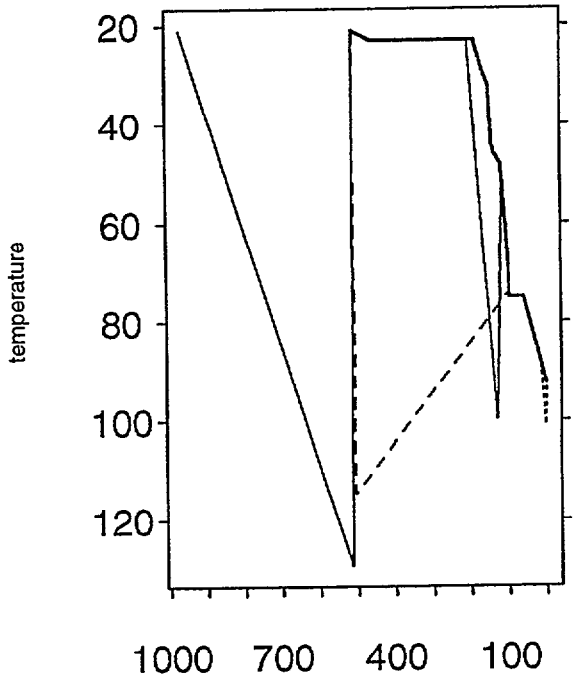
profile likelihoods



thermal histories

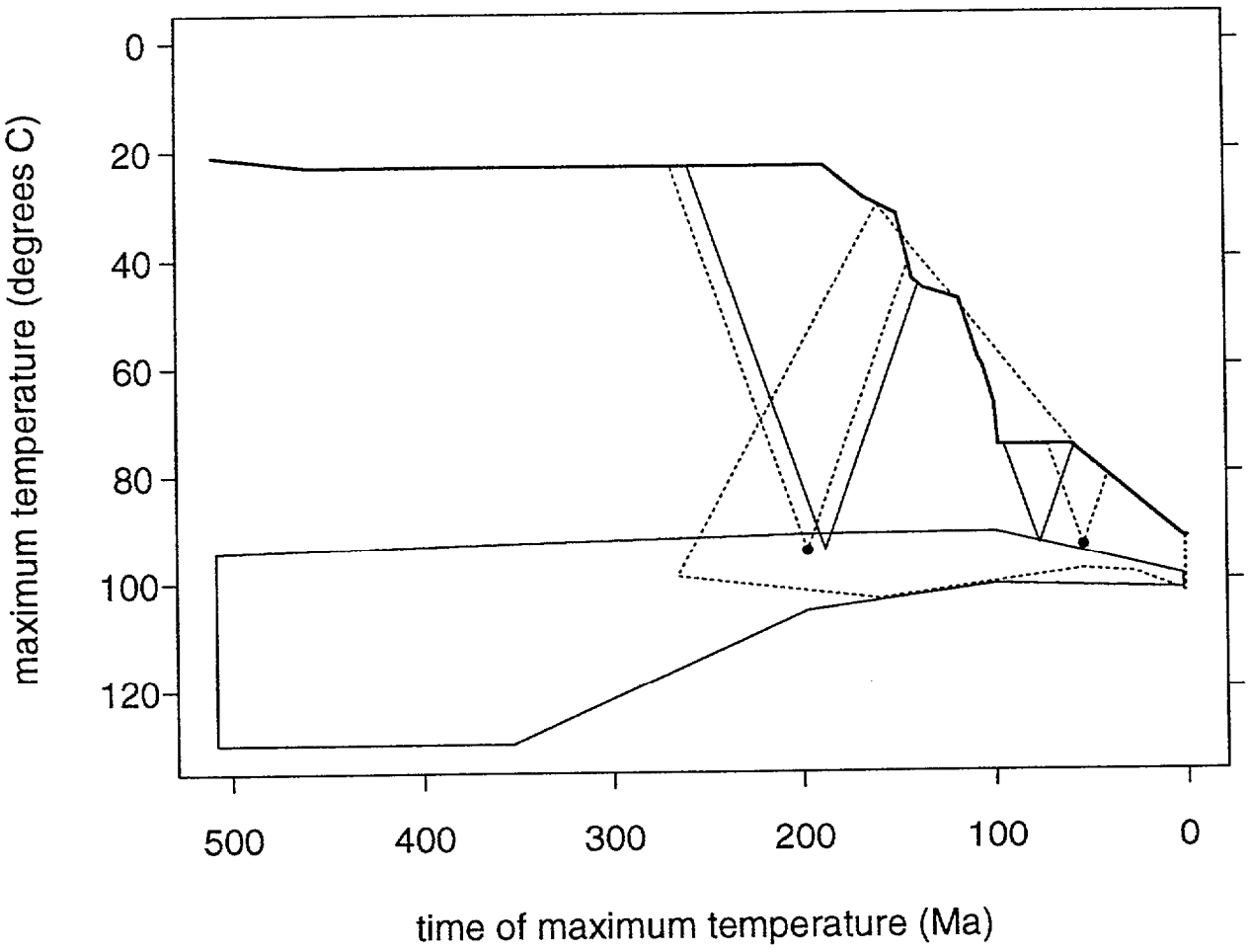






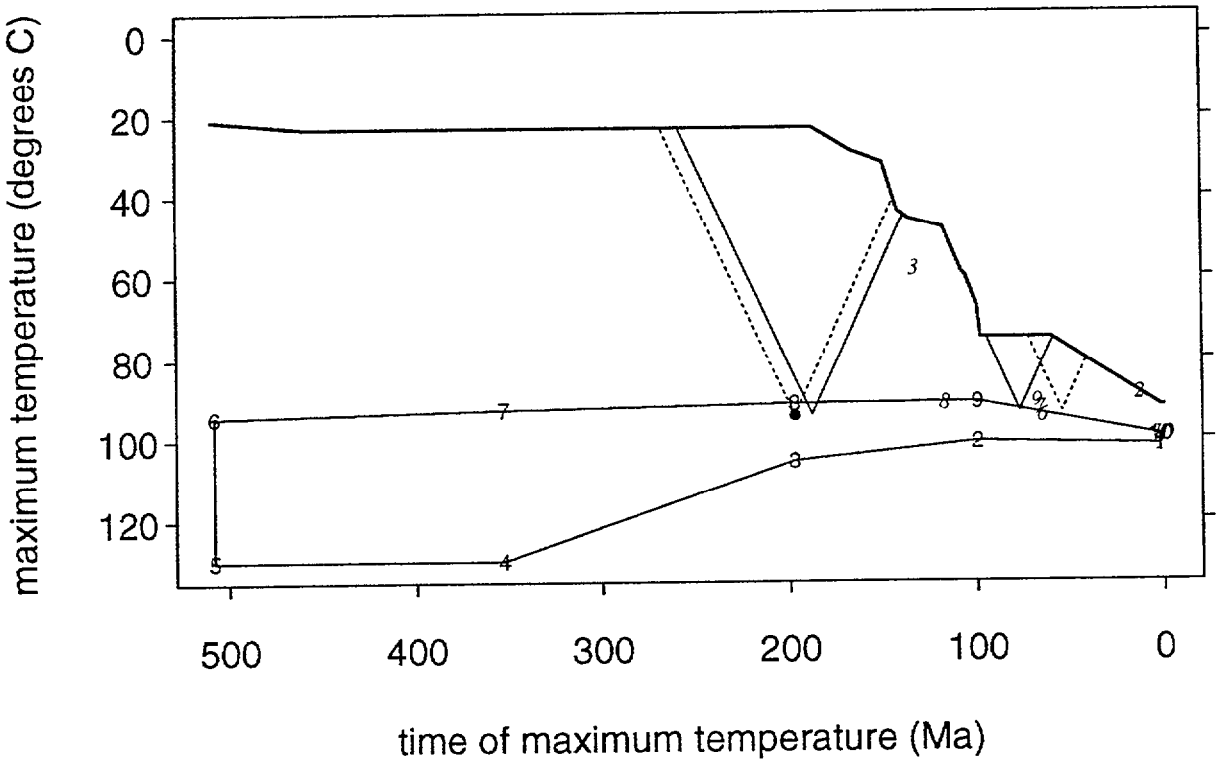
582-5

episodes 1 and 2

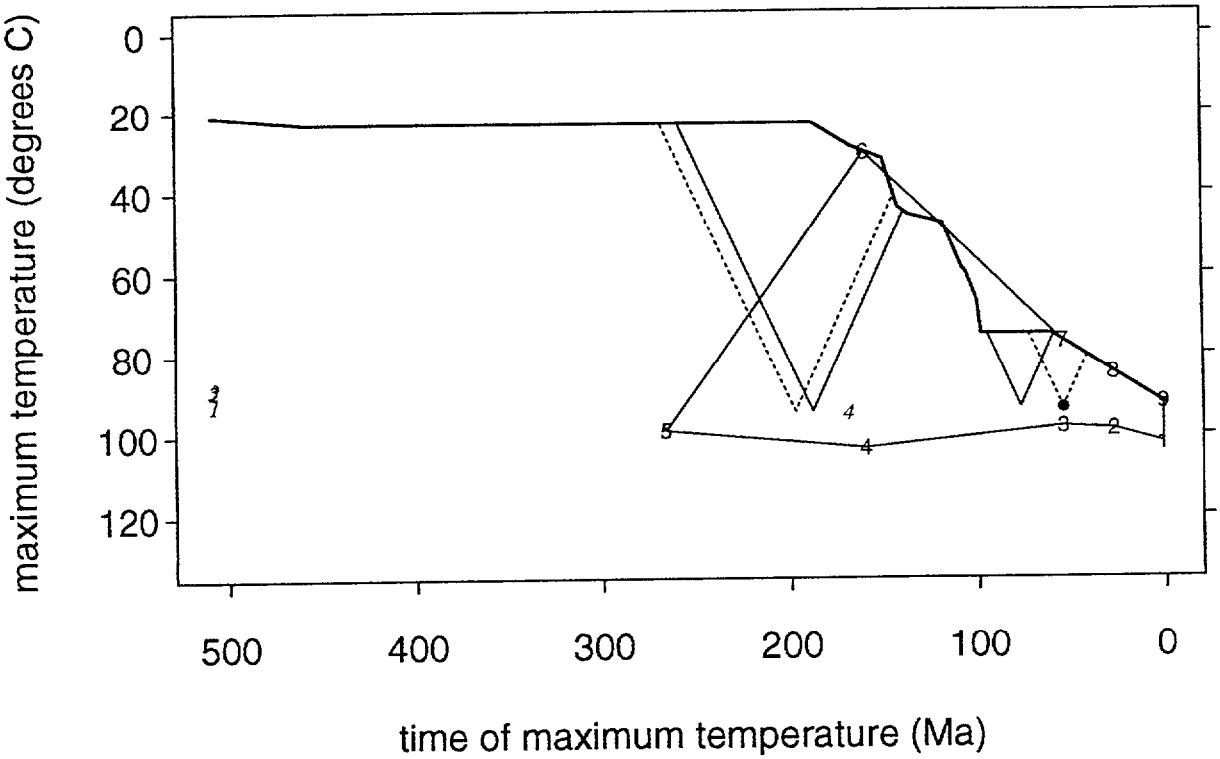


582-5

episode 1

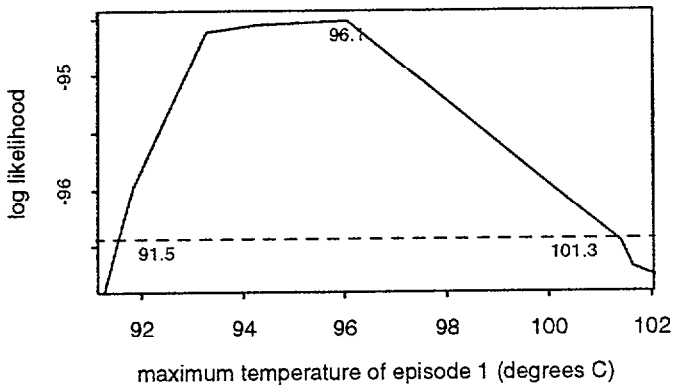


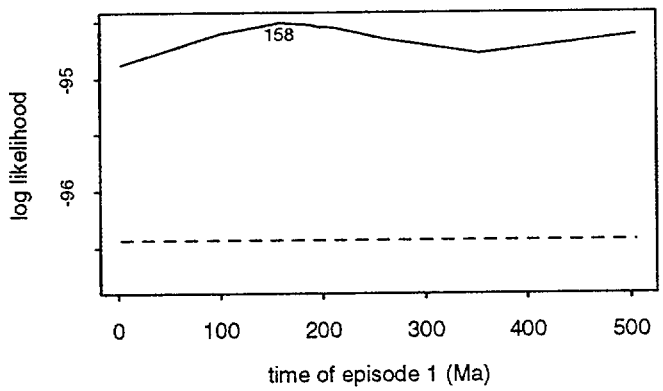
episode 2

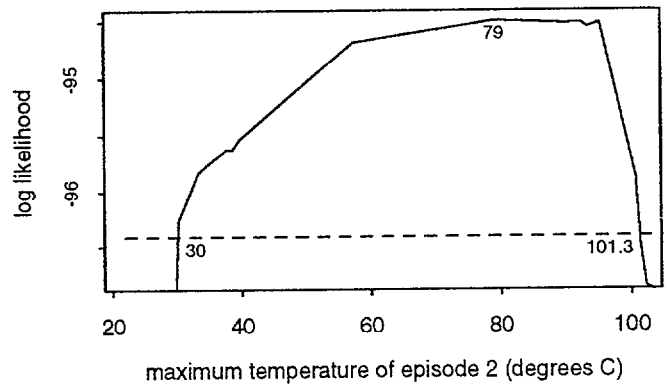


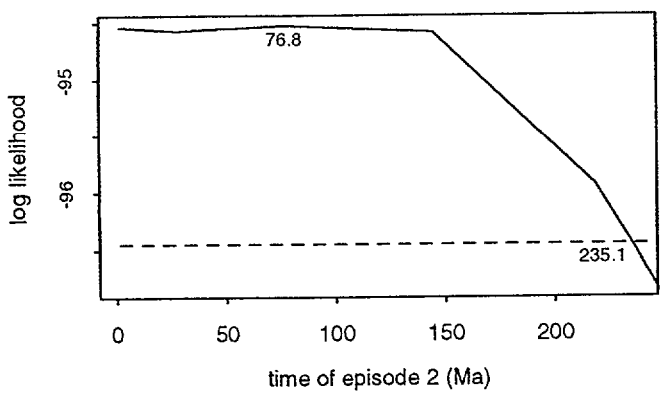
582-5

profile likelihoods

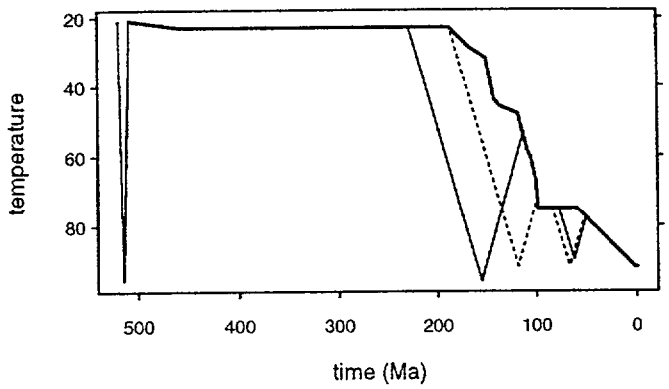


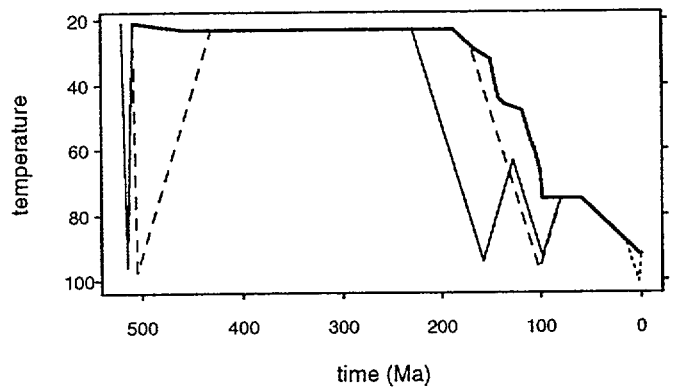


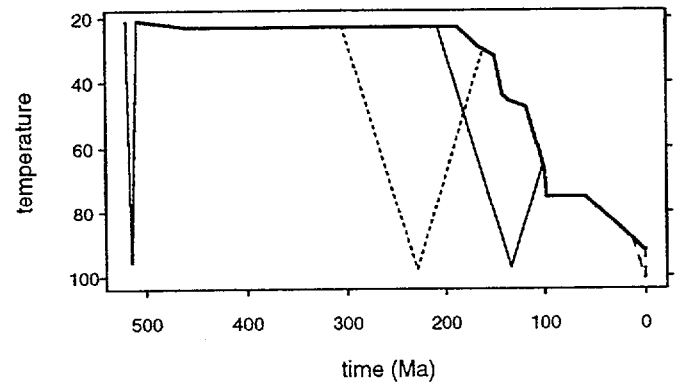


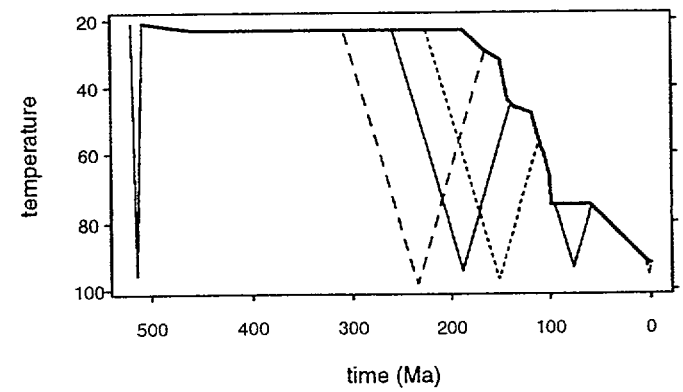


thermal histories

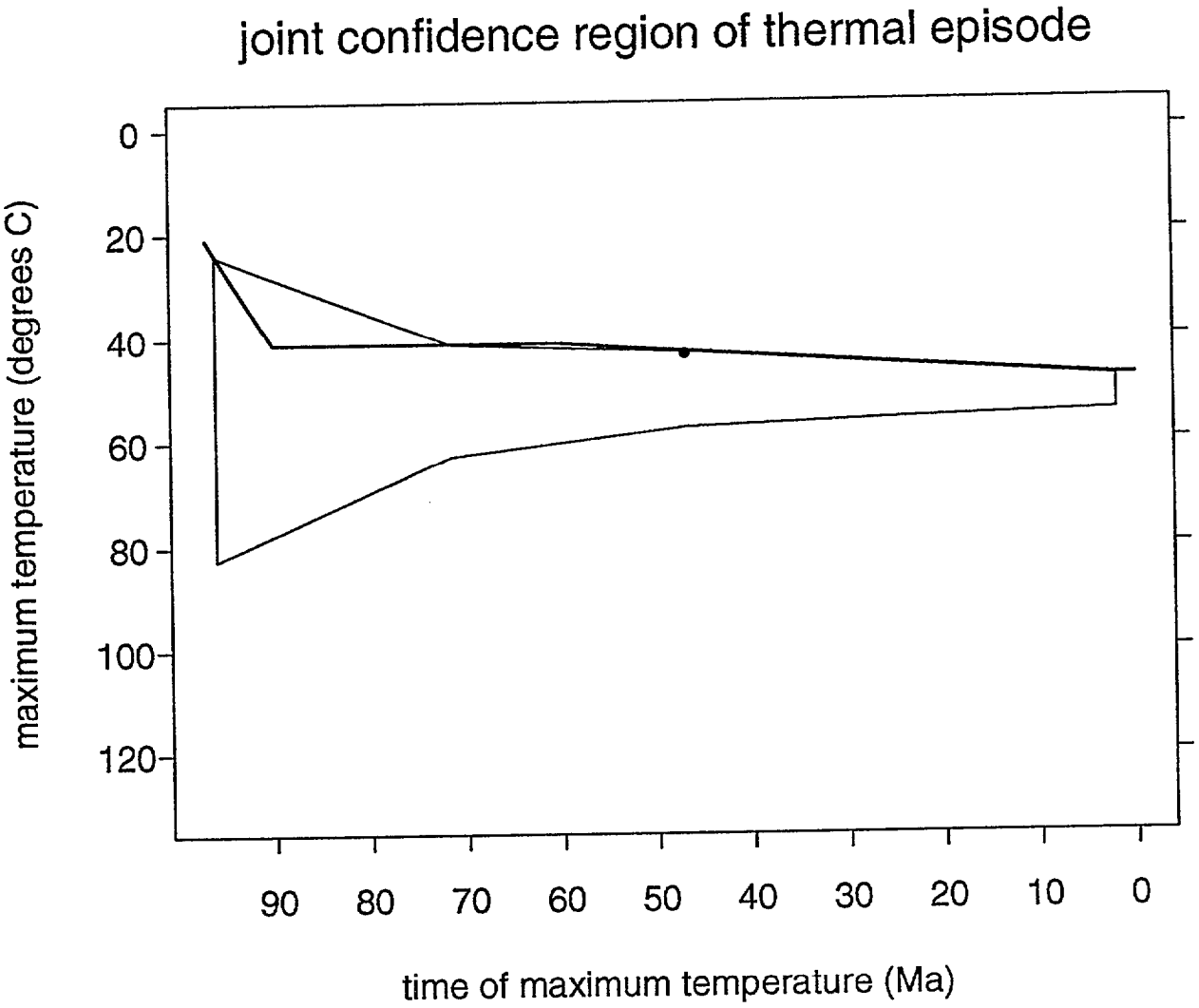




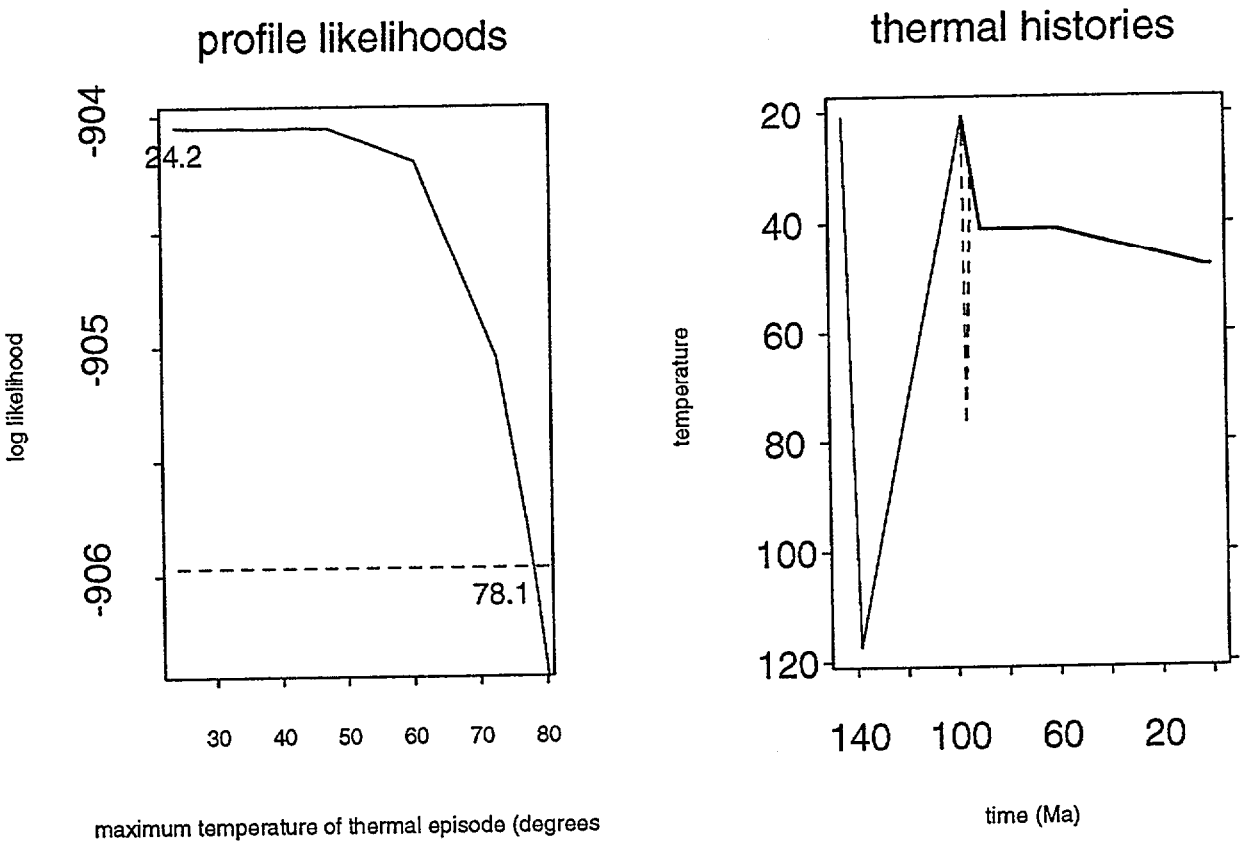


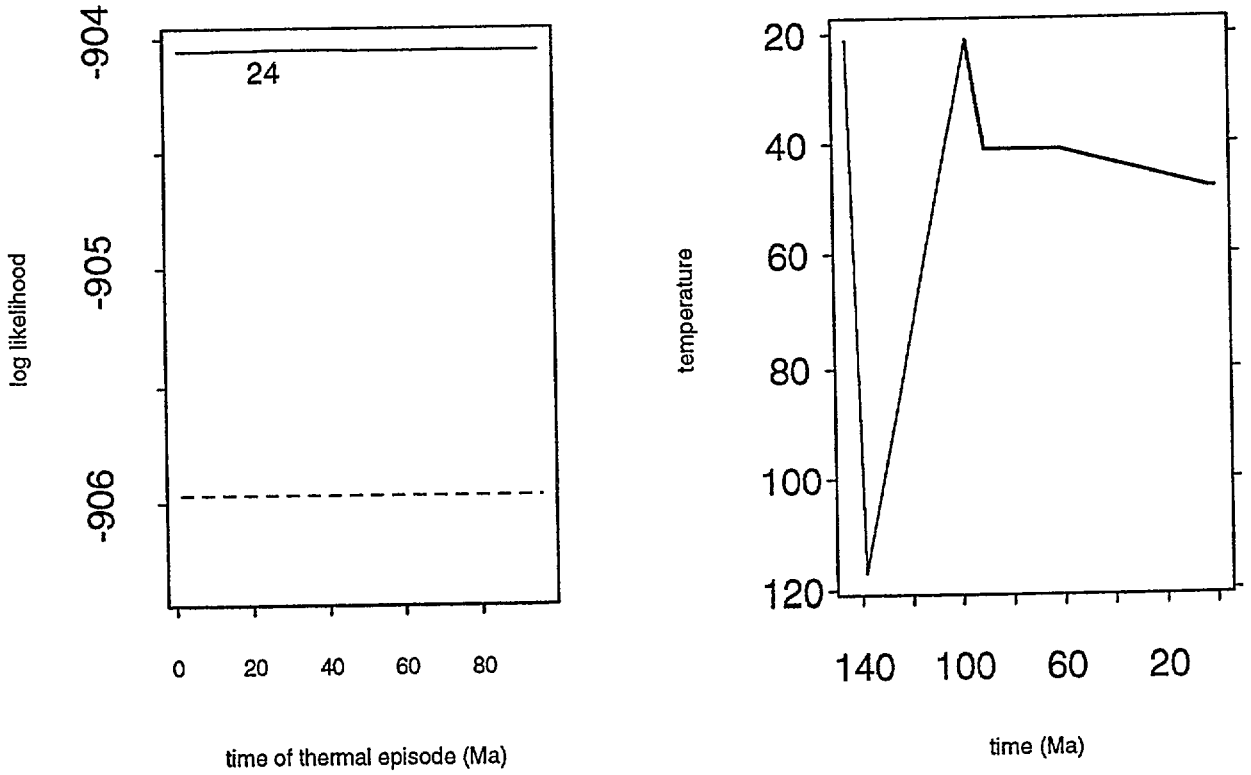


582-6

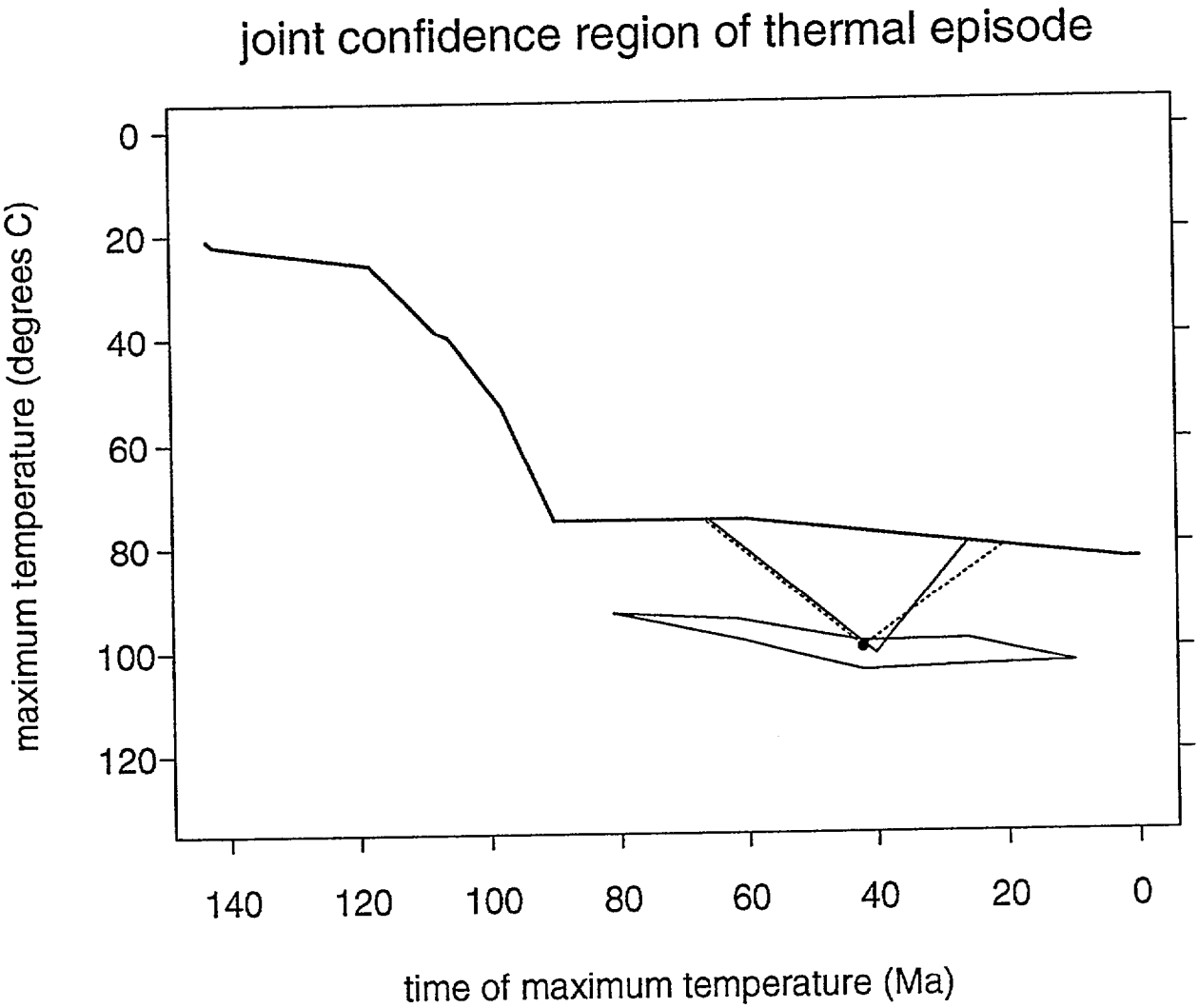

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
90
80
70
60
50
40
30
20
10
0
time of maximum temperature (Ma)

582-6

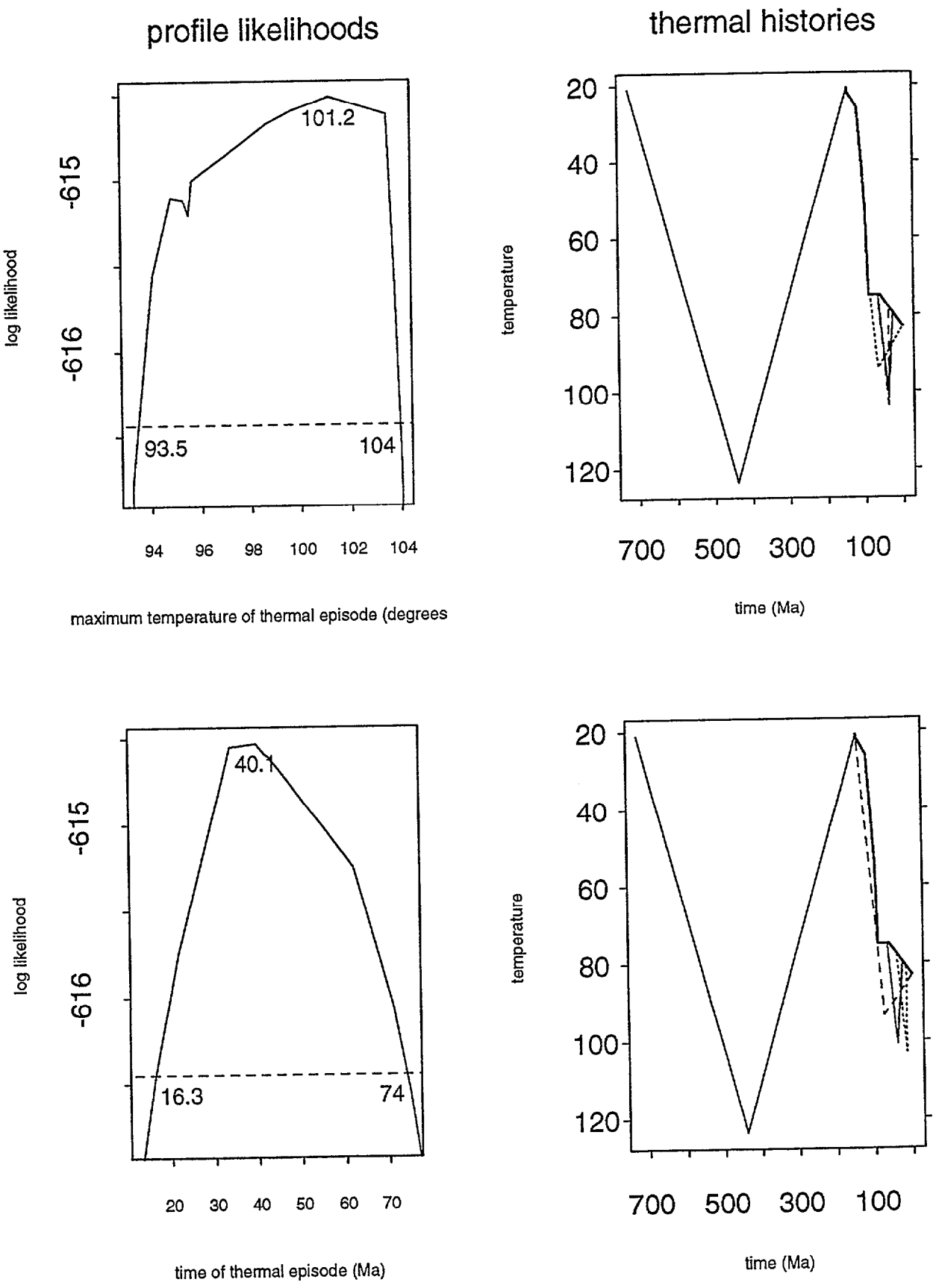

profile likelihoods
thermal histories
log likelihood
-904
-905
-906
24.2
78.1
30
40
50
60
70
80
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
140
100
60
20
time (Ma)


log likelihood
-904
-905
-906
24
0
20
40
60
80
time of thermal episode (Ma)
temperature
20
40
60
80
100
120
140
100
60
20
time (Ma)

582-7

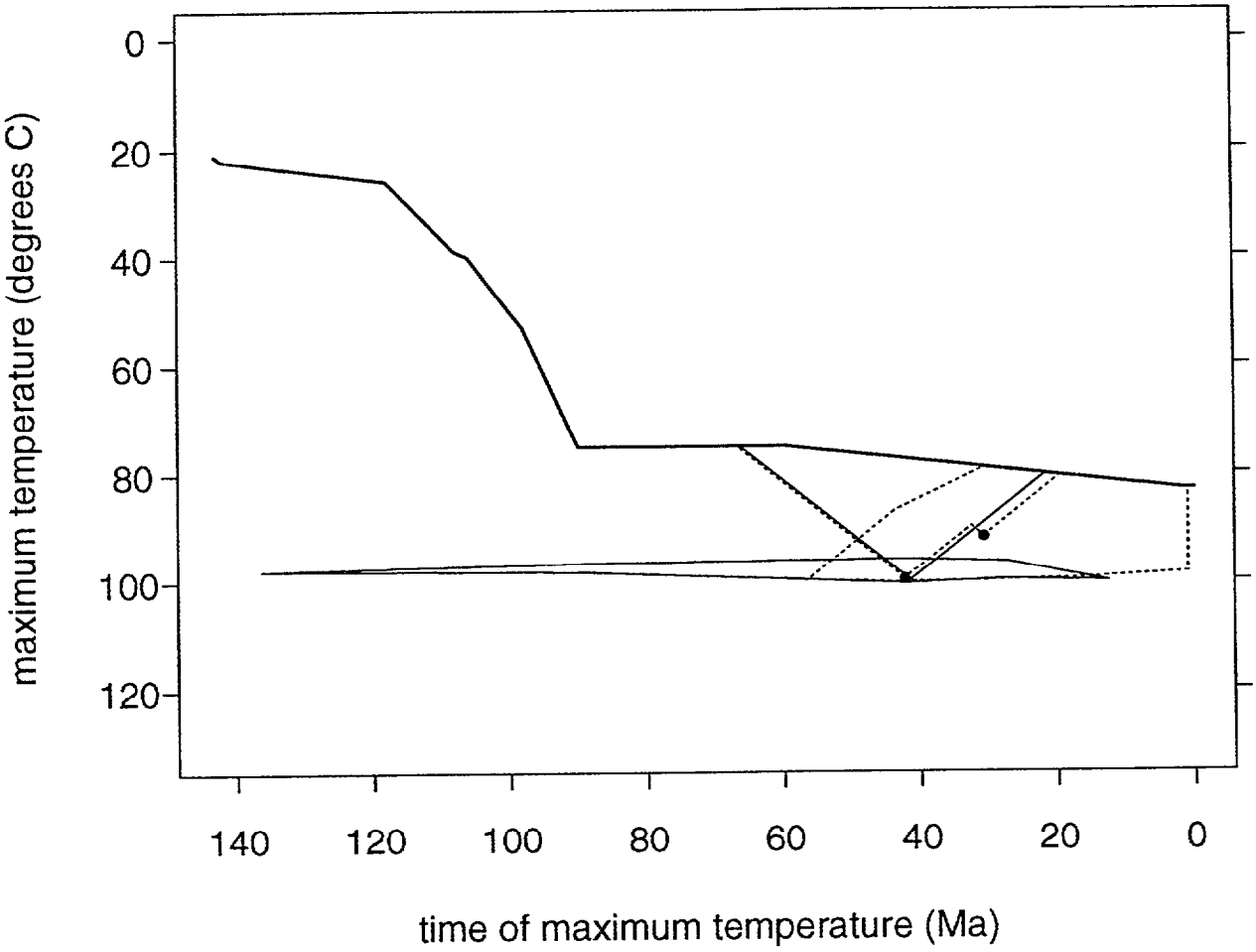

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

582-7


profile likelihoods
thermal histories
log likelihood
-615
-616
101.2
93.5
104
94
96
98
100
102
104
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
700
500
300
100
time (Ma)
log likelihood
-615
-616
40.1
16.3
74
20
30
40
50
60
70
time of thermal episode (Ma)
temperature
20
40
60
80
100
120
700
500
300
100
time (Ma)

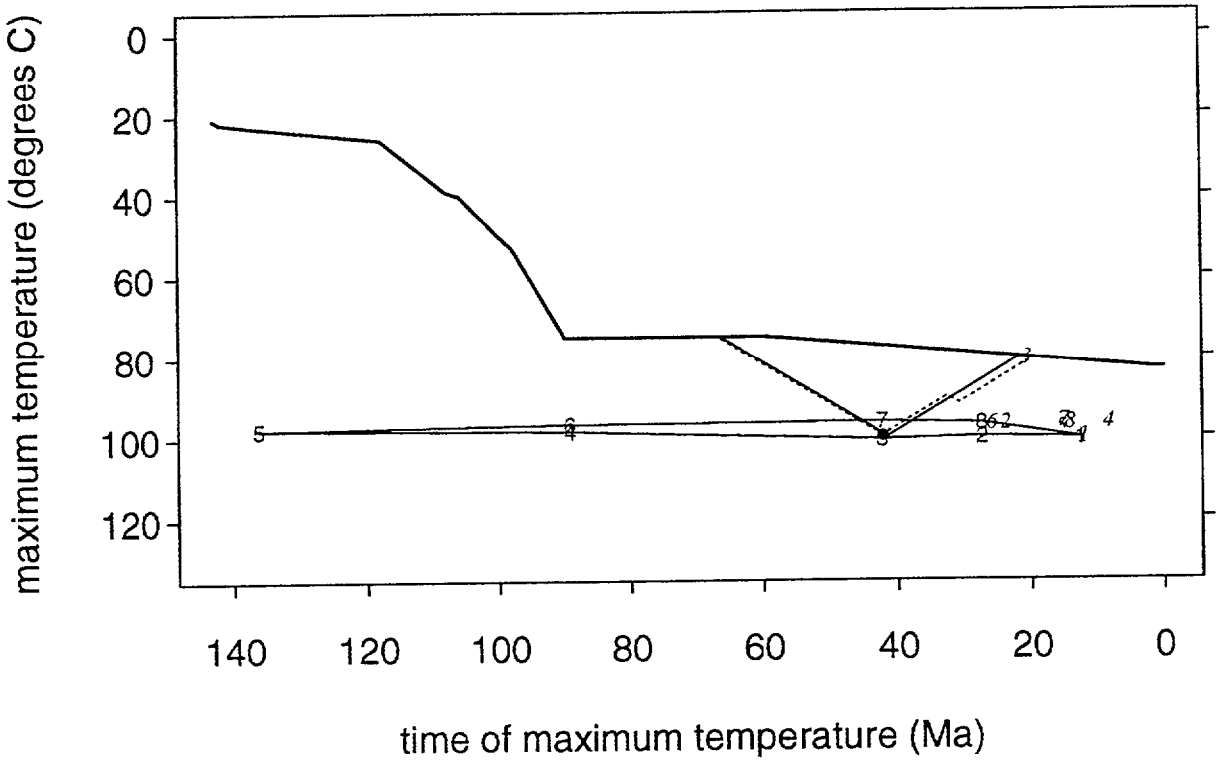
582-7

episodes 1 and 2

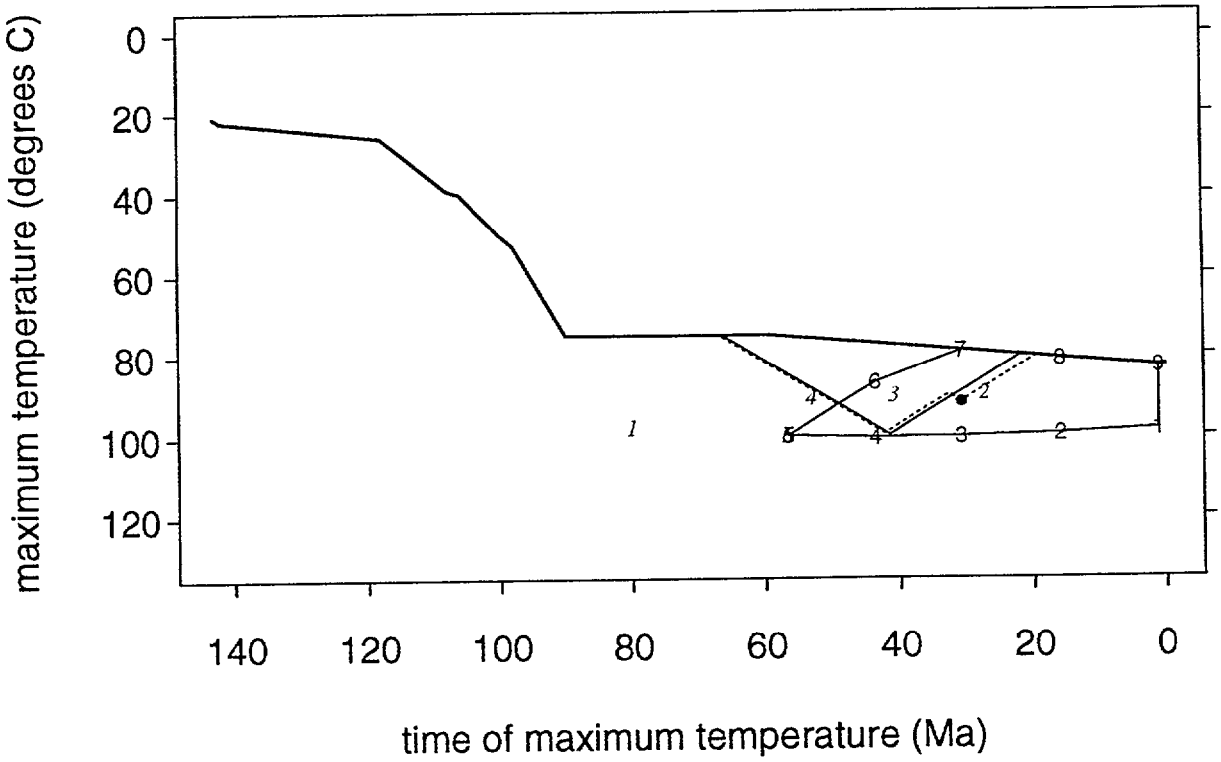


582-7

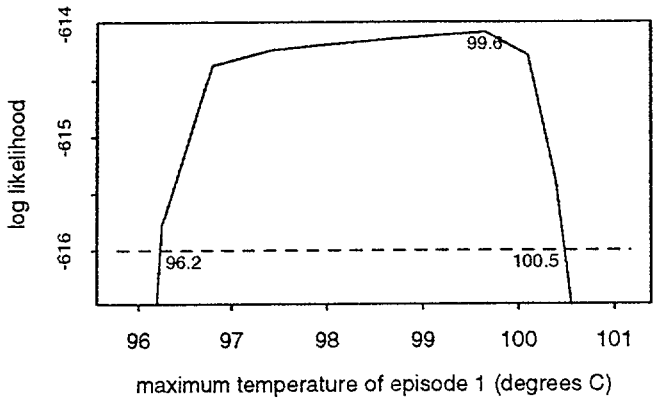
episode 1

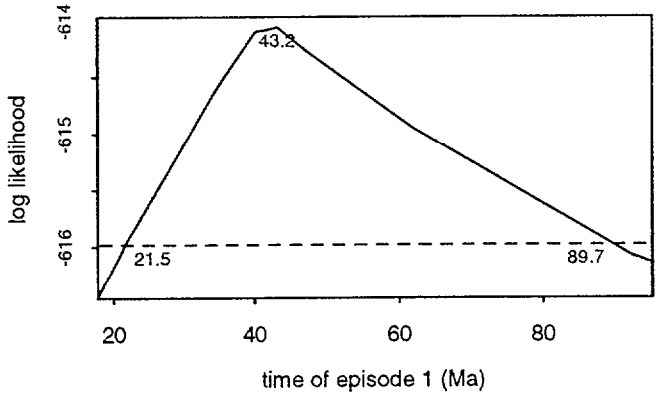


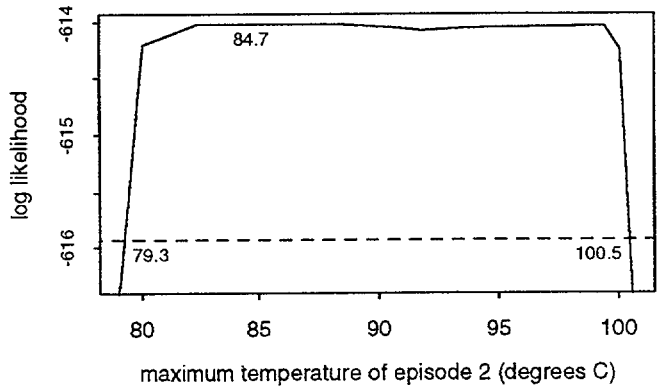
episode 2

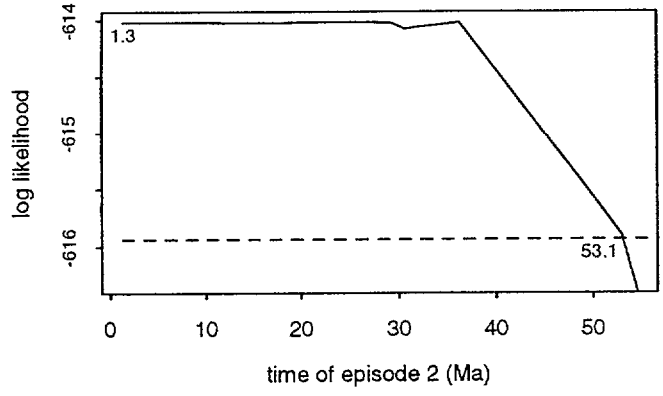


profile likelihoods

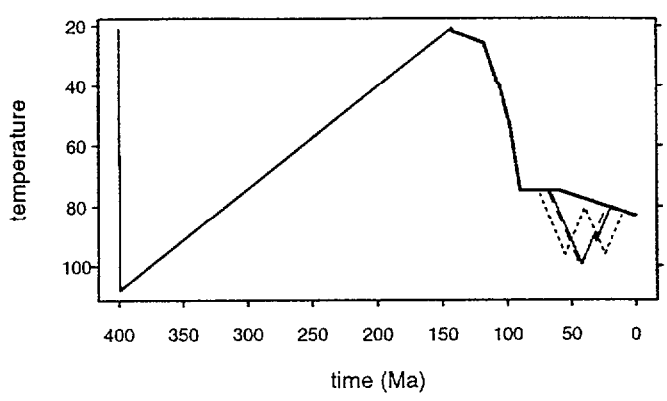


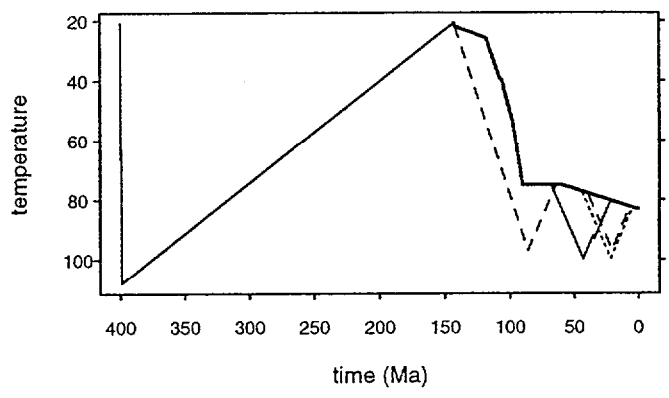


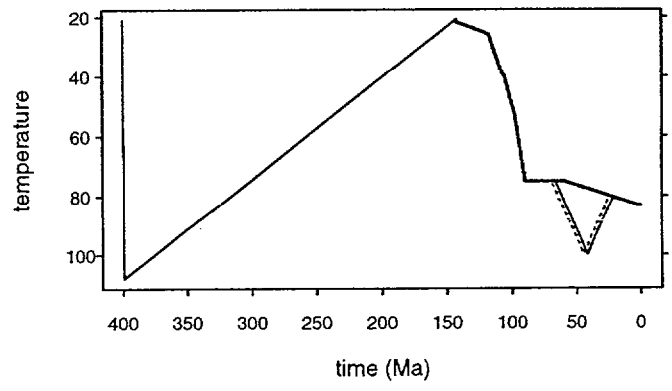


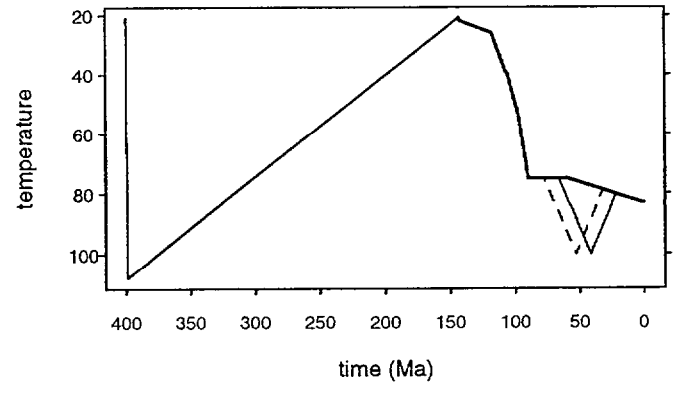


thermal histories

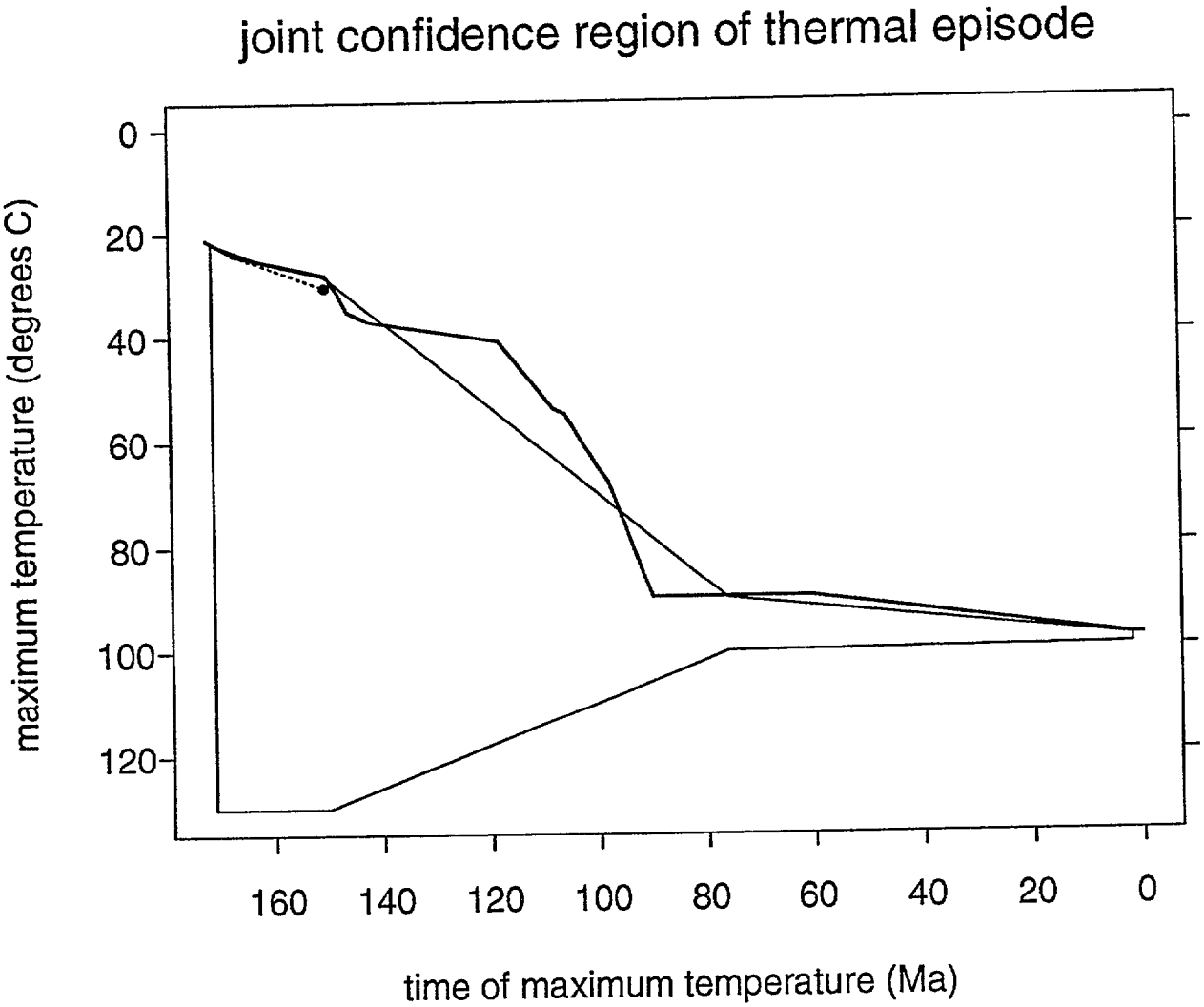




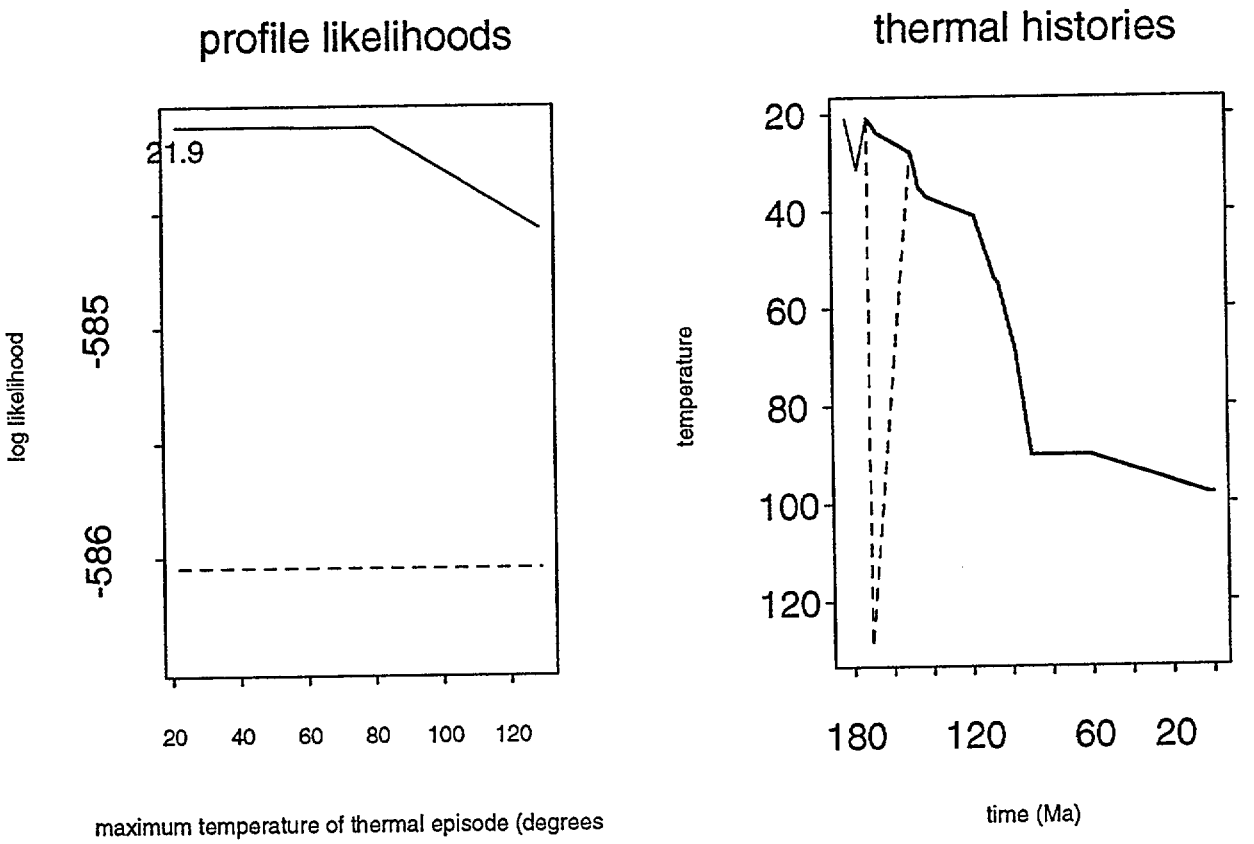


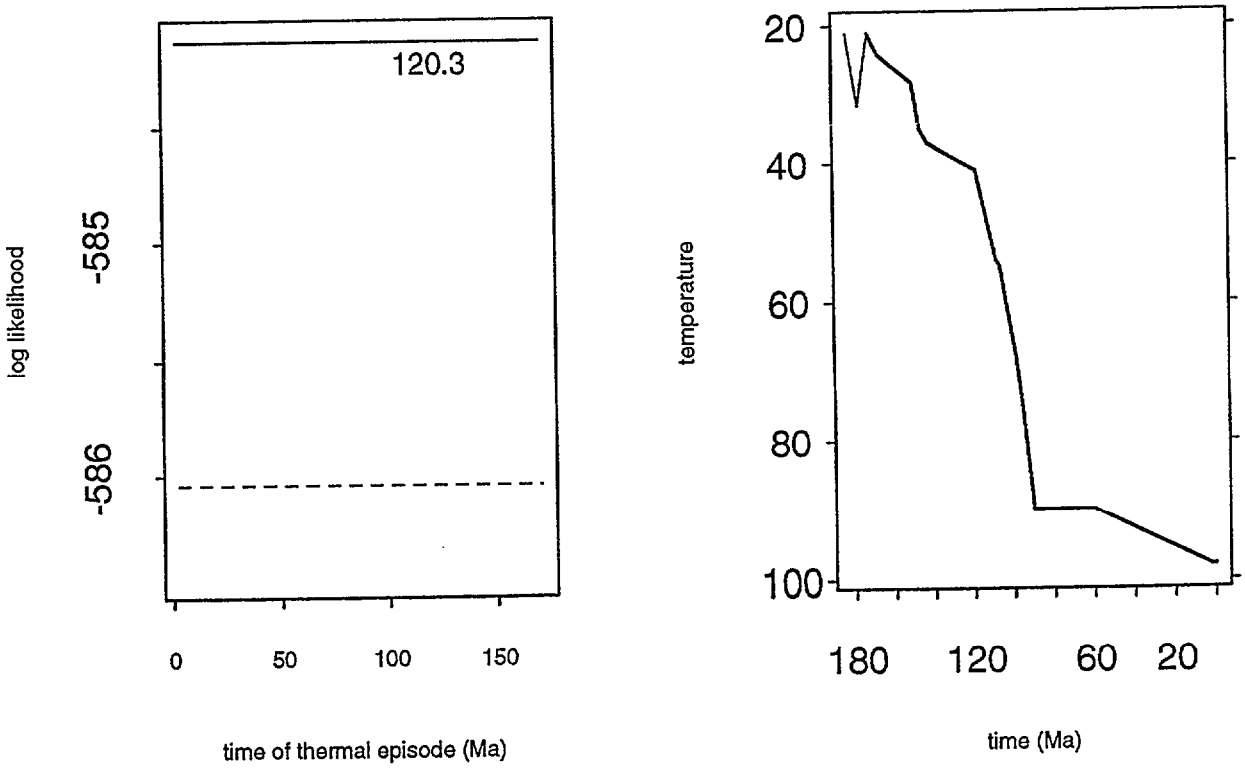


582-8

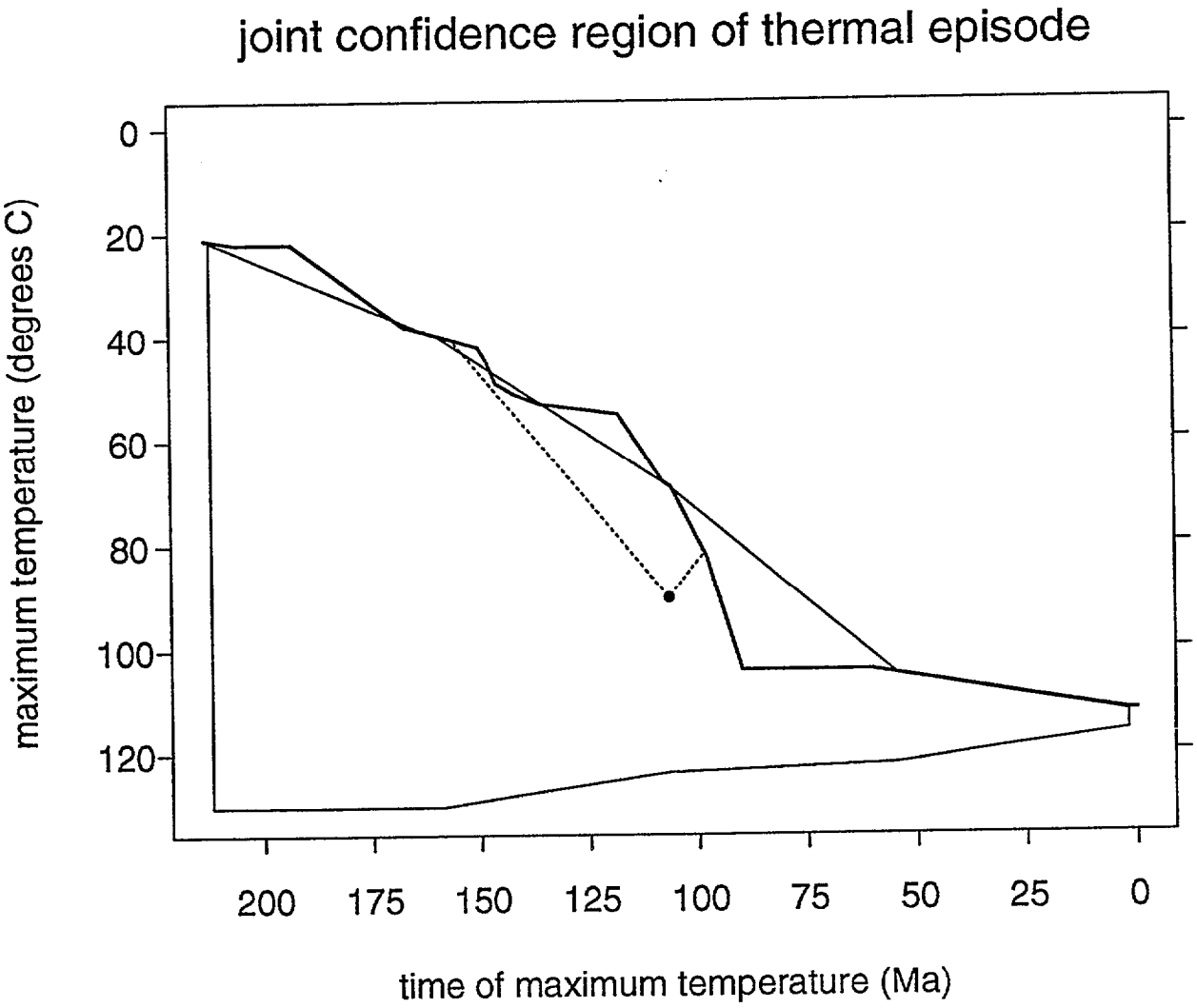

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
160
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

582-8

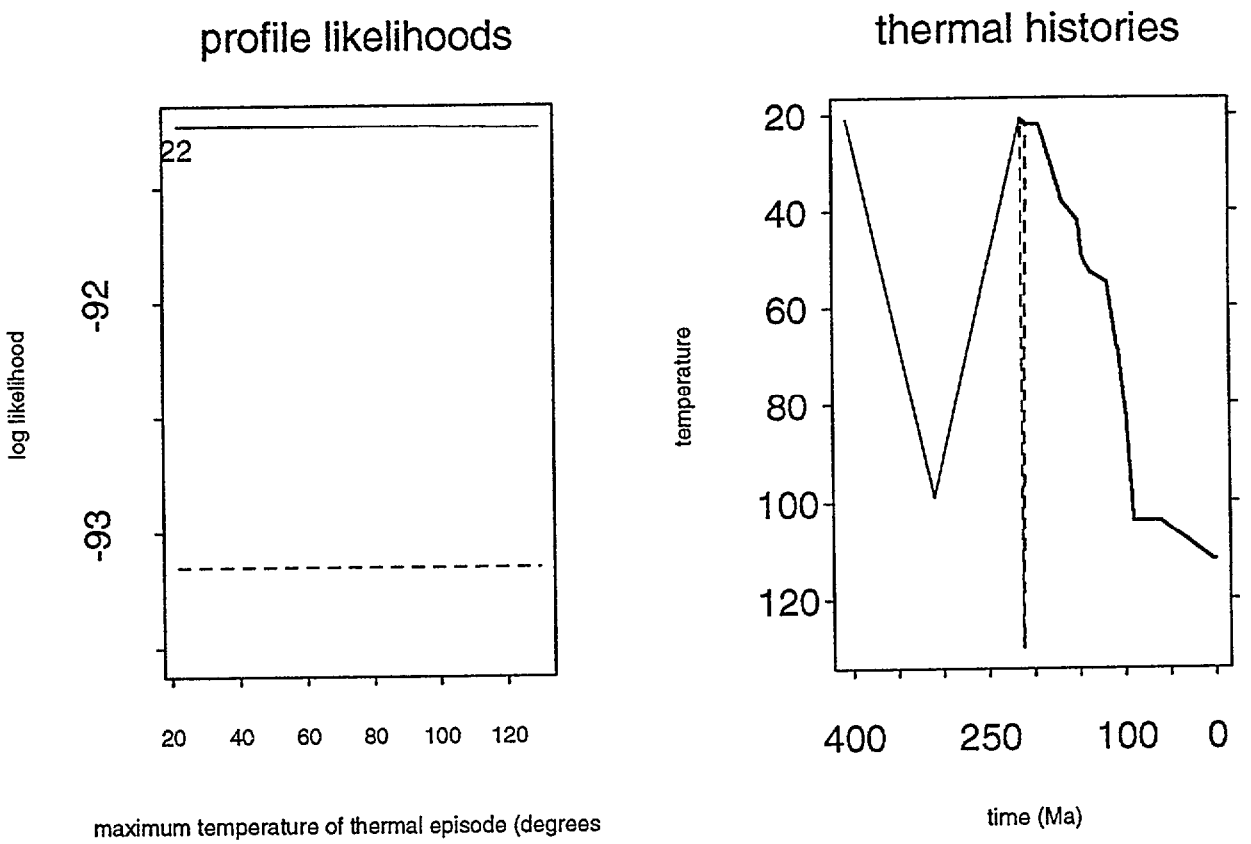

profile likelihoods
thermal histories
21.9
log likelihood
-585
-586
20
40
60
80
100
120
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
180
120
60
20
time (Ma)

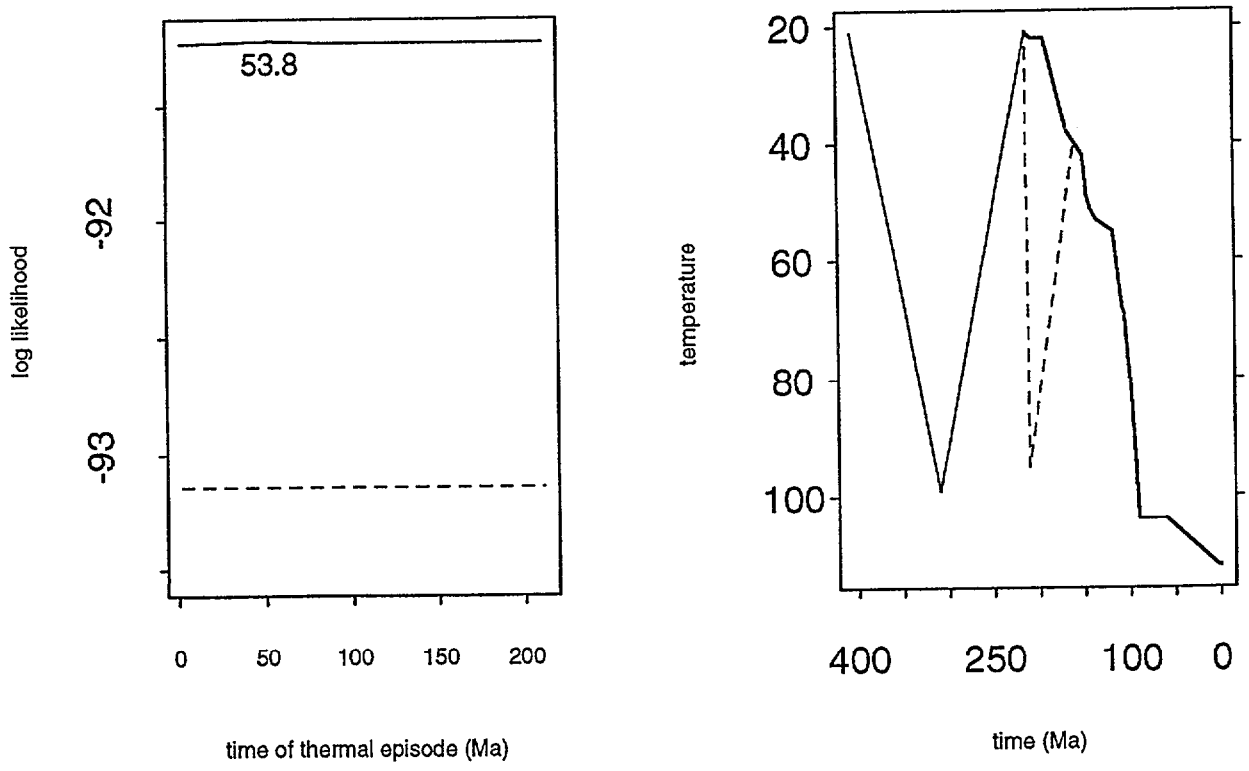

120.3
log likelihood
-585
-586
0
50
100
150
time of thermal episode (Ma)
temperature
20
40
60
80
100
180
120
60
20
time (Ma)

582-10

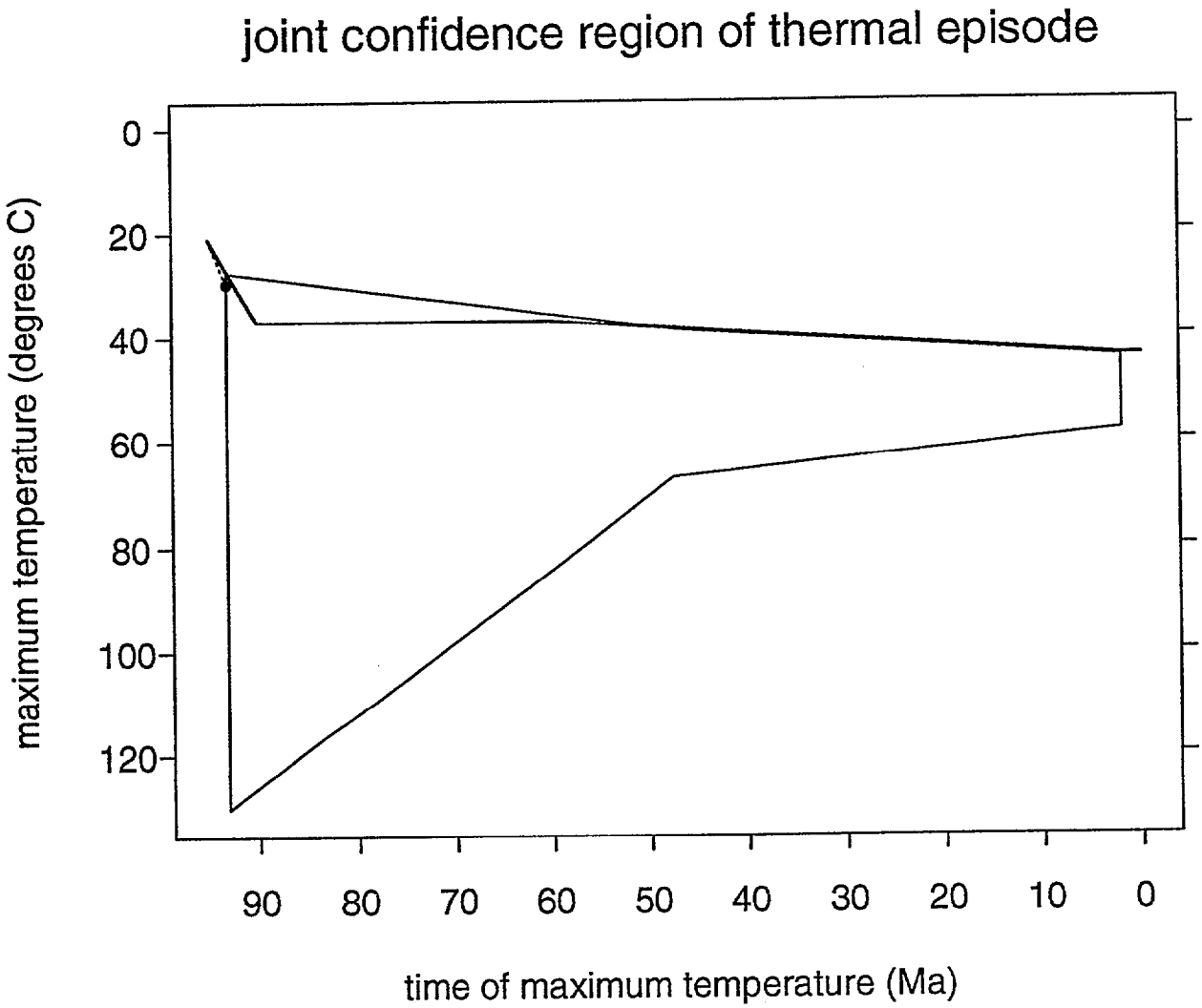

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
200
175
150
125
100
75
50
25
0
time of maximum temperature (Ma)

582-10

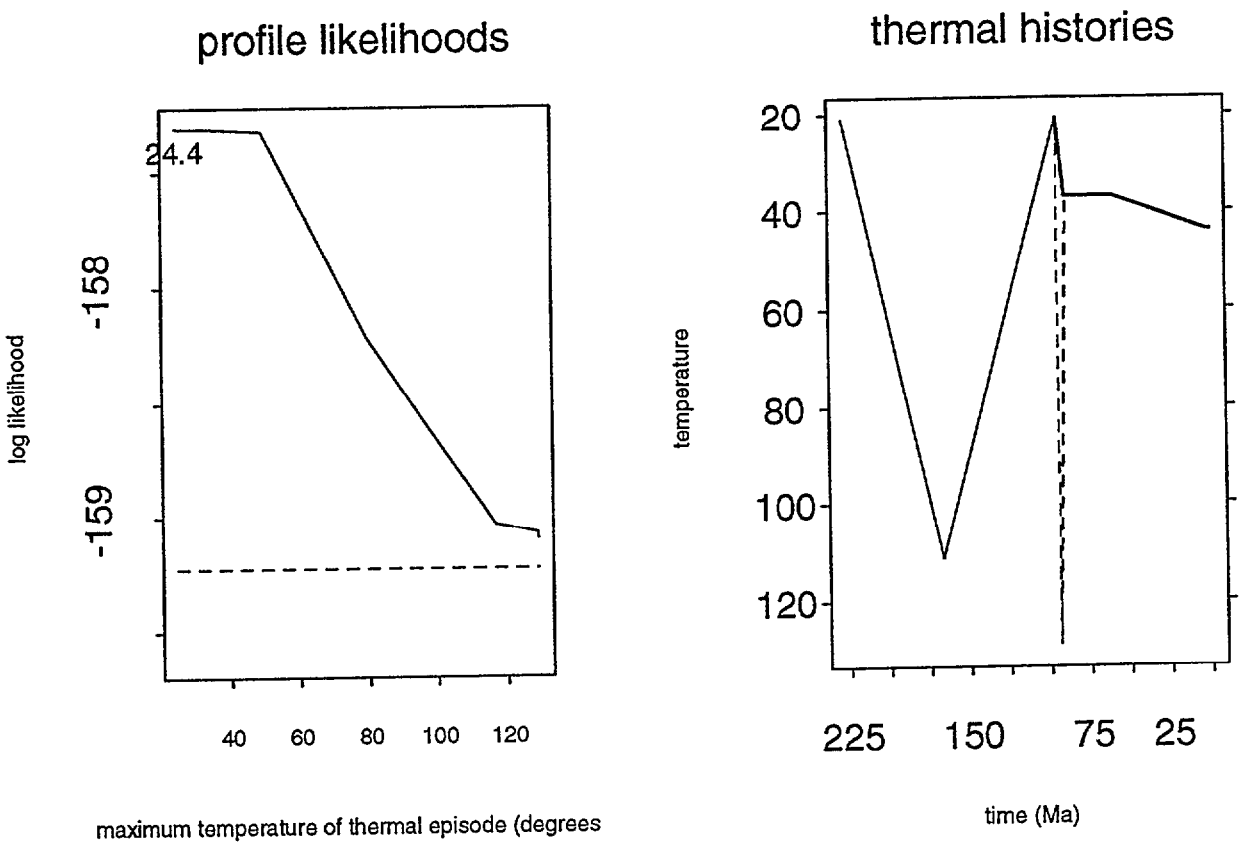

profile likelihoods
thermal histories
log likelihood
-92
-93
22
20
40
60
80
100
120
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
400
250
100
0
time (Ma)

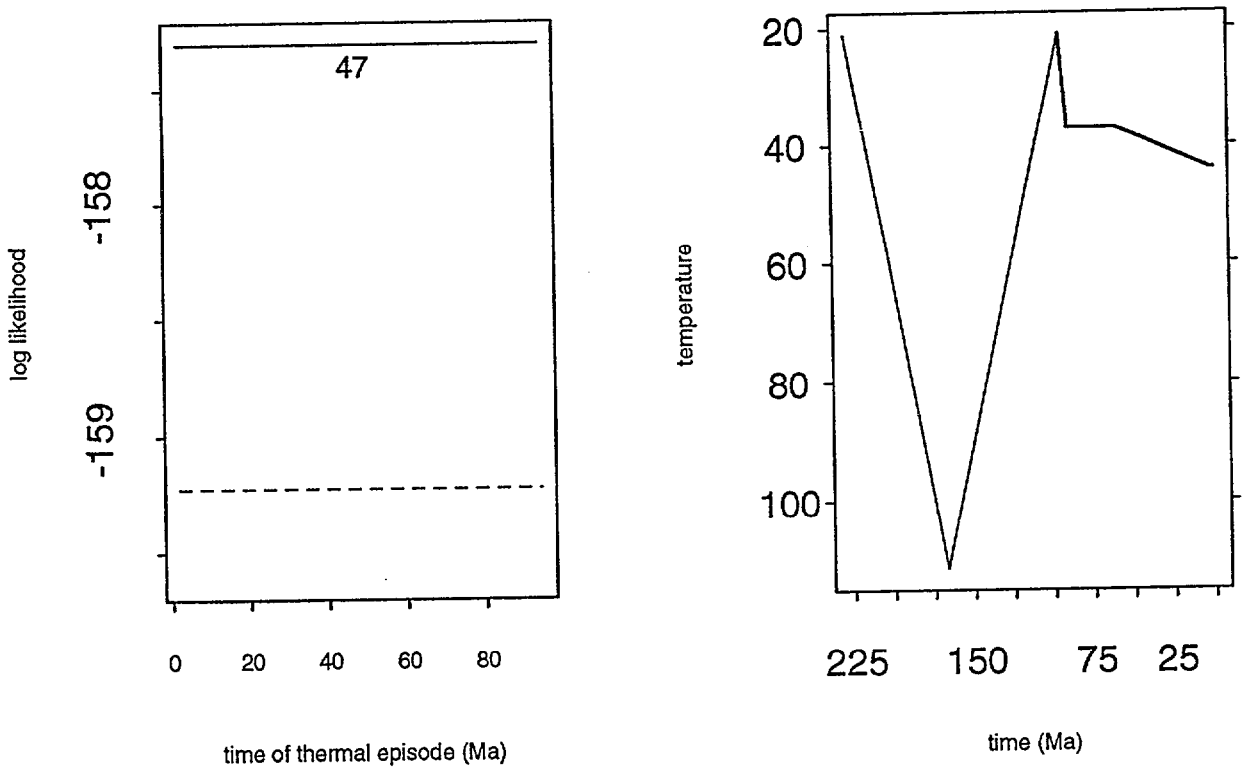

log likelihood
-92
-93
53.8
0
50
100
150
200
time of thermal episode (Ma)
temperature
20
40
60
80
100
400
250
100
0
time (Ma)

582-11

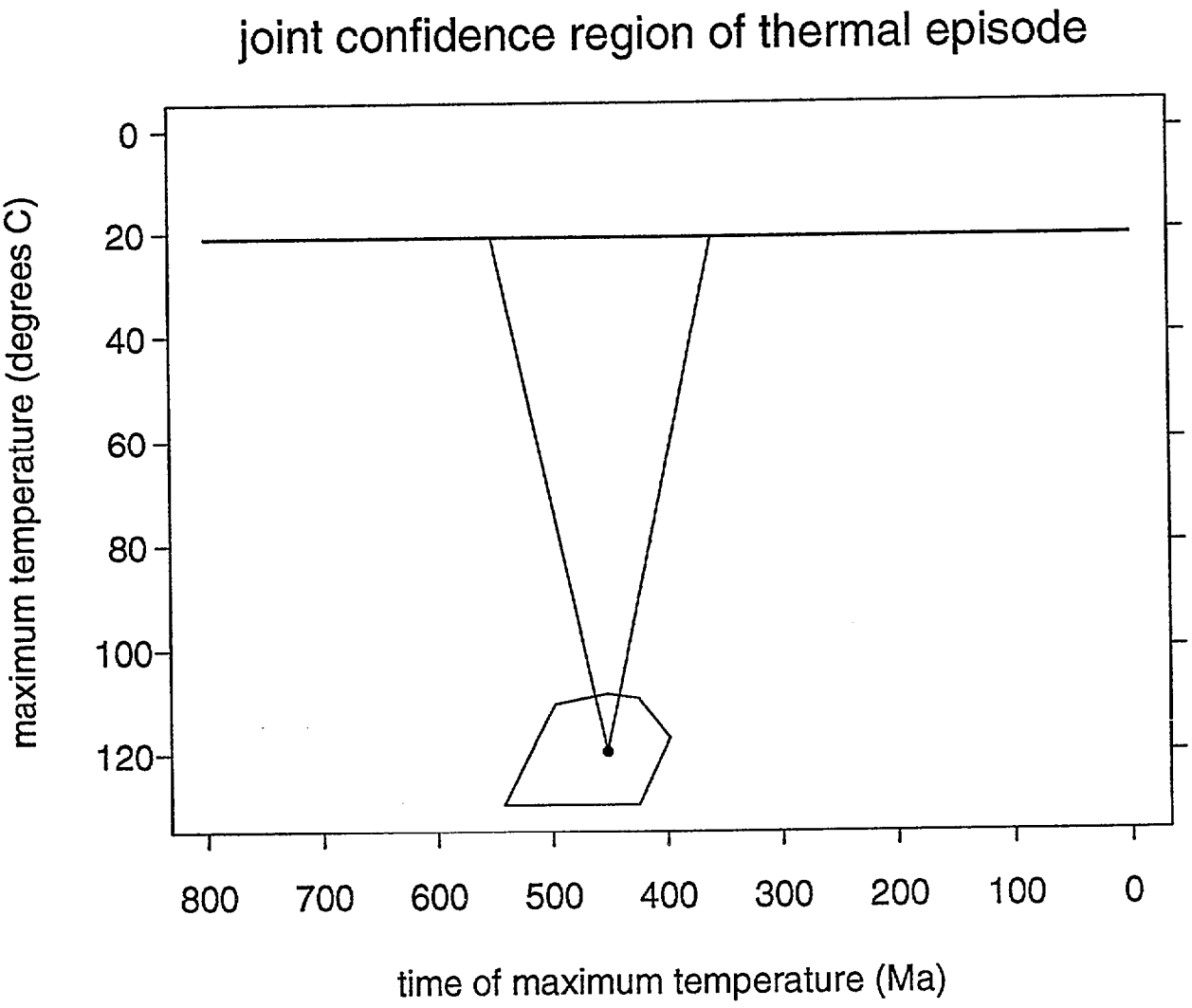

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
90
80
70
60
50
40
30
20
10
0
time of maximum temperature (Ma)

582-11

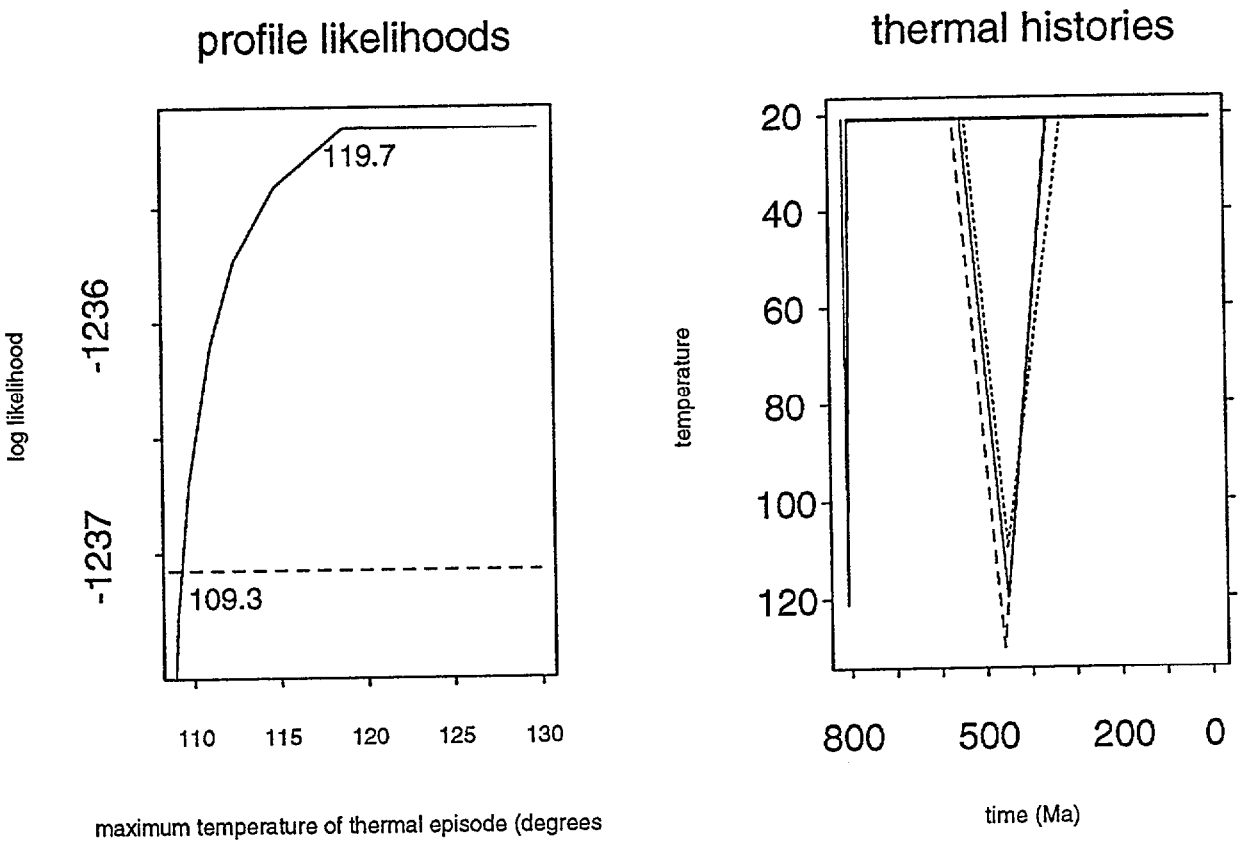

profile likelihoods
thermal histories
log likelihood
-158
-159
24.4
40
60
80
100
120
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
225
150
75
25
time (Ma)

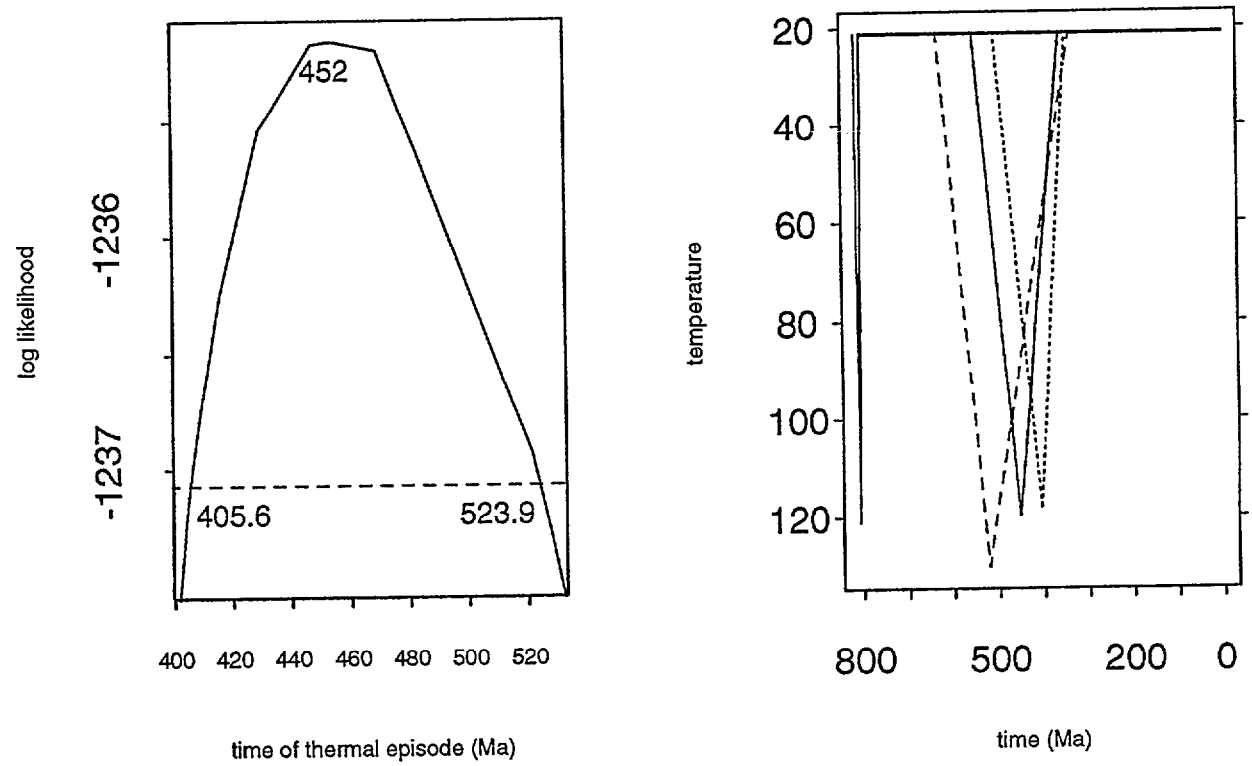

log likelihood
-158
-159
47
0
20
40
60
80
time of thermal episode (Ma)
temperature
20
40
60
80
100
225
150
75
25
time (Ma)

582-13


joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
800
700
600
500
400
300
200
100
0
time of maximum temperature (Ma)

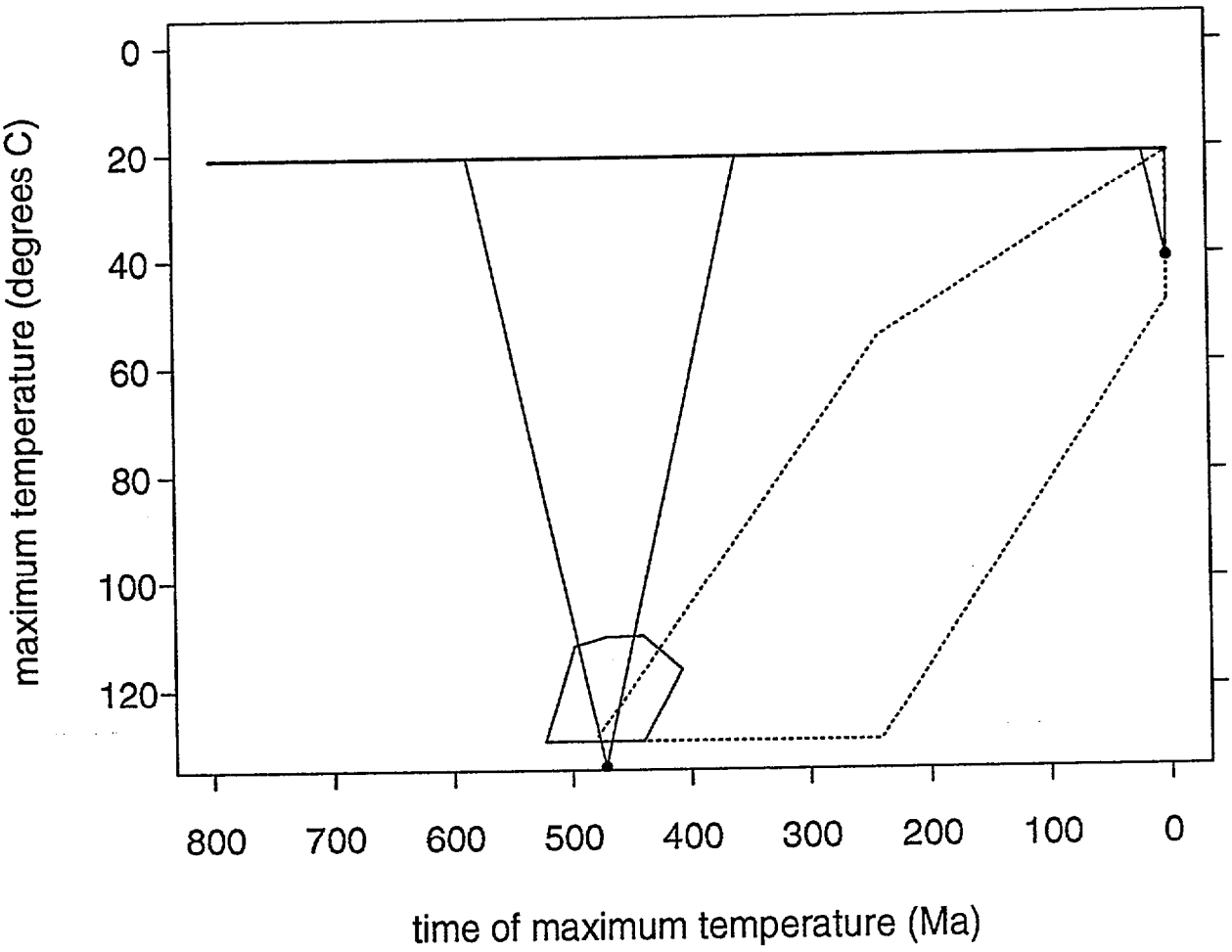
582-13


profile likelihoods
thermal histories
log likelihood
-1236
-1237
119.7
109.3
110
115
120
125
130
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
800
500
200
0
time (Ma)


log likelihood
-1236
-1237
452
405.6
523.9
400
420
440
460
480
500
520
time of thermal episode (Ma)
temperature
20
40
60
80
100
120
800
500
200
0
time (Ma)

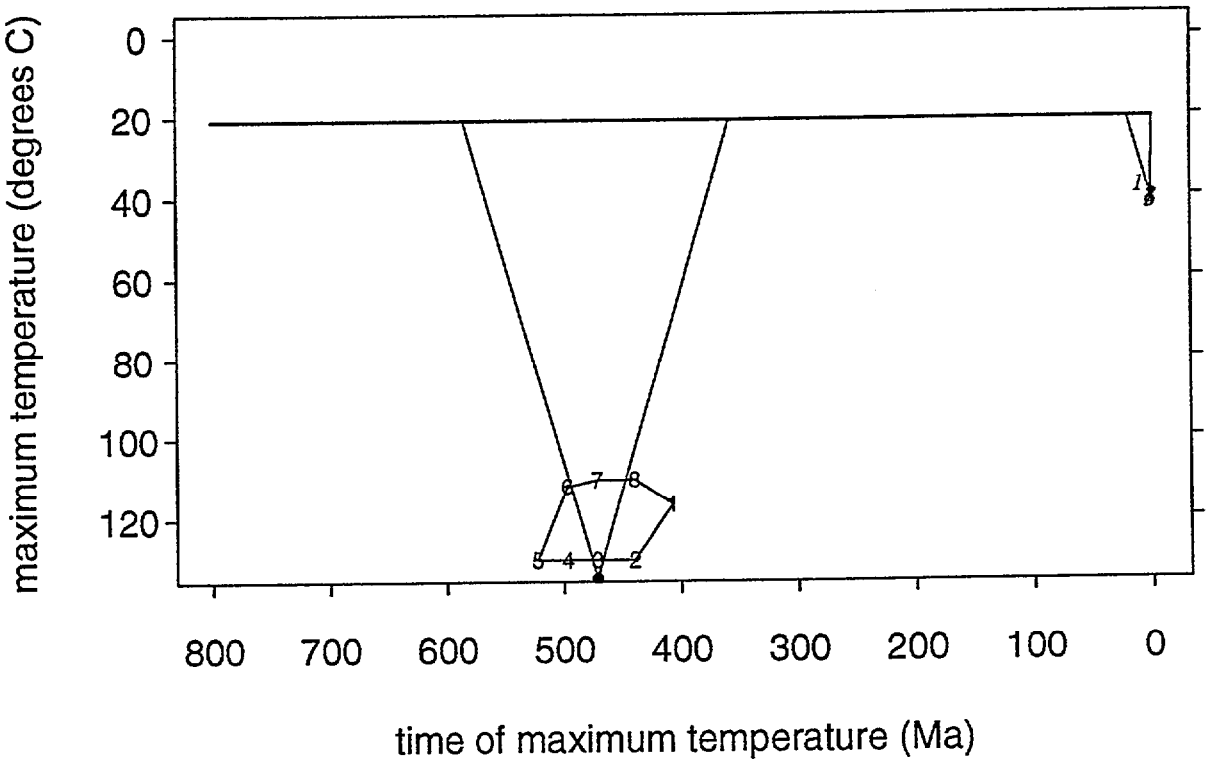
582-13

episodes 1 and 2

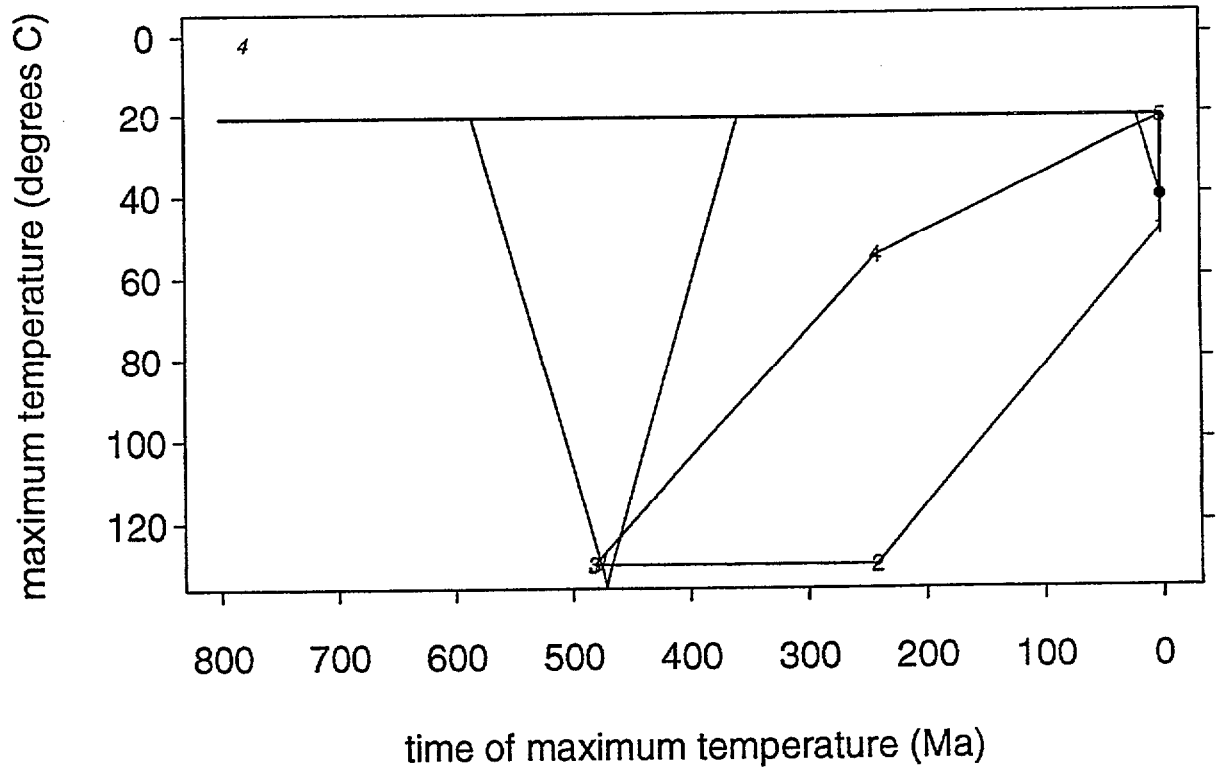


582-13

episode 1

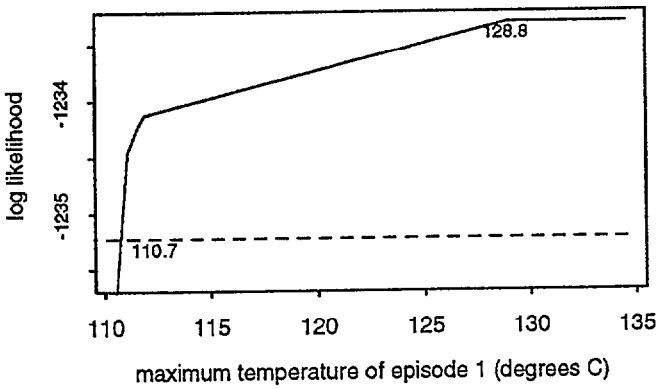


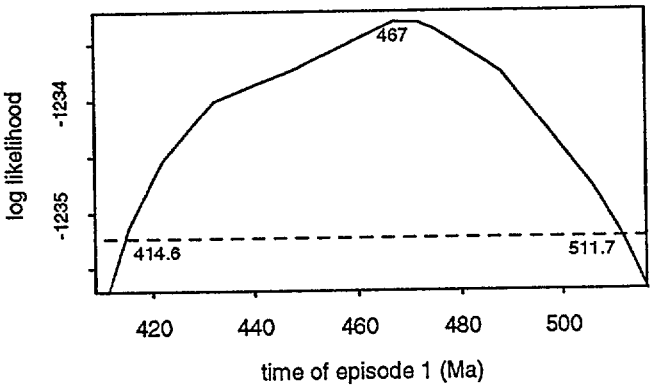
episode 2

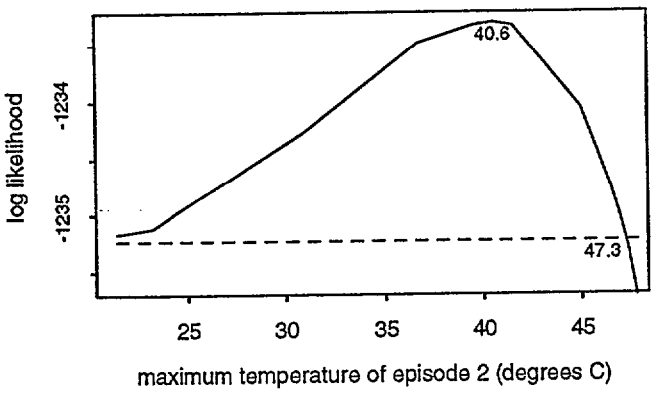


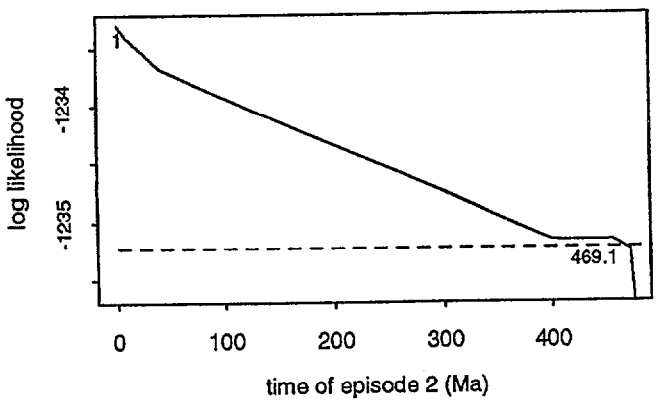
582-13

profile likelihoods

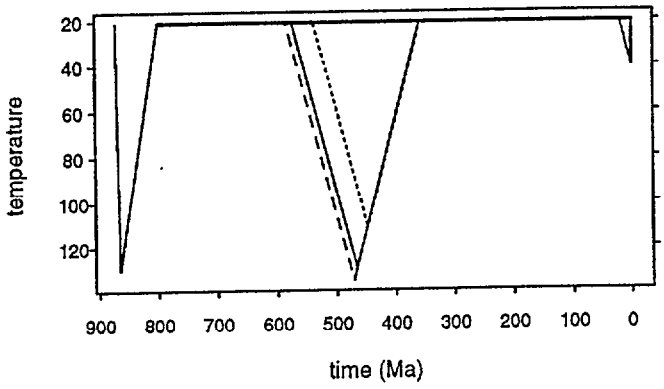


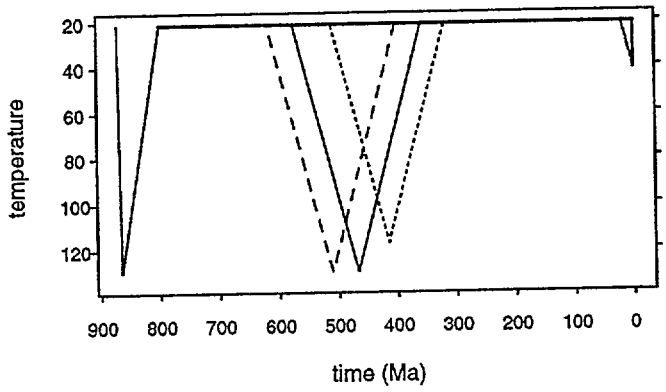


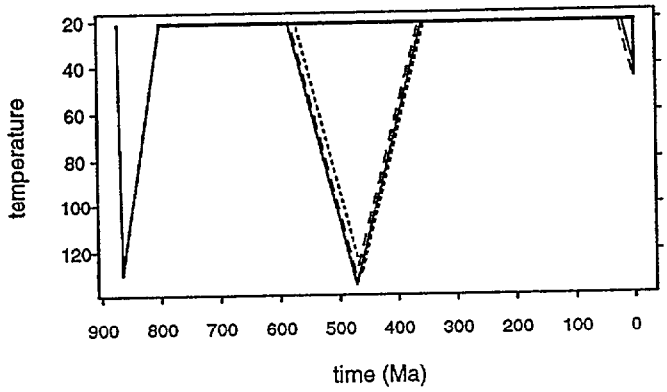


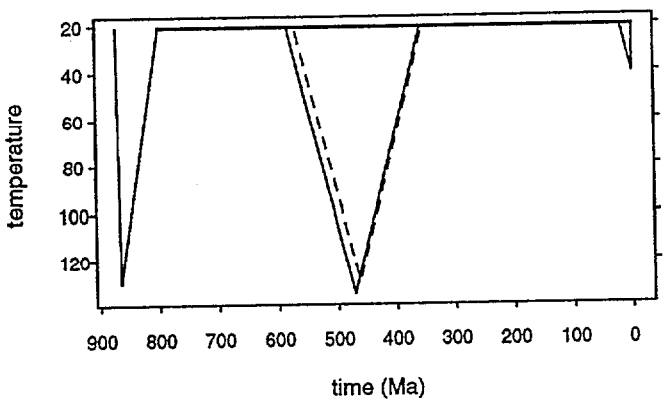


thermal histories

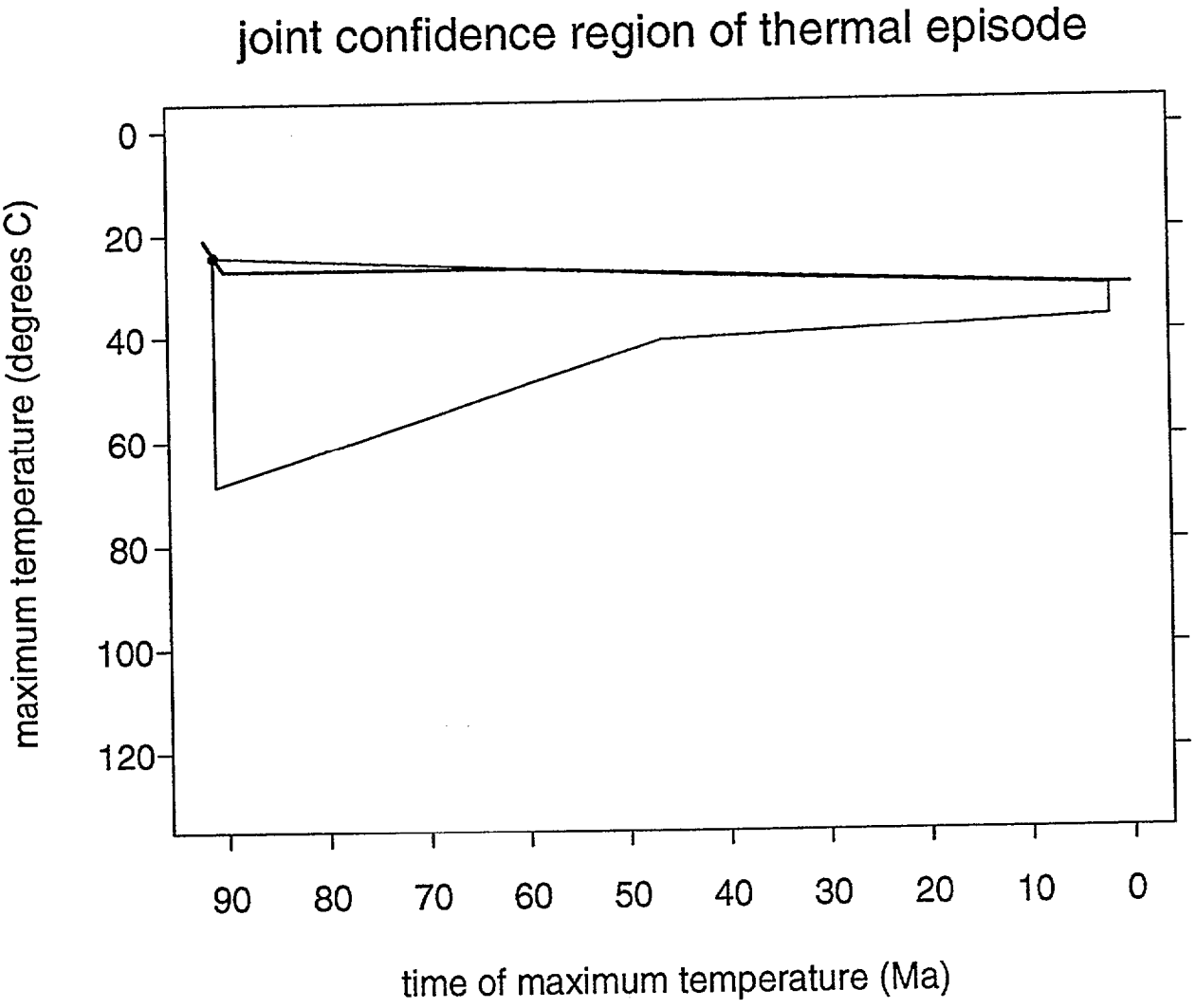




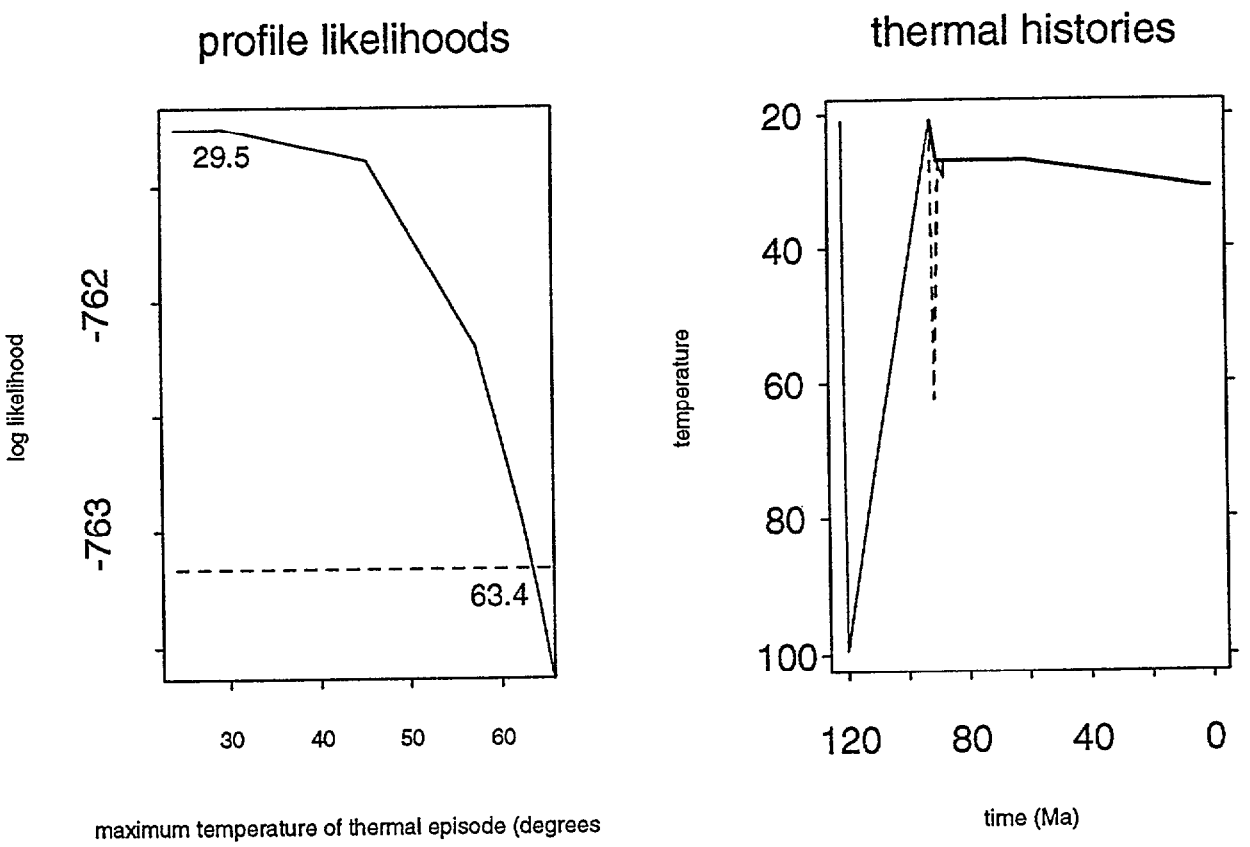


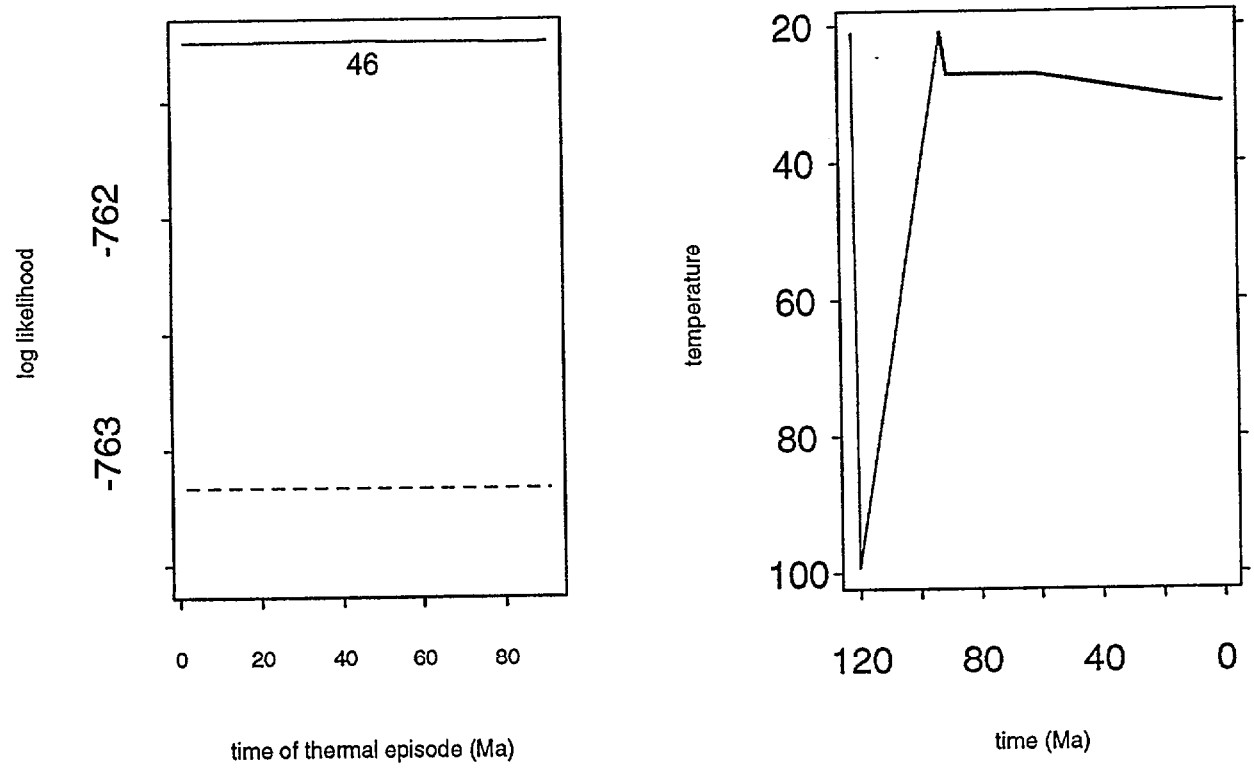


582-14

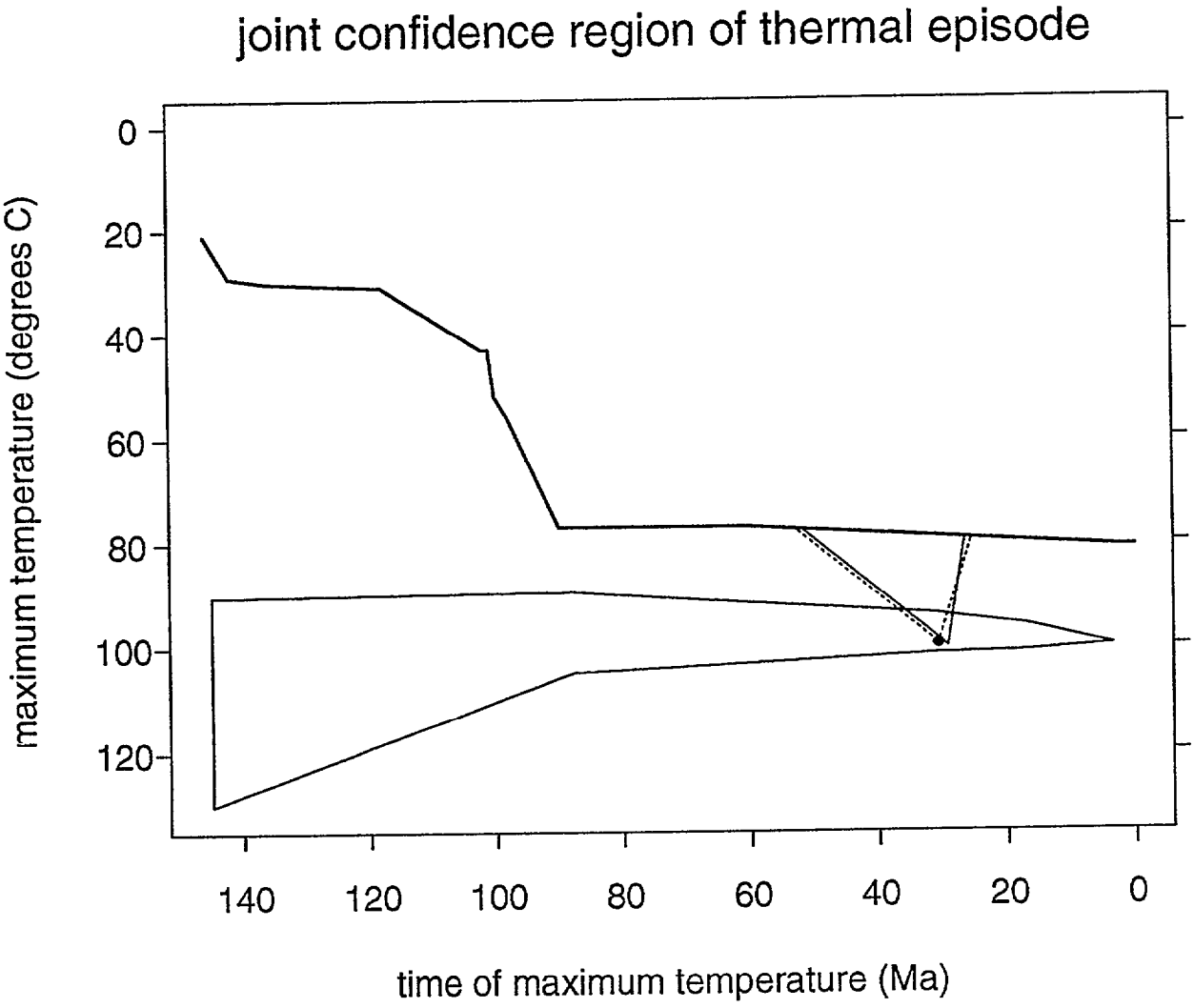

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
90
80
70
60
50
40
30
20
10
0
time of maximum temperature (Ma)

582-14


profile likelihoods
thermal histories
log likelihood
-762
-763
29.5
63.4
30
40
50
60
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
80
40
0
time (Ma)

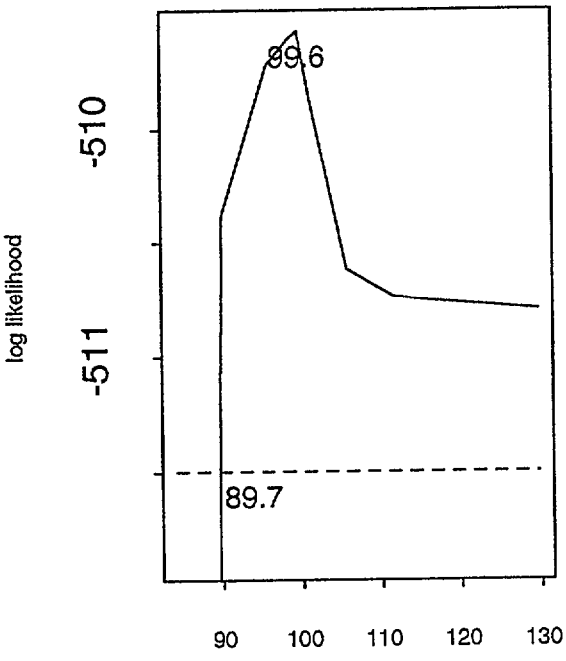

log likelihood
-762
-763
46
0
20
40
60
80
time of thermal episode (Ma)
temperature
20
40
60
80
100
120
80
40
0
time (Ma)

582-15

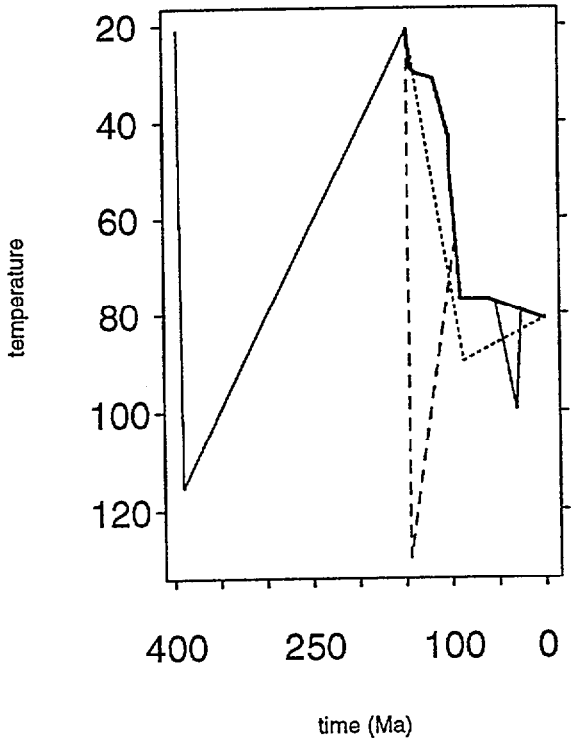

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

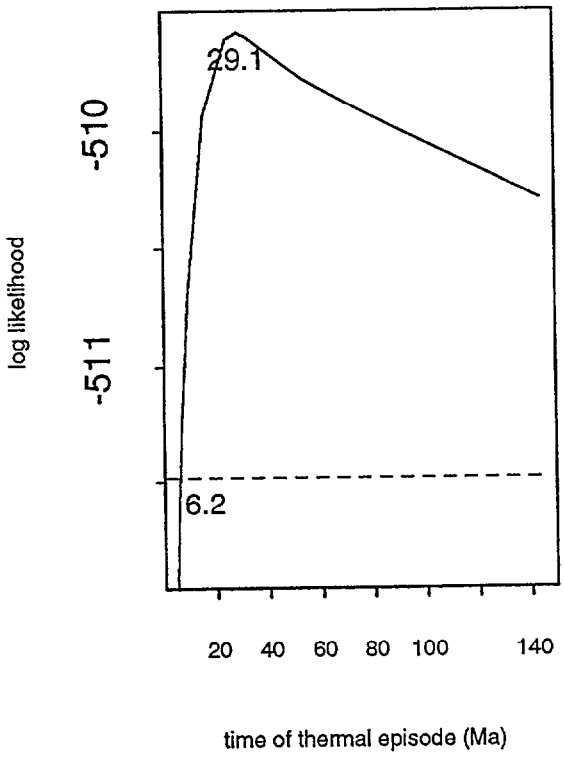
582-15

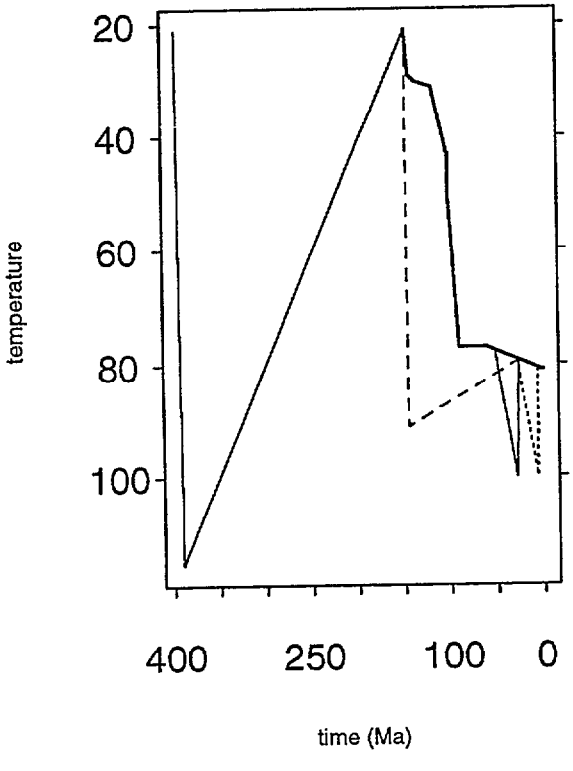
profile likelihoods



thermal histories

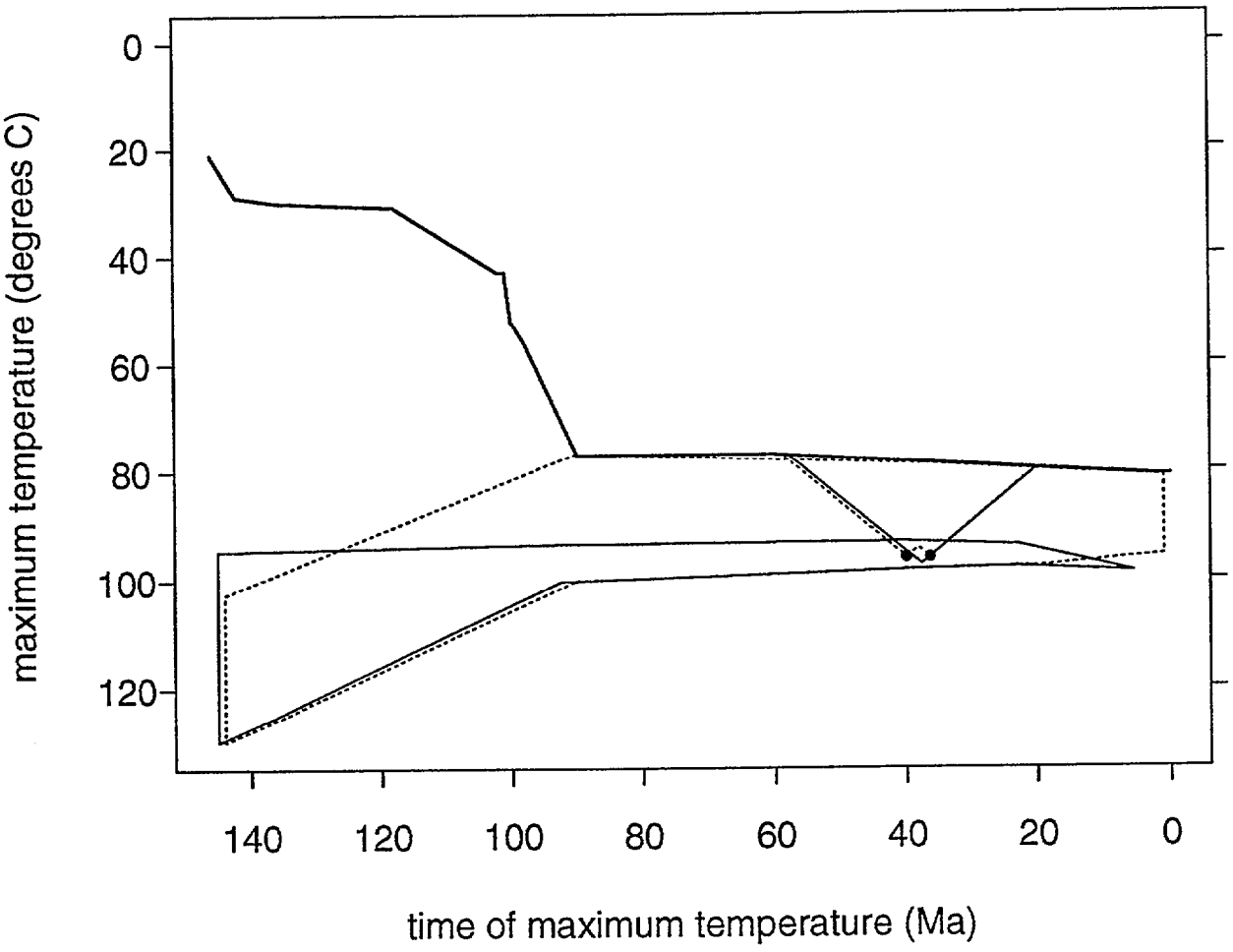






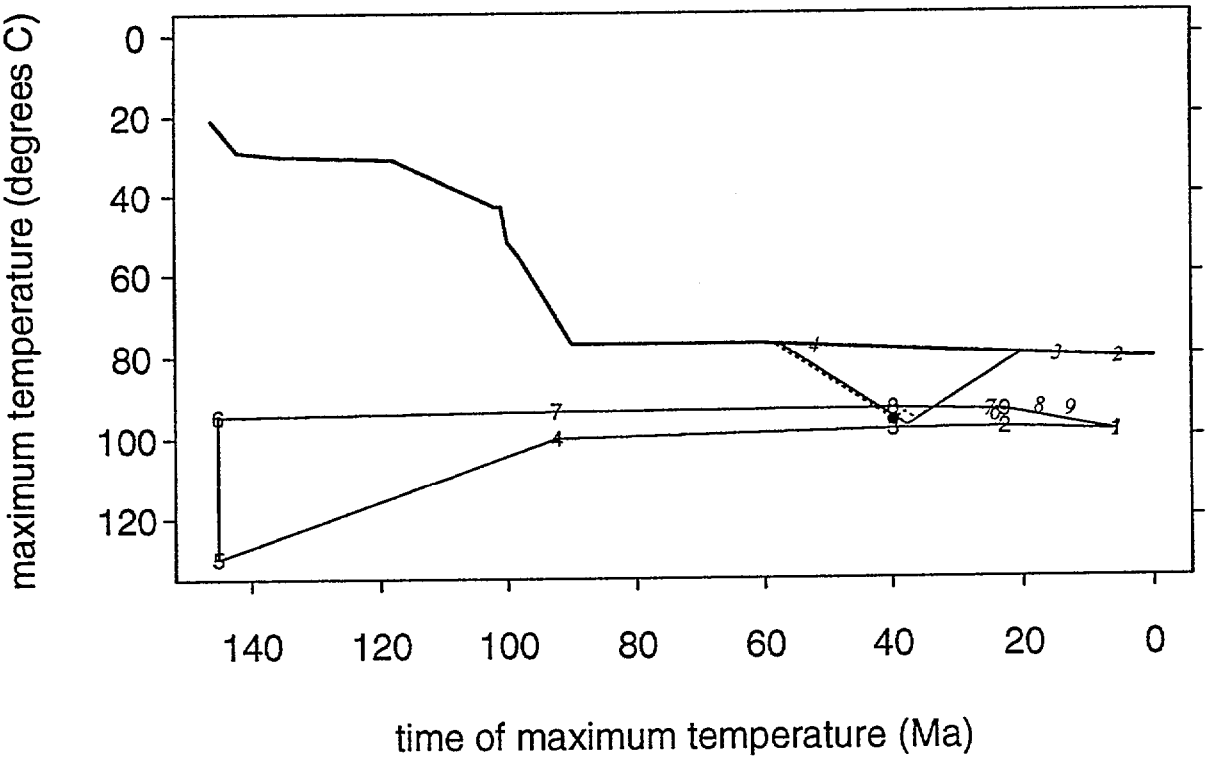
582-15

episodes 1 and 2

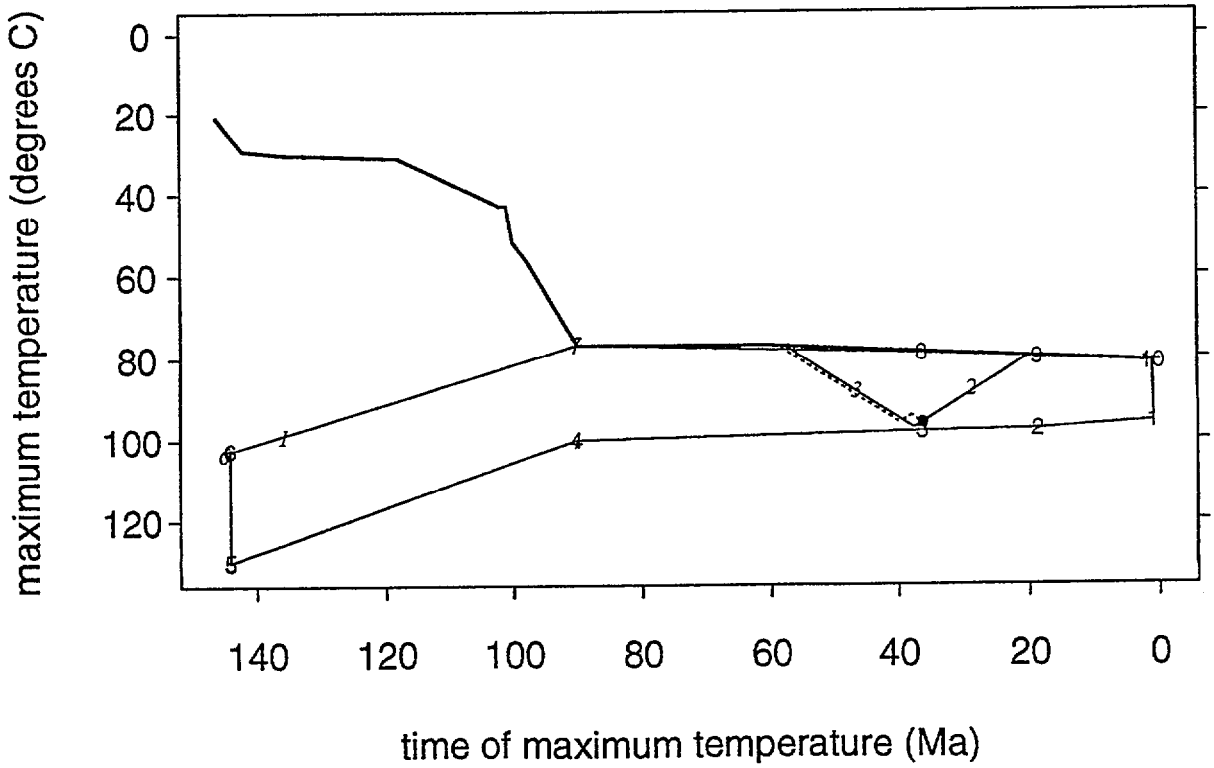


582-15

episode 1

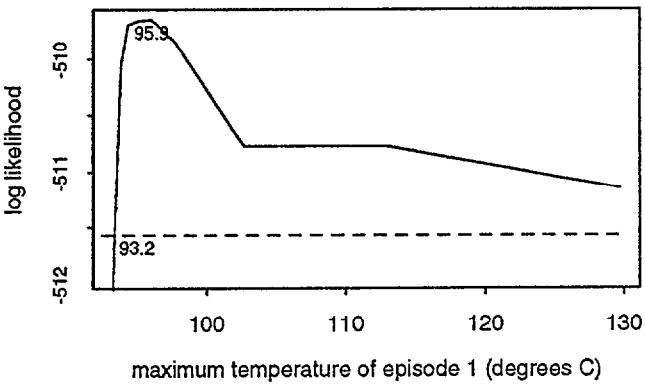


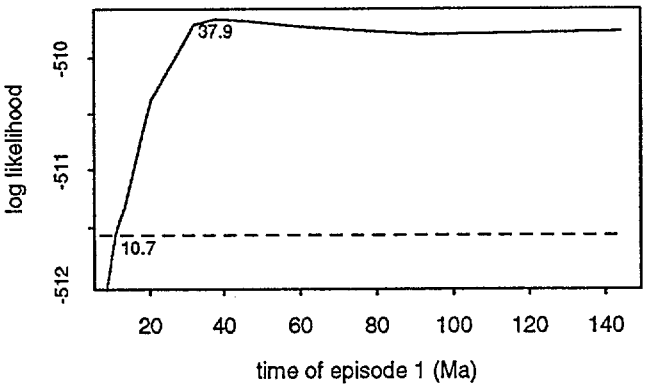
episode 2

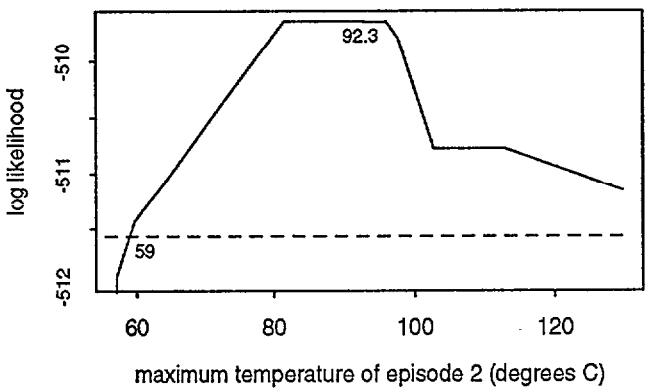


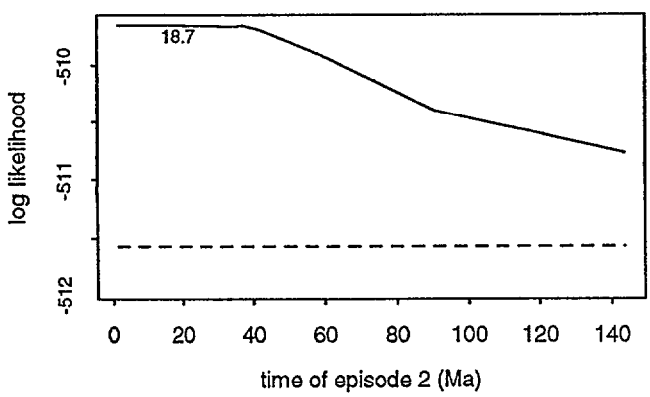
582-15

profile likelihoods

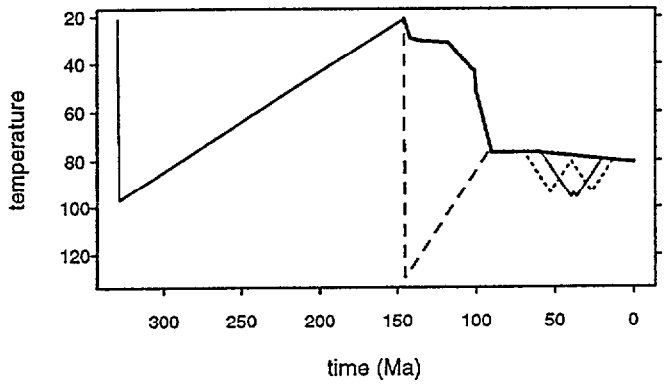


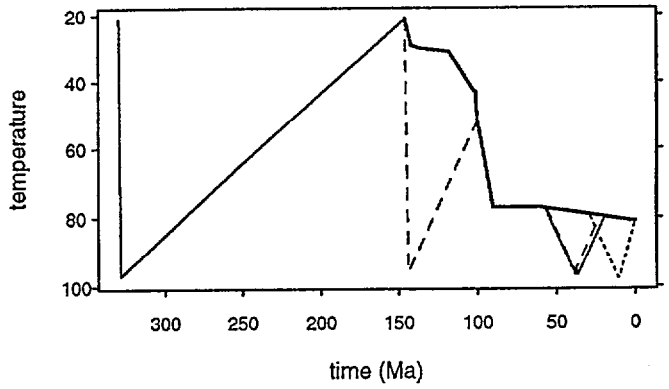


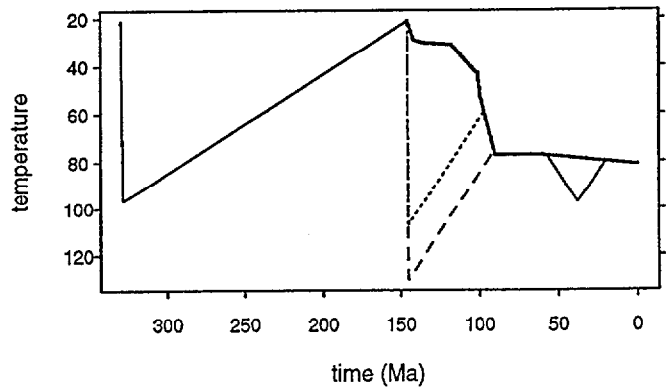


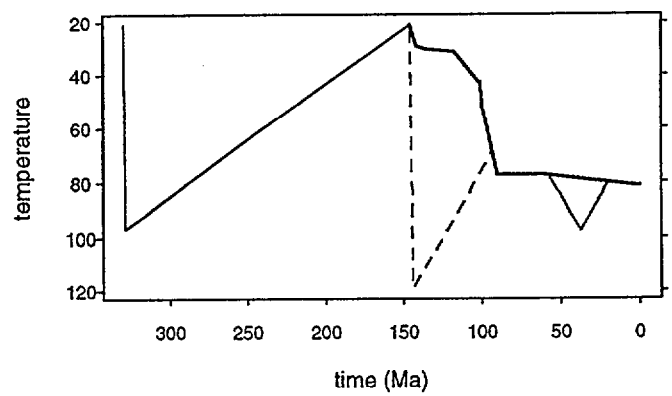


thermal histories

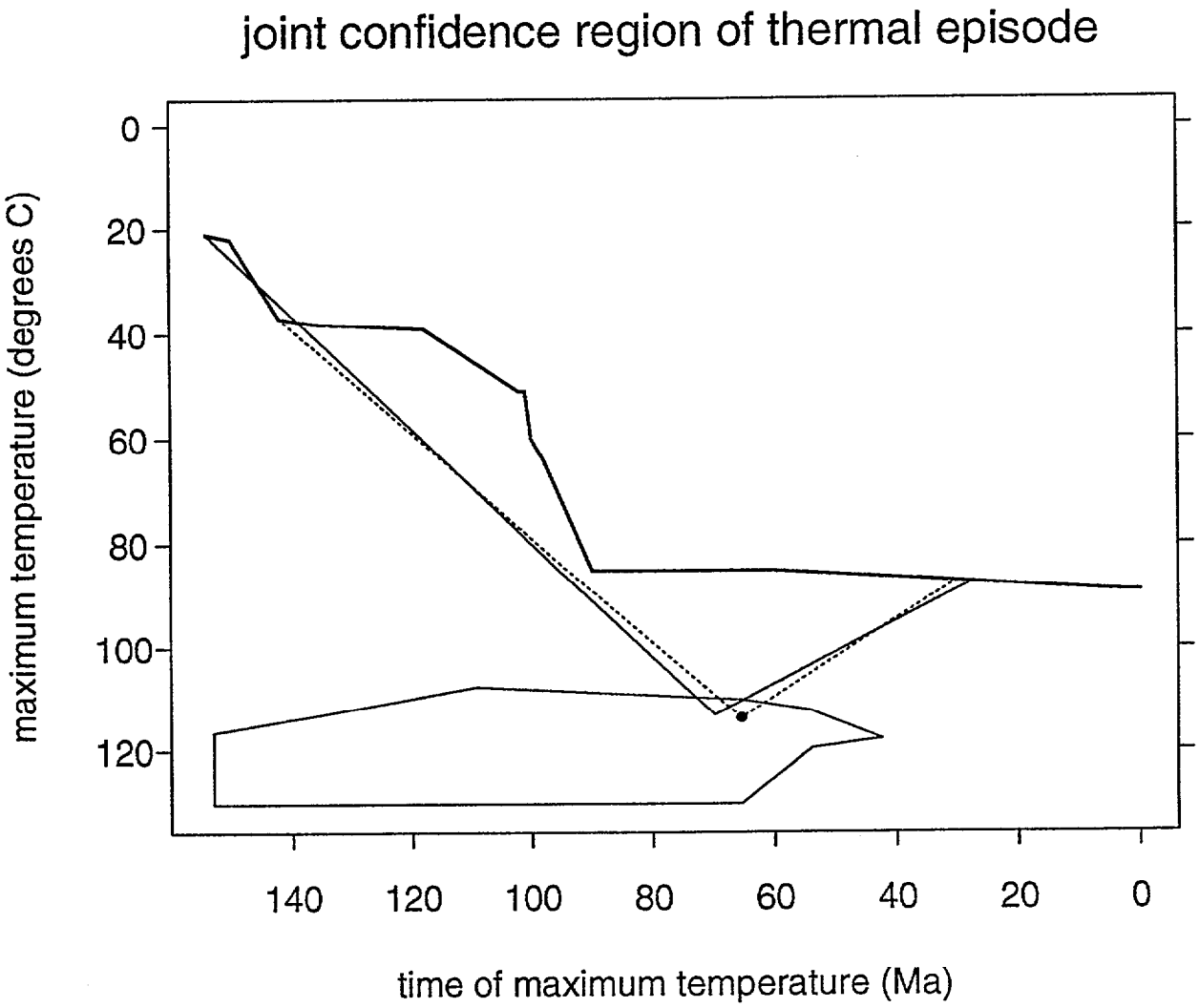




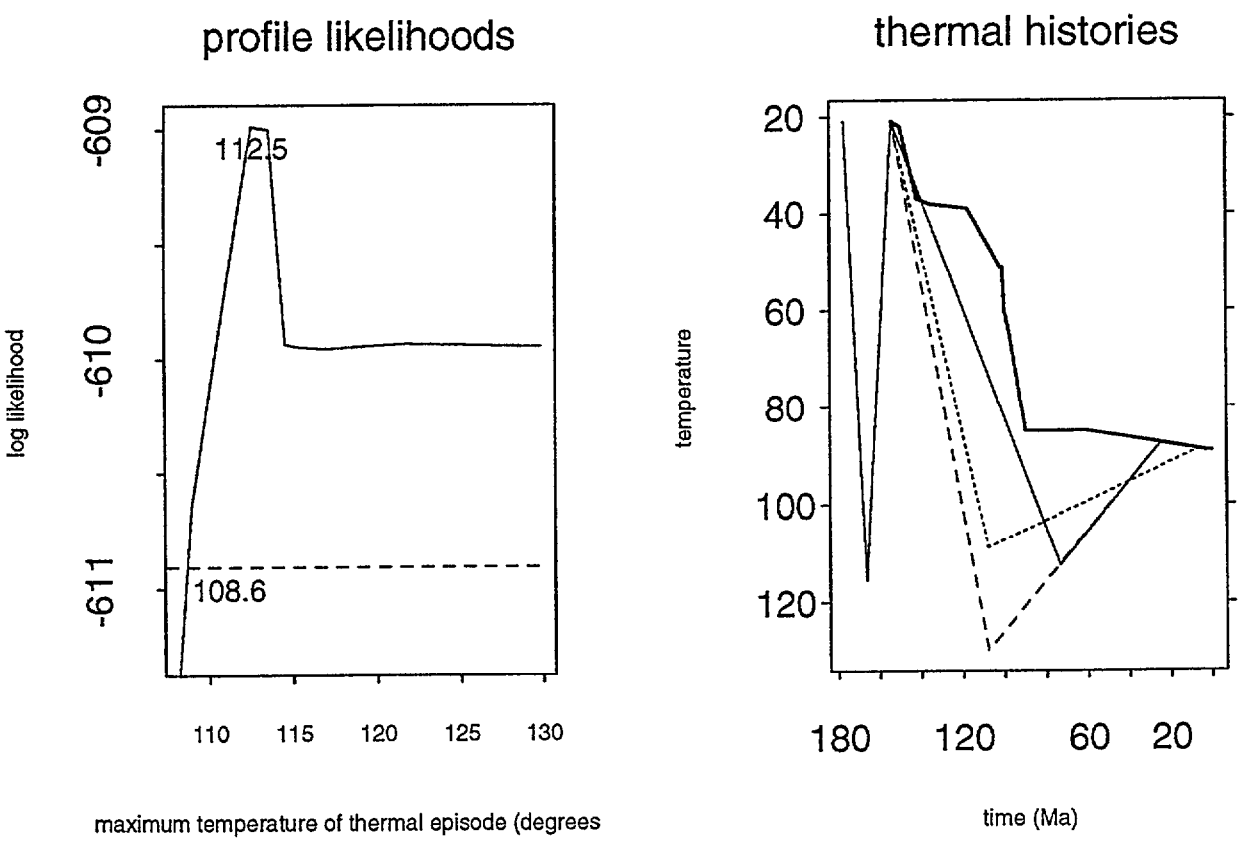


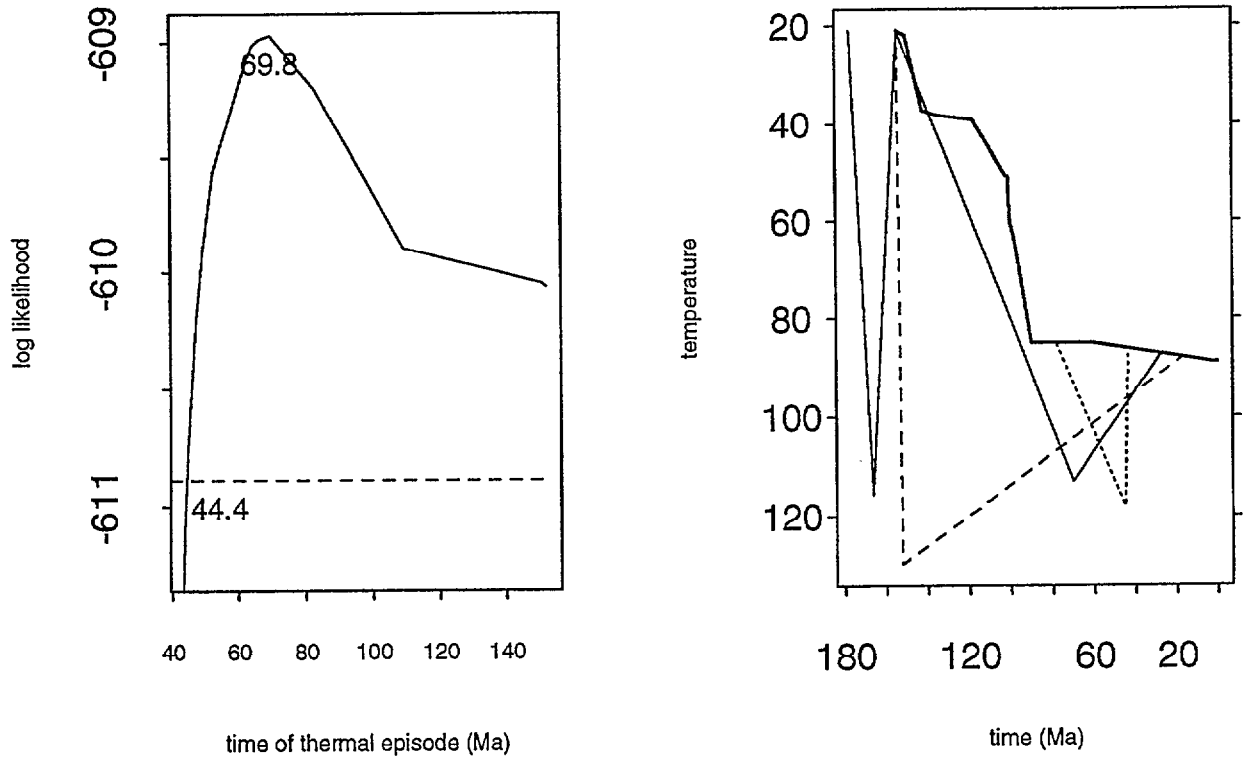


582-16


joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
140
120
100
80
60
40
20
0
time of maximum temperature (Ma)

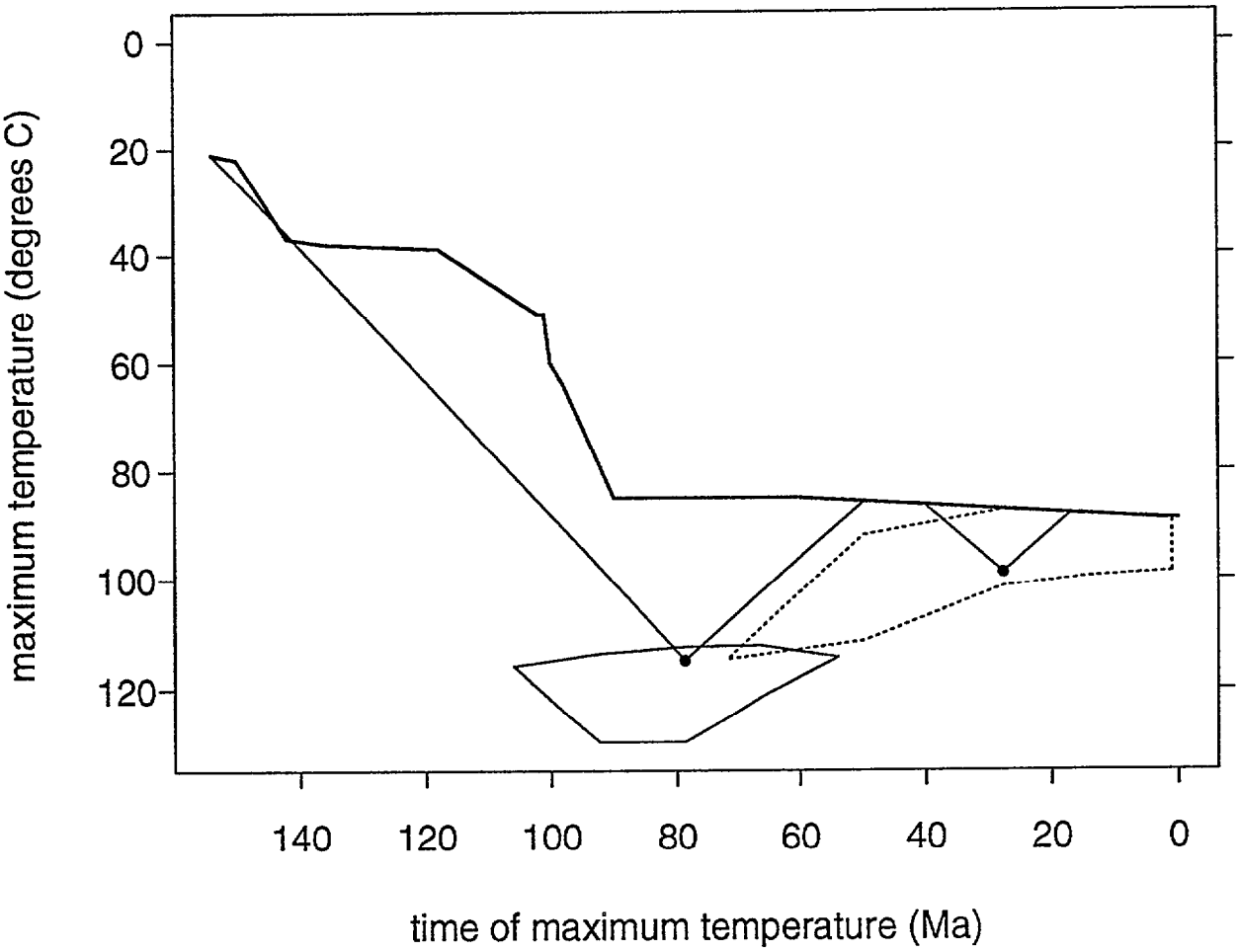
582-16


profile likelihoods
thermal histories
log likelihood
-609
-610
-611
112.5
108.6
110
115
120
125
130
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
180
120
60
20
time (Ma)


log likelihood
-609
-610
-611
69.8
44.4
40
60
80
100
120
140
time of thermal episode (Ma)
temperature
20
40
60
80
100
120
180
120
60
20
time (Ma)

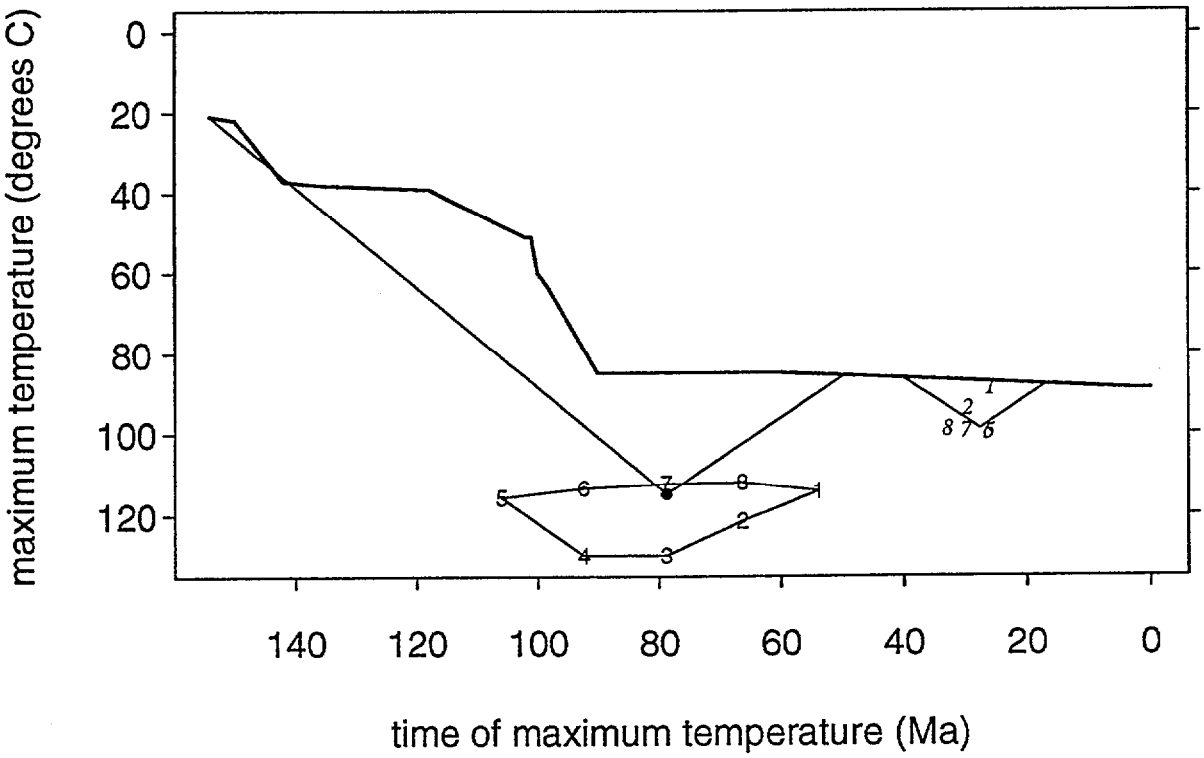
582-16

episodes 1 and 2

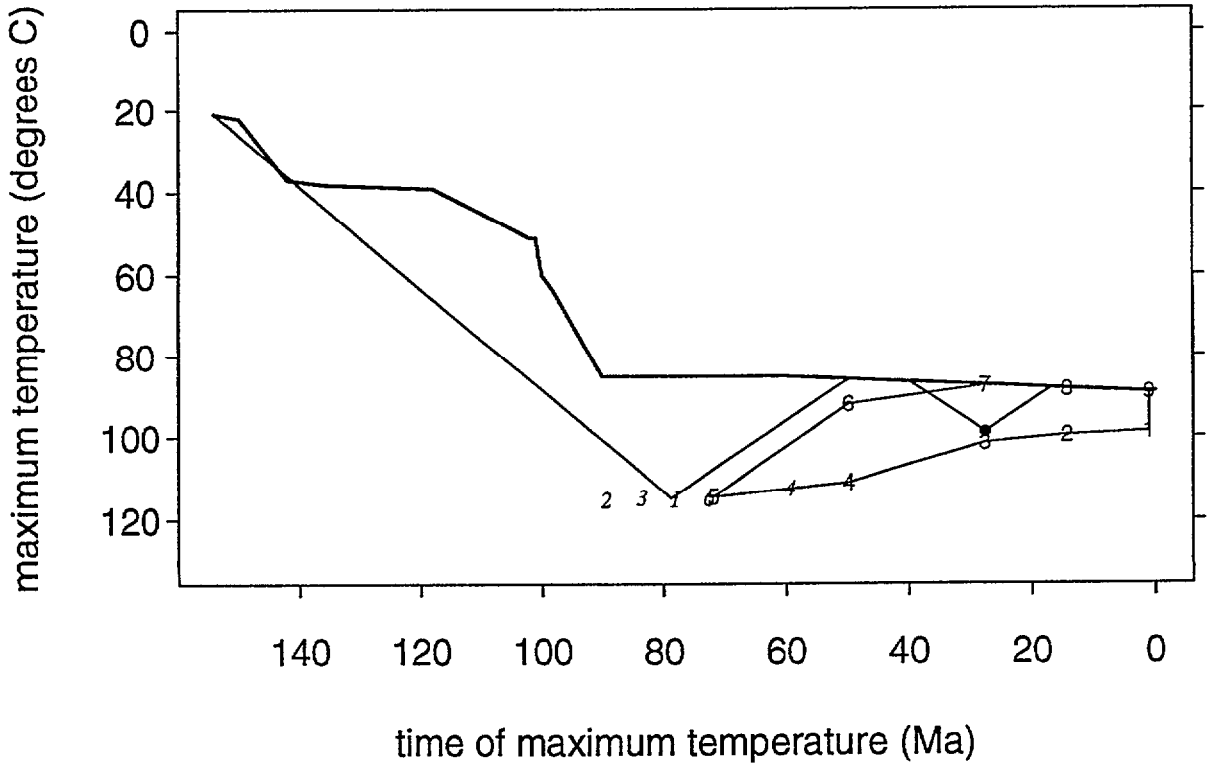


582-16

episode 1

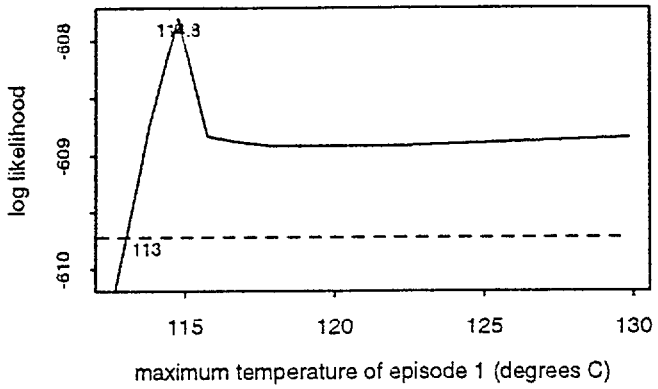


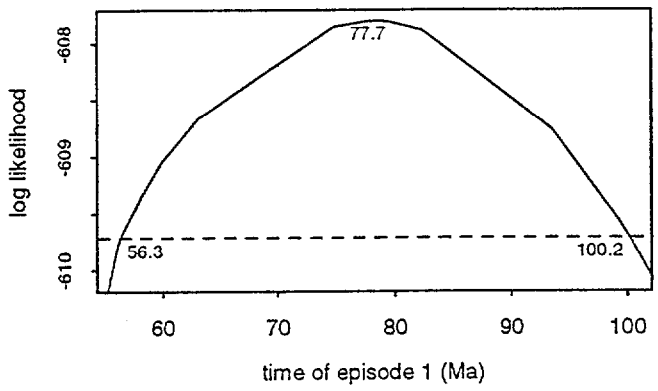
episode 2

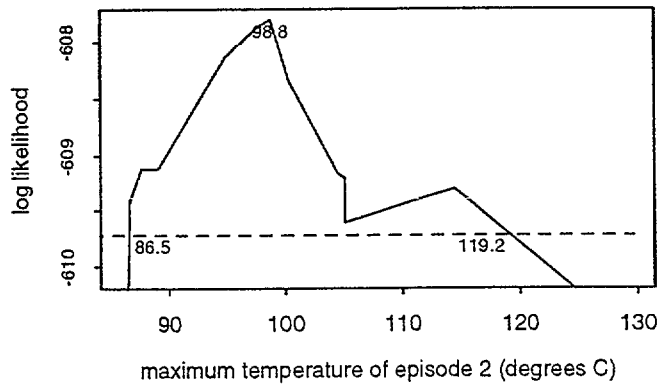


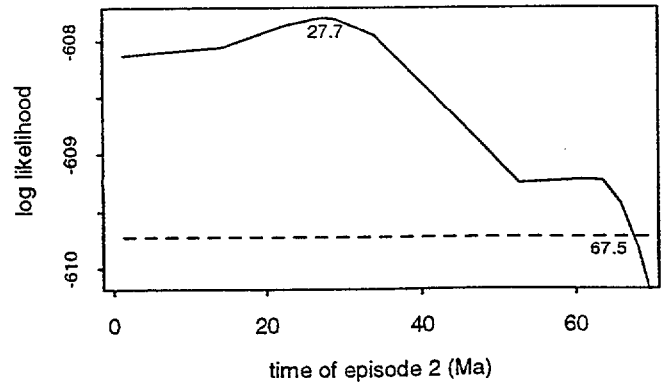
582-16

profile likelihoods

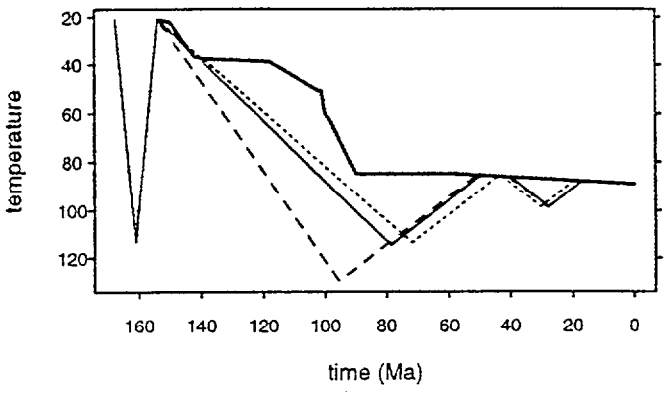


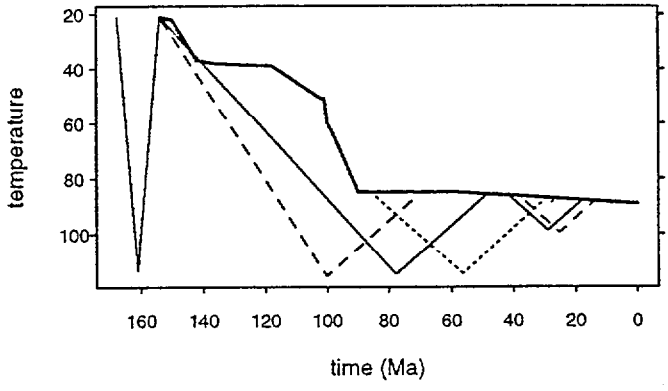


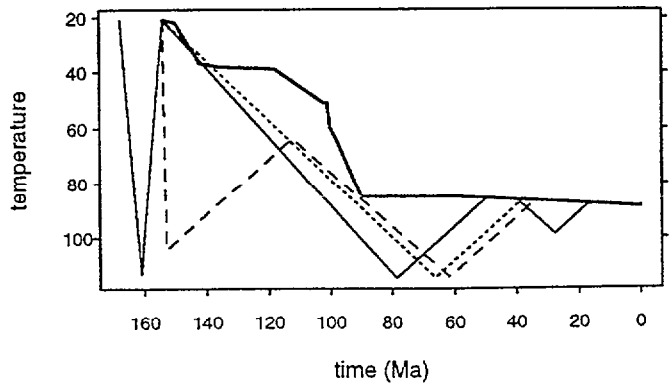


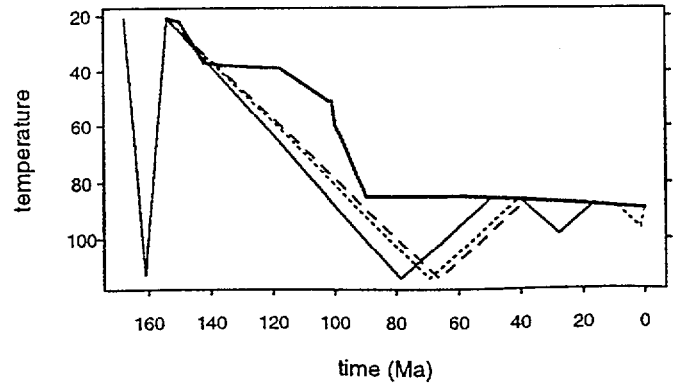


thermal histories

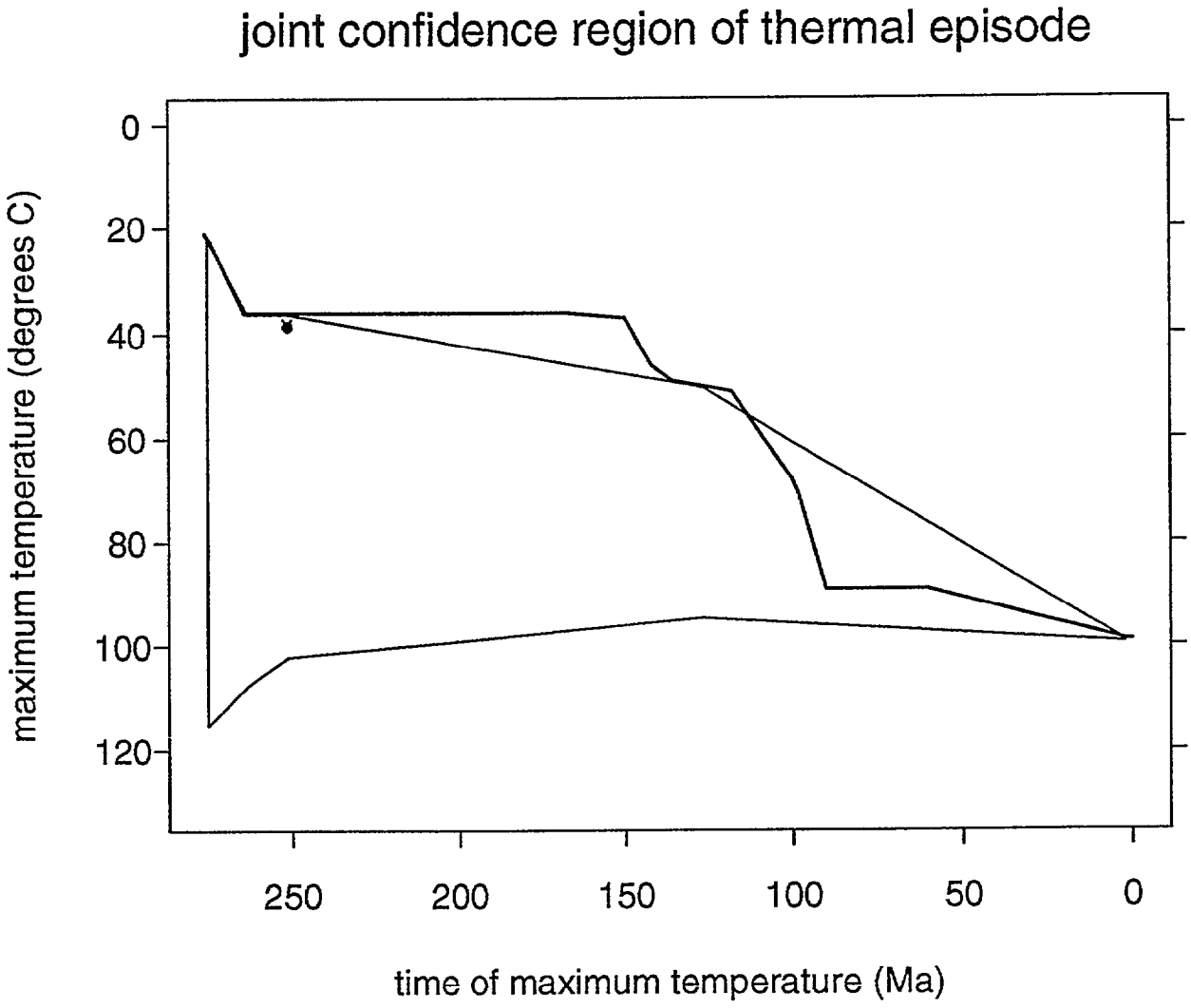




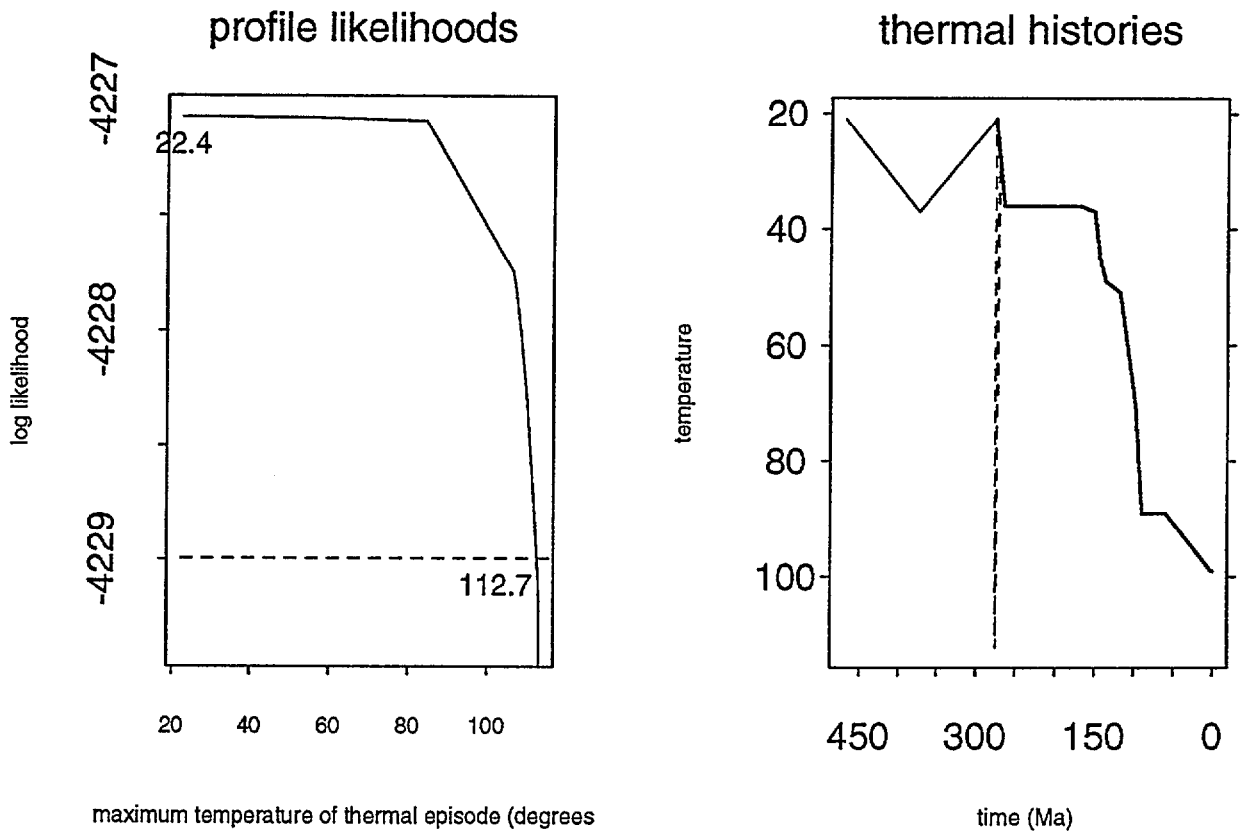


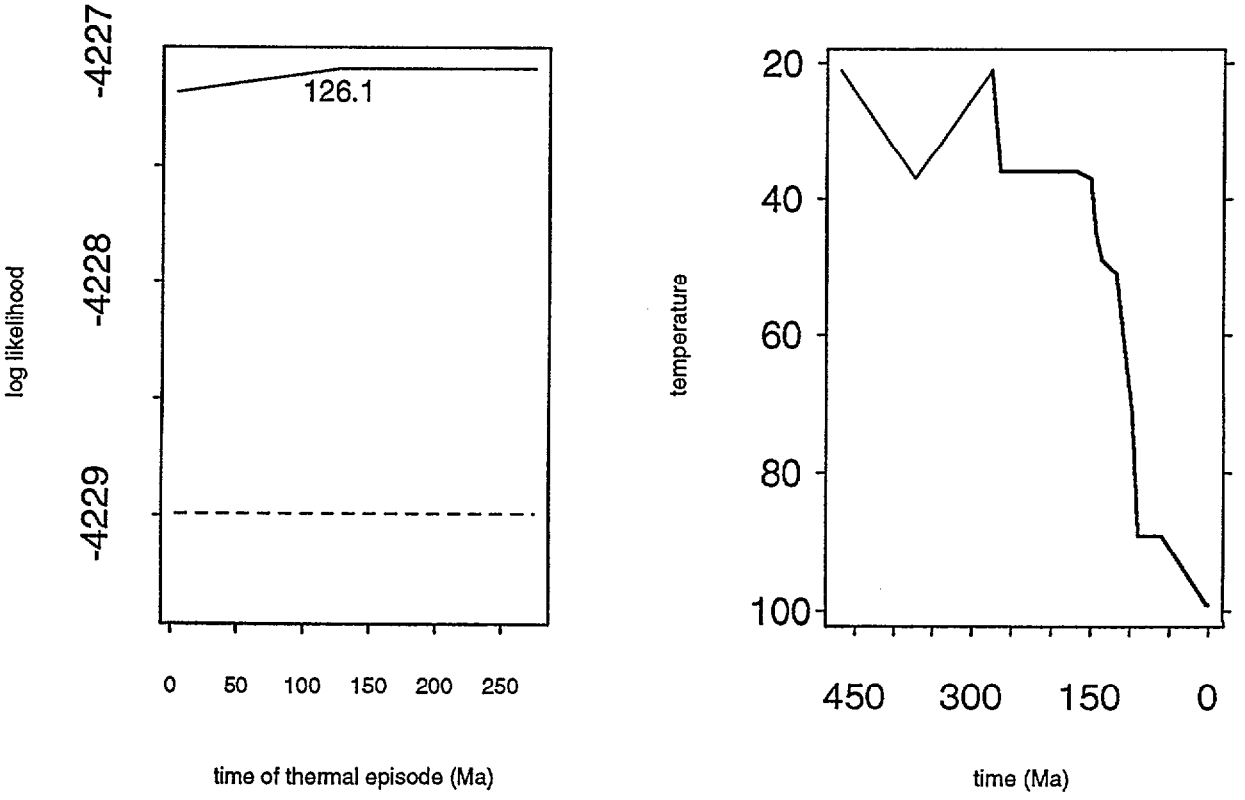


8642-54


joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
250
200
150
100
50
0
time of maximum temperature (Ma)

8642-54


profile likelihoods
thermal histories
log likelihood
-4227
-4228
-4229
22.4
112.7
20
40
60
80
100
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
450
300
150
0
time (Ma)


log likelihood
-4227
-4228
-4229
126.1
0
50
100
150
200
250
time of thermal episode (Ma)
temperature
20
40
60
80
100
450
300
150
0
time (Ma)

PART TWO:

Summary of thermal history modelling

Path: C:\JOBS\GC582
File: 582-1 .SM1 5,327 .a.. 05-12-95 13:50:38 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-1.cnn
file of lengths: 582-1.lng
zeta: 386.9030
rho d: 1.2687
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	14	0	Ma0	275.0	T0	21.0
		1	Ma1	274.0	T1	22.0
		2	Ma2	264.0	T2	23.0
		3	Ma3	260.0	T3	26.0
		4	Ma4	148.0	T4	26.0
		5	Ma5	146.0	T5	31.0
		6	Ma6	143.0	T6	33.0
		7	Ma7	142.0	T7	34.0
		8	Ma8	136.0	T8	36.0
		9	Ma9	118.0	T9	38.0
		10	Ma10	98.0	T10	59.0
		11	Ma11	90.0	T11	70.0
		12	Ma12	60.0	T12	70.0
		13	Ma13	2.0	T13	78.0
		14	Ma14	0.0	T14	78.0

LIKELIHOOD STATISTICS

number of fits + refits: 2

fit #	log likelihood
1	-392.1333
2	-391.8942

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 0.9748

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	1250.7	T0	21.0
		1	Ma1	750.8	T1	83.2
		2	Ma2	275.0	T2	21.0

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File: 582-1 .SM1 5,327 .a.. 05-12-95 13:50:38 Page 2

3	Ma3	68.7	T3	96.5	
4	Ma4	0.0	T4	78.0	

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
3	1	255	222	275.9	240.6	1.5	
4	1	7	34	50.3	240.6	-4.2	*

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.24	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.03	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.07	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.15	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.27	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.44	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.64	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.84	0	0.00	0	0.00	0	0.00	0	0.00
9	0	1.02	0	0.00	0	0.00	0	0.00	0	0.00
10	0	1.21	0	0.00	0	0.00	0	0.00	0	0.00
11	0	1.33	0	0.00	0	0.00	0	0.00	0	0.00
12	2	1.11	0	0.00	0	0.00	0	0.00	0	0.00
13	1	0.59	0	0.00	0	0.00	0	0.00	0	0.00
14	1	0.20	0	0.00	0	0.00	0	0.00	0	0.00
15	3	0.05	0	0.00	0	0.00	0	0.00	0	0.00
16	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
17	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	13.6	9.40	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		2.67		0.00		0.00		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.1	1-20	8	8.00	0.00

chi-squared statistic for lengths: 0.0 with 1 groups
chi-squared statistic for counts : 20.1 with 2 grains

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File: 582-1 .SM1 5,327 .a.. 05-12-95 13:50:38 Page 3

overall chi-squared statistic: 20.1 on -3 degrees of freedom

usual chi-squared statistic for counts : 20.0 on 1 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	68.73	100.88
1	68.73	89.86
1	274.00	119.88
1	274.00	88.07
1	171.36	101.76
1	171.36	87.22
1	2.00	99.80
1	2.00	99.06
1	35.36	100.58
1	35.36	93.25

Path: C:\JOBS\GC582
File: 582-1 .SUM 6,233 .a.. 20-09-95 11:32:40 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-1.cnn
file of lengths: 582-1.lng
zeta: 386.9030
rho_d: 1.2687
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	14	0	Ma0	275.0	T0	21.0
		1	Ma1	274.0	T1	22.0
		2	Ma2	264.0	T2	23.0
		3	Ma3	260.0	T3	26.0
		4	Ma4	148.0	T4	26.0
		5	Ma5	146.0	T5	31.0
		6	Ma6	143.0	T6	33.0
		7	Ma7	142.0	T7	34.0
		8	Ma8	136.0	T8	36.0
		9	Ma9	118.0	T9	38.0
		10	Ma10	98.0	T10	59.0
		11	Ma11	90.0	T11	70.0
		12	Ma12	60.0	T12	70.0
		13	Ma13	2.0	T13	78.0
		14	Ma14	0.0	T14	78.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-392.2500

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	10	0	Ma0	775.9	T0	21.0
		1	Ma1	774.9	T1	90.7
		2	Ma2	275.0	T2	21.0
		3	Ma3	274.0	T3	22.0

Path: C:\JOBS\GC582
File: 582-1 .SUM 6,233 .a.. 20-09-95 11:32:40 Page 2

4	Ma4	264.0	T4	23.0
5	Ma5	260.0	T5	26.0
6	Ma6	151.5	T6	26.0
7	Ma7	81.8	T7	95.7
8	Ma8	81.7	T8	95.7
9	Ma9	81.7	T9	95.7
10	Ma10	56.4	T10	70.5
11	Ma11	2.0	T11	78.0
12	Ma12	0.0	T12	78.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
3	1	255	222	275.9	240.6	1.5	
4	1	7	34	50.3	240.6	-4.2	*

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	1.11	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.04	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.10	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.22	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.40	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.63	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.83	0	0.00	0	0.00	0	0.00	0	0.00
9	0	1.00	0	0.00	0	0.00	0	0.00	0	0.00
10	0	1.21	0	0.00	0	0.00	0	0.00	0	0.00
11	0	1.43	0	0.00	0	0.00	0	0.00	0	0.00
12	2	1.23	0	0.00	0	0.00	0	0.00	0	0.00
13	1	0.63	0	0.00	0	0.00	0	0.00	0	0.00
14	1	0.20	0	0.00	0	0.00	0	0.00	0	0.00
15	3	0.05	0	0.00	0	0.00	0	0.00	0	0.00
16	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
17	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	13.6	9.33	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		4.46		0.00		0.00		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

Path: C:\JOBS\GC582
File: 582-1 .SUM 6,233 .a.. 20-09-95 11:32:40 Page 3

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.1	1-10	0	4.44	2.11
0.0-0.1	11-20	8	3.56	-2.35

chi-squared statistic for lengths: 10.0 with 2 groups
chi-squared statistic for counts : 20.1 with 2 grains
overall chi-squared statistic: 30.1 on -3 degrees of freedom

usual chi-squared statistic for counts : 20.0 on 1 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	81.76	96.91
1	81.76	90.37
1	274.00	103.22
1	274.00	92.28
1	177.88	98.06
1	177.88	90.61
1	2.00	99.13
1	2.00	96.94
1	41.88	96.56
1	41.88	90.72
2	81.66	96.90
2	81.66	70.20
2	1.00	99.28
2	1.00	78.20
2	41.33	96.70
2	41.33	72.78
2	273.00	103.22
2	273.00	99.77
2	177.33	98.05
2	177.33	26.20

Path: C:\JOBS\GC582
File: 582-3 .SM1 8,163 .a.. 04-12-95 12:17:52 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-3.cnn
file of lengths: 582-3.lng
zeta: 386.9030
rho_d: 1.2721
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	9	0	Ma0	142.0	T0	21.0
		1	Ma1	136.0	T1	24.0
		2	Ma2	118.0	T2	27.0
		3	Ma3	108.0	T3	37.0
		4	Ma4	106.0	T4	38.0
		5	Ma5	100.0	T5	46.0
		6	Ma6	98.0	T6	53.0
		7	Ma7	60.0	T7	53.0
		8	Ma8	2.0	T8	71.0
		9	Ma9	0.0	T9	71.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-1083.9692

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 0.8101

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	384.9	T0	21.0
		1	Ma1	181.4	T1	97.5
		2	Ma2	142.0	T2	21.0
		3	Ma3	37.0	T3	84.5
		4	Ma4	0.0	T4	71.0

AGE ESTIMATES

Path: C:\JOBS\GC582
File: 582-3 .SM1 8,163 .a.. 04-12-95 12:17:52 Page 2

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
3	1	35	34	248.5	136.4	2.6	
4	1	25	54	112.9	136.4	-0.8	
5	6	11	19	140.9	285.5	-1.9	
6	1	40	95	102.8	136.4	-1.5	
7	1	38	110	84.5	136.4	-2.6	
8	1	17	73	57.1	136.4	-3.4	*
9	8	3	10	73.4	297.2	-2.3	
10	1	40	170	57.6	136.4	-5.1	*
11	2	35	28	300.5	179.7	2.1	
12	1	19	17	269.3	136.4	2.1	
14	1	102	85	288.7	136.4	5.3	*
15	1	8	27	72.5	136.4	-1.6	
16	1	6	6	241.5	136.4	1.0	
17	1	12	26	112.6	136.4	-0.6	
18	5	114	76	358.9	271.8	1.9	
20	4	47	43	263.5	247.0	0.3	
21	10	13	19	166.2	303.9	-1.7	
22	1	2	9	54.5	136.4	-1.2	
23	1	63	38	395.6	136.4	5.5	*

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	37.91	0	0.03	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.02	0	0.01	0	0.00	0	0.00	0	0.00
6	0	0.04	0	0.01	0	0.00	0	0.02	0	0.00
7	0	0.08	0	0.02	0	0.00	0	0.06	0	0.02
8	0	0.27	0	0.03	0	0.00	0	0.13	0	0.08
9	0	0.98	0	0.05	0	0.00	0	0.23	0	0.20
10	5	2.34	1	0.14	0	0.00	0	0.37	1	0.38
11	2	3.44	0	0.26	0	0.00	0	0.63	0	0.62
12	3	3.19	0	0.26	0	0.00	2	0.79	1	0.81
13	1	1.86	0	0.15	0	0.00	1	0.53	1	0.61
14	1	0.63	0	0.05	0	0.00	0	0.19	0	0.23
15	1	0.11	0	0.01	0	0.00	0	0.04	0	0.04
16	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Path: C:\JOBS\GC582
File: 582-3 .SM1 8,163 .a.. 04-12-95 12:17:52 Page 3

mean:	11.0	10.76	9.5	10.71	0.0	0.00	11.8	10.83	11.2	11.10
mu*:		5.21		6.90		0.00		9.57		10.56

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.03	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.10	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.24	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.42	0	0.00	0	0.00	0	0.00	0	0.00
12	1	0.55	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.44	0	0.00	0	0.00	0	0.00	0	0.00
14	0	0.18	0	0.00	0	0.00	0	0.00	0	0.00
15	0	0.04	0	0.00	0	0.00	0	0.00	0	0.00
16	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	13.5	11.28	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		11.11		0.00		11.59		0.00		11.86

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.6	1-10	7	5.89	-0.46
0.0-0.6	11-11	2	5.37	1.45
0.0-0.6	12-12	7	5.61	-0.59
0.0-0.6	13-20	6	5.13	-0.39

chi-squared statistic for lengths: 2.8 with 4 groups
chi-squared statistic for counts : 142.8 with 19 grains
overall chi-squared statistic: 145.6 on 17 degrees of freedom

usual chi-squared statistic for counts : 172.6 on 18 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp

Path: C:\JOBS\GC582
File: 582-3 .SM1 8,163 .a.. 04-12-95 12:17:52 Page 4

1	37.04	92.38
1	37.04	74.24
1	141.00	89.74
1	141.00	74.04
1	89.02	94.94
1	89.02	72.54
1	2.00	90.86
1	2.00	83.57
1	19.52	91.88
1	19.52	77.66

Path: B:\PRINT
File: 582-3 .SUM 9,189 .a.. 20-09-95 14:21:36 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-3.cnn
file of lengths: 582-3.lng
zeta: 386.9030
rho_d: 1.2721
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	9	0	Ma0	142.0	T0	21.0
		1	Ma1	136.0	T1	24.0
		2	Ma2	118.0	T2	27.0
		3	Ma3	108.0	T3	37.0
		4	Ma4	106.0	T4	38.0
		5	Ma5	100.0	T5	46.0
		6	Ma6	98.0	T6	53.0
		7	Ma7	60.0	T7	53.0
		8	Ma8	2.0	T8	71.0
		9	Ma9	0.0	T9	71.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-1084.0064

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	13	0	Ma0	391.1	T0	21.0
		1	Ma1	184.8	T1	97.3
		2	Ma2	142.0	T2	21.0
		3	Ma3	136.0	T3	24.0
		4	Ma4	118.0	T4	27.0
		5	Ma5	108.0	T5	37.0
		6	Ma6	106.0	T6	38.0
		7	Ma7	100.0	T7	46.0
		8	Ma8	98.0	T8	53.0

9	Ma9	75.0	T9	53.0
10	Ma10	42.0	T10	86.0
11	Ma11	38.9	T11	82.8
12	Ma12	38.8	T12	82.9
13	Ma13	21.0	T13	65.1
14	Ma14	2.0	T14	71.0
15	Ma15	0.0	T15	71.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
3	1	35	34	248.5	136.4	2.6	
4	1	25	54	112.9	136.4	-0.8	
5	6	11	19	140.9	289.6	-2.0	
6	1	40	95	102.8	136.4	-1.5	
7	1	38	110	84.5	136.4	-2.6	
8	1	17	73	57.1	136.4	-3.4	*
9	8	3	10	73.4	301.7	-2.4	
10	1	40	170	57.6	136.4	-5.1	*
11	2	35	28	300.5	181.5	2.0	
12	1	19	17	269.3	136.4	2.1	
14	1	102	85	288.7	136.4	5.3	*
15	1	8	27	72.5	136.4	-1.6	
16	1	6	6	241.5	136.4	1.0	
17	1	12	26	112.6	136.4	-0.6	
18	5	114	76	358.9	275.5	1.8	
20	4	47	43	263.5	250.2	0.3	
21	10	13	19	166.2	308.5	-1.8	
22	1	2	9	54.5	136.4	-1.2	
23	1	63	38	395.6	136.4	5.5	*

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	39.51	0	0.03	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.02	0	0.01	0	0.00	0	0.00	0	0.00
6	0	0.04	0	0.01	0	0.00	0	0.02	0	0.00
7	0	0.10	0	0.02	0	0.00	0	0.06	0	0.02
8	0	0.37	0	0.03	0	0.00	0	0.13	0	0.08
9	0	1.14	0	0.06	0	0.00	0	0.23	0	0.21
10	5	2.35	1	0.15	0	0.00	0	0.38	1	0.39

11	2	3.21	0	0.25	0	0.00	0	0.65	0	0.64
12	3	3.04	0	0.25	0	0.00	2	0.78	1	0.81
13	1	1.90	0	0.15	0	0.00	1	0.51	1	0.59
14	1	0.67	0	0.05	0	0.00	0	0.19	0	0.22
15	1	0.12	0	0.01	0	0.00	0	0.04	0	0.05
16	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.0	10.72	9.5	10.67	0.0	0.00	11.8	10.80	11.2	11.07
mu*:		5.12		6.86		0.00		9.54		10.53

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.03	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.10	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.25	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.43	0	0.00	0	0.00	0	0.00	0	0.00
12	1	0.55	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.43	0	0.00	0	0.00	0	0.00	0	0.00
14	0	0.17	0	0.00	0	0.00	0	0.00	0	0.00
15	0	0.04	0	0.00	0	0.00	0	0.00	0	0.00
16	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	13.5	11.26	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		11.09		0.00		11.57		0.00		11.84

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.6	1-10	7	6.24	-0.30
0.0-0.6	11-11	2	5.17	1.39
0.0-0.6	12-12	7	5.43	-0.67
0.0-0.6	13-20	6	5.16	-0.37

chi-squared statistic for lengths: 2.6 with 4 groups
chi-squared statistic for counts : 142.7 with 19 grains
overall chi-squared statistic: 145.3 on 16 degrees of freedom

usual chi-squared statistic for counts : 172.6 on 18 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	42.02	89.21
1	42.02	76.79
1	141.00	96.42
1	141.00	78.69
1	91.51	91.24
1	91.51	77.03
1	2.00	90.67
1	2.00	83.99
1	22.01	88.68
1	22.01	77.94
2	38.79	89.13
2	38.79	59.78
2	1.00	90.78
2	1.00	71.20
2	19.90	88.61
2	19.90	65.65
2	19.90	82.10
2	87.06	90.94
2	87.06	53.20

Path: C:\JOBS\GC582
File: 582-4 .SM1 8,750 .a.. 04-12-95 12:35:52 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-4.cnn
file of lengths: 582-4.lng
zeta: 386.9030
rho_d: 1.2754
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	11	0	Ma0	156.0	T0	21.0
		1	Ma1	150.0	T1	22.0
		2	Ma2	142.0	T2	35.0
		3	Ma3	136.0	T3	36.0
		4	Ma4	118.0	T4	39.0
		5	Ma5	108.0	T5	49.0
		6	Ma6	106.0	T6	51.0
		7	Ma7	100.0	T7	58.0
		8	Ma8	98.0	T8	65.0
		9	Ma9	60.0	T9	65.0
		10	Ma10	2.0	T10	83.0
		11	Ma11	0.0	T11	83.0

LIKELIHOOD STATISTICS

number of fits + refits: 2

fit #	log likelihood
1	-994.5900
2	-992.5308

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 15.7164

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	250.5	T0	21.0
		1	Ma1	249.2	T1	100.3
		2	Ma2	156.0	T2	21.0
		3	Ma3	94.2	T3	105.3
		4	Ma4	0.0	T4	83.0

Path: C:\JOBS\GC582
File: 582-4 .SM1 8,750 .a.. 04-12-95 12:35:52 Page 2

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
4	10	20	28	173.9	194.5	-0.4	
5	4	87	138	153.7	151.4	0.1	
7	10	14	20	170.4	194.5	-0.4	
8	5	13	36	88.5	170.3	-2.1	
9	10	10	18	135.6	194.5	-0.9	
10	1	2	7	70.1	68.3	0.0	
11	1	10	86	28.6	68.3	-2.7	
12	2	6	11	133.2	100.1	0.6	
13	4	4	27	36.4	151.4	-2.9	
14	3	79	124	155.3	127.7	1.4	
16	6	34	22	370.5	181.0	2.7	
17	1	11	62	43.6	68.3	-1.4	
18	9	19	29	159.7	194.0	-0.7	
19	10	26	25	251.6	194.5	0.9	
20	7	15	10	359.9	186.2	1.7	
21	1	32	203	38.8	68.3	-3.0	*
22	1	37	31	288.0	68.3	6.5	*
23	2	16	26	150.1	100.1	1.3	
24	10	4	8	122.2	194.5	-0.8	
25	2	21	29	176.2	100.1	2.0	

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	54.41	0	0.05	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
3	0	0.01	0	0.02	0	0.01	0	0.00	0	0.00
4	0	0.01	0	0.05	0	0.03	0	0.00	0	0.00
5	0	0.02	0	0.10	0	0.09	0	0.00	0	0.00
6	0	0.03	0	0.16	0	0.21	0	0.00	0	0.01
7	0	0.09	0	0.23	0	0.40	0	0.00	0	0.04
8	0	0.41	0	0.32	1	0.62	0	0.00	0	0.14
9	0	1.49	0	0.63	0	0.85	0	0.00	2	0.34
10	2	3.51	2	1.60	1	1.46	0	0.00	0	0.60
11	6	4.98	2	2.80	1	2.68	0	0.00	1	0.89
12	4	4.06	4	2.57	7	2.83	0	0.00	0	1.05
13	4	1.84	0	1.17	1	1.39	0	0.00	1	0.69
14	1	0.46	2	0.28	0	0.34	0	0.00	0	0.21
15	0	0.07	0	0.04	0	0.06	0	0.00	0	0.03
16	0	0.01	0	0.01	0	0.01	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

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18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.3	10.55	11.3	10.42	11.0	10.35	0.0	0.00	10.0	10.83
mu*:		4.03		5.93		7.60		9.04		10.19

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.07	0	0.02	0	0.00	0	0.00	0	0.00
9	0	0.26	1	0.12	0	0.00	0	0.01	0	0.08
10	1	0.58	0	0.38	0	0.00	0	0.12	0	0.74
11	1	0.92	1	0.71	0	0.00	1	0.42	0	2.64
12	1	1.09	0	0.87	0	0.00	1	0.66	1	4.28
13	1	0.77	1	0.63	0	0.00	0	0.53	4	3.51
14	0	0.25	0	0.22	0	0.00	0	0.22	4	1.45
15	0	0.04	0	0.03	0	0.00	0	0.04	3	0.27
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.02
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.0	11.04	10.5	11.25	0.0	0.00	11.0	11.69	12.3	11.73
mu*:		10.84		11.17		0.00		11.65		11.68

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.1	1-10	2	5.58	1.51
0.0-0.1	11-11	6	4.98	-0.46
0.0-0.1	12-20	9	6.45	-1.01
0.1-0.2	1-11	4	5.93	0.79
0.1-0.2	12-20	6	4.07	-0.96
0.2-0.3	1-10	2	3.69	0.88
0.2-0.3	11-20	9	7.31	-0.62
0.3-0.7	1-11	7	5.10	-0.84
0.3-0.7	12-20	4	5.90	0.78
0.7-1.0	1-11	2	4.02	1.01
0.7-1.0	12-12	2	4.94	1.32

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0.7-1.0 13-20 11 6.04 -2.02

chi-squared statistic for lengths: 14.4 with 12 groups
chi-squared statistic for counts : 95.1 with 20 grains
overall chi-squared statistic: 109.5 on 26 degrees of freedom

usual chi-squared statistic for counts : 141.8 on 19 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	94.22	107.61
1	94.22	98.22
1	128.89	98.49
1	111.56	109.65
1	111.56	96.55
1	69.63	102.99
1	81.92	105.80
1	81.92	99.58

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File: 582-4 .SUM 9,410 .a.. 20-09-95 16:46:48 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-4.cnn
file of lengths: 582-4.lng
zeta: 386.9030
rho_d: 1.2754
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	11	0	Ma0	156.0	T0	21.0
		1	Ma1	150.0	T1	22.0
		2	Ma2	142.0	T2	35.0
		3	Ma3	136.0	T3	36.0
		4	Ma4	118.0	T4	39.0
		5	Ma5	108.0	T5	49.0
		6	Ma6	106.0	T6	51.0
		7	Ma7	100.0	T7	58.0
		8	Ma8	98.0	T8	65.0
		9	Ma9	60.0	T9	65.0
		10	Ma10	2.0	T10	83.0
		11	Ma11	0.0	T11	83.0

LIKELIHOOD STATISTICS

number of fits + refits: 2

fit #	log likelihood
1	-994.2643
2	-993.3079

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	7	0	Ma0	250.5	T0	21.0
		1	Ma1	249.2	T1	100.7
		2	Ma2	156.0	T2	21.0
		3	Ma3	102.1	T3	101.1
		4	Ma4	67.5	T4	66.6
		5	Ma5	65.8	T5	68.3

6	Ma6	62.6	T6	65.0
7	Ma7	60.0	T7	65.0
8	Ma8	2.0	T8	83.0
9	Ma9	0.0	T9	83.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
4	10	20	28	173.9	194.5	-0.4	
5	4	87	138	153.7	151.7	0.1	
7	10	14	20	170.4	194.5	-0.4	
8	5	13	36	88.5	170.3	-2.1	
9	10	10	18	135.6	194.5	-0.9	
10	1	2	7	70.1	68.7	0.0	
11	1	10	86	28.6	68.7	-2.7	
12	2	6	11	133.2	100.4	0.6	
13	4	4	27	36.4	151.7	-2.9	
14	3	79	124	155.3	128.1	1.4	
16	6	34	22	370.5	180.8	2.7	
17	1	11	62	43.6	68.7	-1.4	
18	9	19	29	159.7	194.0	-0.7	
19	10	26	25	251.6	194.5	0.9	
20	7	15	10	359.9	186.2	1.7	
21	1	32	203	38.8	68.7	-3.1	*
22	1	37	31	288.0	68.7	6.5	*
23	2	16	26	150.1	100.4	1.3	
24	10	4	8	122.2	194.5	-0.8	
25	2	21	29	176.2	100.4	2.0	

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%)									
	0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	55.05	0	0.05	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.02	0	0.01	0	0.00	0	0.00
4	0	0.01	0	0.05	0	0.03	0	0.00	0	0.00
5	0	0.02	0	0.09	0	0.09	0	0.00	0	0.00
6	0	0.05	0	0.16	0	0.21	0	0.00	0	0.01
7	0	0.15	0	0.24	0	0.39	0	0.00	0	0.04
8	0	0.52	0	0.36	1	0.62	0	0.00	0	0.14
9	0	1.60	0	0.71	0	0.89	0	0.00	2	0.33
10	2	3.51	2	1.65	1	1.53	0	0.00	0	0.60
11	6	4.85	2	2.75	1	2.68	0	0.00	1	0.91
12	4	3.94	4	2.49	7	2.77	0	0.00	0	1.06

13	4	1.81	0	1.15	1	1.37	0	0.00	1	0.68
14	1	0.46	2	0.28	0	0.34	0	0.00	0	0.21
15	0	0.07	0	0.04	0	0.06	0	0.00	0	0.03
16	0	0.01	0	0.01	0	0.01	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.3	10.49	11.3	10.38	11.0	10.33	0.0	0.00	10.0	10.83
mu*:		4.05		5.95		7.62		9.06		10.19

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.07	0	0.02	0	0.00	0	0.00	0	0.00
9	0	0.26	1	0.12	0	0.00	0	0.01	0	0.08
10	1	0.58	0	0.38	0	0.00	0	0.12	0	0.73
11	1	0.93	1	0.72	0	0.00	1	0.42	0	2.65
12	1	1.10	0	0.88	0	0.00	1	0.66	1	4.31
13	1	0.76	1	0.63	0	0.00	0	0.53	4	3.51
14	0	0.25	0	0.22	0	0.00	0	0.21	4	1.43
15	0	0.04	0	0.03	0	0.00	0	0.04	3	0.27
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.02
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.0	11.03	10.5	11.24	0.0	0.00	11.0	11.69	12.3	11.72
mu*:		10.84		11.16		0.00		11.65		11.68

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.1	1-10	2	5.86	1.60
0.0-0.1	11-11	6	4.85	-0.52
0.0-0.1	12-20	9	6.29	-1.08
0.1-0.2	1-11	4	6.03	0.83
0.1-0.2	12-20	6	3.97	-1.02
0.2-0.3	1-10	2	3.77	0.91

0.2-0.3	11-20	9	7.23	-0.66
0.3-0.7	1-11	7	5.12	-0.83
0.3-0.7	12-20	4	5.88	0.78
0.7-1.0	1-11	2	4.02	1.01
0.7-1.0	12-12	2	4.97	1.33
0.7-1.0	13-20	11	6.02	-2.03

chi-squared statistic for lengths: 15.2 with 12 groups
chi-squared statistic for counts : 94.9 with 20 grains
overall chi-squared statistic: 110.1 on 25 degrees of freedom

usual chi-squared statistic for counts : 141.8 on 19 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	102.06	103.20
1	102.06	96.07
1	102.06	101.14
1	116.39	104.12
1	116.39	96.24
1	116.39	101.82
1	89.04	101.87
1	89.04	96.35
2	65.81	91.64
2	65.81	65.20
2	1.00	88.40
2	1.00	83.20
2	33.41	86.09
2	33.41	73.51
2	33.41	73.51
2	97.66	102.78
2	97.66	69.79

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File: 582-5 .SM1 5,625 .a.. 05-12-95 14:20:56 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-5.cnn
file of lengths: 582-5.lng
zeta: 386.9030
rho_d: 1.2788
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	14	0	Ma0	509.0	T0	21.0
		1	Ma1	460.0	T1	23.0
		2	Ma2	188.0	T2	23.0
		3	Ma3	167.0	T3	29.0
		4	Ma4	150.0	T4	32.0
		5	Ma5	142.0	T5	44.0
		6	Ma6	136.0	T6	46.0
		7	Ma7	118.0	T7	48.0
		8	Ma8	108.0	T8	59.0
		9	Ma9	106.0	T9	60.0
		10	Ma10	100.0	T10	67.0
		11	Ma11	98.0	T11	75.0
		12	Ma12	60.0	T12	75.0
		13	Ma13	2.0	T13	92.0
		14	Ma14	0.0	T14	92.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-94.4881

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 3.3994

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	970.2	T0	21.0
		1	Ma1	512.4	T1	129.3
		2	Ma2	509.0	T2	21.0
		3	Ma3	130.8	T3	99.7

Path: C:\JOBS\GC582
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4 Ma4 0.0 T4 92.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	1	4	44	22.5	48.3	-1.5
6	1	5	10	122.5	48.3	1.8
7	2	12	13	224.4	142.7	1.2
8	3	17	24	172.9	219.9	-0.8
10	1	6	26	56.8	48.3	0.4
11	1	2	6	81.9	48.3	0.7
12	1	0	3	0.0	48.3	-0.8

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	84.10	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.02	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.05	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.09	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.13	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.16	0	0.00	0	0.00	0	0.00	0	0.00
10	1	0.18	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.16	0	0.00	0	0.00	0	0.00	0	0.00
12	0	0.11	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.06	0	0.00	0	0.00	0	0.00	0	0.00
14	0	0.02	0	0.00	0	0.00	0	0.00	0	0.00
15	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	9.5	9.08	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		0.69		2.07		3.22		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals

Path: C:\JOBS\GC582
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0.0-0.1 1-20 1 1.00 0.00

chi-squared statistic for lengths: 0.0 with 1 groups
chi-squared statistic for counts : 8.5 with 7 grains
overall chi-squared statistic: 8.5 on 2 degrees of freedom

usual chi-squared statistic for counts : 21.1 on 6 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	130.84	105.29
1	130.84	86.78
1	508.00	130.00
1	508.00	107.52
1	319.42	130.00
1	319.42	88.67
1	2.00	101.86
1	2.00	99.62
1	66.42	103.16
1	66.42	88.93

Path: B:\PRINT
File: 582-5 .SUM 6,834 .a.. 20-09-95 18:50:20 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-5.cnn
file of lengths: 582-5.lng
zeta: 386.9030
rho_d: 1.2788
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	14	0	Ma0	509.0	T0	21.0
		1	Ma1	460.0	T1	23.0
		2	Ma2	188.0	T2	23.0
		3	Ma3	167.0	T3	29.0
		4	Ma4	150.0	T4	32.0
		5	Ma5	142.0	T5	44.0
		6	Ma6	136.0	T6	46.0
		7	Ma7	118.0	T7	48.0
		8	Ma8	108.0	T8	59.0
		9	Ma9	106.0	T9	60.0
		10	Ma10	100.0	T10	67.0
		11	Ma11	98.0	T11	75.0
		12	Ma12	60.0	T12	75.0
		13	Ma13	2.0	T13	92.0
		14	Ma14	0.0	T14	92.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-94.5474

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	16	0	Ma0	519.7	T0	21.0
		1	Ma1	514.4	T1	95.8
		2	Ma2	509.0	T2	21.0
		3	Ma3	460.0	T3	23.0

4	Ma4	268.6	T4	23.0
5	Ma5	197.3	T5	94.3
6	Ma6	144.0	T6	41.0
7	Ma7	142.0	T7	44.0
8	Ma8	136.0	T8	46.0
9	Ma9	118.0	T9	48.0
10	Ma10	108.0	T10	59.0
11	Ma11	106.0	T11	60.0
12	Ma12	100.0	T12	67.0
13	Ma13	98.0	T13	75.0
14	Ma14	72.5	T14	75.0
15	Ma15	54.1	T15	93.4
16	Ma16	41.2	T16	80.5
17	Ma17	2.0	T17	92.0
18	Ma18	0.0	T18	92.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	1	4	44	22.5	47.5	-1.5
6	1	5	10	122.5	47.5	1.8
7	2	12	13	224.4	143.3	1.1
8	3	17	24	172.9	221.7	-0.8
10	1	6	26	56.8	47.5	0.4
11	1	2	6	81.9	47.5	0.7
12	1	0	3	0.0	47.5	-0.8

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	57.06	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.02	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.03	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.06	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.09	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.12	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.15	0	0.00	0	0.00	0	0.00	0	0.00
10	1	0.17	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.15	0	0.00	0	0.00	0	0.00	0	0.00
12	0	0.11	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.06	0	0.00	0	0.00	0	0.00	0	0.00
14	0	0.02	0	0.00	0	0.00	0	0.00	0	0.00

15	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	9.5	8.94	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		1.32		4.02		6.27		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.1	1-20	1	1.00	0.00

chi-squared statistic for lengths: 0.0 with 1 groups
chi-squared statistic for counts : 8.6 with 7 grains
overall chi-squared statistic: 8.6 on 1 degrees of freedom

usual chi-squared statistic for counts : 21.1 on 6 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	197.28	105.54
1	197.28	91.23
1	508.00	130.00
1	508.00	94.38
1	352.64	130.00
1	352.64	92.71
1	2.00	101.77
1	2.00	99.26
1	99.64	100.83
1	99.64	91.02
2	54.11	98.13
2	54.11	76.93
2	1.00	102.34
2	1.00	92.20
2	27.55	98.74
2	27.55	84.71
2	27.55	94.34
2	160.05	103.43
2	160.05	30.43

Path: C:\JOBS\GC582
File: 582-6 .SM1 8,257 .a.. 05-12-95 17:08:32 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-6.cnn
file of lengths: 582-6.lng
zeta: 386.9030
rho_d: 1.2822
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	4	0	Ma0	97.0	T0	21.0
		1	Ma1	90.0	T1	41.0
		2	Ma2	60.0	T2	41.0
		3	Ma3	2.0	T3	48.0
		4	Ma4	0.0	T4	48.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-904.0511

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 2.1262

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	144.6	T0	21.0
		1	Ma1	138.6	T1	117.0
		2	Ma2	97.0	T2	21.0
		3	Ma3	47.0	T3	43.2
		4	Ma4	0.0	T4	48.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	10	15	25	147.1	130.2	0.4
7	10	18	43	103.0	130.2	-0.8
8	10	11	25	108.2	130.2	-0.5

Path: C:\JOBS\GC582
File: 582-6 .SM1 8,257 .a.. 05-12-95 17:08:32 Page 2

10	10	6	5	291.0	130.2	1.4	
12	10	6	25	59.3	130.2	-1.8	
13	10	17	20	207.5	130.2	1.4	
14	10	40	62	158.1	130.2	1.0	
15	4	25	36	170.0	122.1	1.3	
16	10	10	27	91.2	130.2	-1.0	
17	8	43	67	157.3	128.7	1.0	
18	9	12	25	118.0	130.0	-0.3	
20	8	36	112	79.2	128.7	-2.6	
22	10	13	18	176.7	130.2	0.9	
24	4	4	3	322.5	122.1	1.3	
27	9	17	35	119.4	130.0	-0.3	
28	10	35	31	274.1	130.2	3.1	*
29	10	25	19	318.4	130.2	3.1	*
31	10	21	33	155.9	130.2	0.7	
33	10	13	26	122.8	130.2	-0.2	
34	2	47	107	108.0	117.9	-0.5	

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%)									
	0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	5.43	0	0.00	0	0.01	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
8	0	0.00	0	0.00	0	0.00	0	0.01	0	0.01
9	0	0.00	0	0.00	0	0.00	0	0.01	0	0.02
10	0	0.00	0	0.01	0	0.00	0	0.03	0	0.04
11	0	0.00	0	0.02	0	0.00	0	0.06	0	0.08
12	0	0.00	0	0.08	0	0.00	0	0.18	0	0.22
13	0	0.00	1	0.26	0	0.00	1	0.65	0	0.79
14	0	0.00	0	0.38	0	0.00	0	1.15	1	1.50
15	0	0.00	0	0.21	0	0.00	2	0.74	1	1.05
16	0	0.00	0	0.04	0	0.00	0	0.16	1	0.25
17	0	0.00	0	0.00	0	0.00	0	0.01	1	0.02
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	12.5	13.25	0.0	0.00	13.8	13.39	15.0	13.43
mu*:		0.00		12.23		0.00		12.70		12.98

chlorine (%)

Path: C:\JOBS\GC582
File: 582-6 .SM1 8,257 .a.. 05-12-95 17:08:32 Page 3

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.01	0	0.00	0	0.00	0	0.00	0	0.01
8	0	0.02	0	0.01	0	0.01	0	0.01	0	0.04
9	0	0.03	0	0.02	0	0.02	0	0.03	0	0.17
10	0	0.05	0	0.04	0	0.03	0	0.07	1	0.49
11	0	0.10	0	0.08	0	0.06	0	0.15	1	1.01
12	0	0.26	1	0.20	0	0.14	0	0.31	1	2.10
13	1	0.92	0	0.69	0	0.48	0	1.03	1	6.83
14	1	1.85	1	1.45	3	1.07	1	2.43	6	16.23
15	1	1.38	2	1.15	0	0.90	3	2.21	20	14.95
16	2	0.35	0	0.31	0	0.26	1	0.68	13	4.67
17	0	0.03	0	0.03	0	0.02	2	0.07	2	0.48
18	0	0.00	0	0.00	0	0.00	0	0.00	2	0.02
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	14.3	13.47	13.5	13.53	13.5	13.59	15.1	13.67	14.6	13.68
mu*:		13.14		13.29		13.42		13.57		13.59

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals	
0.0-0.6	1-13	3	3.88	0.45	
0.0-0.6	14-14	2	4.88	1.30	
0.0-0.6	15-20	8	4.24	-1.83	
0.6-0.9	1-14	6	8.36	0.82	
0.6-0.9	15-20	8	5.64	-0.99	
0.9-1.0	1-12	3	3.82	0.42	
0.9-1.0	13-13	1	6.83	2.23	
0.9-1.0	14-14	6	16.23	2.54	
0.9-1.0	15-15	20	14.95	-1.31	
0.9-1.0	16-20	17	5.16	-5.21	*

chi-squared statistic for lengths: 47.4 with 10 groups
chi-squared statistic for counts : 42.4 with 20 grains
overall chi-squared statistic: 89.8 on 24 degrees of freedom

usual chi-squared statistic for counts : 41.5 on 19 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

Path: C:\JOBS\GC582
File: 582-6 .SM1 8,257 .a.. 05-12-95 17:08:32 Page 4

episode	time	Temp
1	46.96	57.27
1	46.96	42.77
1	96.00	82.62
1	96.00	24.06
1	71.48	62.84
1	71.48	41.20
1	2.00	54.47
1	2.00	48.20
1	24.48	55.75
1	24.48	45.49

Path: C:\JOBS\GC582
File: 582-7 .SM1 7,419 .a.. 04-12-95 13:16:08 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-7.cnn
file of lengths: 582-7.lng
zeta: 386.9030
rho_d: 1.2855
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	11	0	Ma0	143.0	T0	21.0
		1	Ma1	142.0	T1	22.0
		2	Ma2	136.0	T2	23.0
		3	Ma3	118.0	T3	26.0
		4	Ma4	108.0	T4	39.0
		5	Ma5	106.0	T5	40.0
		6	Ma6	100.0	T6	50.0
		7	Ma7	98.0	T7	53.0
		8	Ma8	90.0	T8	75.0
		9	Ma9	60.0	T9	75.0
		10	Ma10	2.0	T10	83.0
		11	Ma11	0.0	T11	83.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-614.5929

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 0.8919

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	725.8	T0	21.0
		1	Ma1	441.2	T1	123.4
		2	Ma2	143.0	T2	21.0
		3	Ma3	42.1	T3	99.7
		4	Ma4	0.0	T4	83.0

Path: C:\JOBS\GC582
File: 582-7 .SM1 7,419 .a.. 04-12-95 13:16:08 Page 2

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	5	13	13	244.0	245.8	0.0
4	10	6	16	92.6	316.4	-2.8
5	10	11	15	179.8	316.4	-1.5
6	1	39	501	19.3	28.6	-2.4
7	1	6	61	24.4	28.6	-0.4
8	1	9	53	42.1	28.6	1.1
9	2	147	325	111.5	92.3	1.9
10	1	18	78	57.1	28.6	2.7

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	87.68	0	51.38	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.02	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.06	0	0.00	0	0.00	0	0.00
4	0	0.01	0	0.14	0	0.00	0	0.00	0	0.00
5	0	0.01	0	0.26	0	0.00	0	0.00	0	0.00
6	0	0.02	0	0.43	0	0.00	0	0.00	0	0.00
7	0	0.04	0	0.62	0	0.00	0	0.00	0	0.00
8	0	0.08	0	0.79	0	0.00	0	0.00	0	0.00
9	0	0.17	2	0.98	0	0.00	0	0.00	0	0.00
10	1	0.34	0	1.28	0	0.00	0	0.00	0	0.00
11	1	0.51	5	1.66	0	0.00	0	0.00	0	0.00
12	0	0.48	1	1.55	0	0.00	0	0.00	0	0.00
13	0	0.25	1	0.84	0	0.00	0	0.00	0	0.00
14	0	0.07	0	0.27	0	0.00	0	0.00	0	0.00
15	0	0.01	0	0.06	0	0.00	0	0.00	0	0.00
16	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	10.0	10.44	10.4	9.48	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		0.56		1.82		0.00		0.00		4.92

	chlorine (%) 0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	39.62

Path: C:\JOBS\GC582
File: 582-7 .SM1 7,419 .a.. 04-12-95 13:16:08 Page 3

1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.02
10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.10
11	0	0.00	0	0.00	0	0.00	0	0.00	0	0.27
12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.34
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.19
14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.05
15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
16	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	15.5	11.22
mu*:		0.00		0.00		0.00		0.00		6.38

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-1.0	1- 9	2	3.69	0.88
0.0-1.0	10-11	7	4.16	-1.39
0.0-1.0	12-20	3	4.16	0.57

chi-squared statistic for lengths: 3.0 with 3 groups
chi-squared statistic for counts : 27.9 with 8 grains
overall chi-squared statistic: 30.9 on 5 degrees of freedom

usual chi-squared statistic for counts : 125.5 on 7 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	42.12	104.15
1	42.12	98.56
1	80.87	92.98
1	61.49	97.98
1	61.49	94.25
1	9.77	102.84
1	25.94	103.44
1	25.94	98.34

Path: B:\PRINT
File: 582-7 .SUM 8,567 .a.. 20-09-95 22:42:34 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-7.cnn
file of lengths: 582-7.lng
zeta: 386.9030
rho_d: 1.2855
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	11	0	Ma0	143.0	T0	21.0
		1	Ma1	142.0	T1	22.0
		2	Ma2	136.0	T2	23.0
		3	Ma3	118.0	T3	26.0
		4	Ma4	108.0	T4	39.0
		5	Ma5	106.0	T5	40.0
		6	Ma6	100.0	T6	50.0
		7	Ma7	98.0	T7	53.0
		8	Ma8	90.0	T8	75.0
		9	Ma9	60.0	T9	75.0
		10	Ma10	2.0	T10	83.0
		11	Ma11	0.0	T11	83.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-614.0775

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	15	0	Ma0	399.9	T0	21.0
		1	Ma1	398.8	T1	107.9
		2	Ma2	143.0	T2	21.0
		3	Ma3	142.0	T3	22.0
		4	Ma4	136.0	T4	23.0
		5	Ma5	118.0	T5	26.0
		6	Ma6	108.0	T6	39.0

7	Ma7	106.0	T7	40.0
8	Ma8	100.0	T8	50.0
9	Ma9	98.0	T9	53.0
10	Ma10	90.0	T10	75.0
11	Ma11	66.9	T11	75.0
12	Ma12	42.2	T12	99.7
13	Ma13	32.5	T13	90.0
14	Ma14	30.7	T14	91.8
15	Ma15	19.5	T15	80.6
16	Ma16	2.0	T16	83.0
17	Ma17	0.0	T17	83.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	5	13	13	244.0	246.0	0.0
4	10	6	16	92.6	300.7	-2.6
5	10	11	15	179.8	300.7	-1.3
6	1	39	501	19.3	28.3	-2.3
7	1	6	61	24.4	28.3	-0.3
8	1	9	53	42.1	28.3	1.1
9	2	147	325	111.5	92.4	1.9
10	1	18	78	57.1	28.3	2.7

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	77.07	0	9.32	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.02	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.06	0	0.00	0	0.00	0	0.00
4	0	0.01	0	0.14	0	0.00	0	0.00	0	0.00
5	0	0.01	0	0.26	0	0.00	0	0.00	0	0.00
6	0	0.02	0	0.43	0	0.00	0	0.00	0	0.00
7	0	0.04	0	0.63	0	0.00	0	0.00	0	0.00
8	0	0.08	0	0.81	0	0.00	0	0.00	0	0.00
9	0	0.17	2	0.99	0	0.00	0	0.00	0	0.00
10	1	0.33	0	1.28	0	0.00	0	0.00	0	0.00
11	1	0.50	5	1.64	0	0.00	0	0.00	0	0.00
12	0	0.47	1	1.53	0	0.00	0	0.00	0	0.00
13	0	0.25	1	0.84	0	0.00	0	0.00	0	0.00
14	0	0.07	0	0.27	0	0.00	0	0.00	0	0.00
15	0	0.01	0	0.06	0	0.00	0	0.00	0	0.00
16	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

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18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	10.0	10.42	10.4	9.46	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		1.03		3.39		0.00		0.00		9.17

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.09
11	0	0.00	0	0.00	0	0.00	0	0.00	0	0.28
12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.35
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.20
14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.05
15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
16	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	15.5	11.31
mu*:		0.00		0.00		0.00		0.00		11.28

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-1.0	1- 9	2	3.72	0.89
0.0-1.0	10-11	7	4.13	-1.41
0.0-1.0	12-20	3	4.15	0.56

chi-squared statistic for lengths: 3.1 with 3 groups
chi-squared statistic for counts : 26.7 with 8 grains
overall chi-squared statistic: 29.8 on 4 degrees of freedom

usual chi-squared statistic for counts : 125.5 on 7 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)

OF THE THERMAL EPISODES

episode	time	Temp
1	42.22	100.58
1	42.22	96.15
1	42.22	99.65
1	89.21	98.32
1	89.21	96.67
1	89.21	96.90
1	27.38	99.91
1	27.38	96.65
2	30.72	100.19
2	30.72	79.24
2	1.00	98.56
2	1.00	83.20
2	15.86	99.67
2	15.86	81.29
2	15.86	81.94
2	43.62	100.39
2	43.62	86.99

Path: C:\JOBS\GC582
File: 582-8 .SM1 8,222 .a.. 05-12-95 17:20:42 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-8.cnn
file of lengths: 582-8.lng
zeta: 386.9030
rho_d: 1.2889
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	15	0	Ma0	172.0	T0	21.0
		1	Ma1	167.0	T1	24.0
		2	Ma2	150.0	T2	28.0
		3	Ma3	148.0	T3	31.0
		4	Ma4	146.0	T4	35.0
		5	Ma5	142.0	T5	37.0
		6	Ma6	136.0	T6	38.0
		7	Ma7	118.0	T7	41.0
		8	Ma8	108.0	T8	54.0
		9	Ma9	106.0	T9	55.0
		10	Ma10	100.0	T10	65.0
		11	Ma11	98.0	T11	68.0
		12	Ma12	90.0	T12	90.0
		13	Ma13	60.0	T13	90.0
		14	Ma14	2.0	T14	98.0
		15	Ma15	0.0	T15	98.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-584.1225

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 1.0981

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	183.0	T0	21.0
		1	Ma1	177.2	T1	31.3
		2	Ma2	172.0	T2	21.0

Path: C:\JOBS\GC582
File: 582-8 .SM1 8,222 .a.. 05-12-95 17:20:42 Page 2

3	Ma3	150.1	T3	30.2
4	Ma4	0.0	T4	98.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
4	2	0	17	0.0	11.0	-0.9	
6	1	2	4	123.5	5.9	5.0	*
7	7	22	89	61.3	117.6	-2.8	
8	5	11	52	52.5	92.6	-1.7	
10	1	2	256	1.9	5.9	-1.6	
11	10	24	30	196.4	132.8	1.5	
12	10	10	19	129.9	132.8	-0.1	
13	1	4	42	23.7	5.9	2.9	
14	1	6	40	37.3	5.9	4.8	*
15	1	2	13	38.2	5.9	2.8	
18	3	34	49	170.7	34.6	8.0	*
19	1	58	66	215.5	5.9	32.9	*
20	1	5	10	123.5	5.9	8.0	*
21	10	6	7	210.2	132.8	0.8	
22	5	6	5	292.5	92.6	2.0	
23	8	2	11	45.2	127.5	-1.4	

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	88.41	0	0.00	0	0.17	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.01	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.03	0	0.00	0	0.00
4	0	0.01	0	0.00	0	0.05	0	0.00	0	0.00
5	0	0.02	0	0.00	0	0.10	0	0.00	0	0.01
6	0	0.03	0	0.00	0	0.17	0	0.00	0	0.02
7	0	0.06	0	0.00	0	0.26	0	0.00	0	0.05
8	0	0.09	0	0.00	0	0.35	0	0.00	1	0.11
9	0	0.14	0	0.00	0	0.44	0	0.00	0	0.17
10	0	0.18	0	0.00	0	0.49	0	0.00	0	0.21
11	0	0.19	0	0.00	1	0.47	0	0.00	0	0.20
12	0	0.16	0	0.00	1	0.35	0	0.00	0	0.14
13	1	0.08	0	0.00	1	0.18	0	0.00	0	0.07
14	0	0.03	0	0.00	0	0.07	0	0.00	0	0.02
15	0	0.01	0	0.00	0	0.02	0	0.00	0	0.00
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	12.5	9.60	0.0	0.00	11.5	8.96	0.0	0.00	7.5	9.66
mu*:		0.48		0.89		2.82		0.00		7.58

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.04	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.15	0	0.00	0	0.00	0	0.02
9	0	0.00	0	0.39	0	0.00	0	0.00	0	0.15
10	0	0.00	0	0.68	0	0.00	0	0.00	1	0.63
11	0	0.00	3	0.80	0	0.00	0	0.00	1	1.29
12	0	0.00	0	0.59	0	0.00	0	0.00	1	1.23
13	0	0.00	0	0.27	0	0.00	0	0.00	0	0.55
14	0	0.00	0	0.07	0	0.00	0	0.00	0	0.12
15	0	0.00	0	0.01	0	0.00	0	0.00	1	0.01
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	10.5	10.27	0.0	0.00	0.0	0.00	11.5	10.94
mu*:		0.00		9.66		10.48		0.00		10.92

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-1.0	1-10	2	5.05	1.36
0.0-1.0	11-20	10	6.95	-1.16

chi-squared statistic for lengths: 3.2 with 2 groups
chi-squared statistic for counts : 1297.8 with 16 grains
overall chi-squared statistic: 1301.0 on 12 degrees of freedom

usual chi-squared statistic for counts : 177.5 on 15 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

Path: C:\JOBS\GC582
File: 582-8 .SM1 8,222 .a.. 05-12-95 17:20:42 Page 4

episode	time	Temp
1	150.07	130.00
1	150.07	28.18
1	171.00	130.00
1	171.00	21.80
1	160.54	130.00
1	160.54	25.72
1	2.00	99.67
1	2.00	98.20
1	76.04	100.36
1	76.04	90.20

Path: C:\JOBS\GC582
File: 582-10 .SM1 7,413 .a.. 05-12-95 17:35:20 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-10.cnn
file of lengths: 582-10.lng
zeta: 386.9030
rho d: 1.2956
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	18	0	Ma0	213.0	T0	21.0
		1	Ma1	206.0	T1	22.0
		2	Ma2	193.0	T2	22.0
		3	Ma3	188.0	T3	25.0
		4	Ma4	167.0	T4	38.0
		5	Ma5	150.0	T5	42.0
		6	Ma6	148.0	T6	45.0
		7	Ma7	146.0	T7	49.0
		8	Ma8	142.0	T8	51.0
		9	Ma9	136.0	T9	53.0
		10	Ma10	118.0	T10	55.0
		11	Ma11	108.0	T11	68.0
		12	Ma12	106.0	T12	69.0
		13	Ma13	100.0	T13	79.0
		14	Ma14	98.0	T14	82.0
		15	Ma15	90.0	T15	104.0
		16	Ma16	60.0	T16	104.0
		17	Ma17	2.0	T17	112.0
		18	Ma18	0.0	T18	112.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-91.2307

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 1.0373

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate

Path: C:\JOBS\GC582
File: 582-10 .SM1 7,413 .a.. 05-12-95 17:35:20 Page 2

2	2	0	Ma0	405.3	T0	21.0
		1	Ma1	309.2	T1	99.0
		2	Ma2	213.0	T2	21.0
		3	Ma3	106.6	T3	90.1
		4	Ma4	0.0	T4	112.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	10	12	19	156.4	156.4	0.0
4	5	16	24	165.0	5.6	16.3 *

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	94.64
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.02
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.04
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.07
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.13
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.20
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.29
10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.36
11	0	0.00	0	0.00	0	0.00	0	0.00	0	0.37
12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.29
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.15
14	0	0.00	0	0.00	0	0.00	0	0.00	1	0.05
15	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	14.0	9.44
mu*:		0.00		0.00		0.00		0.00		0.20

	chlorine (%) 0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit

Path: C:\JOBS\GC582
File: 582-10 .SM1 7,413 .a.. 05-12-95 17:35:20 Page 3

0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		0.00		0.00		0.00		0.00		5.72

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.5	1-20	2	2.00	0.00

chi-squared statistic for lengths: 0.0 with 1 groups
chi-squared statistic for counts : 266.9 with 2 grains
overall chi-squared statistic: 266.9 on -3 degrees of freedom

usual chi-squared statistic for counts : 0.0 on 1 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	106.62	123.71
1	106.62	68.89
1	212.00	130.00
1	212.00	21.34
1	159.31	130.00
1	159.31	40.01
1	2.00	115.93
1	2.00	112.20
1	54.31	121.98
1	54.31	104.98

Path: C:\JOBS\GC582
File: 582-11 .SM1 6,996 .a.. 05-12-95 17:48:42 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-11.cnn
file of lengths: 582-11.lng
zeta: 386.9030
rho d: 1.2989
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	4	0	Ma0	95.0	T0	21.0
		1	Ma1	90.0	T1	37.0
		2	Ma2	60.0	T2	37.0
		3	Ma3	2.0	T3	44.0
		4	Ma4	0.0	T4	44.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-157.3064

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 1.1055

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	228.8	T0	21.0
		1	Ma1	167.0	T1	111.2
		2	Ma2	95.0	T2	21.0
		3	Ma3	93.1	T3	29.5
		4	Ma4	0.0	T4	44.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	10	6	6	246.5	193.6	0.4
4	10	13	15	214.2	193.6	0.3
5	10	11	12	226.3	193.6	0.4

Path: C:\JOBS\GC582
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6	5	14	16	216.2	166.0	0.7
7	6	3	5	149.0	173.4	-0.2
9	7	4	7	142.0	180.1	-0.4
11	6	7	6	286.7	173.4	0.9
13	10	9	10	222.3	193.6	0.3
17	1	1	7	35.8	138.9	-1.4
19	10	16	21	188.7	193.6	-0.1

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

chlorine (%)

	0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		9.04		0.00		0.00		0.00		10.89

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.01	0	0.00	0	0.00	0	0.00	0	0.01
8	0	0.02	0	0.00	0	0.00	0	0.00	0	0.06
9	0	0.02	0	0.00	0	0.00	0	0.00	0	0.21
10	0	0.03	0	0.00	0	0.00	0	0.00	1	0.45
11	0	0.04	0	0.00	0	0.00	0	0.00	0	0.63
12	0	0.06	0	0.00	0	0.00	0	0.00	0	0.71
13	0	0.15	0	0.00	0	0.00	0	0.00	0	1.15
14	0	0.31	0	0.00	0	0.00	0	0.00	0	2.41
15	0	0.26	0	0.00	0	0.00	0	0.00	4	2.41
16	1	0.08	0	0.00	0	0.00	0	0.00	2	0.85
17	0	0.01	0	0.00	0	0.00	0	0.00	1	0.10
18	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	15.5	13.07	0.0	0.00	0.0	0.00	0.0	0.00	14.7	13.12
mu*:		11.39		11.84		0.00		0.00		12.75

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-1.0	1-13	1	3.58	1.36
0.0-1.0	14-20	9	6.42	-1.02

chi-squared statistic for lengths: 2.9 with 2 groups
chi-squared statistic for counts : 4.0 with 10 grains
overall chi-squared statistic: 6.9 on 6 degrees of freedom

usual chi-squared statistic for counts : 4.7 on 9 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	93.09	130.00
1	93.09	27.31
1	2.00	58.19
1	2.00	44.20
1	47.55	67.00
1	47.55	38.70

Path: C:\JOBS\GC582
File: 582-13 .SM1 8,171 .a.. 05-12-95 16:45:50 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-13.cnn
file of lengths: 582-13.lng
zeta: 386.9030
rho d: 1.3023
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	3	0	Ma0	800.0	T0	21.0
		1	Ma1	600.0	T1	21.0
		2	Ma2	200.0	T2	21.0
		3	Ma3	0.0	T3	21.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-1235.1528

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 1.0631

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	812.2	T0	21.0
		1	Ma1	806.2	T1	121.0
		2	Ma2	800.0	T2	21.0
		3	Ma3	452.0	T3	119.7
		4	Ma4	0.0	T4	21.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
5	4	81	66	302.0	413.5	-2.0
8	3	23	11	506.4	409.9	0.6
10	4	43	28	375.7	413.5	-0.4
13	3	25	14	434.9	409.9	0.2

Path: C:\JOBS\GC582
File: 582-13 .SM1 8,171 .a.. 05-12-95 16:45:50 Page 2

14	4	34	21	395.5	413.5	-0.2
15	4	47	29	395.9	413.5	-0.2
18	4	121	98	303.8	413.5	-2.3
19	3	19	11	421.1	409.9	0.1
20	3	29	13	538.8	409.9	0.9
21	3	52	34	374.2	409.9	-0.4
23	4	78	38	497.4	413.5	1.0
24	4	36	31	286.1	413.5	-1.6
25	3	123	78	385.5	409.9	-0.4
36	5	49	21	562.6	417.3	1.2
28	4	6	4	367.2	413.5	-0.2
29	4	75	36	504.6	413.5	1.0
30	4	98	47	505.0	413.5	1.2
31	4	35	11	755.5	413.5	1.9
32	4	36	14	617.3	413.5	1.3
34	3	28	13	521.0	409.9	0.7

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	47.62	0	0.00	0	46.89	0	46.46	0	45.96
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.01	0	0.00
6	0	0.00	0	0.00	0	0.01	0	0.01	0	0.00
7	0	0.00	0	0.00	0	0.02	0	0.03	0	0.01
8	0	0.00	0	0.00	0	0.04	0	0.06	0	0.01
9	0	0.00	0	0.00	0	0.08	0	0.12	0	0.03
10	0	0.00	0	0.00	0	0.17	0	0.26	0	0.05
11	0	0.01	0	0.00	0	0.36	2	0.54	0	0.11
12	1	0.02	0	0.00	2	0.77	0	1.12	0	0.22
13	0	0.10	0	0.00	1	2.82	4	3.87	0	0.73
14	0	0.31	0	0.00	13	9.62	18	13.55	4	2.60
15	0	0.38	0	0.00	12	13.15	19	19.49	6	3.92
16	0	0.16	0	0.00	6	6.03	7	9.40	0	1.98
17	0	0.02	0	0.00	0	0.89	0	1.45	0	0.32
18	0	0.00	0	0.00	0	0.04	0	0.07	0	0.02
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.5	14.03	0.0	0.00	14.1	14.12	14.0	14.16	14.1	14.19
mu*:		7.22		0.00		7.36		7.44		7.51

	chlorine (%) 0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0

Path: C:\JOBS\GC582
File: 582-13 .SM1 8,171 .a.. 05-12-95 16:45:50 Page 3

length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	45.58	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.03	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.06	0	0.00	0	0.00	0	0.00	0	0.00
12	0	0.11	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.35	0	0.00	0	0.00	0	0.00	0	0.00
14	1	1.25	0	0.00	0	0.00	0	0.00	0	0.00
15	3	1.97	0	0.00	0	0.00	0	0.00	0	0.00
16	1	1.03	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.17	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	14.5	14.22	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		7.57		0.00		0.00		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.3	1-13	4	4.41	0.20
0.0-0.3	14-14	13	9.92	-0.98
0.0-0.3	15-15	12	13.52	0.41
0.0-0.3	16-20	6	7.14	0.43
0.3-0.4	1-13	6	6.03	0.01
0.3-0.4	14-14	18	13.55	-1.21
0.3-0.4	15-15	19	19.49	0.11
0.3-0.4	16-20	7	10.92	1.19
0.4-0.6	1-14	5	5.58	0.25
0.4-0.6	15-15	9	5.88	-1.28
0.4-0.6	16-20	1	3.53	1.35

chi-squared statistic for lengths: 7.8 with 11 groups
chi-squared statistic for counts : 24.0 with 20 grains
overall chi-squared statistic: 31.8 on 25 degrees of freedom

usual chi-squared statistic for counts : 24.0 on 19 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

Path: C:\JOBS\GC582
File: 582-13 .SM1 8,171 .a.. 05-12-95 16:45:50 Page 4

episode	time	Temp
1	451.99	130.00
1	451.99	108.47
1	541.93	130.00
1	496.96	130.00
1	496.96	110.31
1	397.66	117.19
1	424.83	130.00
1	424.83	109.26

Path: C:\JOBS\GC582
File: 582-13 .SUM 8,692 .a.. 05-12-95 16:29:50 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-13.cnn
file of lengths: 582-13.lng
zeta: 386.9030
rho_d: 1.3023
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	3	0	Ma0	800.0	T0	21.0
		1	Ma1	600.0	T1	21.0
		2	Ma2	200.0	T2	21.0
		3	Ma3	0.0	T3	21.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-1233.3096

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	8	0	Ma0	872.1	T0	21.0
		1	Ma1	866.1	T1	129.8
		2	Ma2	800.0	T2	21.0
		3	Ma3	600.0	T3	21.0
		4	Ma4	585.2	T4	21.0
		5	Ma5	471.7	T5	134.5
		6	Ma6	358.1	T6	21.0
		7	Ma7	200.0	T7	21.0
		8	Ma8	20.6	T8	21.0
		9	Ma9	1.0	T9	40.6
		10	Ma10	0.0	T10	21.0

AGE ESTIMATES

Path: C:\JOBS\GC582
File: 582-13 .SUM 8,692 .a.. 05-12-95 16:29:50 Page 2

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
5	4	81	66	302.0	412.0	-1.9
8	3	23	11	506.4	408.0	0.6
10	4	43	28	375.7	412.0	-0.4
13	3	25	14	434.9	408.0	0.2
14	4	34	21	395.5	412.0	-0.2
15	4	47	29	395.9	412.0	-0.2
18	4	121	98	303.8	412.0	-2.3
19	3	19	11	421.1	408.0	0.1
20	3	29	13	538.8	408.0	0.9
21	3	52	34	374.2	408.0	-0.4
23	4	78	38	497.4	412.0	1.0
24	4	36	31	286.1	412.0	-1.5
25	3	123	78	385.5	408.0	-0.4
36	5	49	21	562.6	416.2	1.2
28	4	6	4	367.2	412.0	-0.2
29	4	75	36	504.6	412.0	1.0
30	4	98	47	505.0	412.0	1.2
31	4	35	11	755.5	412.0	1.9
32	4	36	14	617.3	412.0	1.3
34	3	28	13	521.0	408.0	0.8

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	51.04	0	0.00	0	50.30	0	49.87	0	49.41
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.01	0	0.00
6	0	0.00	0	0.00	0	0.01	0	0.01	0	0.00
7	0	0.00	0	0.00	0	0.02	0	0.03	0	0.01
8	0	0.00	0	0.00	0	0.04	0	0.07	0	0.01
9	0	0.00	0	0.00	0	0.09	0	0.13	0	0.03
10	0	0.01	0	0.00	0	0.19	0	0.28	0	0.06
11	0	0.01	0	0.00	0	0.39	2	0.59	0	0.12
12	1	0.03	0	0.00	2	0.92	0	1.31	0	0.26
13	0	0.13	0	0.00	1	3.75	4	5.09	0	0.95
14	0	0.35	0	0.00	13	11.19	18	15.81	4	3.04
15	0	0.34	0	0.00	12	12.38	19	18.61	6	3.78
16	0	0.11	0	0.00	6	4.48	7	7.16	0	1.54
17	0	0.01	0	0.00	0	0.51	0	0.87	0	0.20
18	0	0.00	0	0.00	0	0.02	0	0.03	0	0.01
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

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mean:	11.5	13.83	0.0	0.00	14.1	13.93	14.0	13.97	14.1	14.01
mu*:		6.65		0.00		6.79		6.87		6.94

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	49.08	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.03	0	0.00	0	0.00	0	0.00	0	0.00
11	0	0.06	0	0.00	0	0.00	0	0.00	0	0.00
12	0	0.13	0	0.00	0	0.00	0	0.00	0	0.00
13	0	0.44	0	0.00	0	0.00	0	0.00	0	0.00
14	1	1.47	0	0.00	0	0.00	0	0.00	0	0.00
15	3	1.91	0	0.00	0	0.00	0	0.00	0	0.00
16	1	0.82	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.11	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	14.5	14.05	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		7.00		0.00		0.00		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.3	1-13	4	5.59	0.67
0.0-0.3	14-14	13	11.55	-0.43
0.0-0.3	15-15	12	12.73	0.20
0.0-0.3	16-20	6	5.14	-0.38
0.3-0.4	1-13	6	7.52	0.55
0.3-0.4	14-14	18	15.81	-0.55
0.3-0.4	15-15	19	18.61	-0.09
0.3-0.4	16-20	7	8.06	0.37
0.4-0.6	1-14	5	6.62	0.63
0.4-0.6	15-20	10	8.38	-0.56

chi-squared statistic for lengths: 2.3 with 10 groups
chi-squared statistic for counts : 24.0 with 20 grains
overall chi-squared statistic: 26.3 on 23 degrees of freedom

usual chi-squared statistic for counts : 24.0 on 19 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	471.66	134.52
1	471.66	110.39
1	471.66	134.52
1	497.05	130.00
1	497.05	112.02
1	497.05	130.00
1	439.36	130.00
1	439.36	110.22
2	1.03	48.69
2	1.03	21.20
2	1.03	40.55
2	241.36	130.00
2	241.36	54.85

Path: C:\JOBS\GC582
File: 582-14 .SM1 8,110 .a.. 05-12-95 17:58:24 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-14.cnn
file of lengths: 582-14.lng
zeta: 386.9030
rho d: 1.3057
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	4	0	Ma0	92.0	T0	21.0
		1	Ma1	90.0	T1	27.0
		2	Ma2	60.0	T2	27.0
		3	Ma3	2.0	T3	31.0
		4	Ma4	0.0	T4	31.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-761.2462

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 20.0000

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	121.3	T0	21.0
		1	Ma1	120.3	T1	99.3
		2	Ma2	92.0	T2	21.0
		3	Ma3	91.0	T3	24.2
		4	Ma4	0.0	T4	31.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	10	10	19	131.6	115.2	0.3
6	10	25	57	109.8	115.2	-0.2
7	10	20	42	119.2	115.2	0.1

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File: 582-14 .SM1 8,110 .a.. 05-12-95 17:58:24 Page 2

8	6	21	44	119.4	114.0	0.2	
9	8	8	10	199.0	114.7	1.2	
10	5	50	23	527.0	113.6	6.9	*
11	3	10	31	81.0	112.8	-0.9	
12	9	20	38	131.6	115.1	0.5	
14	2	9	22	102.5	112.4	-0.2	
15	8	17	36	118.2	114.7	0.1	
16	3	9	27	83.6	112.8	-0.8	
18	8	19	37	128.4	114.7	0.4	
21	9	9	13	172.5	115.1	0.9	
22	6	16	50	80.3	114.0	-1.2	
23	8	12	36	83.6	114.7	-1.0	
25	7	15	23	162.7	114.3	1.1	
27	8	9	19	118.5	114.7	0.1	
28	6	4	7	142.7	114.0	0.4	
29	10	7	19	92.4	115.2	-0.5	
30	10	9	11	203.4	115.2	1.3	

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%)									
	0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.00	0	0.00	0	0.01	0	0.01	0	0.01
11	0	0.00	0	0.00	0	0.02	1	0.03	0	0.06
12	0	0.00	0	0.00	0	0.06	0	0.08	0	0.20
13	0	0.00	0	0.00	0	0.20	0	0.28	0	0.71
14	0	0.00	0	0.00	1	0.61	1	0.88	1	2.28
15	0	0.00	0	0.00	0	0.75	1	1.14	2	3.10
16	0	0.00	0	0.00	1	0.31	0	0.50	4	1.43
17	0	0.00	0	0.00	0	0.04	0	0.07	1	0.21
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	14.5	14.04	12.8	14.10	15.1	14.16
mu*:		0.00		13.91		13.99		14.06		14.13

chlorine (%)

Path: C:\JOBS\GC582
File: 582-14 .SM1 8,110 .a.. 05-12-95 17:58:24 Page 3

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
10	0	0.00	0	0.01	0	0.00	0	0.00	0	0.01
11	0	0.01	0	0.05	0	0.05	0	0.01	0	0.16
12	0	0.02	0	0.21	0	0.22	1	0.05	0	0.94
13	0	0.08	1	0.79	0	0.89	0	0.21	1	4.14
14	0	0.28	0	2.68	2	3.11	0	0.75	5	15.06
15	0	0.39	3	3.95	3	4.79	1	1.21	18	24.55
16	1	0.19	5	1.98	2	2.50	0	0.66	22	13.62
17	0	0.03	1	0.32	4	0.42	1	0.12	11	2.39
18	0	0.00	0	0.02	1	0.02	0	0.01	3	0.13
19	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	15.5	14.21	15.0	14.25	15.4	14.30	14.2	14.36	15.3	14.37
mu*:		14.18		14.23		14.28		14.34		14.35

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals	
0.0-0.5	1-14	4	5.44	0.62	
0.0-0.5	15-20	9	7.56	-0.52	
0.5-0.7	1-14	1	4.12	1.54	
0.5-0.7	15-20	10	6.88	-1.19	
0.7-0.8	1-14	2	4.27	1.10	
0.7-0.8	15-20	10	7.73	-0.82	
0.8-1.0	1-13	2	5.52	1.50	
0.8-1.0	14-14	5	15.80	2.72	
0.8-1.0	15-15	19	25.75	1.33	
0.8-1.0	16-20	38	16.93	-5.12	*

chi-squared statistic for lengths: 43.9 with 10 groups
chi-squared statistic for counts : 57.4 with 20 grains
overall chi-squared statistic: 101.3 on 24 degrees of freedom

usual chi-squared statistic for counts : 50.2 on 19 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

Path: C:\JOBS\GC582
File: 582-14 .SM1 8,110 .a.. 05-12-95 17:58:24 Page 4

episode	time	Temp
1	90.99	68.69
1	90.99	24.22
1	2.00	37.12
1	2.00	31.20
1	46.50	41.10
1	46.50	28.13

Path: C:\JOBS\GC582
File: 582-15 .SM1 5,559 .a.. 04-12-95 16:58:48 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-15.cnn
file of lengths: 582-15.lng
zeta: 386.9030
rho_d: 1.3090
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	11	0	Ma0	146.0	T0	21.0
		1	Ma1	142.0	T1	29.0
		2	Ma2	136.0	T2	30.0
		3	Ma3	118.0	T3	31.0
		4	Ma4	102.0	T4	43.0
		5	Ma5	101.0	T5	43.0
		6	Ma6	100.0	T6	52.0
		7	Ma7	98.0	T7	56.0
		8	Ma8	90.0	T8	77.0
		9	Ma9	60.0	T9	77.0
		10	Ma10	2.0	T10	81.0
		11	Ma11	0.0	T11	81.0

LIKELIHOOD STATISTICS

number of fits + refits: 2

fit #	log likelihood
1	-510.0628
2	-509.5762

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 3.8506

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	395.0	T0	21.0
		1	Ma1	390.5	T1	115.4
		2	Ma2	146.0	T2	21.0
		3	Ma3	30.6	T3	99.6
		4	Ma4	0.0	T4	81.0

Path: C:\JOBS\GC582
File: 582-15 .SM1 5,559 .a.. 04-12-95 16:58:48 Page 2

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
3	1	17	134	32.0	75.8	-3.5	*
4	1	92	69	329.1	75.8	10.2	*
5	1	54	233	58.4	75.8	-1.7	
6	1	12	16	187.2	75.8	2.5	
7	1	21	141	37.6	75.8	-3.1	*
8	1	4	3	329.1	75.8	2.1	
9	1	5	77	16.4	75.8	-3.7	*

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	16.27	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.04	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.10	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.20	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.37	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.58	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.81	0	0.00	0	0.00	0	0.00	0	0.00
8	2	0.99	0	0.00	0	0.00	0	0.00	0	0.00
9	0	1.20	0	0.00	0	0.00	0	0.00	0	0.00
10	0	1.64	0	0.00	0	0.00	0	0.00	0	0.00
11	1	2.23	0	0.00	0	0.00	0	0.00	0	0.00
12	5	2.14	0	0.00	0	0.00	0	0.00	0	0.00
13	1	1.19	0	0.00	0	0.00	0	0.00	0	0.00
14	1	0.39	0	0.00	0	0.00	0	0.00	0	0.00
15	1	0.09	0	0.00	0	0.00	0	0.00	0	0.00
16	1	0.02	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.6	9.51	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		2.80		0.00		0.00		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.1	1- 9	2	4.30	1.11
0.0-0.1	10-11	1	3.87	1.46

Path: C:\JOBS\GC582
File: 582-15 .SM1 5,559 .a.. 04-12-95 16:58:48 Page 3

0.0-0.1 12-20 9 3.83 -2.64

chi-squared statistic for lengths: 10.4 with 3 groups
chi-squared statistic for counts : 153.2 with 7 grains
overall chi-squared statistic: 163.6 on 4 degrees of freedom

usual chi-squared statistic for counts : 152.2 on 6 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	30.61	101.43
1	30.61	93.98
1	145.00	130.00
1	145.00	90.26
1	87.81	104.81
1	87.81	89.54
1	3.50	99.91
1	17.05	101.03
1	17.05	95.99

Path: C:\JOBS\GC582
File: 582-15 .SUM 6,804 .a.. 04-12-95 14:07:06 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-15.cnn
file of lengths: 582-15.lng
zeta: 386.9030
rho_d: 1.3090
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	11	0	Ma0	146.0	T0	21.0
		1	Ma1	142.0	T1	29.0
		2	Ma2	136.0	T2	30.0
		3	Ma3	118.0	T3	31.0
		4	Ma4	102.0	T4	43.0
		5	Ma5	101.0	T5	43.0
		6	Ma6	100.0	T6	52.0
		7	Ma7	98.0	T7	56.0
		8	Ma8	90.0	T8	77.0
		9	Ma9	60.0	T9	77.0
		10	Ma10	2.0	T10	81.0
		11	Ma11	0.0	T11	81.0

LIKELIHOOD STATISTICS

number of fits + refits: 2

fit #	log likelihood
1	-509.8618
2	-509.6515

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	16	0	Ma0	330.0	T0	21.0
		1	Ma1	328.6	T1	96.7
		2	Ma2	146.0	T2	21.0
		3	Ma3	142.0	T3	29.0
		4	Ma4	136.0	T4	30.0
		5	Ma5	118.0	T5	31.0

6	Ma6	102.0	T6	43.0
7	Ma7	101.0	T7	43.0
8	Ma8	100.0	T8	52.0
9	Ma9	98.0	T9	56.0
10	Ma10	90.0	T10	77.0
11	Ma11	60.0	T11	77.0
12	Ma12	58.7	T12	77.1
13	Ma13	39.8	T13	95.9
14	Ma14	38.1	T14	94.2
15	Ma15	36.3	T15	95.9
16	Ma16	20.2	T16	79.7
17	Ma17	2.0	T17	81.0
18	Ma18	0.0	T18	81.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
3	1	17	134	32.0	75.8	-3.5	*
4	1	92	69	329.1	75.8	10.2	*
5	1	54	233	58.4	75.8	-1.7	
6	1	12	16	187.2	75.8	2.5	
7	1	21	141	37.6	75.8	-3.1	*
8	1	4	3	329.1	75.8	2.1	
9	1	5	77	16.4	75.8	-3.7	*

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	2.97	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.04	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.09	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.19	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.34	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.55	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.77	0	0.00	0	0.00	0	0.00	0	0.00
8	2	0.99	0	0.00	0	0.00	0	0.00	0	0.00
9	0	1.25	0	0.00	0	0.00	0	0.00	0	0.00
10	0	1.71	0	0.00	0	0.00	0	0.00	0	0.00
11	1	2.26	0	0.00	0	0.00	0	0.00	0	0.00
12	5	2.14	0	0.00	0	0.00	0	0.00	0	0.00
13	1	1.18	0	0.00	0	0.00	0	0.00	0	0.00
14	1	0.38	0	0.00	0	0.00	0	0.00	0	0.00
15	1	0.09	0	0.00	0	0.00	0	0.00	0	0.00
16	1	0.02	0	0.00	0	0.00	0	0.00	0	0.00

17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.6	9.55	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
mu*:		3.37		0.00		0.00		0.00		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.1	1- 9	2	4.22	1.08
0.0-0.1	10-11	1	3.97	1.49
0.0-0.1	12-20	9	3.81	-2.66

chi-squared statistic for lengths: 10.5 with 3 groups
chi-squared statistic for counts : 153.2 with 7 grains
overall chi-squared statistic: 163.7 on 3 degrees of freed

usual chi-squared statistic for counts : 152.2 on 6 degrees of freed

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	39.85	98.12
1	39.85	93.01
1	145.00	130.00
1	145.00	94.57
1	92.42	100.20
1	92.42	93.41
1	92.42	94.57
1	22.73	97.70
1	22.73	93.69
2	36.35	98.05
2	36.35	78.83
2	1.00	95.61
2	1.00	81.20
2	18.67	97.55
2	18.67	80.05
2	144.00	130.00
2	144.00	102.53
2	90.17	100.14
2	90.17	76.75

Path: C:\JOBS\GC582
File: 582-16 .SM1 8,364 .a.. 04-12-95 17:16:04 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-16.cnn
file of lengths: 582-16.lng
zeta: 386.9030
rho_d: 1.3124
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	12	0	Ma0	154.0	T0	21.0
		1	Ma1	150.0	T1	22.0
		2	Ma2	142.0	T2	37.0
		3	Ma3	136.0	T3	38.0
		4	Ma4	118.0	T4	39.0
		5	Ma5	102.0	T5	51.0
		6	Ma6	101.0	T6	51.0
		7	Ma7	100.0	T7	60.0
		8	Ma8	98.0	T8	64.0
		9	Ma9	90.0	T9	85.0
		10	Ma10	60.0	T10	85.0
		11	Ma11	2.0	T11	89.0
		12	Ma12	0.0	T12	89.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-609.0003

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 0.7454

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	177.1	T0	21.0
		1	Ma1	166.2	T1	115.6
		2	Ma2	154.0	T2	21.0
		3	Ma3	65.5	T3	113.5
		4	Ma4	0.0	T4	89.0

Path: C:\JOBS\GC582
File: 582-16 .SM1 8,364 .a.. 04-12-95 17:16:04 Page 2

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	3	25	111	56.9	33.1	2.5
4	2	4	38	26.7	27.5	-0.1
5	2	10	78	32.5	27.5	0.5
6	1	0	30	0.0	22.0	-1.6
8	2	24	141	43.1	27.5	2.1
10	1	0	17	0.0	22.0	-1.2
11	1	0	16	0.0	22.0	-1.2
12	1	0	34	0.0	22.0	-1.7
14	1	7	29	61.0	22.0	2.5
15	1	11	200	13.9	22.0	-1.5
16	1	6	47	32.3	22.0	0.9
17	3	15	101	37.6	33.1	0.5
18	1	5	88	14.4	22.0	-0.9
19	5	27	221	30.9	44.2	-1.8
20	4	24	154	39.4	38.7	0.1
21	2	13	77	42.7	27.5	1.5
22	4	4	7	143.5	38.7	2.3
23	4	1	17	14.9	38.7	-1.0
25	5	3	7	107.9	44.2	1.3
26	1	1	103	2.5	22.0	-2.6

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	72.78	0	0.00	0	66.79	0	63.82	0	7.92
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.01	0	0.00	0	0.00	0	0.00	0	0.01
4	0	0.02	0	0.00	0	0.01	0	0.01	0	0.01
5	0	0.05	0	0.00	0	0.01	0	0.01	1	0.02
6	0	0.12	0	0.00	0	0.04	0	0.03	0	0.03
7	0	0.26	0	0.00	0	0.10	0	0.08	0	0.05
8	0	0.51	0	0.00	0	0.24	0	0.19	0	0.09
9	0	0.83	0	0.00	0	0.53	1	0.47	1	0.18
10	3	1.15	0	0.00	2	0.96	2	1.02	0	0.41
11	0	1.28	0	0.00	1	1.27	2	1.61	0	0.77
12	1	1.03	0	0.00	1	1.10	1	1.53	1	0.82
13	1	0.53	0	0.00	0	0.55	0	0.79	0	0.45
14	1	0.17	0	0.00	1	0.16	0	0.22	0	0.13
15	0	0.04	0	0.00	0	0.03	0	0.03	0	0.02
16	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Path: C:\JOBS\GC582
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18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.0	9.89	0.0	0.00	10.9	10.37	10.0	10.63	8.2	10.65
mu*:		1.84		2.31		2.79		3.26		3.72

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.02
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.06
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.10
10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.15
11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.20
12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.23
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.17
14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.06
15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	10.5	10.64
mu*:		0.00		0.00		0.00		0.00		9.30

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.3	1-10	5	4.83	-0.08
0.0-0.3	11-20	6	6.17	0.07
0.3-1.0	1-11	8	5.54	-1.04
0.3-1.0	12-20	2	4.46	1.16

chi-squared statistic for lengths: 2.5 with 4 groups
chi-squared statistic for counts : 49.7 with 20 grains
overall chi-squared statistic: 52.2 on 18 degrees of freedom

usual chi-squared statistic for counts : 61.1 on 19 degrees of freedom

Path: C:\JOBS\GC582
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VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODE

episode	time	Temp
1	65.46	130.00
1	65.46	110.13
1	153.00	130.00
1	153.00	116.57
1	109.23	130.00
1	109.23	107.50
1	42.34	117.93
1	53.90	119.68
1	53.90	112.35

Path: C:\JOBS\GC582
File: 582-16 .SUM 9,107 .a.. 04-12-95 15:35:44 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-16.cnn
file of lengths: 582-16.lng
zeta: 386.9030
rho_d: 1.3124
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	12	0	Ma0	154.0	T0	21.0
		1	Ma1	150.0	T1	22.0
		2	Ma2	142.0	T2	37.0
		3	Ma3	136.0	T3	38.0
		4	Ma4	118.0	T4	39.0
		5	Ma5	102.0	T5	51.0
		6	Ma6	101.0	T6	51.0
		7	Ma7	100.0	T7	60.0
		8	Ma8	98.0	T8	64.0
		9	Ma9	90.0	T9	85.0
		10	Ma10	60.0	T10	85.0
		11	Ma11	2.0	T11	89.0
		12	Ma12	0.0	T12	89.0

LIKELIHOOD STATISTICS

number of fits + refits: 5

fit #	log likelihood
1	-610.0796
2	-609.4460
3	-609.1666
4	-608.9939
5	-607.7998

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	7	0	Ma0	167.8	T0	21.0
		1	Ma1	161.1	T1	113.2

2	Ma2	154.0	T2	21.0
3	Ma3	78.7	T3	114.8
4	Ma4	49.6	T4	85.7
5	Ma5	40.1	T5	86.4
6	Ma6	27.7	T6	98.8
7	Ma7	16.9	T7	88.0
8	Ma8	2.0	T8	89.0
9	Ma9	0.0	T9	89.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals	
3	3	25	111	56.9	35.3	2.2	
4	2	4	38	26.7	26.7	0.0	
5	2	10	78	32.5	26.7	0.6	
6	1	0	30	0.0	18.1	-1.5	
8	2	24	141	43.1	26.7	2.2	
10	1	0	17	0.0	18.1	-1.1	
11	1	0	16	0.0	18.1	-1.1	
12	1	0	34	0.0	18.1	-1.6	
14	1	7	29	61.0	18.1	3.1	*
15	1	11	200	13.9	18.1	-0.8	
16	1	6	47	32.3	18.1	1.4	
17	3	15	101	37.6	35.3	0.2	
18	1	5	88	14.4	18.1	-0.5	
19	5	27	221	30.9	51.2	-2.5	
20	4	24	154	39.4	43.5	-0.4	
21	2	13	77	42.7	26.7	1.6	
22	4	4	7	143.5	43.5	2.0	
23	4	1	17	14.9	43.5	-1.1	
25	5	3	7	107.9	51.2	1.1	
26	1	1	103	2.5	18.1	-2.3	

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	66.94	0	0.00	0	56.94	0	53.83	0	5.45
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.01	0	0.00	0	0.00	0	0.00	0	0.01
4	0	0.03	0	0.00	0	0.01	0	0.01	0	0.01
5	0	0.06	0	0.00	0	0.04	0	0.02	1	0.02
6	0	0.11	0	0.00	0	0.09	0	0.06	0	0.03
7	0	0.22	0	0.00	0	0.19	0	0.15	0	0.05
8	0	0.43	0	0.00	0	0.35	0	0.35	0	0.12

Path: C:\JOBS\GC582
File: 582-16 .SUM 9,107 .a.. 04-12-95 15:35:44 Page 3

9	0	0.75	0	0.00	0	0.58	1	0.66	1	0.27
10	3	1.12	0	0.00	2	0.89	2	1.06	0	0.50
11	0	1.34	0	0.00	1	1.13	2	1.43	0	0.73
12	1	1.12	0	0.00	1	1.00	1	1.32	1	0.72
13	1	0.58	0	0.00	0	0.52	0	0.70	0	0.40
14	1	0.18	0	0.00	1	0.16	0	0.21	0	0.12
15	0	0.04	0	0.00	0	0.03	0	0.04	0	0.02
16	0	0.01	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.0	9.98	0.0	0.00	10.9	10.09	10.0	10.34	8.2	10.48
mu*:		1.60		2.37		3.13		3.87		4.56

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
7	0	0.00	0	0.00	0	0.00	0	0.00	0	0.02
8	0	0.00	0	0.00	0	0.00	0	0.00	0	0.05
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.09
10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.14
11	0	0.00	0	0.00	0	0.00	0	0.00	1	0.22
12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.25
13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.17
14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.06
15	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	10.5	10.75
mu*:		0.00		0.00		0.00		0.00		9.61

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.3	1-10	5	4.90	-0.04
0.0-0.3	11-20	6	6.10	0.04

0.3-1.0	1-10	5	3.61	-0.73
0.3-1.0	11-20	5	6.39	0.55

chi-squared statistic for lengths: 0.8 with 4 groups
chi-squared statistic for counts : 50.1 with 20 grains
overall chi-squared statistic: 51.0 on 17 degrees of freedom

usual chi-squared statistic for counts : 61.1 on 19 degrees of freedom

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	78.69	130.00
1	78.69	112.31
1	78.69	114.77
1	92.32	130.00
1	92.32	113.49
1	92.32	115.22
1	66.28	121.46
1	66.28	112.07
2	27.68	101.47
2	27.68	87.43
2	1.00	98.70
2	1.00	89.20
2	14.34	99.66
2	14.34	88.35
2	14.34	96.90
2	49.74	111.21
2	49.74	92.00

Path: C:\JOBS\GC582
File: 642-54 .SM1 7,070 .a.. 25-09-95 1:05:10 Page 1

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 642-54.cnn
file of lengths: 642-54.lng
zeta: 354.7900
rho d: 1.3960
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	14	0	Ma0	276.0	T0	21.0
		1	Ma1	274.0	T1	23.0
		2	Ma2	264.0	T2	36.0
		3	Ma3	167.0	T3	36.0
		4	Ma4	150.0	T4	37.0
		5	Ma5	143.0	T5	45.0
		6	Ma6	142.0	T6	46.0
		7	Ma7	136.0	T7	49.0
		8	Ma8	118.0	T8	51.0
		9	Ma9	100.0	T9	68.0
		10	Ma10	98.0	T10	71.0
		11	Ma11	90.0	T11	89.0
		12	Ma12	60.0	T12	89.0
		13	Ma13	2.0	T13	99.0
		14	Ma14	0.0	T14	99.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-4227.0725

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 1.1411

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	470.1	T0	21.0
		1	Ma1	373.2	T1	37.0
		2	Ma2	276.0	T2	21.0
		3	Ma3	251.2	T3	38.5

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4 Ma4 0.0 T4 99.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age
3	4	294	330	216.9	154.4
4	1	29	70	101.8	5.0
5	1	24	68	86.8	5.0
7	4	42	52	197.0	154.4
8	9	226	179	305.3	338.2
9	1	42	115	89.8	5.0
10	2	106	179	145.0	9.3
11	8	211	210	244.1	323.8
12	1	3	32	23.2	5.0
14	1	11	22	122.6	5.0
17	4	82	98	204.0	154.4
18	7	163	111	353.8	293.7
19	2	102	186	134.4	9.3
21	6	184	195	229.5	260.2
22	1	60	161	91.6	5.0
24	2	11	49	55.4	9.3
26	1	53	181	72.1	5.0
27	2	43	63	166.8	9.3
28	7	125	142	214.4	293.7
29	2	113	234	118.5	9.3

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	96.33	0	91.76	0	0.26	0	0.01	0	0.00
1	0	0.00	0	0.01	0	0.01	0	0.00	0	0.00
2	0	0.01	0	0.02	0	0.02	0	0.02	0	0.00
3	0	0.01	0	0.05	0	0.05	0	0.07	0	0.00
4	0	0.03	0	0.10	0	0.09	0	0.21	0	0.00
5	0	0.07	0	0.19	0	0.16	0	0.52	0	0.01
6	0	0.13	0	0.35	0	0.24	0	1.07	0	0.03
7	0	0.23	0	0.58	0	0.32	0	1.81	0	0.06
8	0	0.37	0	0.91	0	0.39	1	2.58	0	0.12
9	0	0.55	2	1.27	0	0.43	0	3.07	0	0.18
10	1	0.71	3	1.58	2	0.43	2	3.06	0	0.21
11	1	0.78	1	1.66	1	0.37	4	2.54	0	0.18
12	1	0.63	2	1.31	0	0.27	6	1.70	0	0.12
13	1	0.33	0	0.68	0	0.14	4	0.87	1	0.06
14	0	0.11	1	0.23	0	0.06	1	0.34	0	0.02
15	0	0.03	0	0.06	0	0.02	0	0.11	0	0.01

Path: C:\JOBS\GC582
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16	0	0.00	0	0.01	0	0.01	0	0.03	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.01	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.0	9.61	10.3	9.43	9.8	8.38	11.2	8.84	12.5	9.42
mu*:		0.15		0.29		1.87		4.83		7.03

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.01	0	0.01	0	0.00	0	0.00	0	0.00
6	0	0.05	0	0.05	0	0.00	0	0.00	0	0.00
7	1	0.19	0	0.25	0	0.00	0	0.01	0	0.01
8	0	0.48	1	0.93	0	0.00	1	0.13	1	0.17
9	0	0.87	2	2.24	0	0.00	2	0.96	0	1.36
10	3	1.14	0	3.59	0	0.00	0	3.41	0	5.26
11	0	1.07	6	3.80	0	0.00	3	5.93	3	9.65
12	1	0.71	2	2.62	0	0.00	7	5.03	7	8.38
13	0	0.33	1	1.15	0	0.00	1	2.07	12	3.44
14	0	0.10	3	0.32	0	0.00	4	0.41	5	0.67
15	0	0.02	0	0.06	0	0.00	0	0.04	1	0.06
16	0	0.00	0	0.01	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	9.3	9.77	10.9	10.10	0.0	0.00	11.3	10.77	12.1	10.81
mu*:		8.22		9.31		10.29		10.76		10.80

PART THREE:

Default Burial Histories derived from preserved stratigraphy in each well and VR data plotted with respect to depth

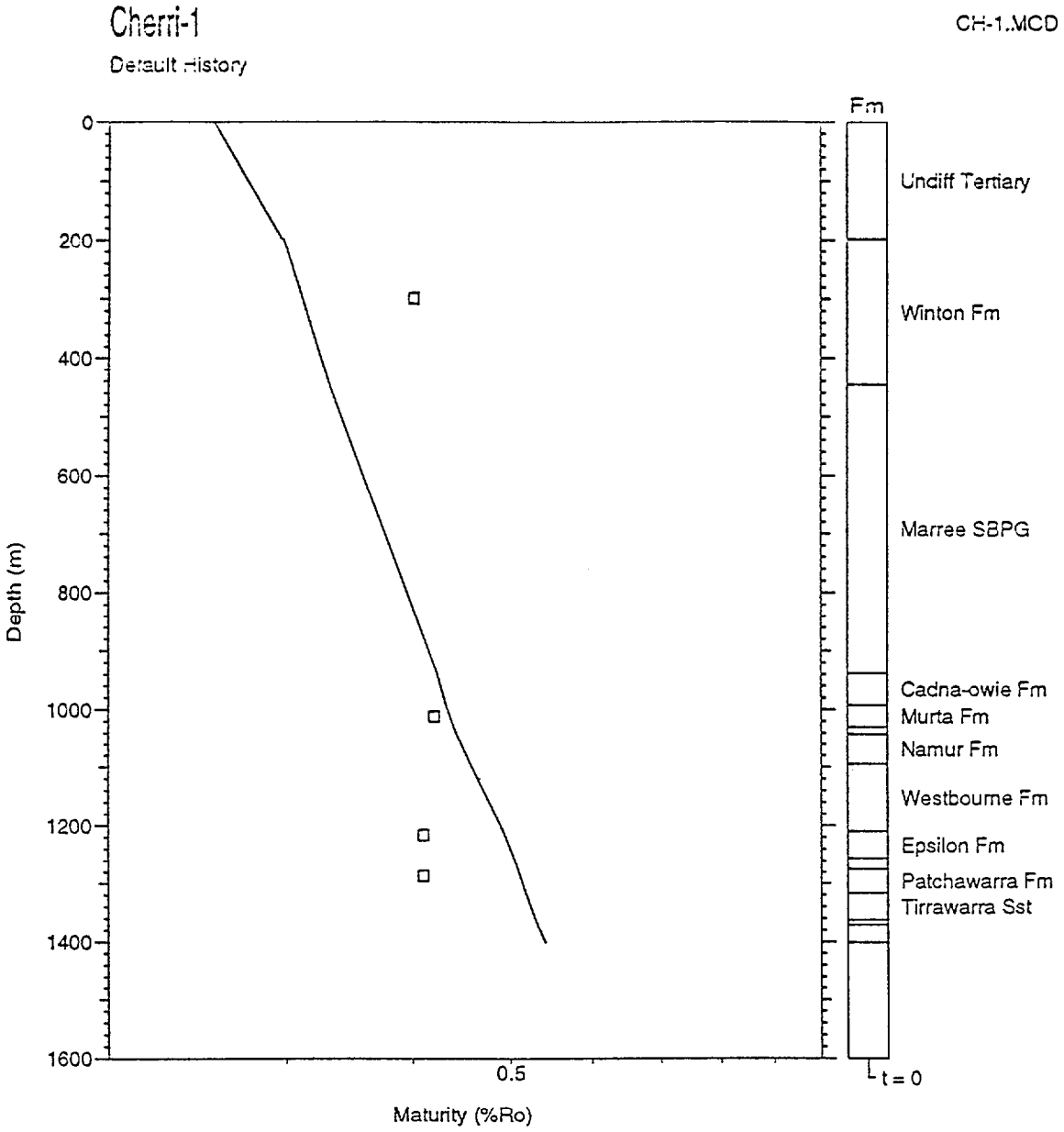


Figure 3.1: Vitrinite reflectance data (supplied by MESA) in the **Cherri-1 well** plotted against depth (TVD) with respect to KB. The solid line shows the VR profile predicted from the Default Thermal History, i.e., the profile predicted if samples throughout the section are currently at their maximum temperatures since deposition.

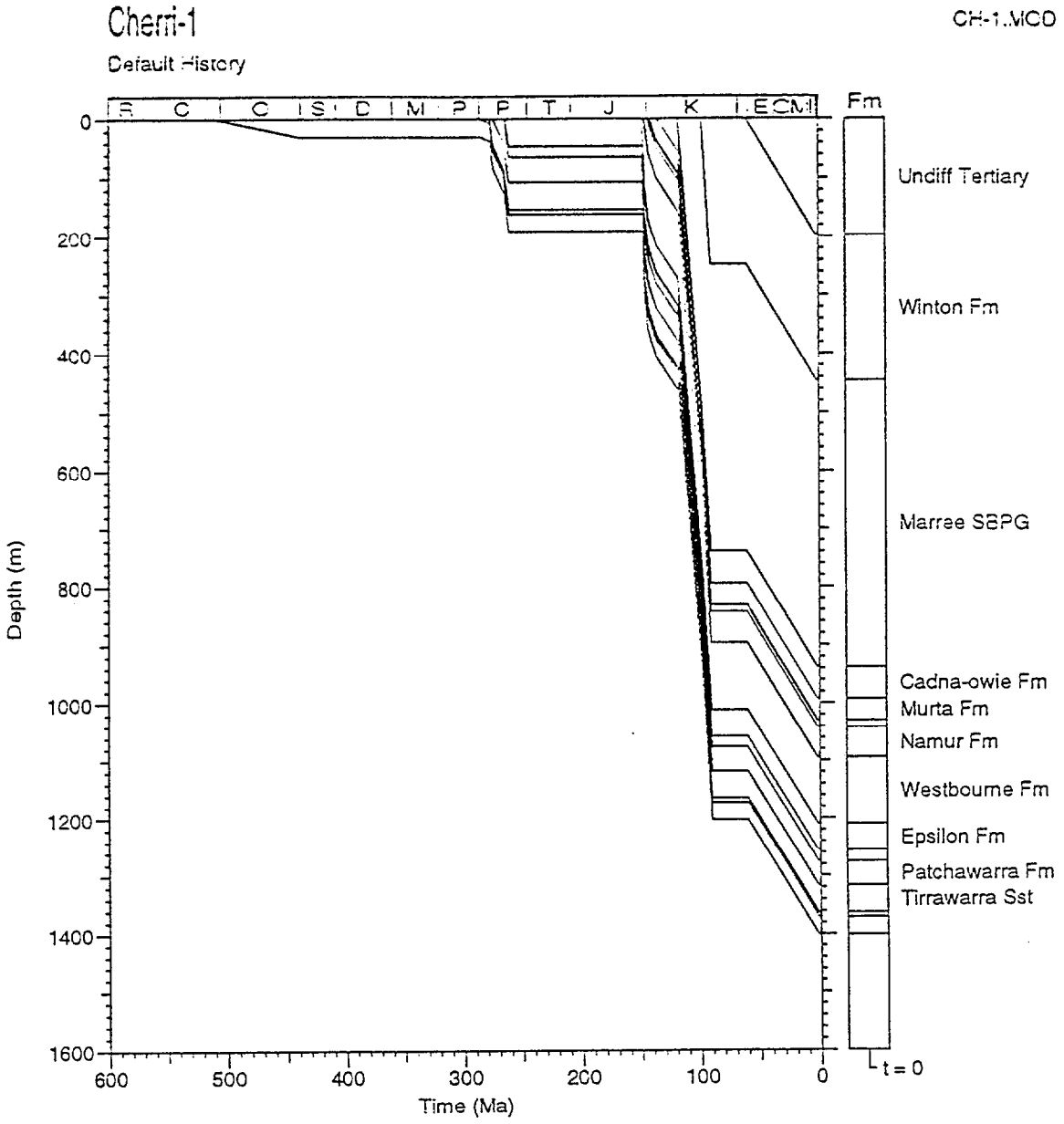


Figure 3.2: Default Burial History showing the history derived from the preserved stratigraphy in the **Cherri-1 well**. This history, together with the present geothermal gradient of 43.2°C/km (Table A.3) and a surface temperature of 21°C, has been used to calculate the Default Thermal History, as used in Figure 3.1. Default parameters can be compared with observed AFTA and VR parameters to evaluate the degree of heating which is attributable to the present thermal regime, hence determine whether samples have been hotter in the past.

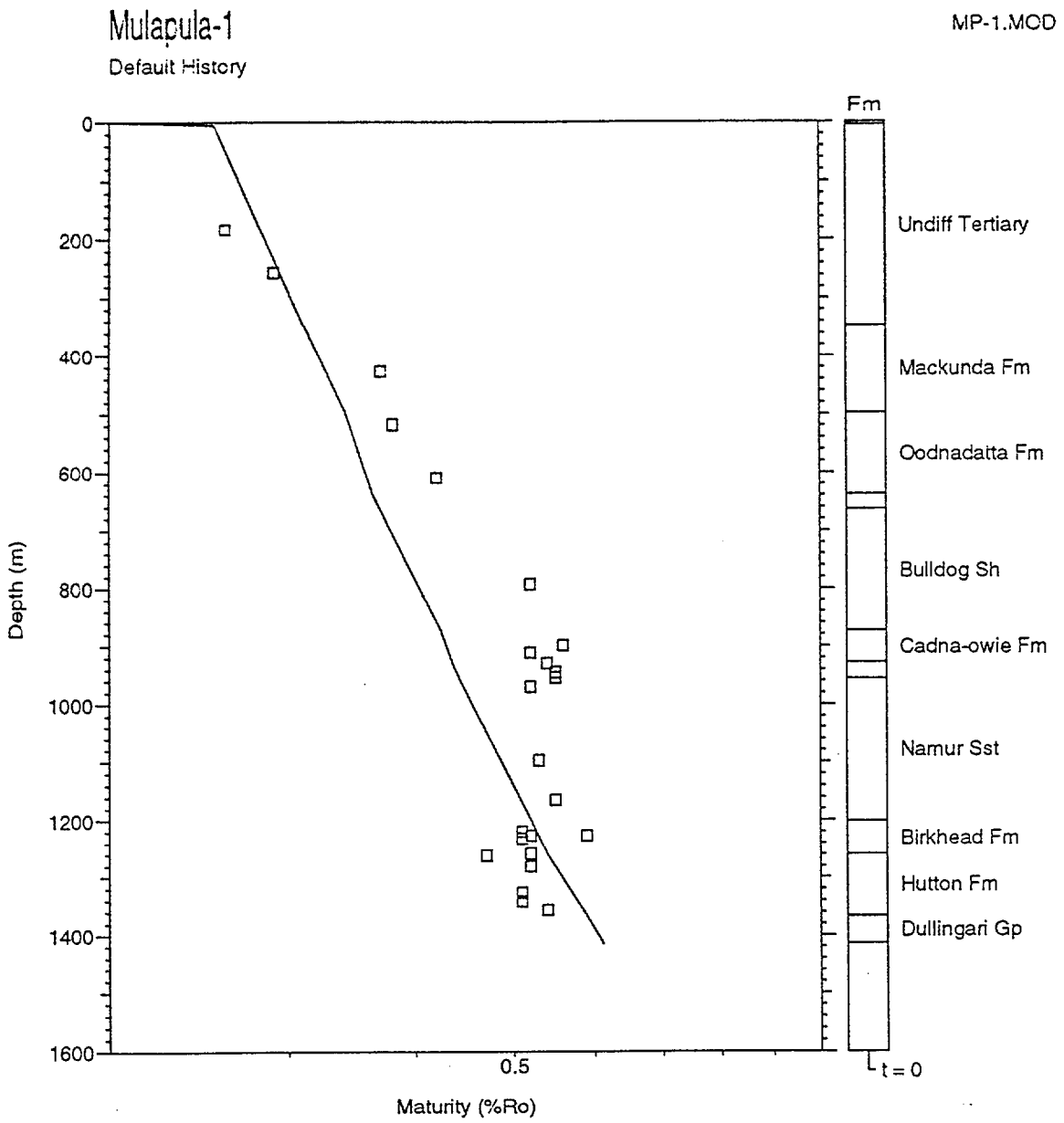


Figure 3.3: Vitrinite reflectance data (supplied by MESA) in the **Mulapula-1 well** plotted against depth (TVD) with respect to KB. The solid line shows the VR profile predicted from the Default Thermal History, i.e., the profile predicted if samples throughout the section are currently at their maximum temperatures since deposition.

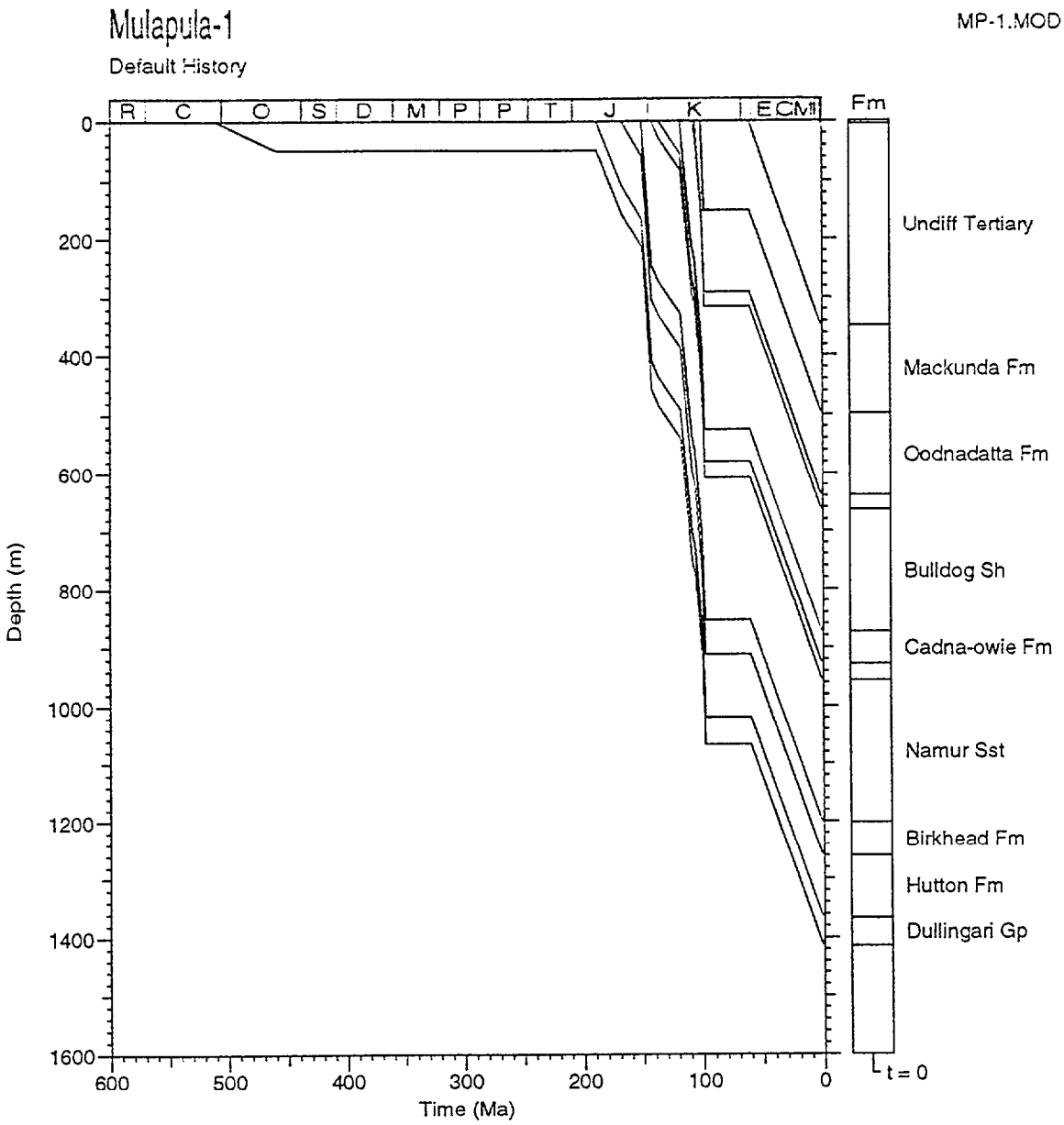


Figure 3.4: Default Burial History showing the history derived from the preserved stratigraphy in the **Mulapula-1 well**. This history, together with the present geothermal gradient of 50.7°C/km (Table A.3) and a surface temperature of 21°C, has been used to calculate the Default Thermal History, as used in Figure 3.3. Default parameters can be compared with observed AFTA and VR parameters to evaluate the degree of heating which is attributable to the present thermal regime, hence determine whether samples have been hotter in the past.

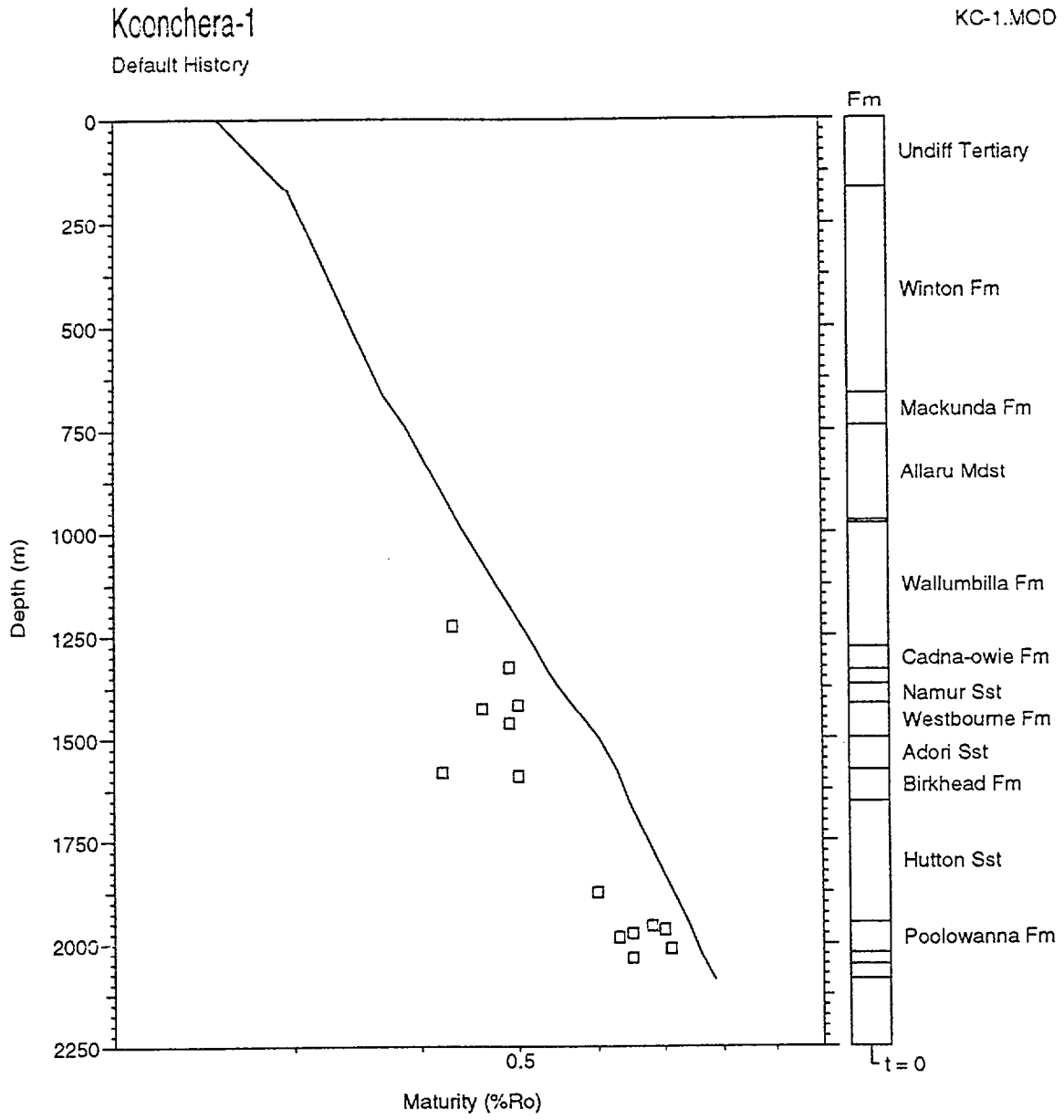


Figure 3.5: Vitrinite reflectance data (supplied by MESA) in the **Koonchera-1 well** plotted against depth (TVD) with respect to KB. The solid line shows the VR profile predicted from the Default Thermal History, i.e., the profile predicted if samples throughout the section are currently at their maximum temperatures since deposition.

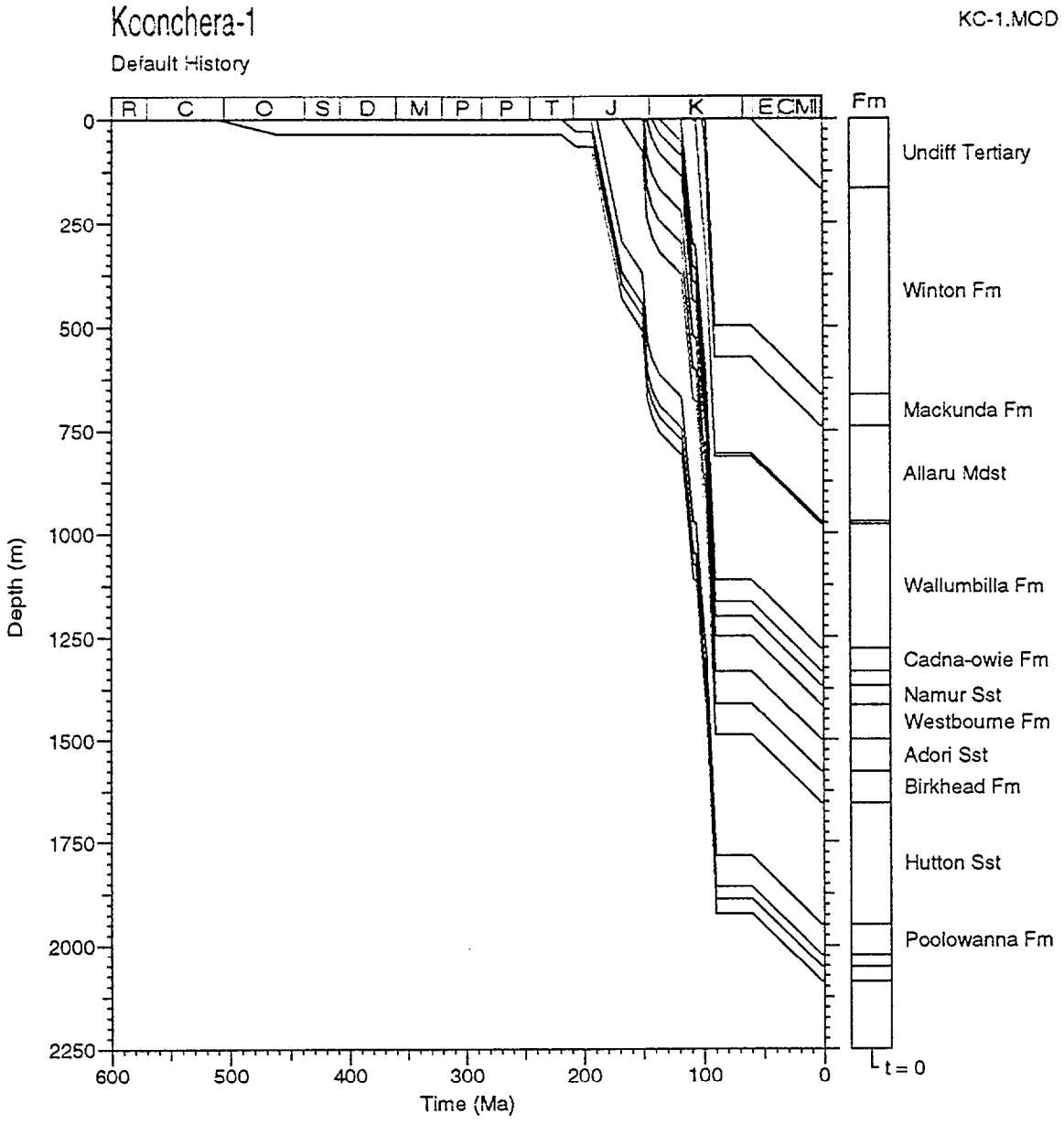


Figure 3.6: Default Burial History showing the history derived from the preserved stratigraphy in the **Koonchera-1 well**. This history, together with the present geothermal gradient of 44.5°C/km (Table A.3) and a surface temperature of 21°C, has been used to calculate the Default Thermal History, as used in Figure 3.5. Default parameters can be compared with observed AFTA and VR parameters to evaluate the degree of heating which is attributable to the present thermal regime, hence determine whether samples have been hotter in the past.

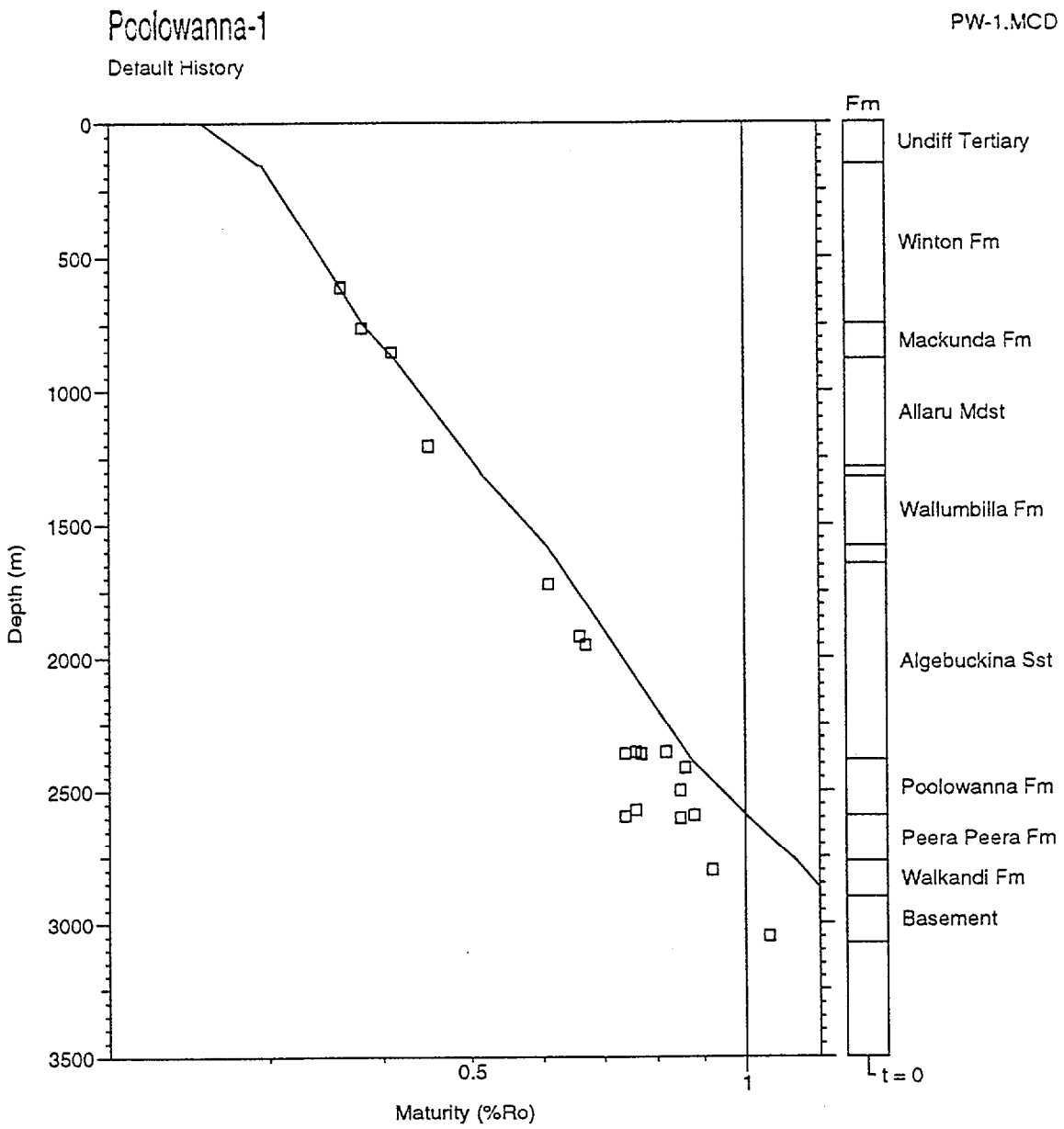


Figure 3.7: Vitrinite reflectance data (supplied by MESA) in the **Poolowanna-1 well** plotted against depth (TVD) with respect to KB. The solid line shows the VR profile predicted from the Default Thermal History, i.e., the profile predicted if samples throughout the section are currently at their maximum temperatures since deposition.

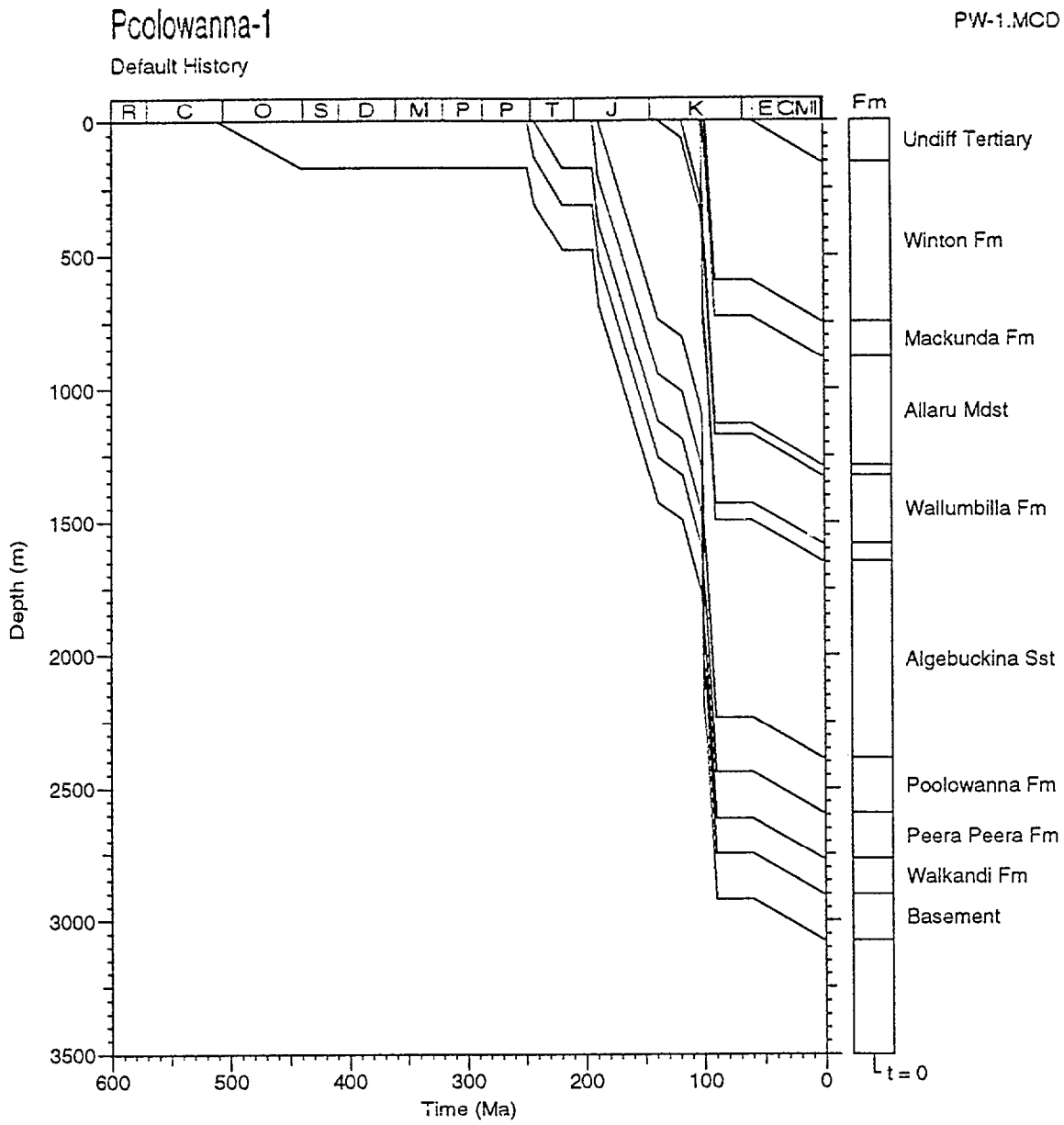


Figure 3.8: Default Burial History showing the history derived from the preserved stratigraphy in the **Poolowanna-1 well.** This history, together with the present geothermal gradient of 42.3°C/km (Table A.3) and a surface temperature of 21°C, has been used to calculate the Default Thermal History, as used in Figure 3.7. Default parameters can be compared with observed AFTA and VR parameters to evaluate the degree of heating which is attributable to the present thermal regime, hence determine whether samples have been hotter in the past.

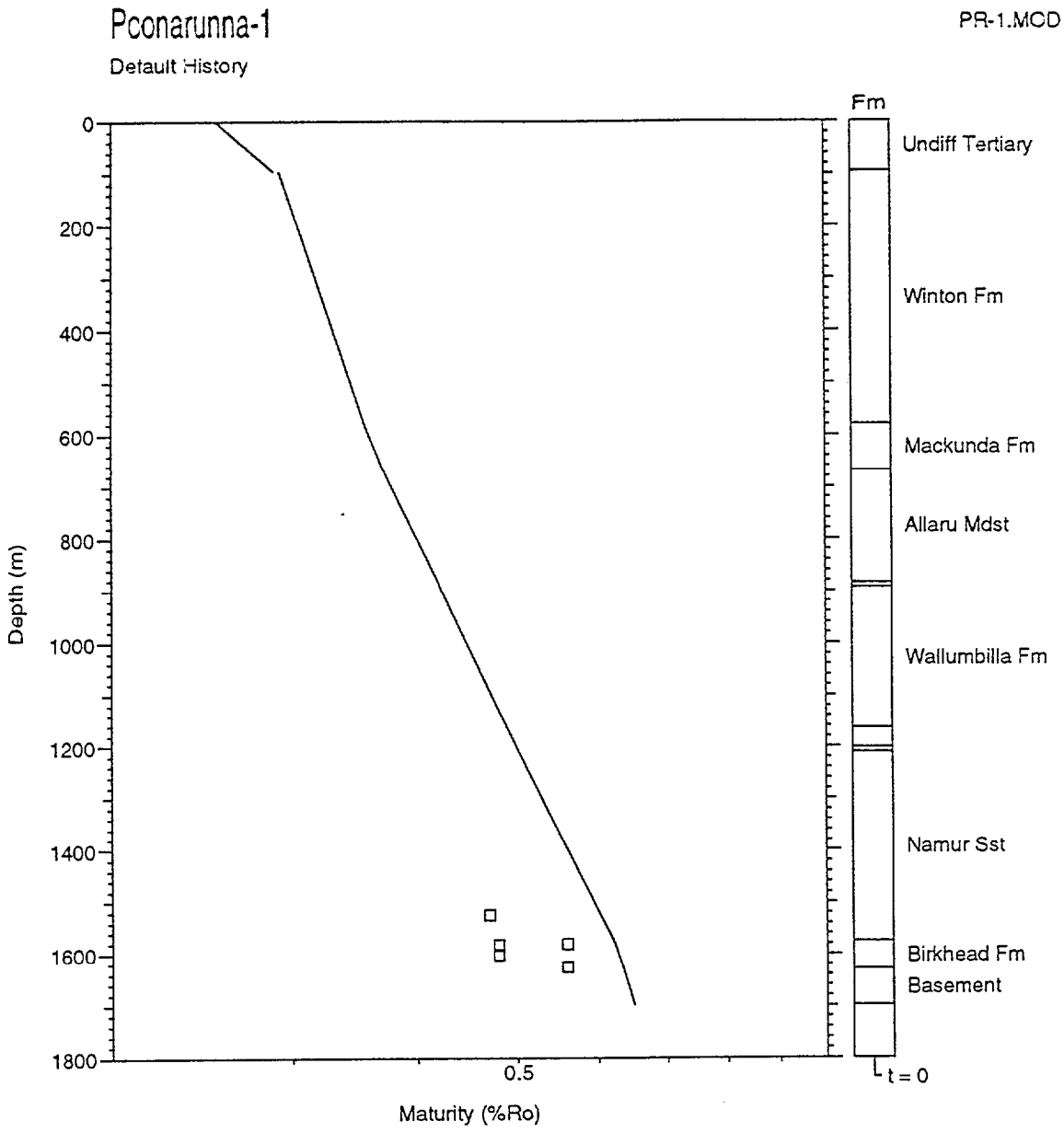


Figure 3.9: Vitrinite reflectance data (supplied by MESA) in the **Poonarunna-1 well** plotted against depth (TVD) with respect to KB. The solid line shows the VR profile predicted from the Default Thermal History, i.e., the profile predicted if samples throughout the section are currently at their maximum temperatures since deposition.

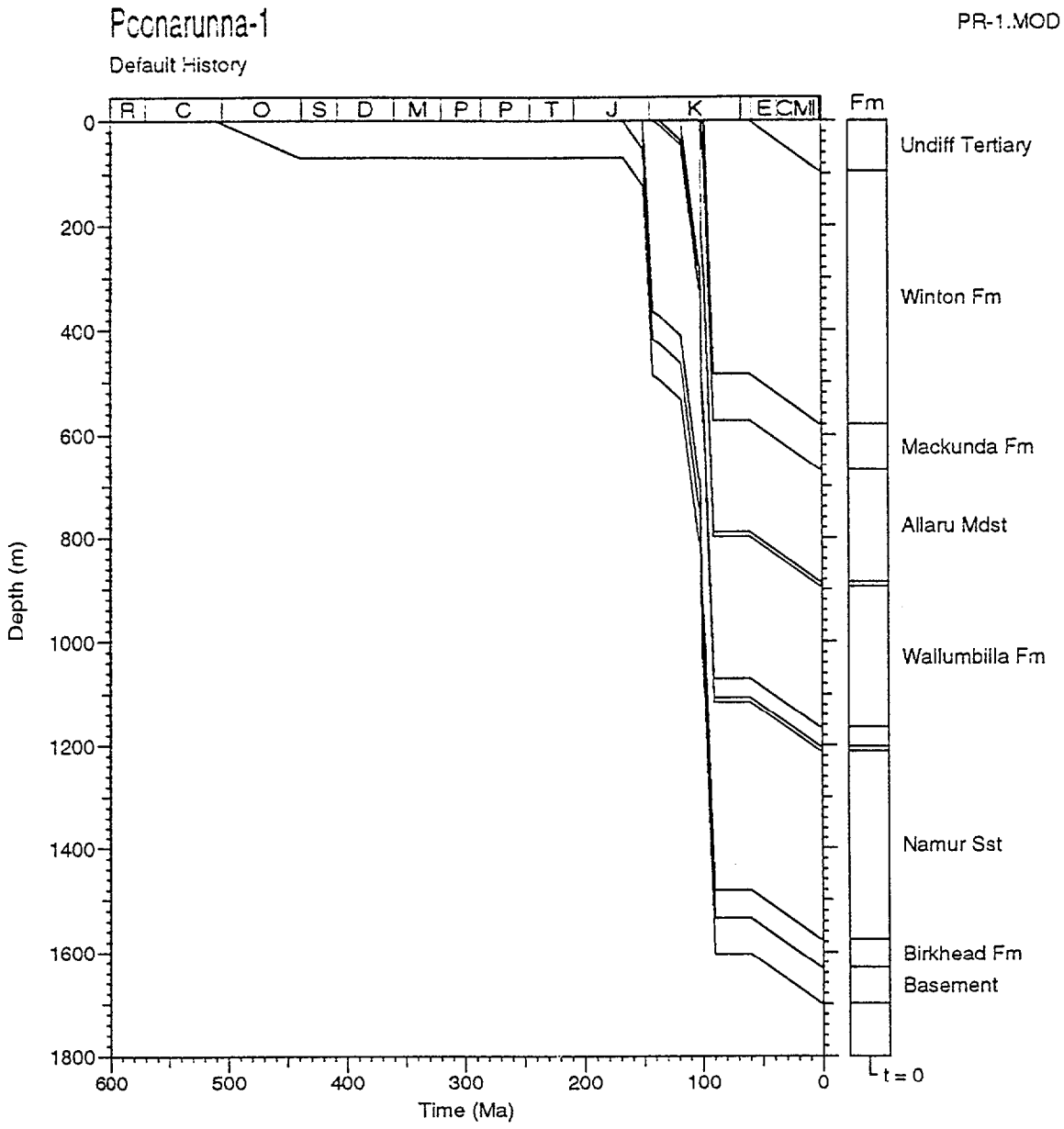


Figure 3.10: Default Burial History showing the history derived from the preserved stratigraphy in the **Poonarunna-1 well**. This history, together with the present geothermal gradient of 42.7°C/km (Table A.3) and a surface temperature of 21°C, has been used to calculate the Default Thermal History, as used in Figure 3.9. Default parameters can be compared with observed AFTA and VR parameters to evaluate the degree of heating which is attributable to the present thermal regime, hence determine whether samples have been hotter in the past.

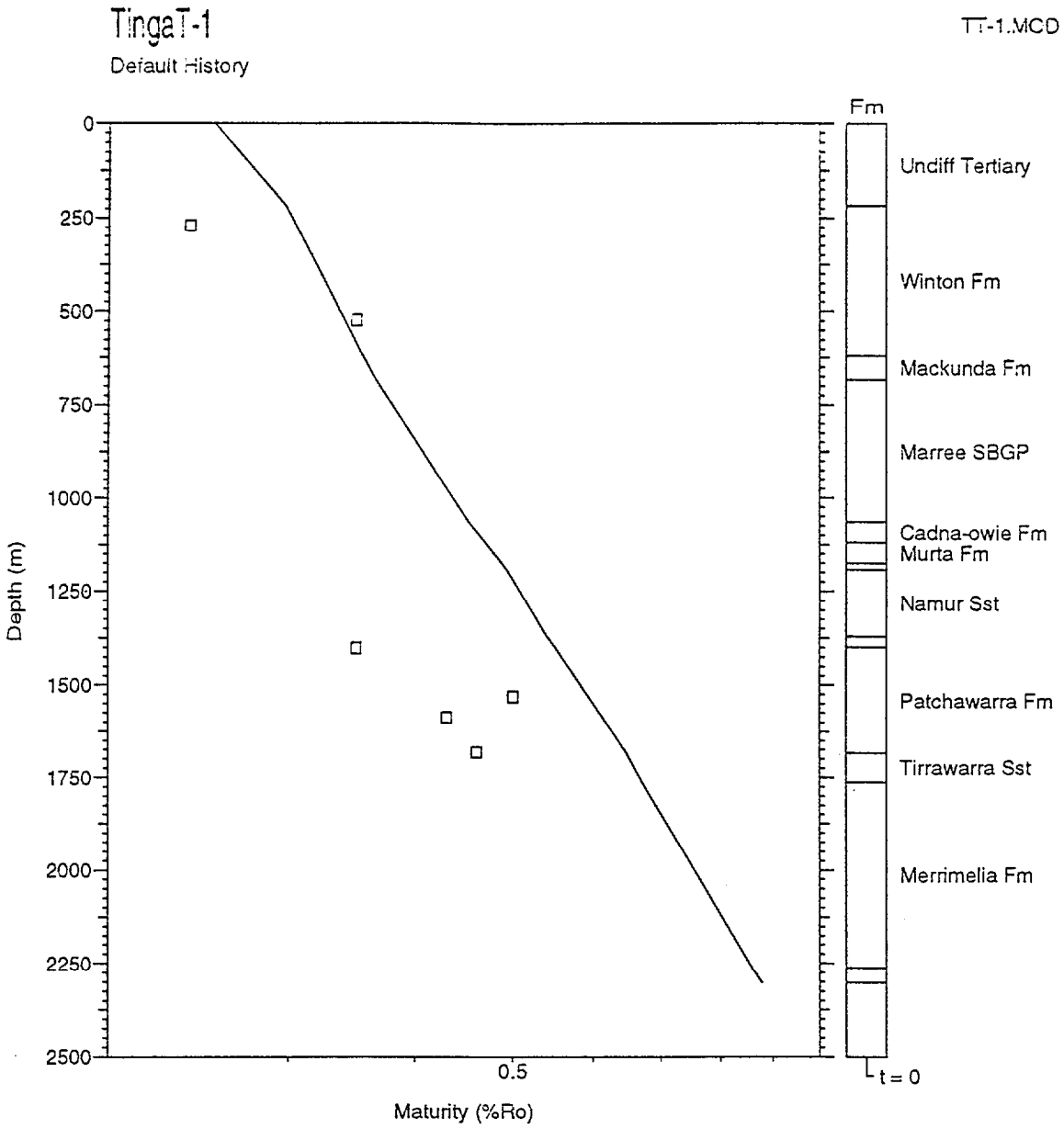


Figure 3.11: Vitrinite reflectance data (supplied by MESA) in the **Tinga Tingana-1 well** plotted against depth (TVD) with respect to KB. The solid line shows the VR profile predicted from the Default Thermal History, i.e., the profile predicted if samples throughout the section are currently at their maximum temperatures since deposition.

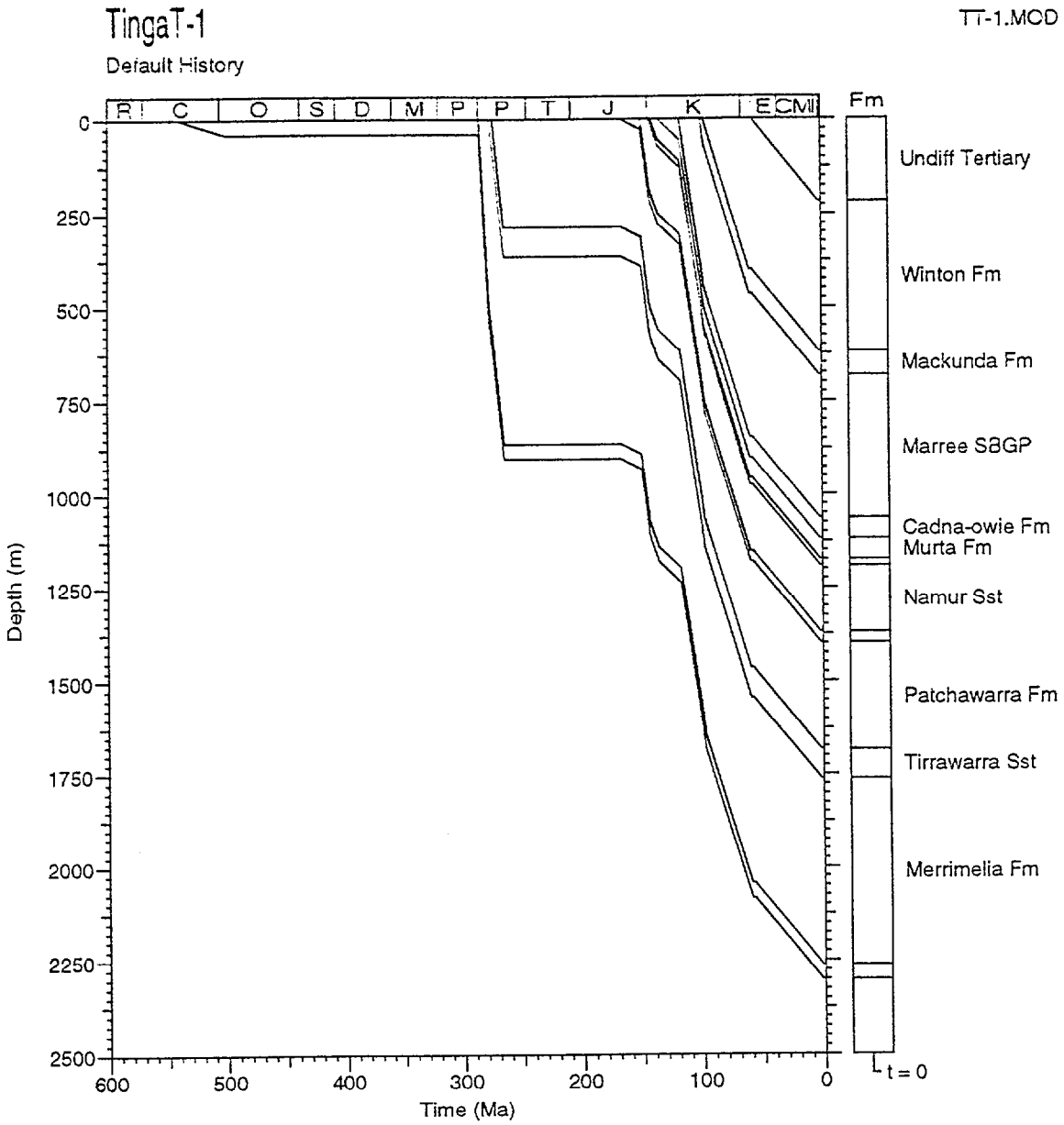


Figure 3.12: Default Burial History showing the history derived from the preserved stratigraphy in the **Tinga Tingana-1 well**. This history, together with the present geothermal gradient of 45.0°C/km (Table A.3) and a surface temperature of 21°C, has been used to calculate the Default Thermal History, as used in Figure 3.11. Default parameters can be compared with observed AFTA and VR parameters to evaluate the degree of heating which is attributable to the present thermal regime, hence determine whether samples have been hotter in the past.

APPENDIX A

Sample Details

A.1 Apatite yields and quality

Sixteen samples from the **Western Eromanga Basin and Eringa Trough** region were submitted for Apatite Fission Track Analysis (AFTA®) by Mines and Energy South Australia. Fifteen samples are from five wells and one sample is from outcrop (Tables A.1 and A.2). An additional AFTA sample (8642-54) from the Tinga Tingana-1 well which was originally part of NERDDC Project No. 720 (Gleadow et al., 1988) was re-processed for this report, as requested.

The yield of detrital apatite obtained after mineral separation from the sixteen samples varied from very poor to excellent, while two samples (GC582-2 and -12) failed to yield any apatite suitable for analysis, as summarised in Table A.1. All grains analysed are of very good quality and contain highly suitable polished surfaces. Resulting AFTA data are reliable and should form the basis of a firm thermal history interpretation.

A.2 Stratigraphic details

Stratigraphic ages of each sample are summarised in Table A.1. Chronostratigraphic and chronometric (numerical) age information was supplied by Mines and Energy South Australia.

A.3 Present temperatures

In the application of any technique involving estimation of paleotemperatures, it is critical to control the present temperature, since estimation of maximum paleotemperatures proceeds from determining how much of the observed effect can be explained by the magnitude of present temperatures.

Uncorrected BHT temperature data were provided by Mines and Energy South Australia, as summarised in Table A.3. The raw BHT data were adjusted using a simplified correction procedure adapted from the literature (Oxburgh and Andrews-Speed, 1981; Andrews-Speeds et al., 1984). In this procedure we increased the difference between the surface temperature and the uncorrected BHT by 20%, for uncorrected temperatures below 150°F (<66°C) and by 25% for temperatures above 150°F (>66°C). An estimate of 21°C was assumed for the present mean annual surface temperature.

A.4 Grain morphologies

Apatite grains in all samples are characterised either by sub-euhedral to sub-rounded forms, or well-rounded forms. Most grains are moderate to large in size (generally 50 to 150 μm). Grains are generally of high quality, though some grains are of poorer quality due to the presence of minor crystal dislocations. No distinct trends in apatite grain morphologies which might reflect different sedimentary provenance were evident.

A.5 Apatite compositions

The annealing kinetics of fission tracks in apatite are affected by chemical composition, specifically the Cl content.

For this study, chlorine compositions were determined for all individual apatite grains in which fission track ages were determined. Chlorine contents were measured using a semi-automated Jeol JXA-5A electron microprobe equipped with three wavelength dispersive crystal spectrometers, with an accelerating voltage of 15KV and beam current of 25nA. The beam was defocussed to 20 μm to avoid the problems associated with apatite decomposition, which occur under a fully focussed 1μm - 2μm beam. The X-Y co-ordinates of apatite grains within the grain mount were transferred from the Autoscan Fission Track Stage to a file suitable for direct input into the electron microprobe. Pure rock salt (NaCl) was used as a standard for chlorine, which was the only element determined in each apatite grain. Count rates were converted to wt% Cl using an empirically determined correction factor. This allows for atomic number absorption and fluorescence matrix effects, which are normally calculated explicitly when analysing for all elements. Durango apatite (Melbourne University Standard APT151) was analysed at regular intervals throughout the analysis to monitor microprobe performance.

Using this approach, lower limits of detection for chlorine content have been calculated for typical analytical conditions (beam current, counting time, etc.), and are listed in Table A.5. Errors in wt% composition are given as a percentage and quoted at 1σ for chlorine determinations. A generalised summary of error values for various values of wt% chlorine is presented in Table A.6.

The measured range of chlorine content of apatites (both age and length grains) within each sample is shown in histogram format in Figure A.2. Plots of single grain age versus weight % chlorine are shown in Figure B.5. Chlorine contents appear in the fission track age summary sheets in Appendix B.

References

Andrews-Speed, C.P., Oxburgh, E.R. and Cooper, B.A. (1984). Temperatures and depth-dependent heat flow in the South-western North Sea. *In:* , L.V. and Hobson, G.D. (eds.), The petroleum geology of the continental shelf of NW Europe, 3, 141-151.

Gleadow, A.J.W., Duddy, I.R, Green, P.F. and Lovering, J.F. (1988). Assessment of hydrocarbon resource potential in Australian sedimentary basins: development of fission track techniques. *End of Grant Technical Report NERDDC Project No. 720.*

Oxburgh, E.R. and Andrews-Speed, C.P. (1981). Temperatures and depth-dependent heat flow in the Western North Sea. *AAPG Bulletin*, 68, 1764-1781.

Table A.1: Details of AFTA samples and apatite yields - well samples from Western Eromanga - Eringa Trough (Geotrack Report #582)

Sample number	Depth (m)	Sample type	Stratigraphic subdivision	Stratigraphic age (Ma)	Present temperature *1 (°C)	Raw weight (g)	Washed weight (g)	Apatite yield *2
Cherri 1								
GC582-1	1327-1333 *(4354-4373')*	cuttings	Tirrawarra Sst	281-274	78	1180	109	Very Poor
Mulapula 1								
GC582-2	613-695 *(2010-2280')*	cuttings	Oodnadatta - Coonikiana	108-100	54	620	162	None
GC582-3	969-997 *(3180-3270')*	cuttings	Namur Sst	150-141.5	71	960	728	Excellent
GC582-4	1218-1230 *(3997-4034')*	core	Birkhead Fm	167-150	83	1200	75	Excellent
GC582-5	1413-1415 *(4635-4643')*	core	Dullingari Gp	510-460	92	1180	247	Poor
Koonchera 1								
GC582-6	585-631 *(1920-2070')*	cuttings	Winton Fm	97.5-90	48	940	355	Excellent
GC582-7	1375-1402 *(4510-4600')*	cuttings	Namur Sst	146-143	83	960	670	Poor
GC582-8	1710-1740 *(5610-5710')*	cuttings	Hutton Sst	188-167	98	1000	762	Good
GC582-9	1987-2012 *(6520-6600')*	cuttings	Poolowanna Fm	193-188	110	1040	812	Poor
GC582-10	2036-2048 *(6680-6720')*	cuttings	Cuddapan Fm	218-205.5	112	860	597	Very Poor
Poolowanna 1								
GC582-11	515-570 *(1690-1870')*	cuttings	Winton Fm	97.5-90	44	1010	168	Fair
GC582-12	1826-1841 *(5990-6040')*	cuttings	Algebuckina Sst	188-138	99	1380	1051	None
Poonarunna 1								
GC582-14	210-250 *(690-820')*	cuttings	Winton Fm	97.5-90	31	530	242	Excellent
GC582-15	1403-1404 *(4603-4605')*	core	Namur Sst	150-141.5	81	1170	948	Poor
GC582-16	1588-1590 *(5210-5216')*	core	Birkhead Fm	167-150	89	1060	814	Excellent
Tinga Tingana 1								
8642-54	1732 *(5683')*	core	Tirrawarra Sst	277-274	99	-	-	Excellent

*1 See Appendix A for discussion of present temperature data.

*2 Yield based on quantity of mineral suitable for age determination. Excellent: >20 grains; Very Good: ~20 grains; Good: 15-20 grains; Fair: 10-15 grains; Poor: 5-10 grains; Very Poor: <5 grains.

Note: All depths quoted are TVD with respect to KB.

Table A.2: Details of AFTA samples and apatite yields - outcrop samples from Western Eromanga - Eringa Trough (Geotrack Report #582)

Sample number	Source number	Stratigraphic subdivision	Stratigraphic age (Ma)	Raw weight (g)	Washed weight (g)	Apatite yield *1
Outcrop samples						
GC582-13	93-7	Musgrave	1500-120	2600	534	Excellent

*1 Yield based on quantity of apatite suitable for age determination. Excellent: >20 grains; Very Good: ~20 grains; Good: 15-20 grains; Fair: 10-15 grains; Poor: 5-10 grains; Very Poor: <5 grains.

Table A.3: Summary of present temperature measurements - Western Eromanga - Eringa Trough wells (Geotrack Report #582)

Ground surface (ft)	Ground surface (m)	Depth (log) (ft)	Uncorrected temperature (°F)	Uncorrected temperature (°C)	Time since circulation (hrs)	Depth (m)	Corrected temperature (°C)	Geothermal gradient (°C/km)
Cherri 1								
0	0	4592	158	70	-	1400	83.8	43.2
		4277	167	75	DST	1304		
Mulapula 1								
16	5			76.7	5.3	1401	92.1	50.7
				82.2*	11.4	1414		
Koonchera 1								
0	0			93.8	4.5	2077	113.5	44.5
				100*	9.16	2075		
				103.3*	13.8	2080		
Poolowanna 1 and 2								
0	0			125.5	11	3069	153.1	42.3
				128.3*	14	3072		
				132.2*	24	3074		
				136.7*	35	3073		
				116.7	6.25	2913	142.1	
				122.8*	11	2911		
Poonarunna 1								
0	0	5574	173	78.3	-	1699	94.1	42.7
		5027	161	71.7	-	1532	85.9	
Tinga Tingana 1								
0	0	Gradient furnished from NERDDC Report May '88						45.0

Quoted BHT values have been corrected by increasing the difference between sea bed temperature and measured BHT by 20% for measured temperatures <150°F (<66°C) and by 25% for temperatures >150°F (>66°C). A surface temperature of 21°C has been assumed.
*Measurement was not used in calculation of present geothermal gradient.
All depths quoted are with respect to KB, except where otherwise stated.

Table A.4: Summary of stratigraphy - wells from Western Eromanga - Eringa Trough (Geotrack Report #582)

	Formation / Group	Age of Top (Ma)	Depth of Top (m)
Cherri 1			
	Tertiary Undifferentiated	2	0
	Unconformity	60	198
	Winton Fm	90	198
	Marree SubGp	97.5	446
	Cadna-owie Fm	117.5	938
	Murta Fm	135.5	993
	McKinlay Mbr	141.5	1030
	Namur Sst	143	1042
	Westbourne Fm	146	1095
	Unconformity	148	1210
	Epsilon Fm	260.5	1210
	Murteree Sh	263.5	1256
	Patchawarra Fm	264.5	1275
	Tirrawarra Sst	274	1317
	Merrimelia Fm	277	1363
	Unconformity	285.5	1371
	Dullingari Gp	440	1371
	Total Depth	510	1401
Mulapula 1			
	Tertiary Undifferentiated	2	5
	Unconformity	60	348
	Mackunda Fm	97.5	348
	Oodnadatta Fm	100	498
	Coonikiana Sst	105.5	639
	Bulldog Sh	108	664
	Cadna-owie Fm	117.5	874
	Murta Fm	135.5	928
	Namur Sst	141.5	956
	Birkhead Fm	150	1202
	Hutton Sst	167	1260
	Unconformity	188	1367
	Dullingari Gp	460	1367
	Total Depth	510	1415

Table A.4: Continued.

	Formation / Group	Age of Top (Ma)	Depth of Top (m)
Koonchera 1			
	Tertiary Undifferentiated	2	0
	Unconformity	60	166
	Winton Fm	90	166
	Mackunda Fm	97.5	664
	Allaru Mdst	100	741
	Toolebuc Fm	105.5	972
	Wallumbilla Fm	108	979
	Cadna-owie Fm	117.5	1279
	Murta Fm	135.5	1333
	Namur Sst	141.5	1368
	Westbourne Fm	146	1415
	Adon Sst	148	1500
	Birkhead Fm	150	1578
	Hutton Sst	167	1654
	Poolowanna Fm	188	1950
	Unconformity	193	2024
	Cuddapan Fm	205.5	2024
	Unconformity	218	2053
	Basement	460	2053
	Total Depth	510	2089
Poolowanna 1			
	Tertiary Undifferentiated	2	0
	Unconformity	60	154
	Winton Fm	90	154
	Mackunda Fm	97.5	748
	Allaru Fm	100	883
	Toolebuc Fm	101	1285
	Wallumbilla Fm	102.5	1323
	Cadna-owie Fm	117.5	1581
	Algebuckina Sst	138	1647
	Poolowanna Fm	188	2387
	Unconformity	193	2593
	Peera Peera Fm	218	2593
	Walkandi Fm	242	2768
	Unconformity	248	2902
	Basement	440	2902
	Total Depth	510	3074
Poonarunna 1			
	Tertiary Undifferentiated	2	0
	Unconformity	60	95
	Winton Fm	90	95
	Mackunda Fm	97.5	580
	Allaru Mdst	100	668
	Toolebuc Fm	101	884
	Wallumbilla Fm	102.5	893
	Cadna-owie Fm	117.5	1165
	Murta Fm	135.5	1202
	Namur Sst	141.5	1211
	Birkhead Fm	150	1576
	Unconformity	167	1630
	Basement	440	1630
	Total Depth	510	1699

Table A.4: Continued.

	Formation / Group	Age of Top (Ma)	Depth of Top (m)
Tinga Tingana 1			
	Tertiary Undifferentiated	2	0
	Unconformity	60	218
	Winton Fm	90	218
	Mackunda Fm	97.5	619
	Marree SubGp	100	683
	Cadna-owie Fm	117.5	1064
	Murta Fm	135.5	1120
	McKinlay Mbr	141.5	1174
	Namur Sst	143	1192
	Birkhead Fm	150	1370
	Unconformity	167	1398
	Patchawarra Fm	264.5	1398
	Tirrawarra Sst	274	1683
	Merrimelia Fm	277	1762
	Unconformity	285.5	2262
	Pando Fm	500	2262
	Total Depth	540	2302

All depths quoted are with respect to KB, except where otherwise stated.

Table A.5: Lower Limits of Detection for Apatite Analyses (Geotrack Report #582)

Element	LLD (95% c.l.)		LLD (99% c.l.)	
	(wt%)	(ppm)	(wt%)	(ppm)
Cl	0.01	126	0.02	182

Table A.6: Per cent errors in chlorine content (Geotrack Report #582)

Chlorine content (wt%)	Error (%)
0.01	9.3
0.02	8.7
0.05	7.3
0.10	6.1
0.20	4.7
0.50	3.2
1.00	2.3
1.50	1.9
2.00	1.7
2.50	1.5
3.00	1.4

Errors quoted are at 1σ. See Appendix A for more details.

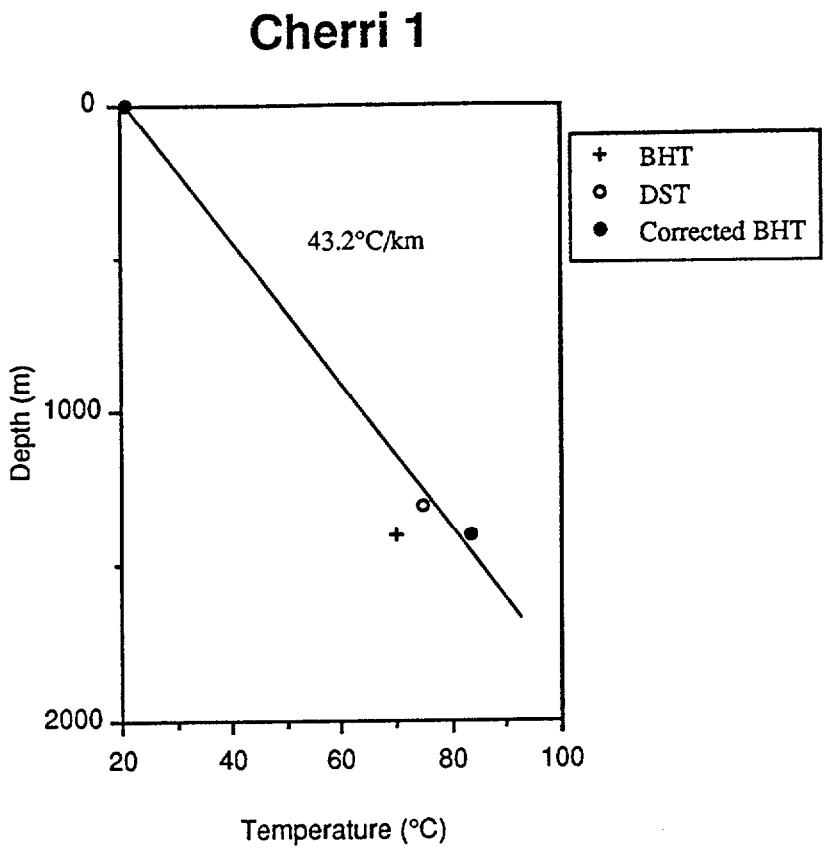


Figure A.1a: Present temperature profile calculated for **well Cherri 1, Western Eromanga - Eringa Trough.** See Table A.3 and Appendix A for more detail.

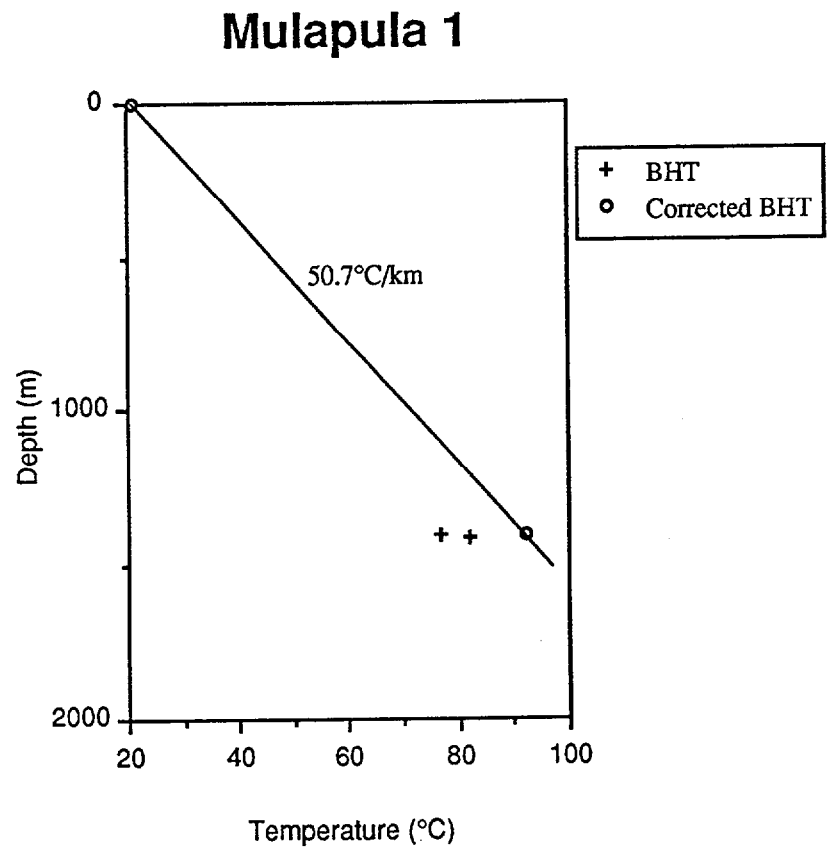


Figure A.1b: Present temperature profile calculated for **well Mulapula 1, Western Eromanga - Eringa Trough.** See Table A.3 and Appendix A for more detail.

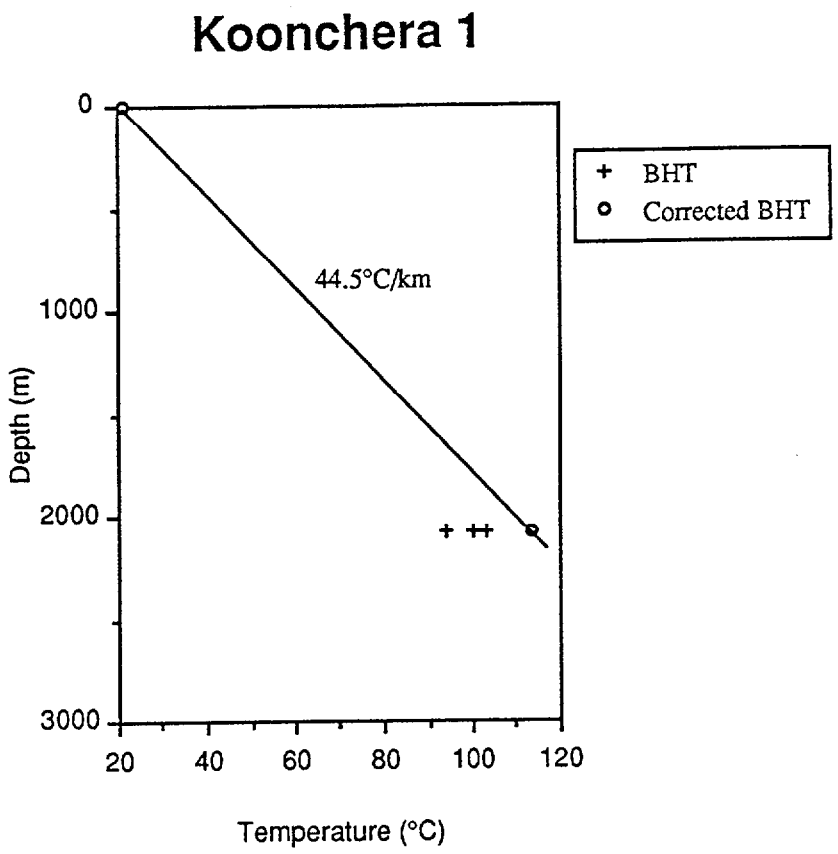


Figure A.1c: Present temperature profile calculated for **well Koonchera 1, Western Eromanga - Eringa Trough.** See Table A.3 and Appendix A for more detail.

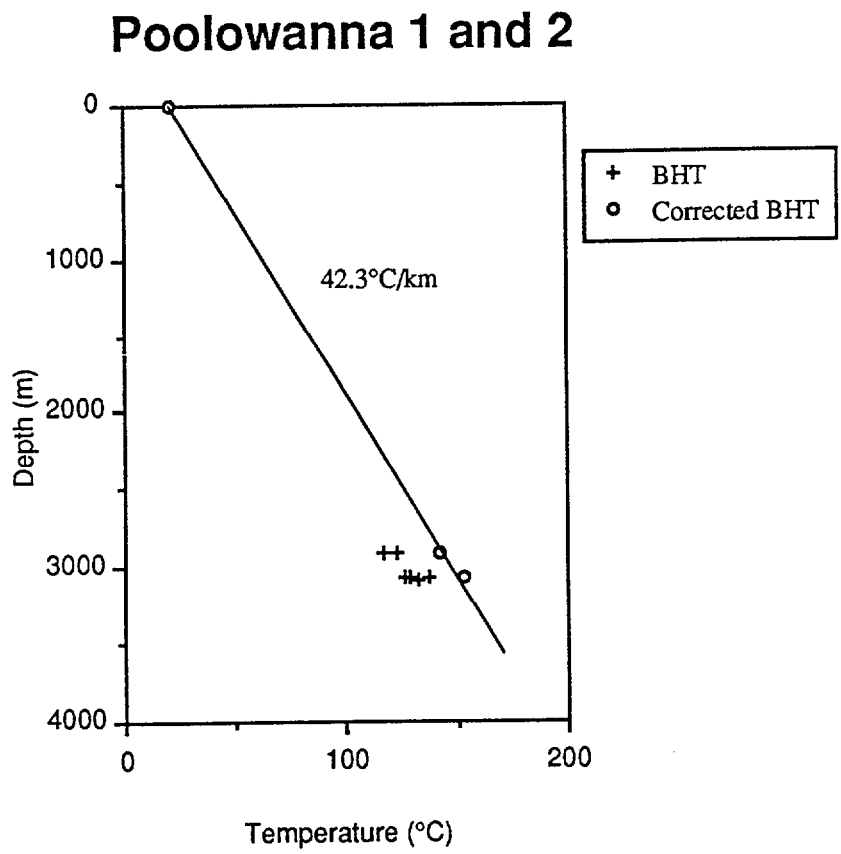


Figure A.1d: Present temperature profile calculated for **wells Poolowanna 1 and 2, Western Eromanga - Eringa Trough.** See Table A.3 and Appendix A for more detail.

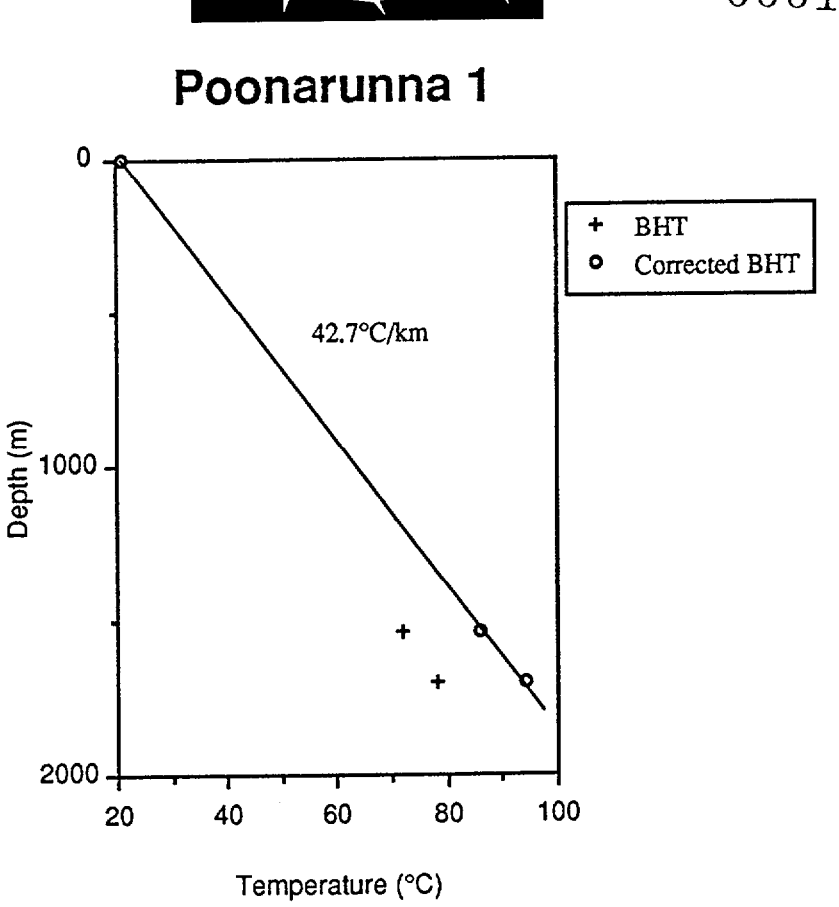


Figure A.1e: Present temperature profile calculated for **well Poonarunna 1, Western Eromanga - Eringa Trough.** See Table A.3 and Appendix A for more detail.

GC582-1

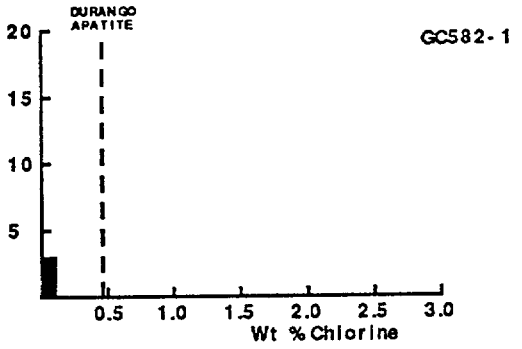
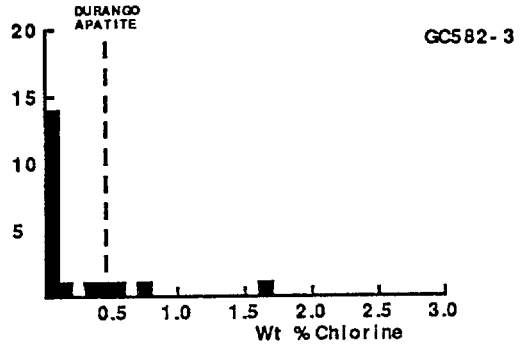


Figure A.2a: Distributions of chlorine content in samples from **well Cherri 1, Western Eromanga - Eringa Trough.**

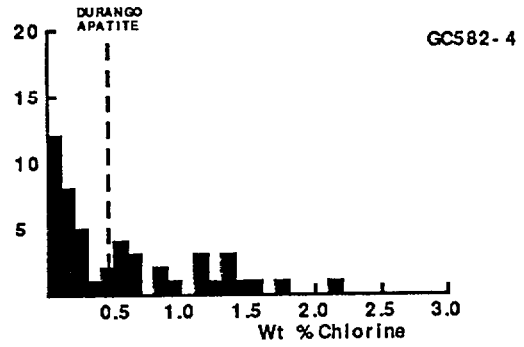
GC582-2

No Apatite

GC582-3



GC582-4



GC582-5

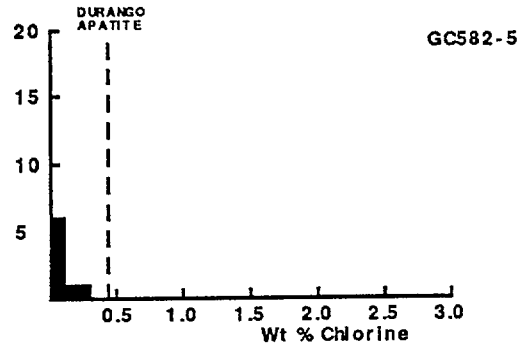
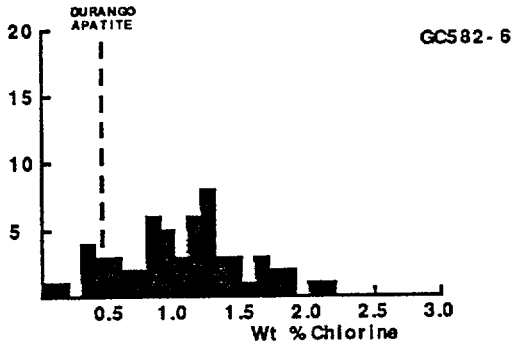
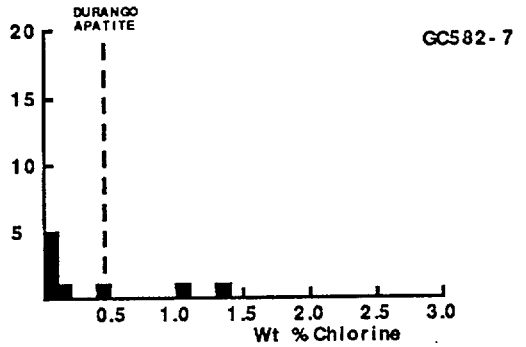


Figure A.2b: Distributions of chlorine content in samples from well **Mulapula 1, Western Eromanga - Eringa Trough.**

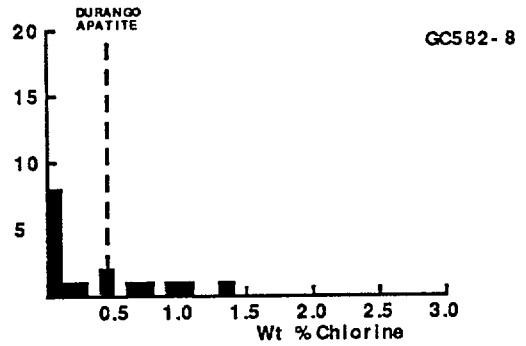
GC582-6



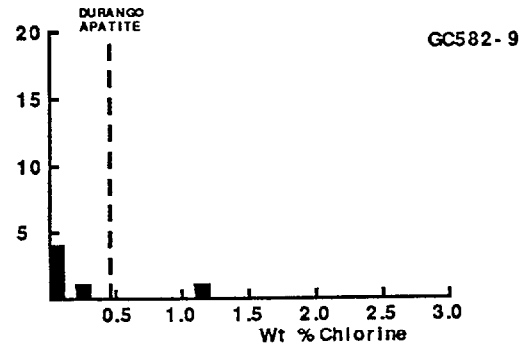
GC582-7



GC582-8



GC582-9



GC582-10

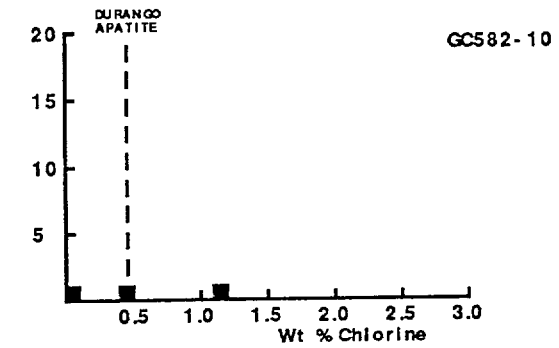
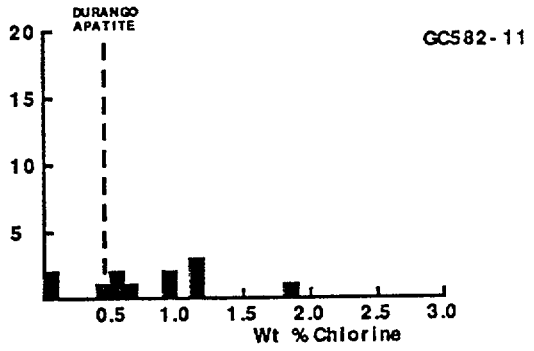


Figure A.2c: Distributions of chlorine content in samples from well **Koonchera 1, Western Eromanga - Eringa Trough.**

GC582-11

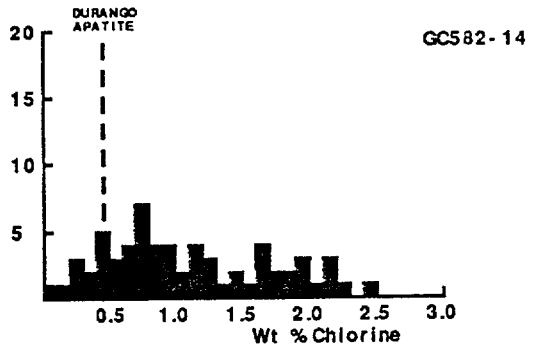


GC582-12

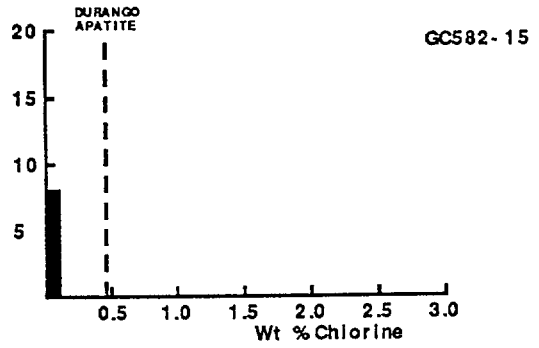
No Apatite

Figure A.2d: Distributions of chlorine content in samples from **well Poolowanna 1, Western Eromanga - Eringa Trough.**

GC582-14



GC582-15



GC582-16

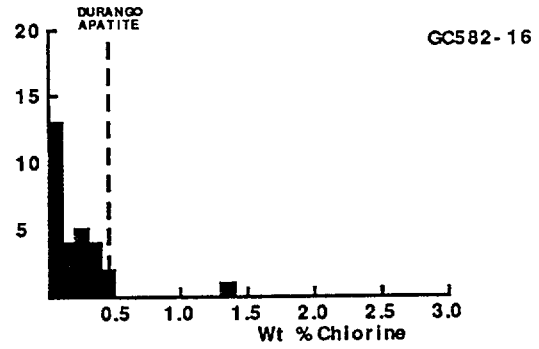


Figure A.2e: Distributions of chlorine content in samples from **well Poonarunna 1, Western Eromanga - Eringa Trough.**

8642-54

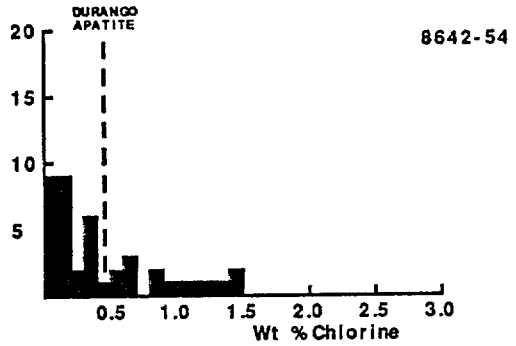


Figure A.2f: Distributions of chlorine content in samples from **well Tinga Tingana 1, Western Eromanga - Eringa Trough.**

GC582-13

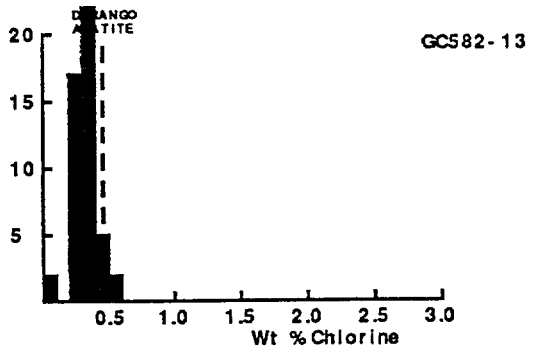


Figure A.2g: Distributions of chlorine content in **outcrop** samples from the **Western Eromanga - Eringa Trough.**

APPENDIX B

Sample Preparation, Analytical Details and Data Presentation

B.1 Sample Preparation

Core and outcrop samples are crushed in a jaw crusher and then ground to sand grade in a rotary disc mill. Cuttings samples are washed and dried before grinding to sand grade. The ground material is then washed to remove dust, dried and processed by conventional heavy liquid and magnetic separation techniques to recover heavy minerals. Apatite grains are mounted in epoxy resin on glass slides, polished and etched for 20 sec in 5M HNO_3 at 20°C to reveal the fossil fission tracks.

After etching, all mounts are cut down to 1.5 X 1 cm, and cleaned in detergent, alcohol and distilled water. The mounts are then sealed in intimate contact with low-uranium muscovite detectors within heat shrink plastic film. Each batch of mounts is stacked between two pieces of uranium standard glass which has been prepared in similar fashion. The stack is then inserted into an aluminium can for irradiation.

B.2 Experimental Details

Fission track ages

Fission track ages are calculated using the standard fission track age equation using the zeta calibration method (equation 5 of Hurford and Green, 1983), viz:

$$\text{F.T. AGE} = \frac{1}{\lambda_D} \ln \left[1 + \left(\frac{\zeta \lambda_D \rho_s g \rho_D}{\rho_i} \right) \right] \qquad \text{B.1}$$

where:
- λ_D = total decay constant of ^{238}U (= 1.55125 x 10^{-10})
- ζ = Zeta calibration factor
- ρ_s = Spontaneous track density
- ρ_i = Induced track density
- ρ_D = Track density from uranium standard glass
- g = A geometry factor (= 0.5)

Fission track ages are determined by the external detector method or EDM (Gleadow, 1981). The EDM has the advantage of allowing fission track ages to be determined on single grains. In apatite, tracks are counted in 20 grains from each mount wherever

possible. In those samples where the desired number is not present, all available grains are counted, the actual number depending on the availability of suitably etched and oriented grains. Only grains oriented with surfaces parallel to the crystallographic c-axis are analysed. Such grains can be identified on the basis of the etching characteristics, as well as from morphological evidence in euhedral grains. The grain mount is scanned sequentially, and the first 20 suitably oriented grains identified are analysed.

Tracks are counted within an eyepiece graticule divided into 100 grid squares. In each grain, the number of spontaneous tracks, N_s, within a certain number of grid squares, N_a, is recorded. The number of induced tracks, N_i, in the corresponding location within the mica external detector is then counted. Spontaneous and induced track densities, ρ_s and ρ_i, respectively, are calculated by dividing the track counts by the total area counted, given by the product of Na and the area or each grid square (determined by calibration against a ruled stage graticule or diffraction grating). Fission track ages may be calculated by substituting track counts, N_s and N_i, for track densities ρ_s and ρ_i in equation B.1, since the areas cancel in the ratio.

Translation between apatite grains in the grain mount and external detector locations corresponding to each grain is carried out using Autoscan™ microcomputer-controlled automatic stages (Smith and Leigh Jones, 1985). This system allows repeated movement between grain and detector, and all grain locations are stored for later reference if required.

Neutron irradiations are carried out in a well thermalised flux (X-7 facility; Cd ratio for Au ~98) in the Australian Atomic Energy Commission's HIFAR research reactor. Total neutron fluence is monitored by counting tracks in mica external detectors attached to two pieces of NBS standard glass SRM612 included in the irradiation canister at each end of the sample stack. In determining track densities in external detectors irradiated adjacent to uranium standard glasses, 25 fields are normally counted in each detector, and the total track count N_D is divided by the total area counted to obtain the track density ρ_D. The positions of the counted fields are arranged in a 5 X 5 grid covering the whole area of the detector. For typical track densities of between ~5 X 10^5 and 5 X 10^6 this is a convenient arrangement to sample across the detector while gathering sufficient counts to achieve a precision of ~±2% in a reasonable time.

A small flux gradient is often present in the irradiation facility over the length of the sample package (note that this developed only in late 1991, after extended refurbishment of the reactor, before which no detectable flux gradient was present). If a detectable gradient is present, the track count in the external detector adjacent to each standard glass is converted to a track density ρ_D and a value for each mount in the stack is calculated by

linear interpolation. When no detectable gradient is present, the track counts in the two external detectors are pooled to give a single value of ρ_D which is used to calculate fission track ages for each sample.

A Zeta calibration factor, ζ, has been determined empirically for each observer by analysing a set of carefully chosen age standards with independently known K-Ar ages, following the methods outlined by Hurford and Green (1983) and Green (1985).

All track counting is carried out using Zeiss(R) Axioplan microscopes, with an overall linear magnification of 1068 x using dry objectives.

For further details and background information on practical aspects of fission track age determination, see e.g. Fleischer, Price and Walker (1975), Naeser (1979) and Hurford (1986).

Track length measurements

For track length studies in apatite, the full lengths of 'confined' fission tracks are measured. Confined tracks are those which do not intersect the polished surface but have been etched from other tracks or fractures, so that the whole length of the track is etched. Confined track lengths are measured using a digitising tablet connected to a microcomputer, superimposed on the microscope field of view via a projection tube. With this system, calibrated against a stage graticule ruled in 2 μm divisions, individual tracks can be measured to a precision of ± 0.2 μm. Tracks are measured only in prismatic grains, characterised by sharp polishing scratches with well etched tracks of narrow cone angle in all orientations, because of the anisotropy of annealing of fission tracks in apatite (as discussed by Green et al., 1986). Tracks are also measured following the recommendations of Laslett et al. (1982), the most important of which is that only horizontal tracks should be measured. One hundred tracks are measured whenever possible. In apatite samples with low track density, or in those samples in which only a small number of apatite grains are obtained, fewer confined tracks may be available, and in such cases, the whole mount is scanned to measure as many confined tracks as possible.

Integrated fission track age and length measurement

Fission track age determination and length measurement are now made in a single pass of the grain mount, in an integrated approach. The location of each grain in which tracks are either counted or measured is recorded for future reference. Thus track length measurements can be tied to age determination in individual grains. As a routine procedure we do not measure the age of every grain in which lengths are determined, as

this would be much too time consuming. Likewise we do not only measure ages in grain in which lengths are measured, as this would bias the age data against low track density grains. Nevertheless, the ability to determine the fission track age of certain grains from which length data originate can be a particularly useful aid to interpretation in some cases. Grain location data are not provided in this report, but are available on request.

B.3 Data Presentation

Fission track age data

Data sheets summarising the apatite fission track age data, including full details of fission track age data for individual apatite grains in each sample, together with the primary counting results and statistical data, are given in the following pages. Individual grain fission track ages are calculated from the ratio of spontaneous to induced fission track counts for each grain using equation B.1, and errors in the single grain ages are calculated using Poissonian statistics, as explained in more detail by Galbraith (1981) and Green (1981). All errors are quoted as $\pm 1\sigma$ throughout this report, unless otherwise stated.

The variability of fission track ages between individual apatite grains within each sample can be assessed using a chi-squared (χ^2) statistic (Galbraith, 1981), the results of which are summarised for each sample in the data sheets. If all the grains counted belong to a single age population, then the probability of obtaining the observed χ^2 value, for ν degrees of freedom (where ν = number of crystals -1), is listed in the data sheets as $P(\chi^2)$ or P(chi squared).

A $P(\chi^2)$ value greater than 5% can be taken as evidence that all grains are consistent with a single population of fission track age. In this case, the best estimate of the fission track age of the sample is given by the "pooled age", calculated from the ratio of the total spontaneous and induced track counts in all grains analysed. Errors for the pooled age are calculated using the 'conventional' technique outlined by Green (1981), based on the total number of tracks counted for each track density measurement (see also Galbraith, 1981).

A $P(\chi^2)$ value of less than 5% denotes a significant spread of single grain ages, and suggests that real differences exist between the fission track ages of individual apatite grains. A significant spread in grain ages can result either from inheritance of detrital grains from mixed source areas (in sedimentary rocks), or from differential annealing in apatite grains of different composition, within a narrow range of temperature.

Calculation of the pooled age inherently assumes that only a single population of ages is present, and is thus not appropriate to samples containing a significant spread of fission track ages. In such cases Galbraith has recently devised a means of estimating the modal age of a distribution of single grain fission track ages which is referred to as the "central age". Calculation of the central age assumes that all single grain ages belong to a Normal distribution of ages with a standard deviation, σ, known as the "age dispersion". An iterative algorithm (as yet unpublished) is used to provide estimates of the central age with its associated error, and the age dispersion, which are all quoted in the data sheets. Note that this treatment replaces use of the "mean age" which has used been in the past for those samples in which $P(\chi^2)<5\%$. For samples in which $P(\chi^2)>5\%$, the central age and the pooled age should be equal, and the age dispersion should be less than ~10%.

Table B.1 summarises the fission track age data in apatite from each sample analysed.

Construction of radial plots of single grain age data

Single grain age data are best represented in the form of radial plot diagrams (Galbraith, 1988, 1990). As illustrated in Figure B.1, these plots display the variation of individual grain ages in a plot of y against x, where:

$$y = (z_j - z_o)/\sigma_i \qquad x = 1/\sigma_j \qquad \text{B.2}$$

and;
z_j = fission track age of grain j
z_o = a reference age
σ_j = error in age for grain j

In this plot, all points on a straight line from the origin define a single value of fission track age, and at any point the value of x is a measure of the precision of each individual grain age. Therefore, precise individual grain ages fall to the right of the plot (small error, high x), which is useful, for example, in enabling precise, young grains to be identified. The age scale is shown radially around the perimeter of the plot (in Ma). If all grains belong to a single age population, all data should scatter between y = +2 and y = -2, equivalent to scatter within $\pm 2\sigma$. Scatter outside these boundaries shows a significant spread of individual grain ages, as also reflected in the values of $P(\chi^2)$ and age dispersion.

In detail, rather than using the fission track age for each grain as in equation B.2, we use:

$$z_j = \frac{N_{sj}}{N_{ij}} \qquad \sigma_j = \{1/N_{sj} + 1/N_{ij}\} \qquad \text{B.3}$$

as we are interested in displaying the scatter within the data from each sample in comparison with that allowed by the Poissonian uncertainty in track counts, without the additional terms which are involved in determination of the fission track age (ρ_D, ζ, etc).

Zero ages cannot be displayed in such a plot. This can be achieved using a modified plot, (Galbraith, 1990) with:

$$z_j = \text{arc sin} \sqrt{\left\{ \frac{N_{sj}+3/8}{N_{sj} + N_{ij} + 3/4} \right\}} \qquad \sigma_j = \frac{1}{2} \sqrt{\left\{ \frac{1}{N_{sj} + N_{ij}} \right\}} \qquad \text{B.4}$$

Note that the numerical terms in the equation for z_j are standard terms, introduced for statistical reasons. Using this arc-sin transformation, zero ages plot on a diagonal line which slopes from upper left to lower right. Note that this line does not go through the origin. Figure B.2 illustrates this difference between conventional and arc-sin radial plots, and also provides a simple guide to the structure of radial plots.

Use of arc-sin radial plots is particularly useful in assessing the relative importance of zero ages. For instance, grains with $N_s = 0$, $N_i = 1$ are compatible with ages up to ~900 Ma (at the 95% confidence level), whereas grains with $N_s = 0$, $N_i = 50$ are only compatible with ages up to ~14 Ma. The two data would readily be distinguishable on the radial plot as the 0,50 datum would plot well to the right (high x) compared to the 0,1 datum.

In this report the value of z corresponding to the fission track age of each sample is adopted as the reference value, z_0.

Note that the x axis of the radial plot is normally not labelled, as this would obscure the age scale around the plot. In general labelling is not considered necessary, as we are concerned only with relative variation within the data, rather than absolute values of precision.

Radial plots of the single grain age data in apatite from each sample analysed in this report are shown in Figure B.3.

Smoothed probability distributions

The single grain ages within each sample are also shown in Figure B.3 in histogram form and also as smoothed probability distributions (Hurford et al., 1984). In constructing these distributions, each grain is represented by a normal probability curve with mean equal to the single grain age, standard deviation given by the error on the single grain age, and the contributions from all grains analysed in each sample are summed to produce the plotted curve. These distributions are generally not as informative as the radial plot

presentation of single grain age data as they convey little assessment of the relative precision of the fission track ages of different grains. However they can be useful for portraying the general form of the distribution of ages within a sample.

Track length data

Distributions of confined track lengths in apatite from each sample are shown as simple histograms in Figure B.4. For every track length measurement the length is recorded to the nearest 0.1 μm, but the measurements have been group into 1 μm intervals in the histograms in Figure B.4. Each distribution has been normalised to 100 tracks for each sample to facilitate comparison. A summary of the length distribution in each sample is presented in Table B.2, which also shows the mean track length in each sample and its associated error, the standard deviation of each distribution, and the number of tracks (N) measured in each sample. The angle which each confined track makes with the crystallographic c-axis is also routinely recorded, as is the width of each fracture within which tracks are revealed. These data are not provided in this report, but can be supplied on request.

B.4 A note on terminology

Note that throughout this report, the term "fission track age" is understood to denote the parameter calculated from the fission track age equation, using the observed spontaneous and induced track counts (either pooled for all grains or for individual grains). The resulting number (with units of Ma) should not be taken as possessing any significance in terms of events taking place at the time indicated by the measured fission track age, but should rather be regarded as a measure of the integrated thermal history of the sample, and should be interpreted in that light. Use of the term "apparent age" is not considered to be useful in this regard, as almost every fission track age should be regarded as an apparent age, in the classic sense, and repeated use becomes cumbersome.

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Table B.1: Apatite fission track analytical results - samples from Western Eromanga - Eringa Trough (Geotrack Report #582)

Sample number	Number of grains	Rho D x10 ^{6} (ND)	Rho S x10 ^{6} (Ns)	Rho I x10 ^{6} (Ni)	Uranium content (ppm)	P(chi squared) (%)	Age dispersion (%)	Fission track age (Ma)
Cherri 1								
GC582-1	2	1.269 (2033)	3.589 (262)	3.507 (256)	32	<1	75	246.4 ± 22.8 *139.6 ± 77.2**
Mulapula 1								
GC582-2			No apatite					
GC582-3	19	1.272 (2033)	1.347 (630)	2.008 (939)	18	<1	58	163.0 ± 9.6 *158.0 ± 24.0**
GC582-4	20	1.275 (2033)	0.585 (460)	1.195 (940)	11	<1	59	119.6 ± 7.6 *134.8 ± 20.6**
GC582-5	7	1.279 (2033)	0.534 (46)	1.461 (126)	13	<1	62	89.7 ± 15.7 *92.8 ± 28.4**
Koonchera 1								
GC582-6	20	1.282 (2033)	0.464 (414)	0.834 (744)	7	<1	28	136.6 ± 9.2 *142.7 ± 13.7**
GC582-7	8	1.286 (2033)	0.989 (249)	4.219 (1062)	37	<1	71	58.0 ± 4.4 *77.3 ± 21.2**
GC582-8	16	1.289 (2033)	0.484 (194)	1.771 (710)	16	<1	79	67.8 ± 5.8 *86.0 ± 19.5**
GC582-9	5	1.292 (2033)	0.294 (27)	1.469 (135)	13	17	21	49.8 ± 10.6
GC582-10	2	1.296 (2033)	0.247 (28)	0.380 (43)	3	91	<1	161.2 ± 39.4
Poolowanna 1								
GC582-11	10	1.299 (2033)	0.313 (84)	0.392 (105)	3	86	<1	198.0 ± 29.5
GC582-12			No apatite					
Poonarunna 1								
GC582-14	20	1.306 (2033)	0.279 (299)	0.527 (564)	5	<1	38	132.5 ± 10.2 *131.1 ± 15.3**
GC582-15	7	1.309 (2033)	0.912 (205)	2.996 (673)	26	<1	95	76.7 ± 6.5 *96.3 ± 36.3**
GC582-16	20	1.312 (2033)	0.314 (180)	2.644 (1516)	23	<1	54	30.1 ± 2.5 *29.4 ± 4.7**
Tinga Tingana 1								
8642-54	20	1.396 (5971)	2.394 (1924)	3.331 (2677)	30	<1	50	175.6 ± 6.5 *147.2 ± 17.7**
Outcrop samples								
GC582-13	20	1.302 (2033)	2.052 (1038)	1.221 (618)	11	20	14	409.8 ± 23.9

Rho S = spontaneous track density; Rho I = induced track density; Rho D = track density in glass standard external detector.
All track densities quoted in units of 1000000 tracks per square cm. Brackets show number of tracks counted.
Rho D and Rho I measured in mica external detectors; Rho S measured in internal surfaces.
* Central age, used where sample contains a significant spread of single grain ages—P(chi squared)<5%. Errors quoted at ±1 sigma.

Ages calculated using dosimeter glass SRM612, with a zeta of 354.8 ± 6.3 (Analyst: H. Gibson) for sample 8642-54
CN5, with a zeta of 386.9 ± 6.9 (Analyst: H. Gibson) for samples GC582 1-16

Table B.2: Length distribution summary data - samples from Western Eromanga - Eringa Trough (Geotrack Report #582)

Sample number	Mean track length (µm)	Standard deviation (µm)	Number of tracks (N)	Number of Tracks in Length Intervals (µm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cherri 1																							
GC582-1	13.30 ± 0.67	1.78	7	-	-	-	-	-	-	-	-	-	-	-	2	1	1	2	-	1	-	-	-
Mulapula 1																							
GC582-2	No apatite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GC582-3	11.32 ± 0.37	1.70	21	-	-	-	-	-	-	-	-	-	7	2	6	3	1	1	1	-	-	-	-
GC582-4	11.49 ± 0.19	1.54	63	-	-	-	-	-	-	-	1	3	6	13	18	12	7	3	-	-	-	-	-
GC582-5	9.20	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Koonchera 1																							
GC582-6	14.42 ± 0.16	1.36	74	-	-	-	-	-	-	-	-	-	1	1	2	4	13	29	17	5	2	-	-
GC582-7	10.80 ± 0.53	1.85	12	-	-	-	-	-	-	-	-	2	1	6	1	1	-	-	1	-	-	-	-
GC582-8	10.90 ± 0.49	1.71	12	-	-	-	-	-	-	-	1	-	1	5	2	2	-	1	-	-	-	-	-
GC582-9	No confined	tracks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GC582-10	14.09 ± 0.56	0.78	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Poolowanna 1																							
GC582-11	14.90 ± 0.65	2.04	10	-	-	-	-	-	-	-	-	-	1	-	-	-	-	4	3	1	1	-	-
GC582-12	No apatite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poonarunna 1																							
GC582-14	15.18 ± 0.12	1.21	100	-	-	-	-	-	-	-	-	-	-	1	1	2	10	28	35	18	4	1	-
GC582-15	11.53 ± 0.67	2.31	12	-	-	-	-	-	-	-	2	-	-	1	5	1	1	1	1	-	-	-	-
GC582-16	10.19 ± 0.40	1.82	21	-	-	-	-	1	-	-	-	2	7	4	4	1	2	-	-	-	-	-	-
Tinga Tingana 1																							
8642-54	11.21 ± 0.16	1.61	102	-	-	-	-	-	-	1	4	6	11	19	26	20	14	1	-	-	-	-	-
Outcrop samples																							
GC582-13	14.02 ± 0.10	1.03	100	-	-	-	-	-	-	-	-	-	-	2	3	5	36	40	14	-	-	-	-

Track length measurements by H. Gibson.

Table B.3: AFTA Data in Compositional Groups - (Geotrack Report #582)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (µm)	Mean track length (µm)	Error in length (µm)	Std deviation (µm)	Number of lengths	Number of grains	Number of tracks in length interval (µm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cherri 1																															
†582-1	**198.8**	**139.6**	**77.1**	**0.0**	**2**	**10.7**	**13.3**	**0.7**	**1.8**	**7**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**2**	**0**	**1**	**0**	**0**	**0**
0.0-0.1	198.8	139.6	77.1	0.0	2	10.7	13.3	0.7	1.8	7	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1	2	0	1	0	0	0
Mulapula 1																															
†582-3	**116.8**	**158.0**	**23.5**	**0.0**	**19**	**12.1**	**11.4**	**0.4**	**1.7**	**21**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**2**	**7**	**3**	**1**	**1**	**1**	**0**	**0**	**0**	**0**
0.0-0.1	114.4	137.6	25.6	0.0	13	11.9	11.1	0.5	1.7	13	6	0	0	0	0	0	0	0	0	0	5	2	3	1	1	1	0	0	0	0	0
0.1-0.2	116.2	300.5	76.5	100.0	1	12.1	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	119.8	263.5	55.9	100.0	1	12.4	11.6	0.4	0.7	3	1	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
0.4-0.5	121.4	358.9	53.8	100.0	1	12.6	11.0	1.0	1.7	3	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0
0.5-0.6	122.5	140.9	53.5	100.0	1	12.7	13.4	1.6	2.2	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7-0.8	124.6	73.4	48.3	100.0	1	12.9	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0-1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1-1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2-1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3-1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.4-1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5-1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.6-1.7	127.2	166.2	59.9	100.0	1	13.2	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)

† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (μm)	Mean track length (μm)	Error in length (μm)	Std deviation (μm)	Number of lengths	Number of grains	Number of tracks in length interval (μm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
†582-4	**121.2**	**134.8**	**20.2**	**0.0**	**20**	**11.5**	**11.5**	**0.2**	**1.5**	**63**	**36**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**6**	**13**	**18**	**12**	**7**	**3**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	110.4	73.4	31.6	0.0	5	10.5	11.3	0.3	1.2	17	9	0	0	0	0	0	0	0	0	0	2	6	4	4	1	0	0	0	0	0	0
0.1-0.2	114.4	158.8	31.3	86.0	3	10.8	11.4	0.4	1.3	10	6	0	0	0	0	0	0	0	0	0	2	2	4	0	2	0	0	0	0	0	0
0.2-0.3	117.7	155.3	22.6	100.0	1	11.1	11.0	0.4	1.3	11	5	0	0	0	0	0	0	0	1	0	1	1	7	1	0	0	0	0	0	0	0
0.3-0.4	120.9	36.4	19.5	100.0	1	11.4	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.4-0.5	123.7	140.3	17.9	11.0	2	11.7	9.9	0.9	1.8	4	1	0	0	0	0	0	0	0	0	2	0	1	0	1	0	0	0	0	0	0	0
0.5-0.6	125.5	370.5	101.7	100.0	1	11.9	11.1	0.5	1.1	4	3	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
0.6-0.7	127.2	359.9	147.1	100.0	1	12.0	10.6	1.0	1.8	3	2	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	130.8	159.7	47.3	100.0	1	12.4	10.6	0.5	0.7	2	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
0.9-1.0	131.1	173.9	51.1	100.0	1	12.4	13.2	0.8	1.1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
1.0-1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1-1.2	131.6	215.7	47.1	37.0	2	12.4	14.5	0.2	0.3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
1.2-1.3	131.8	0.0	0.0	0.0	0	12.5	12.4	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1.3-1.4	132.1	0.0	0.0	0.0	0	12.5	13.0	0.7	1.2	3	3	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0
1.4-1.5	132.3	122.2	74.9	100.0	1	12.5	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5-1.6	132.6	0.0	0.0	0.0	0	12.5	12.8	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1.6-1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.7-1.8	133.1	135.6	53.6	100.0	1	12.6	13.4	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1.8-1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.9-2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.0-2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1-2.2	134.0	0.0	0.0	0.0	0	12.7	13.7	0.2	0.3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
†582-5	**193.3**	**92.8**	**28.3**	**0.0**	**7**	**8.7**	**9.2**	**0.0**	**0.0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	165.7	47.1	12.5	15.0	5	8.7	9.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0.1-0.2	232.4	224.4	90.0	100.0	1	9.3	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.2-0.3	291.9	172.9	54.9	100.0	1	9.8	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl	Default fission track age*	Measured fission track age	Error in age	P (χ 2)	Number of grains	Default fission track length*	Mean track length	Error in length	Std deviation	Number of lengths	Number of grains	Number of tracks in length interval																			
												1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Wt %	(Ma)	(Ma)	(Ma)			(μm)	(μm)	(μm)	(μm)			(μm)																			
Koonchera 1																															
†582-6	91.8	142.7	13.1	0.0	20	14.0	14.4	0.2	1.4	74	48	0	0	0	0	0	0	0	0	0	1	1	2	4	13	29	17	5	2	0	0
0.0-0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1-0.2	88.6	108.0	19.1	100.0	1	13.5	12.7	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	89.8	181.8	44.8	41.0	2	13.7	13.7	0.4	0.7	3	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0
0.4-0.5	90.3	0.0	0.0	0.0	0	13.7	15.0	0.6	1.1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
0.5-0.6	90.7	0.0	0.0	0.0	0	13.8	14.1	0.6	1.3	5	3	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	0	0	0	0
0.6-0.7	91.1	0.0	0.0	0.0	0	13.9	13.5	0.7	1.3	4	2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0
0.7-0.8	91.6	112.4	27.2	1.0	2	13.9	13.4	0.2	0.3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
0.8-0.9	92.0	118.8	27.0	98.0	2	14.0	15.0	0.3	0.9	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	2	0	0	0
0.9-1.0	92.1	208.6	39.3	18.0	3	14.0	14.5	0.5	1.2	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	0	0
1.0-1.1	92.2	91.2	33.8	100.0	1	14.0	13.9	1.0	2.2	5	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	1	0	0	0	0
1.1-1.2	92.3	133.0	19.8	44.0	3	14.0	14.5	0.4	0.9	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0
1.2-1.3	92.3	139.0	42.3	15.0	2	14.0	14.7	0.2	0.8	14	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	3	1	0	0	0
1.3-1.4	92.4	0.0	0.0	0.0	0	14.1	15.3	0.3	0.7	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0
1.4-1.5	92.5	155.9	43.7	100.0	1	14.1	14.9	1.9	3.2	3	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0
1.5-1.6	92.5	207.5	68.6	100.0	1	14.1	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.6-1.7	92.6	0.0	0.0	0.0	0	14.1	15.0	0.3	0.4	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0
1.7-1.8	92.7	274.1	67.9	100.0	1	14.1	14.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1.8-1.9	92.8	59.3	27.0	100.0	1	14.1	12.8	0.8	1.6	4	2	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0
1.9-2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.0-2.1	92.9	0.0	0.0	0.0	0	14.1	17.5	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
2.1-2.2	93.0	0.0	0.0	0.0	0	14.1	15.5	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (µm)	Mean track length (µm)	Error in length (µm)	Std deviation (µm)	Number of lengths	Number of grains	Number of tracks in length interval (µm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
†582-7	**100.2**	**77.3**	**21.1**	**0.0**	**8**	**11.1**	**10.8**	**0.5**	**1.9**	**12**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**6**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
0.0-0.1	88.4	33.0	7.9	0.0	4	10.1	10.0	0.3	0.4	2	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
0.1-0.2	98.9	111.5	11.4	100.0	1	10.5	10.4	0.4	1.2	9	1	0	0	0	0	0	0	0	0	2	0	5	1	1	0	0	0	0	0	0	0
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	111.0	244.0	95.9	100.0	1	11.5	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5-0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0-1.1	118.6	92.6	44.4	100.0	1	12.2	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.1-1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2-1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3-1.4	119.4	179.8	71.5	100.0	1	12.3	15.7	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
†582-8	**55.3**	**86.0**	**19.3**	**0.0**	**16**	**10.6**	**10.9**	**0.5**	**1.7**	**12**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**5**	**2**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
0.0-0.1	5.5	63.4	25.1	0.0	7	9.3	12.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0.1-0.2	10.9	0.0	0.0	110.0	1	9.2	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.2-0.3	34.9	170.7	38.3	100.0	1	8.9	11.4	0.5	0.8	3	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	89.6	115.5	66.3	1.0	2	9.7	7.1	0.0	0.0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0.5-0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6-0.7	113.5	61.3	14.7	100.0	1	10.3	10.3	0.0	0.0	3	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
0.7-0.8	122.7	45.2	34.7	100.0	1	10.6	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	127.6	196.4	54.0	100.0	1	11.0	10.2	0.6	0.8	2	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
1.0-1.1	128.1	210.2	117.1	100.0	1	11.0	11.8	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1.1-1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2-1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3-1.4	129.5	129.9	50.8	100.0	1	11.1	14.1	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl	Default fission track age*	Measured fission track age	Error in age	P (χ 2)	Number of grains	Default fission track length*	Mean track length	Error in length	Std deviation	Number of lengths	Number of grains	Number of tracks in length interval																			
												1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Wt %	(Ma)	(Ma)	(Ma)			(μm)	(μm)	(μm)	(μm)			(μm)																			
†582-9	19.9	49.8	10.6	17.0	5	8.8	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0-0.1	0.2	47.9	16.6	6.0	3	7.7	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	1.5	46.5	13.6	100.0	1	8.8	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.5-0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0-1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1-1.2	97.2	93.1	63.0	100.0	1	9.6	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
†582-10	50.6	161.2	39.3	91.0	2	9.0	14.1	0.6	0.8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0.0-0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	5.1	165.0	53.4	100.0	1	9.0	14.1	0.6	0.8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0.5-0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0-1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1-1.2	96.1	156.4	57.8	100.0	1	9.4	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (μm)	Mean track length (μm)	Error in length (μm)	Std deviation (μm)	Number of lengths	Number of grains	Number of tracks in length interval (μm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Poolowanna 1																															
†582-11	**90.4**	**198.0**	**29.3**	**86.0**	**10**	**14.1**	**14.9**	**0.6**	**2.0**	**10**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**4**	**3**	**1**	**1**	**0**	**0**
0.0-0.1	87.6	35.8	38.3	100.0	1	13.6	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	89.6	216.2	79.3	100.0	1	13.9	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5-0.6	89.9	224.5	98.2	47.0	2	14.0	15.9	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0.6-0.7	90.3	142.0	89.1	100.0	1	14.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	91.2	233.1	79.0	90.0	2	14.2	15.9	0.7	1.2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
1.0-1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1-1.2	91.3	199.5	53.8	77.0	2	14.2	13.7	1.0	2.2	5	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	1	0	0	0	0
1.2-1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3-1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.4-1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5-1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.6-1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.7-1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.8-1.9	91.7	214.2	81.3	100.0	1	14.2	16.9	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (μm)	Mean track length (μm)	Error in length (μm)	Std deviation (μm)	Number of lengths	Number of grains	Number of tracks in length interval 1 (μm)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
†Poonarunna 1																															
†582-14	90.2	131.1	14.8	0.0	20	14.5	15.2	0.1	1.2	100	50	0	0	0	0	0	0	0	0	0	0	1	1	2	10	28	35	18	4	1	0
0.0-0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1-0.2	88.7	102.5	40.6	100.0	1	14.2	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.2-0.3	89.0	82.2	21.8	95.0	2	14.3	14.9	0.9	1.3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
0.3-0.4	89.3	0.0	0.0	0.0	0	14.3	12.8	1.3	2.3	3	2	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0
0.4-0.5	89.6	527.0	133.3	100.0	1	14.4	15.1	0.3	0.8	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	1	0	0	0
0.5-0.6	89.9	101.7	19.0	51.0	3	14.4	15.1	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0.6-0.7	90.1	162.7	54.1	100.0	1	14.5	14.9	0.3	1.0	10	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	5	1	0	0	0
0.7-0.8	90.4	117.9	17.9	65.0	5	14.5	15.5	0.3	1.2	12	5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	4	1	0	0
0.8-0.9	90.7	142.0	33.2	59.0	2	14.5	14.2	1.5	2.5	3	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0
0.9-1.0	90.7	119.2	32.5	100.0	1	14.5	15.4	0.2	0.5	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	1	0	0	0
1.0-1.1	90.8	0.0	0.0	0.0	0	14.6	15.5	0.5	0.9	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
1.1-1.2	90.8	203.4	91.5	100.0	1	14.6	14.7	0.5	1.3	6	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	2	0	0	0	0
1.2-1.3	90.9	92.4	40.9	100.0	1	14.6	15.0	1.2	1.7	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
1.3-1.4	90.9	0.0	0.0	0.0	0	14.6	15.6	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1.4-1.5	91.0	0.0	0.0	0.0	0	14.6	15.0	0.7	1.4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
1.5-1.6	91.0	131.6	51.5	100.0	1	14.6	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.6-1.7	91.1	0.0	0.0	0.0	0	14.6	15.2	0.3	1.1	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	4	4	0	0
1.7-1.8	91.1	0.0	0.0	0.0	0	14.6	15.1	0.4	0.9	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0
1.8-1.9	91.2	0.0	0.0	0.0	0	14.6	16.5	0.6	1.1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0
1.9-2.0	91.2	109.8	26.5	100.0	1	14.6	16.3	0.6	1.1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
2.0-2.1	91.3	0.0	0.0	0.0	0	14.6	14.4	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2.1-2.2	91.3	0.0	0.0	0.0	0	14.6	15.9	0.4	1.0	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	1	0	1	0
2.2-2.3	91.4	0.0	0.0	0.0	0	14.6	14.9	0.3	0.7	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0
2.3-2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.4-2.5	91.5	0.0	0.0	0.0	0	14.7	15.5	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
†582-15	91.3	96.3	36.2	0.0	7	10.2	11.5	0.7	2.3	12	2	0	0	0	0	0	0	0	2	0	0	1	5	1	1	1	1	0	0	0	0
0.0-0.1	91.3	96.3	36.2	0.0	7	10.2	11.5	0.7	2.3	12	2	0	0	0	0	0	0	0	2	0	0	1	5	1	1	1	1	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (µm)	Mean track length (µm)	Error in length (µm)	Std deviation (µm)	Number of lengths	Number of grains	Number of tracks in length interval (µm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
†582-16	66.8	29.4	4.6	0.0	20	10.2	10.2	0.4	1.8	21	13	0	0	0	0	1	0	0	0	2	7	4	4	1	2	0	0	0	0	0	0
0.0-0.1	43.5	13.5	5.7	0.0	9	9.3	11.0	0.6	1.6	6	4	0	0	0	0	0	0	0	0	0	3	0	1	1	1	0	0	0	0	0	0
0.1-0.2	65.0	38.7	5.9	77.0	4	9.4	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.2-0.3	83.4	47.7	8.3	24.0	2	9.8	10.8	0.7	1.5	5	4	0	0	0	0	0	0	0	0	0	2	1	1	0	1	0	0	0	0	0	0
0.3-0.4	99.3	41.2	8.3	6.0	3	10.3	9.9	0.4	0.9	6	3	0	0	0	0	0	0	0	0	1	2	2	1	0	0	0	0	0	0	0	0
0.4-0.5	110.5	33.3	6.5	6.0	2	10.7	8.1	1.9	3.4	3	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
0.5-0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0-1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1-1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2-1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3-1.4	122.7	0.0	0.0	0.0	0	11.8	10.1	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Tinga Tingana 1																															
†8642-54	64.0	147.2	17.4	0.0	20	10.4	11.2	0.2	1.6	102	30	0	0	0	0	0	0	1	4	6	11	19	26	20	14	1	0	0	0	0	0
0.0-0.1	4.1	84.2	6.8	20.0	7	9.0	10.9	0.6	1.2	4	3	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
0.1-0.2	8.7	128.8	9.6	4.0	5	9.1	10.3	0.6	1.7	9	5	0	0	0	0	0	0	0	0	2	3	1	2	0	1	0	0	0	0	0	0
0.2-0.3	43.3	0.0	0.0	0.0	0	8.5	10.1	0.4	0.6	3	2	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0
0.3-0.4	96.6	212.1	15.0	87.0	3	9.0	11.1	0.3	1.3	18	5	0	0	0	0	0	0	0	1	0	2	4	6	4	1	0	0	0	0	0	0
0.4-0.5	136.4	0.0	0.0	0.0	0	9.5	12.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0.5-0.6	157.9	229.5	24.1	100.0	1	9.8	9.5	0.8	1.7	5	2	0	0	0	0	0	0	1	0	0	3	0	1	0	0	0	0	0	0	0	0
0.6-0.7	177.5	275.2	49.5	0.0	2	10.2	10.9	0.5	1.8	15	3	0	0	0	0	0	0	0	1	2	0	6	2	1	3	0	0	0	0	0	0
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	202.3	272.4	19.9	10.0	2	10.8	11.3	0.4	1.7	18	2	0	0	0	0	0	0	0	1	2	0	3	7	1	4	0	0	0	0	0	0
0.9-1.0	203.1	0.0	0.0	0.0	0	10.9	11.8	0.7	1.3	4	1	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0
1.0-1.1	203.9	0.0	0.0	0.0	0	10.9	11.3	0.9	1.3	2	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
1.1-1.2	204.7	0.0	0.0	0.0	0	10.9	13.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1.2-1.3	205.5	0.0	0.0	0.0	0	11.0	11.8	0.5	1.7	10	1	0	0	0	0	0	0	0	1	0	0	1	1	6	1	0	0	0	0	0	0
1.3-1.4	206.3	0.0	0.0	0.0	0	11.0	12.0	0.6	1.1	3	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0
1.4-1.5	207.0	0.0	0.0	0.0	0	11.1	12.6	0.4	1.2	9	2	0	0	0	0	0	0	0	0	0	0	0	3	3	2	1	0	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)

† Combined data for all compositional groups

Table B.3: Continued - (Geotrack Report #582)

Cl	Default fission track age*	Measured fission track age	Error in age	P (χ 2)	Number of grains	Default fission track length*	Mean track length	Error in length	Std deviation	Number of lengths	Number of grains	Number of tracks in length interval																			
												1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Wt %	(Ma)	(Ma)	(Ma)			(μm)	(μm)	(μm)	(μm)			(μm)																			
Outcrop sample																															
†582-13	772.5	409.8	22.8	20.0	20	14.3	14.0	0.1	1.0	100	41	0	0	0	0	0	0	0	0	0	0	2	3	5	36	40	14	0	0	0	0
0.0-0.1	764.2	0.0	0.0	0.0	0	14.1	11.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0.1-0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2-0.3	770.4	419.0	41.0	92.0	7	14.2	14.0	0.2	1.0	32	13	0	0	0	0	0	0	0	0	0	0	0	2	1	13	10	6	0	0	0	0
0.3-0.4	773.4	409.5	34.8	5.0	12	14.3	14.0	0.2	1.1	52	20	0	0	0	0	0	0	0	0	0	0	2	0	4	18	21	7	0	0	0	0
0.4-0.5	776.2	562.6	147.3	100.0	1	14.3	14.2	0.2	0.7	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	6	0	0	0	0	0
0.5-0.6	778.5	0.0	0.0	0.0	0	14.4	14.5	0.3	0.7	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)
† Combined data for all compositional groups

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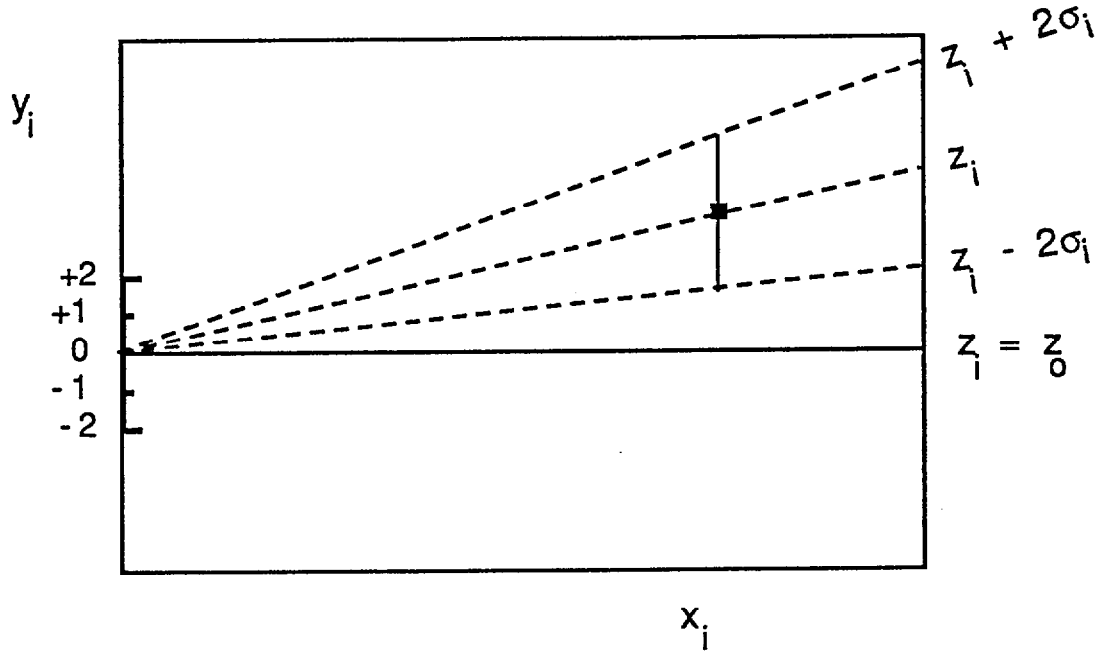
Estimates	z_i
Standard errors	σ_i
Reference value	z_o
Standardised estimates	$y_i = (z_i - z_o) / \sigma_i$
Precision	$x_i = 1 / \sigma_i$

PLOT y_i against x_i



Slope of line from origin through data point $= y_i / x_i$

$= \{(z_i - z_o)/\sigma_i\} / \{1/\sigma_i\}$

$= z_i - z_o$

Key Points:

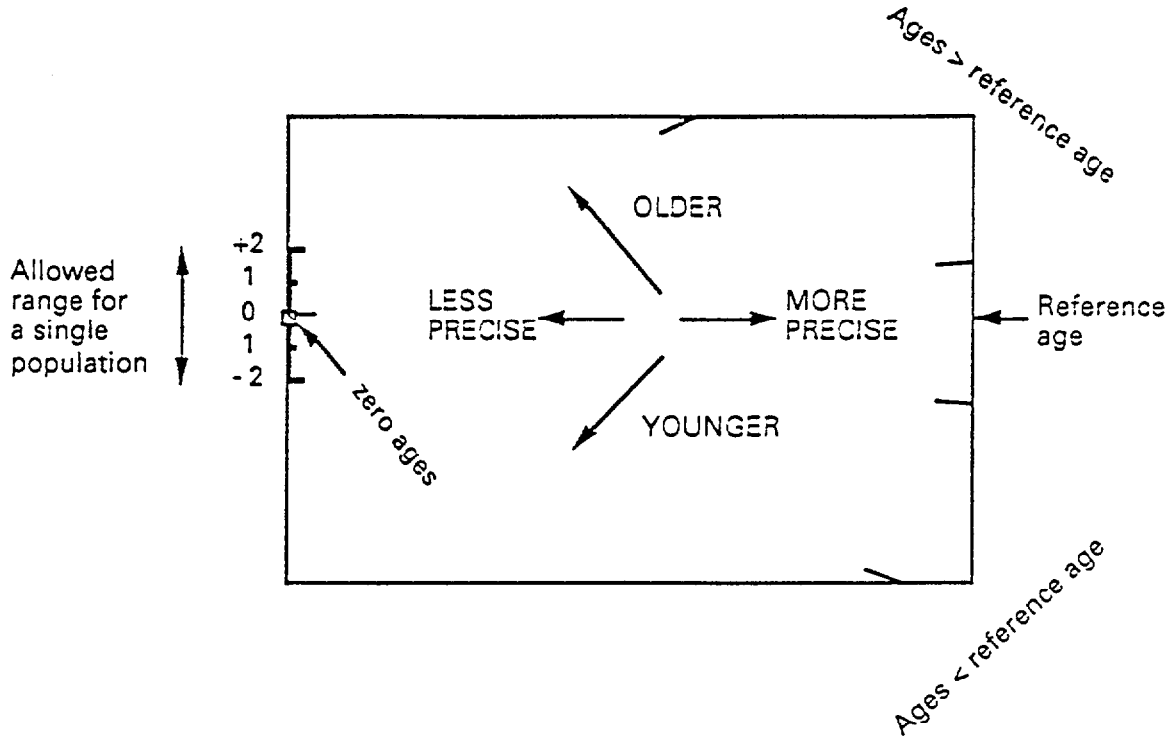
Radial lines emanating from the origin correspond to fixed values of z

Data points with higher values of x_i have greater precision.

Error bars on all points are the same size in this plot.

Figure B.1 Basic construction of a radial plot. In AFTA, the estimates z_i correspond to the fission track age values for individual apatite grains. Any convenient value of age can be chosen as the reference value corresponding to the horizontal in the radial plot. Radial lines emanating from the origin with positive slopes correspond to fission track ages greater than the reference value. Lines with negative slopes correspond to fission track ages less than the reference value.

Normal radial plot (equations B.2 and B.3)



Arc-sin radial plot (equations B.2 and B.4)

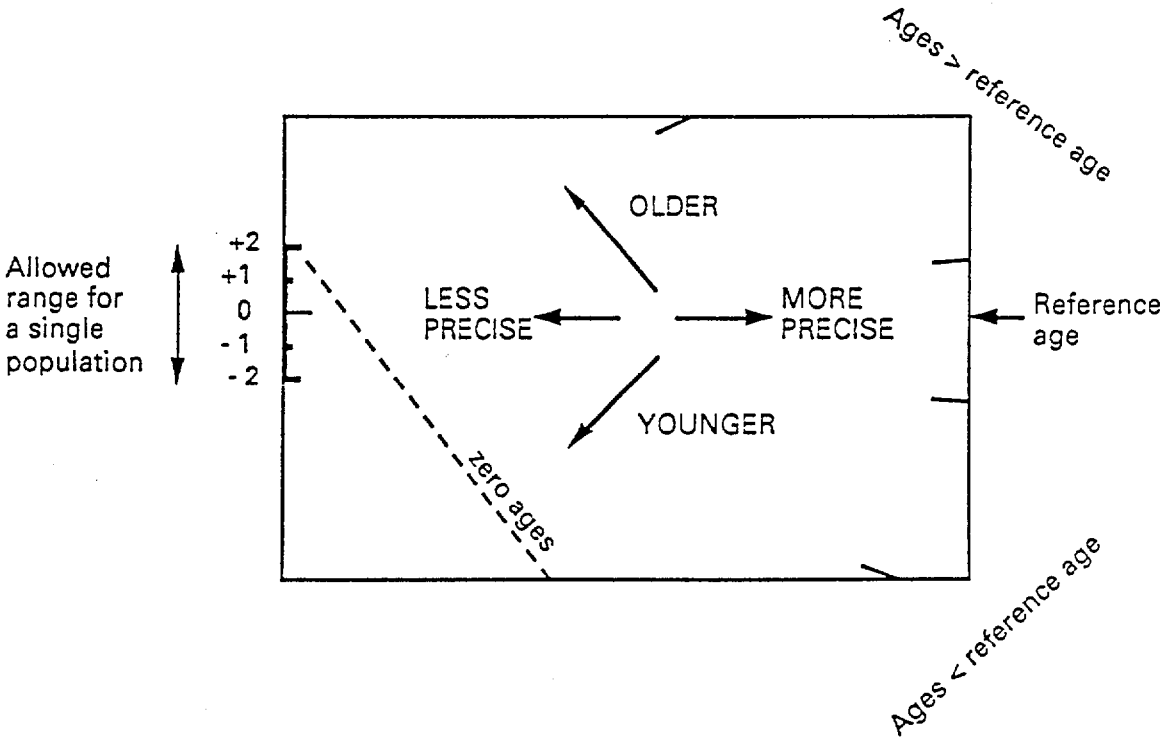


Figure B.2 Simplified structure of Normal and Arc-sin radial plots.

GC582-1

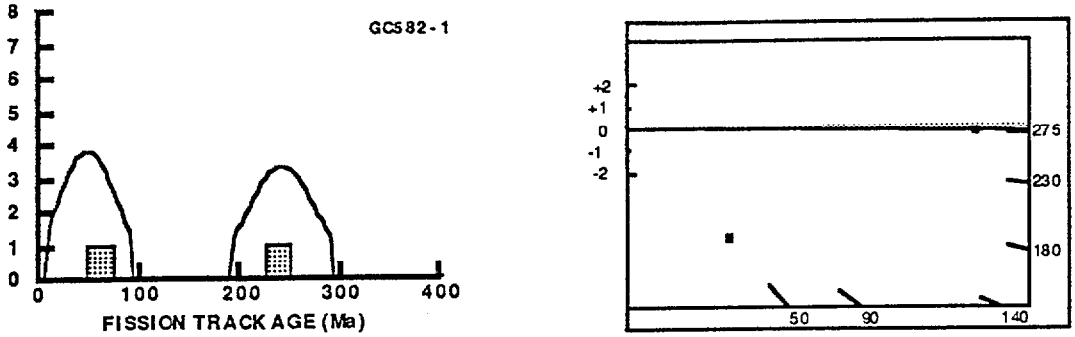
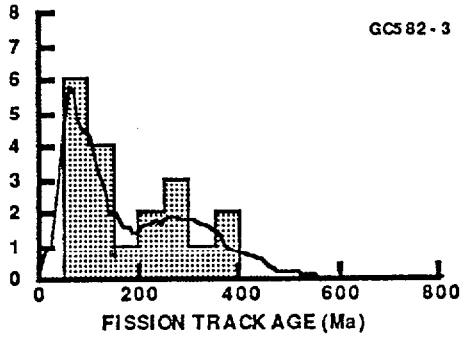


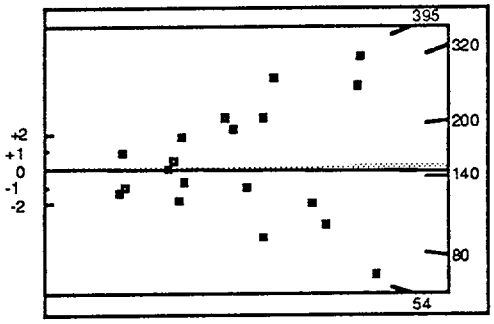
Figure B.3a: Single grain age figures for samples from **well Cherri 1, Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC582-2

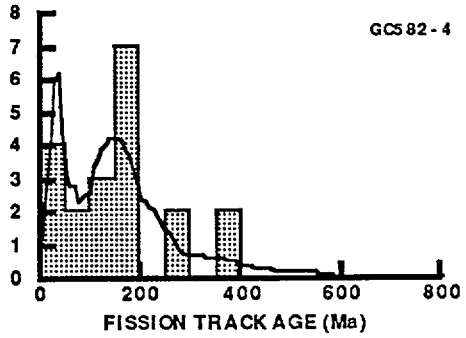
No Apatite

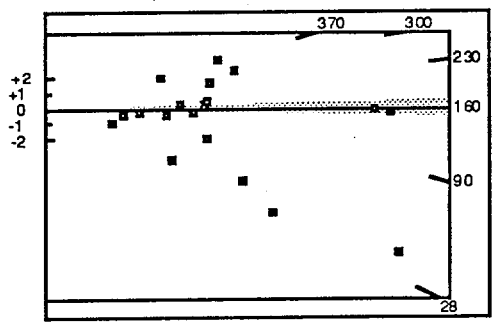
GC582-3



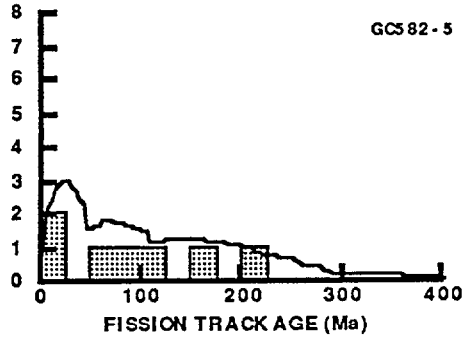


GC582-4





GC582-5



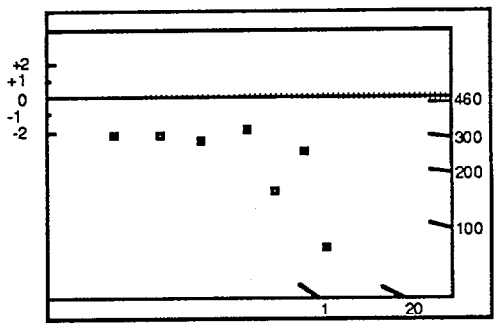
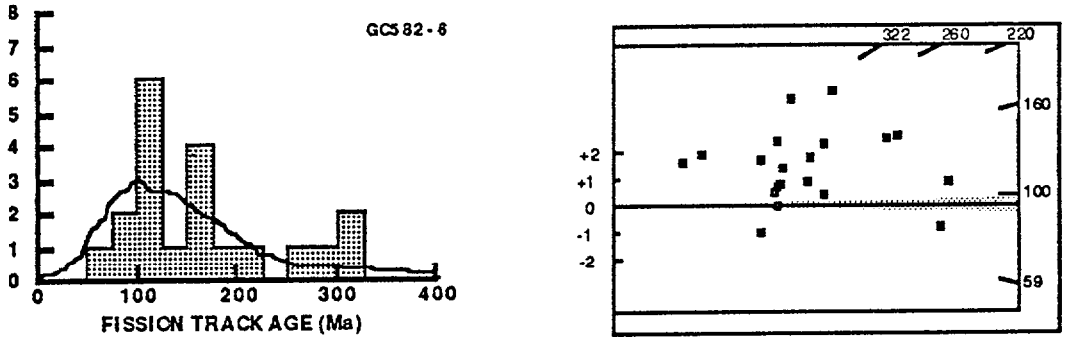
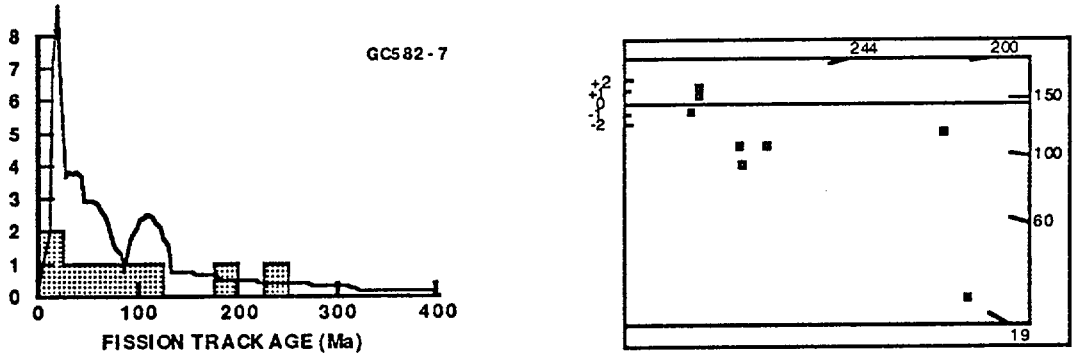


Figure B.3b: Single grain age figures for samples from **well Mulapula 1, Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

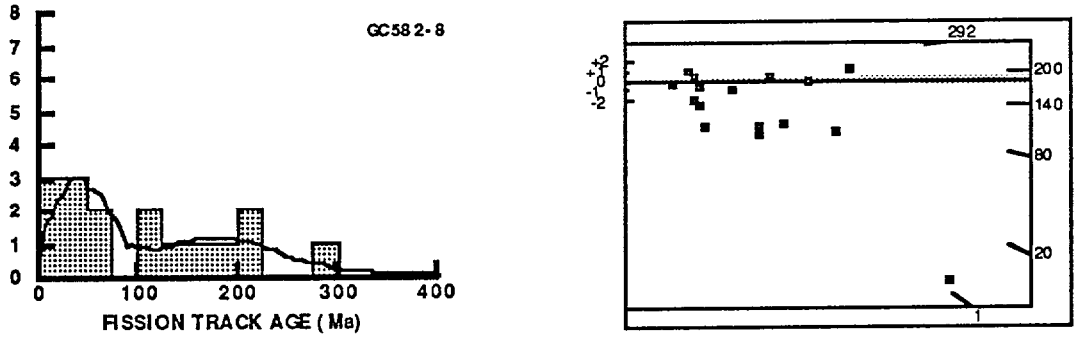
GC582-6



GC582-7



GC582-8



GC582-9

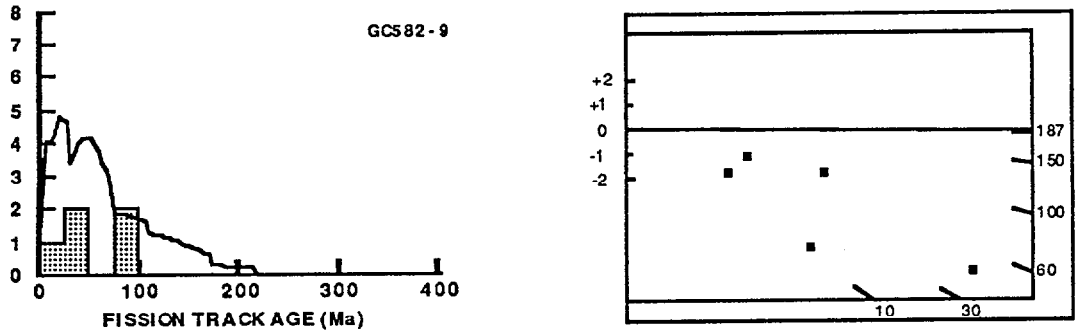


Figure B.3c: Single grain age figures for samples from **well Koonchera 1, Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC582-10

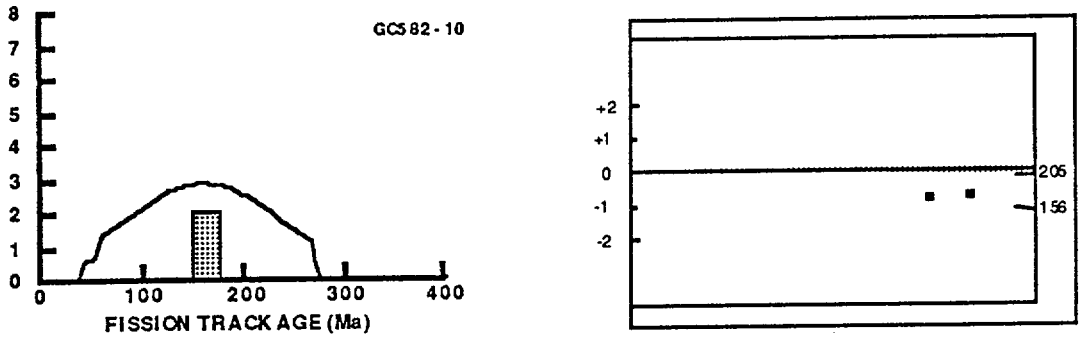
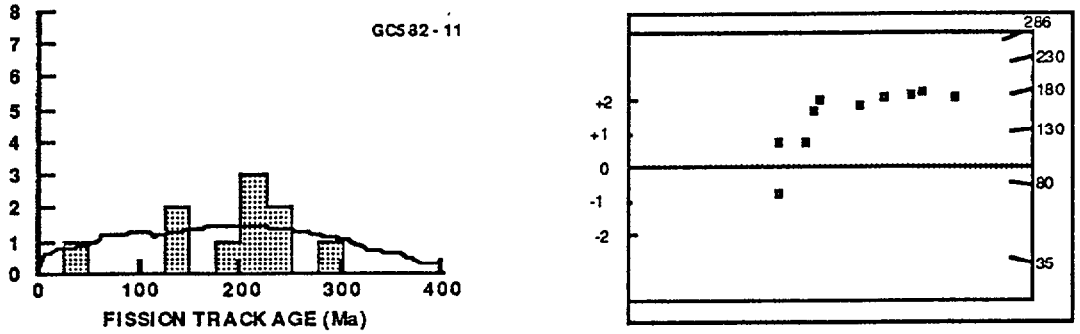


Figure B.3c: Continued

GC582-11

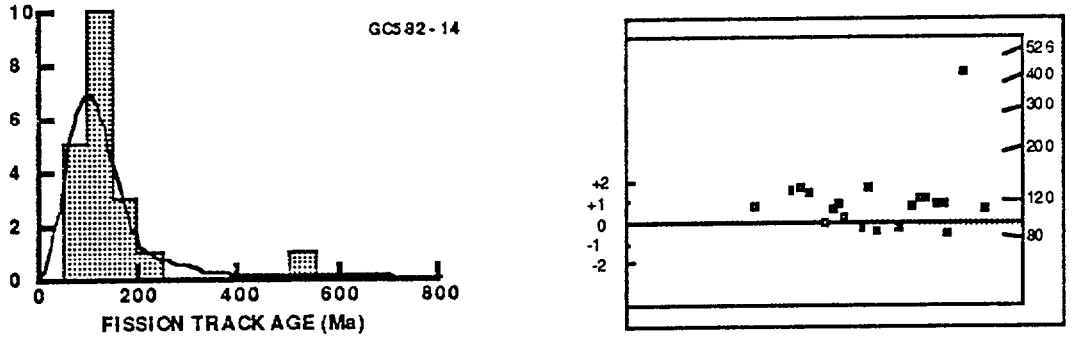


GC582-12

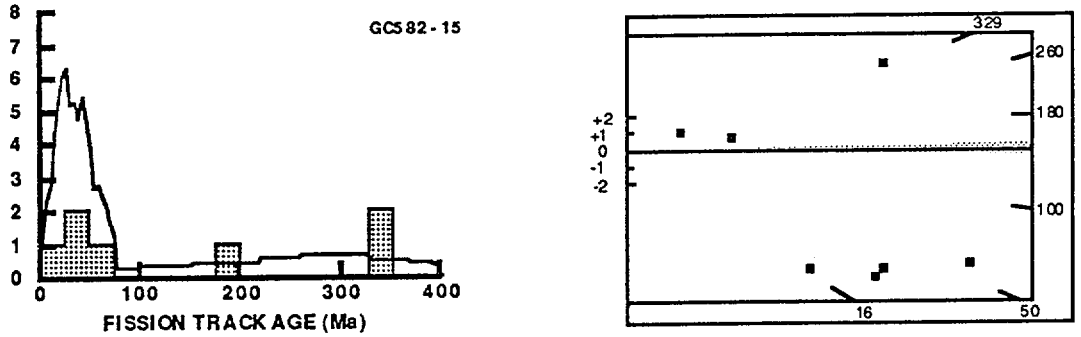
No Apatite

Figure B.3d: Single grain age figures for samples from **well Poolowanna 1, Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC582-14



GC582-15



GC582-16

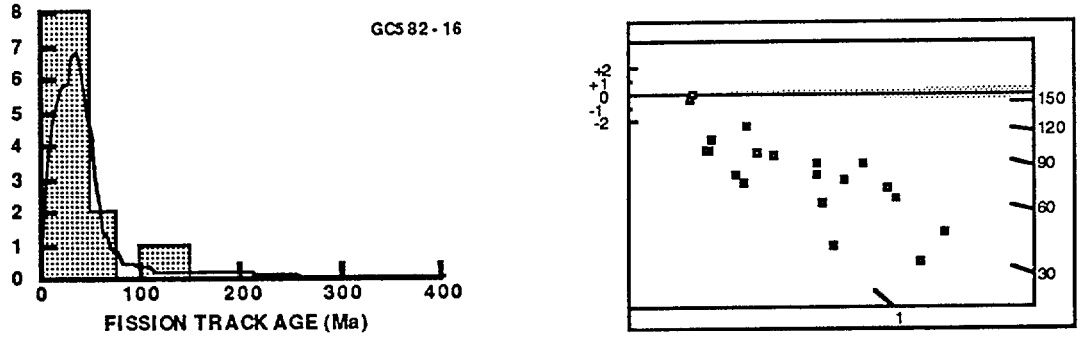


Figure B.3e: Single grain age figures for samples from **well Poonarunna 1, Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

8642-54

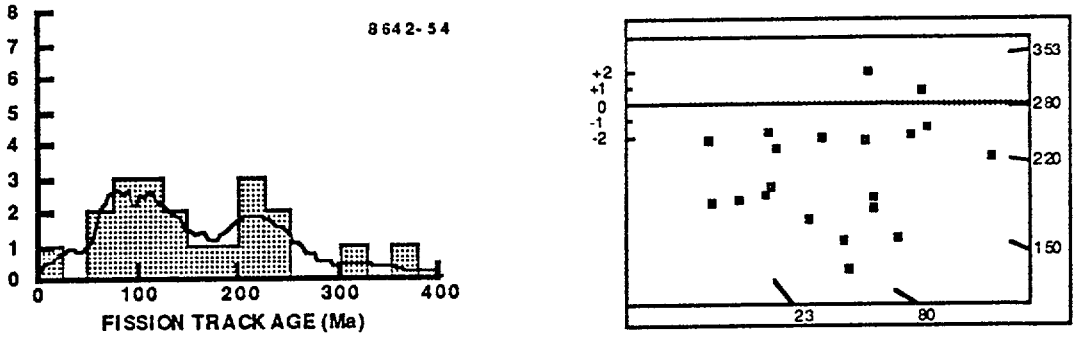


Figure B.3f: Single grain age figures for samples from **well Tinga Tingana 1, Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC582-13

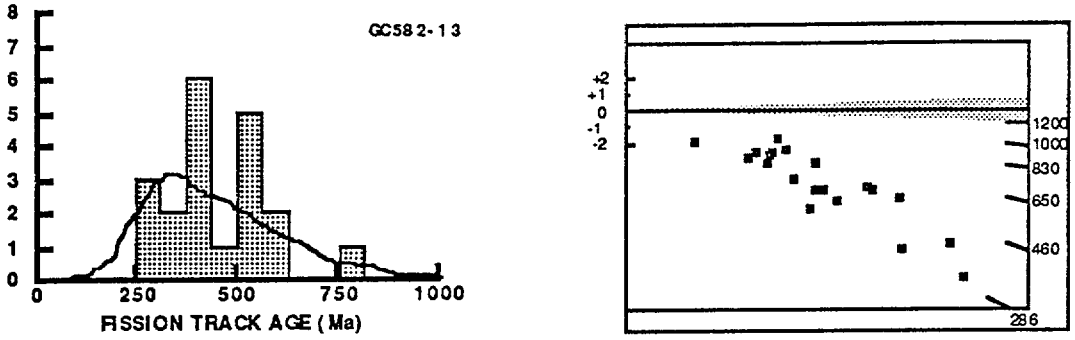


Figure B.3g: Single grain age figures for **outcrop** samples from the **Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC582-1

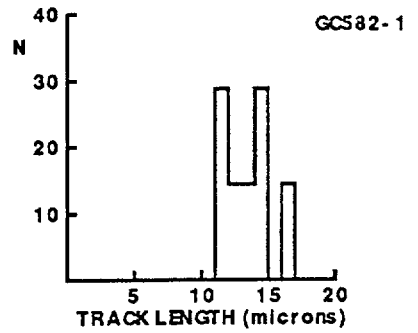
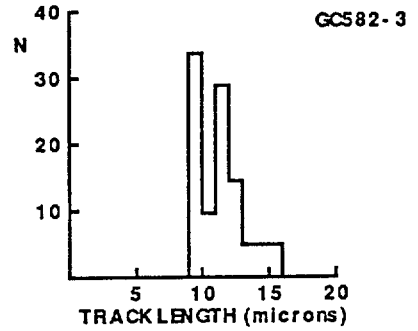


Figure B.4a: Distributions of confined track lengths in samples from well **Cherri 1, Western Eromanga - Eringa Trough.**

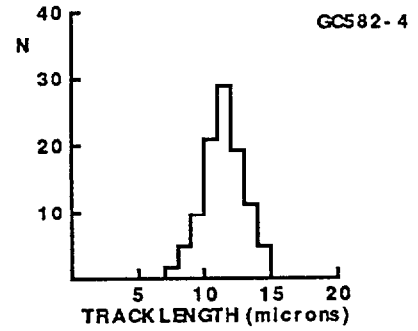
GC582-2

No Apatite

GC582-3



GC582-4



GC582-5

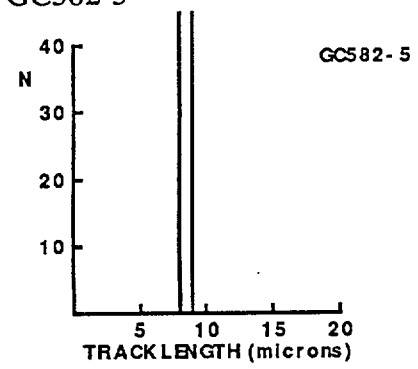
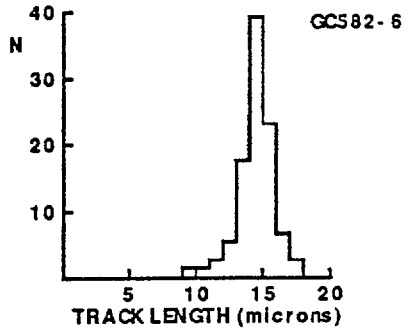
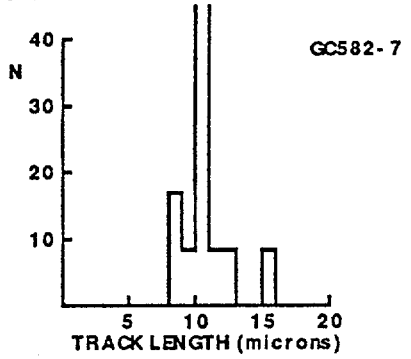


Figure B.4b: Distributions of confined track lengths in samples from well Mulapula 1, Western Eromanga - Eringa Trough.

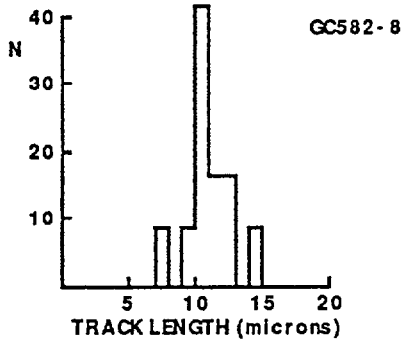
GC582-6



GC582-7



GC582-8



GC582-9

No Confined Tracks

GC582-10

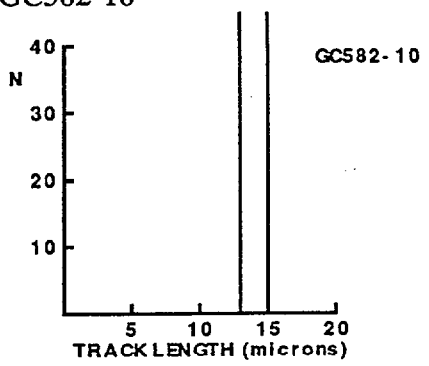
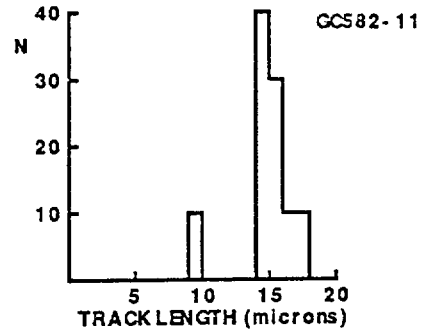


Figure B.4c: Distributions of confined track lengths in samples from well **Koonchera 1, Western Eromanga - Eringa Trough.**

GC582-11

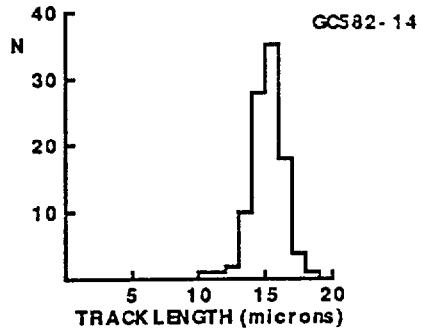


GC582-12

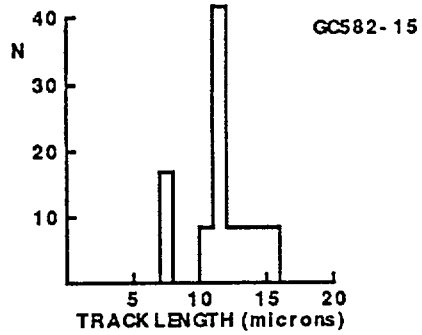
No Apatite

Figure B.4d: Distributions of confined track lengths in samples from **well Poolowanna 1, Western Eromanga - Eringa Trough.**

GC582-14



GC582-15



GC582-16

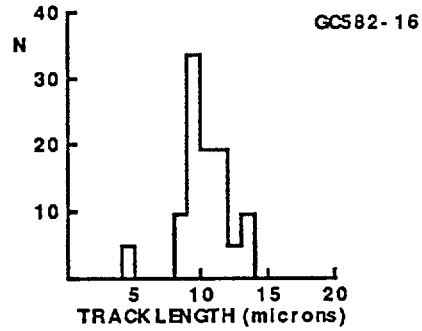


Figure B.4e: Distributions of confined track lengths in samples from well **Poonarunna 1, Western Eromanga - Eringa Trough.**

8642-54

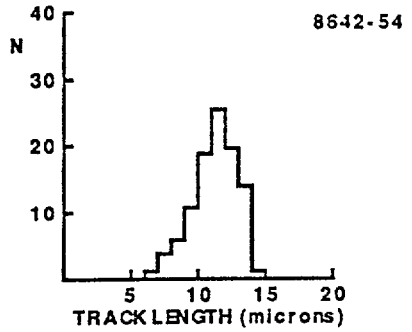


Figure B.4f: Distributions of confined track lengths in samples from well **Tinga Tingana 1, Western Eromanga - Eringa Trough.**

GC582-13

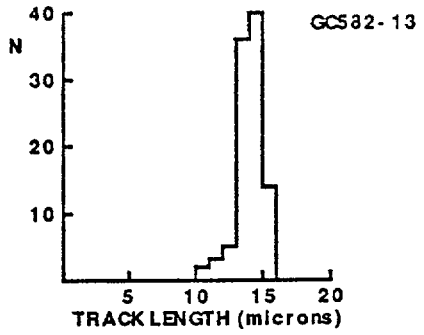


Figure B.4g: Distributions of confined track lengths in **outcrop** samples from the **Western Eromanga - Eringa Trough.**

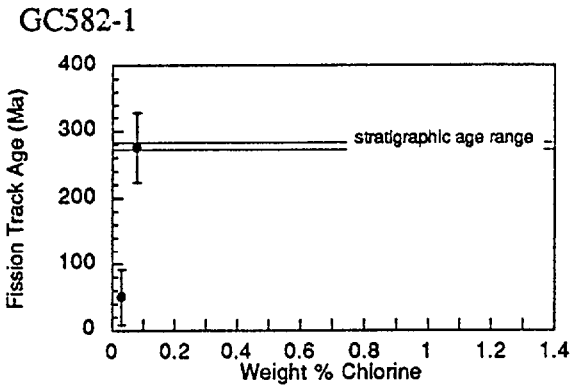
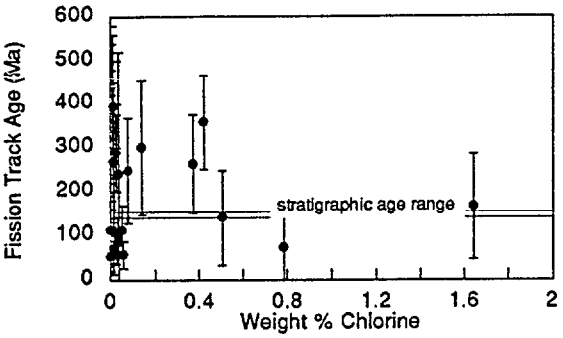


Figure B.5a: Plots of single grain age against weight percent chlorine for samples from well **Cherri 1, Western Eromanga - Eringa Trough.**

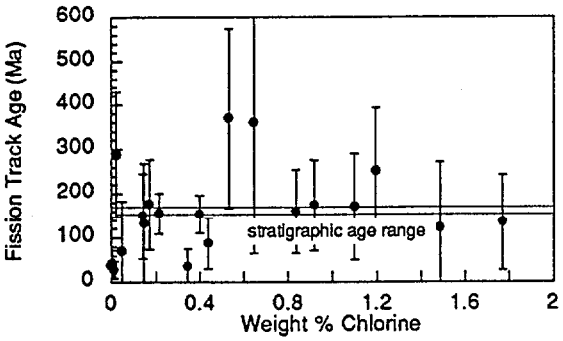
GC582-2

No Apatite

GC582-3



GC582-4



GC582-5

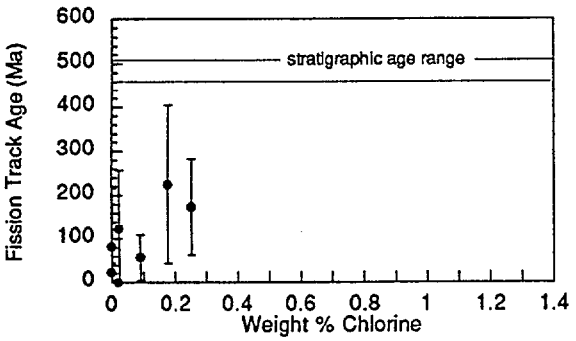
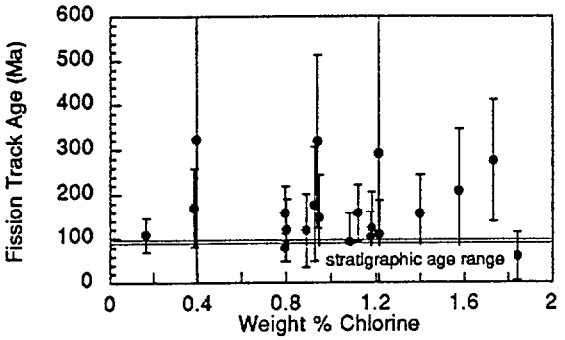
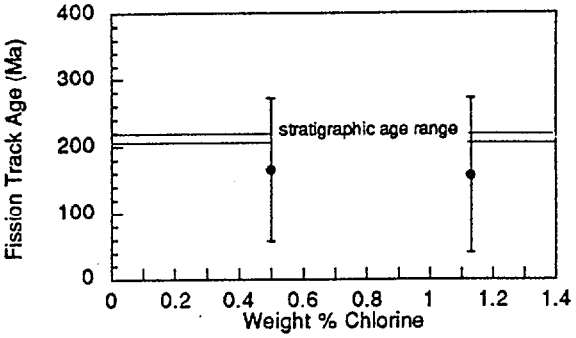


Figure B.5b: Plots of single grain age against weight percent chlorine for samples from well **Mulapula 1, Western Eromanga - Eringa Trough.**

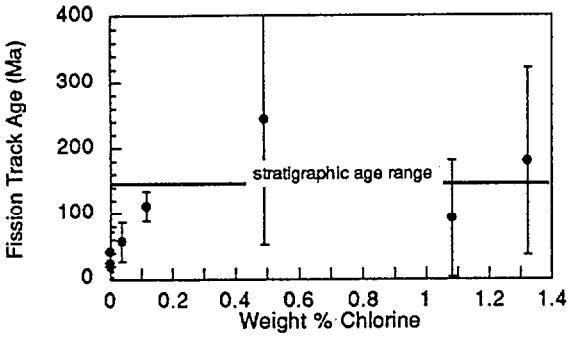
GC582-6



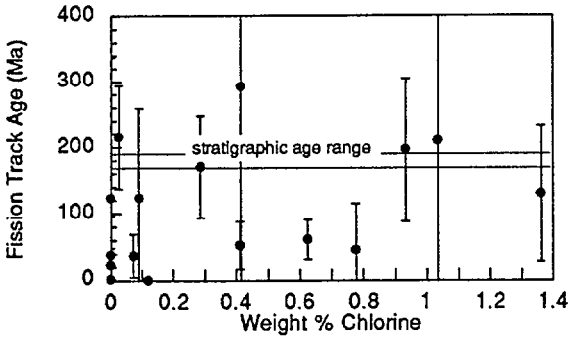
GC582-10



GC582-7



GC582-8



GC582-9

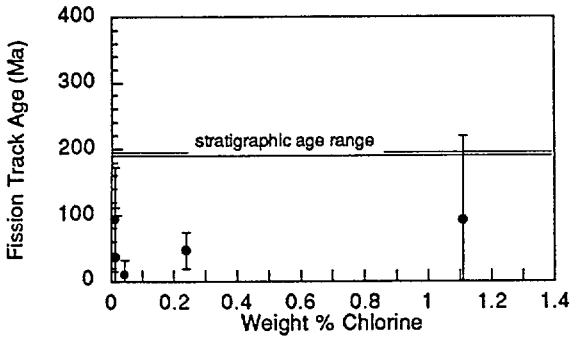
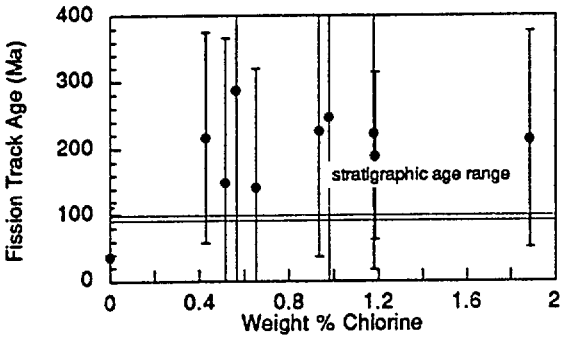


Figure B.5c: Plots of single grain age against weight percent chlorine for samples from well **Koonchera 1, Western Eromanga - Eringa Trough.**

GC582-11

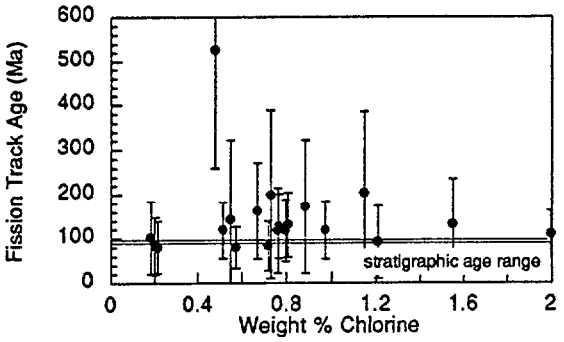


GC582-12

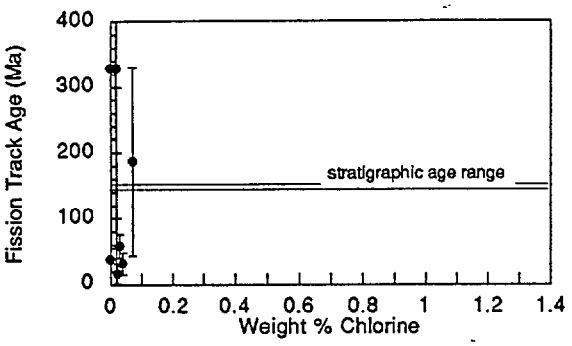
No Apatite

Figure B.5d: Plots of single grain age against weight percent chlorine for samples from well **Poolowanna 1, Western Eromanga - Eringa Trough.**

GC582-14



GC582-15



GC582-16

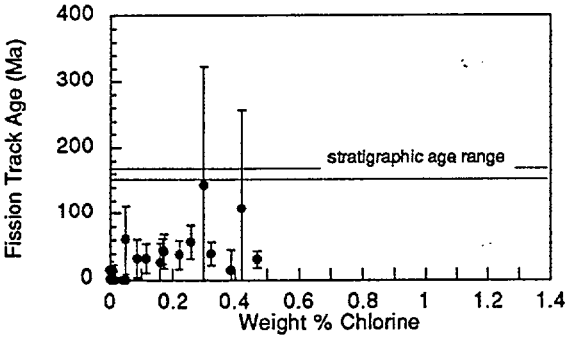


Figure B.5e: Plots of single grain age against weight percent chlorine for samples from well Poonarunna 1, Western Eromanga - Eringa Trough.

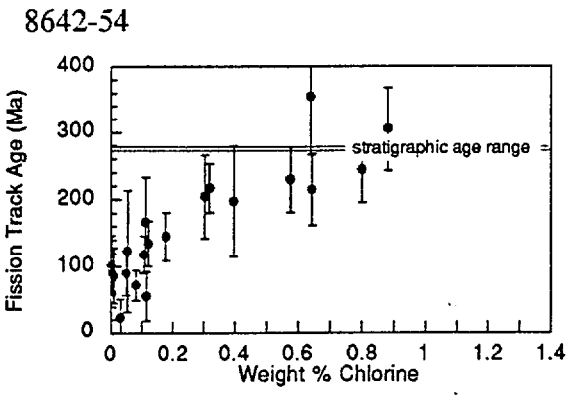


Figure B.5f: Plots of single grain age against weight percent chlorine for samples from well Tinga Tingana 1, Western Eromanga - Eringa Trough.

GC582-13

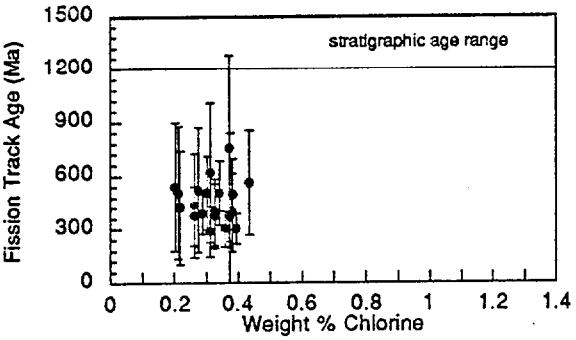


Figure B.5g: Plots of single grain age against weight percent chlorine for **outcrop** samples from **Western Eromanga - Eringa Trough.**

Fission Track Age Data Sheets - Glossary

Ns	=	Number of spontaneous tracks in Na grid squares
Ni	=	Number of induced tracks in Na grid squares
Na	=	Number of grid squares counted in each grain
RATIO	=	Ns/Ni
U (ppm)	=	Uranium content of each grain (= U content of standard glass * $\rho i/\rho_D$)
Cl (wt%)	=	Weight percent chlorine content of each grain
RHOs	=	Spontaneous track density (ρs) = Ns/ (Na*area of basic unit)
RHOi	=	Induced track density (ρi) = Ni/ (Na*area of basic unit)
F.T.AGE	=	Fission track age, calculated using equation B.1
Area of basic unit	=	Area of one grid square
Chi squared	=	χ^2 parameter, used to assess variation of single grain ages within the sample
P(chi squared)	=	Probability of obtaining observed χ^2 value for the relevant number of degrees of freedom, if all grains belong to a single population
Correlation coefficient	=	Correlation coefficient between Ns and Ni
Variance of SQR(Ns)	=	Variance of square root of Ns values - should be ~ 0.25 for Poisson distribution; greater if additional variation present
Variance of SQR(Ni)	=	Variance of square root of Ni values - should be ~ 0.25 for Poisson distribution; greater if additional variation present
Age Dispersion	=	% variation in single grain ages - see discussion in text re "Central age"
Ns/Ni	=	Pooled ratio, total spontaneous tracks divided by total induced tracks for all grains
Mean ratio	=	Mean of (Ns/Ni) for individual grains
Zeta	=	Calibration constant, determined empirically for each observer
RhoD	=	Track density (ρ_D) from uranium standard glass (interpolated from values at each end of stack)
ND	=	Total number of tracks counted for determining ρ_D
POOLED AGE	=	Fission track age calculated from pooled ratio Ns/Ni. Valid only when $\chi^2 > 5\%$
CENTRAL AGE	=	Alternative to pooled age when $\chi^2 < 5\%$

GC582-1 APATITE

IRRADIATION G586
SLIDE NUMBER 1
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	255	222	56	7.236E+06	6.300E+06	1.149	56.6	0.08	275.9 ± 26.5
4	7	34	60	1.854E+05	9.005E+05	0.206	8.1	0.03	50.3 ± 20.9
	262	256		3.589E+06	3.507E+06		31.5		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 19.997 with 1 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 1.000
Variance of SQR(Ns) = 88.75
Variance of SQR(Ni) = 41.12
Age Dispersion = 75.102 %

Ns/Ni = 1.023 ± 0.090
Mean Ratio = 0.677 ± 0.471

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.269E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 246.4 ± 22.8 Ma
CENTRAL AGE = 139.6 ± 77.2 Ma

GC582-3 APATITE

IRRADIATION G586
SLIDE NUMBER 2
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	35	34	40	1.390E+06	1.351E+06	1.029	12.1	0.08	248.5 ± 60.2
4	25	54	32	1.241E+06	2.682E+06	0.463	24.0	0.05	112.9 ± 27.5
5	11	19	50	3.496E+05	6.038E+05	0.579	5.4	0.51	140.9 ± 53.5
6	40	95	50	1.271E+06	3.019E+06	0.421	27.1	0.03	102.8 ± 19.6
7	38	110	90	6.709E+05	1.942E+06	0.345	17.4	0.04	84.5 ± 16.1
8	17	73	50	5.403E+05	2.320E+06	0.233	20.8	0.06	57.1 ± 15.4
9	3	10	30	1.589E+05	5.297E+05	0.300	4.7	0.78	73.4 ± 48.4
10	40	170	40	1.589E+06	6.754E+06	0.235	60.5	0.03	57.6 ± 10.3
11	35	28	20	2.781E+06	2.225E+06	1.250	19.9	0.14	300.5 ± 76.7
12	19	17	50	6.038E+05	5.403E+05	1.118	4.8	0.02	269.3 ± 90.2
14	102	85	50	3.242E+06	2.701E+06	1.200	24.2	0.03	288.7 ± 43.2
15	8	27	48	2.648E+05	8.938E+05	0.296	8.0	0.02	72.5 ± 29.3
16	6	6	15	6.356E+05	6.356E+05	1.000	5.7	0.04	241.5 ± 139.6
17	12	26	40	4.767E+05	1.033E+06	0.462	9.3	0.00	112.6 ± 39.4
18	114	76	20	9.058E+06	6.038E+06	1.500	54.1	0.42	358.9 ± 54.1
20	47	43	30	2.490E+06	2.278E+06	1.093	20.4	0.37	263.5 ± 56.1
21	13	19	40	5.164E+05	7.548E+05	0.684	6.8	1.64	166.2 ± 60.0
22	2	9	24	1.324E+05	5.959E+05	0.222	5.3	0.00	54.5 ± 42.6
23	63	38	24	4.171E+06	2.516E+06	1.658	22.5	0.01	395.6 ± 82.0
	630	939		1.347E+06	2.008E+06		18.0		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 172.610 with 18 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.481
Variance of SQR(Ns) = 6.63
Variance of SQR(Ni) = 8.15
Age Dispersion = 58.070 %

Ns/Ni = 0.671 ± 0.035
Mean Ratio = 0.742 ± 0.107

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.272E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 163.0 ± 9.6 Ma
CENTRAL AGE = 158.0 ± 24.0 Ma

GC582-4 APATITE

IRRADIATION G586
SLIDE NUMBER 3
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
4	20	28	100	3.178E+05	4.449E+05	0.714	4.0	0.92	173.9 ± 51.1
5	87	138	100	1.382E+06	2.193E+06	0.630	19.6	0.40	153.7 ± 21.5
7	14	20	70	3.178E+05	4.540E+05	0.700	4.1	1.10	170.4 ± 59.6
8	13	36	60	3.443E+05	9.534E+05	0.361	8.5	0.44	88.5 ± 28.7
9	10	18	60	2.648E+05	4.767E+05	0.556	4.3	1.77	135.6 ± 53.6
10	2	7	50	6.356E+04	2.225E+05	0.286	2.0	0.05	70.1 ± 56.2
11	10	86	60	2.648E+05	2.278E+06	0.116	20.4	0.02	28.6 ± 9.6
12	6	11	50	1.907E+05	3.496E+05	0.545	3.1	0.15	133.2 ± 67.7
13	4	27	50	1.271E+05	8.581E+05	0.148	7.7	0.35	36.4 ± 19.6
14	79	124	25	5.021E+06	7.882E+06	0.637	70.4	0.21	155.3 ± 22.8
16	34	22	25	2.161E+06	1.398E+06	1.545	12.5	0.53	370.5 ± 101.9
17	11	62	60	2.913E+05	1.642E+06	0.177	14.7	0.01	43.6 ± 14.3
18	19	29	80	3.774E+05	5.760E+05	0.655	5.1	0.84	159.7 ± 47.3
19	26	25	80	5.164E+05	4.966E+05	1.040	4.4	1.20	251.6 ± 70.8
20	15	10	100	2.384E+05	1.589E+05	1.500	1.4	0.64	359.9 ± 147.3
21	32	203	70	7.264E+05	4.608E+06	0.158	41.2	0.00	38.8 ± 7.5
22	37	31	80	7.349E+05	6.158E+05	1.194	5.5	0.03	288.0 ± 70.6
23	16	26	40	6.356E+05	1.033E+06	0.615	9.2	0.14	150.1 ± 47.9
24	4	8	40	1.589E+05	3.178E+05	0.500	2.8	1.49	122.2 ± 74.9
25	21	29	50	6.674E+05	9.217E+05	0.724	8.2	0.17	176.2 ± 50.7
	460	940		5.848E+05	1.195E+06		10.7		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 141.850 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.632
Variance of SQR(Ns) = 4.28
Variance of SQR(Ni) = 9.94
Age Dispersion = 59.131 %

Ns/Ni = 0.489 ± 0.028
Mean Ratio = 0.640 ± 0.092

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.275E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 119.6 ± 7.6 Ma
CENTRAL AGE = 134.8 ± 20.6 Ma

GC582-5 APATITE

IRRADIATION G586
SLIDE NUMBER 4
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	4	44	20	3.178E+05	3.496E+06	0.091	31.2	0.00	22.4 ± 11.7
6	5	10	30	2.648E+05	5.297E+05	0.500	4.7	0.03	122.5 ± 67.2
7	12	13	28	6.810E+05	7.378E+05	0.923	6.6	0.18	224.4 ± 90.1
8	17	24	18	1.501E+06	2.119E+06	0.708	18.9	0.25	172.9 ± 55.0
10	6	26	20	4.767E+05	2.066E+06	0.231	18.4	0.09	56.8 ± 25.8
11	2	6	12	2.648E+05	7.945E+05	0.333	7.1	0.00	81.9 ± 66.9
12	0	3	9	0.000E+00	5.297E+05	0.000	4.7	0.02	0.0 ± 0.0
	46	126		5.336E+05	1.461E+06		13.0		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 21.088 with 6 degrees of freedom
P(chi squared) = 0.2 %
Correlation Coefficient = 0.254
Variance of SQR(Ns) = 1.81
Variance of SQR(Ni) = 2.89
Age Dispersion = 61.734 %

Ns/Ni = 0.365 ± 0.063
Mean Ratio = 0.398 ± 0.126

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.279E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 89.7 ± 15.7 Ma
CENTRAL AGE = 92.8 ± 28.4 Ma

GC582-6 APATITE

IRRADIATION G586
SLIDE NUMBER 5
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	15	25	70	3.405E+05	5.675E+05	0.600	5.0	0.95	147.1 ± 48.2
7	18	43	80	3.575E+05	8.541E+05	0.419	7.6	1.18	103.0 ± 29.1
8	11	25	70	2.497E+05	5.675E+05	0.440	5.0	1.22	108.2 ± 39.3
10	6	5	40	2.384E+05	1.986E+05	1.200	1.8	1.22	291.0 ± 176.4
12	6	25	60	1.589E+05	6.621E+05	0.240	5.9	1.84	59.3 ± 27.0
13	17	20	80	3.377E+05	3.973E+05	0.850	3.5	1.58	207.5 ± 68.7
14	40	62	70	9.080E+05	1.407E+06	0.645	12.5	1.12	158.1 ± 32.4
15	25	36	70	5.675E+05	8.172E+05	0.694	7.3	0.39	170.0 ± 44.5
16	10	27	80	1.986E+05	5.363E+05	0.370	4.8	1.08	91.2 ± 33.9
17	43	67	48	1.424E+06	2.218E+06	0.642	19.7	0.80	157.3 ± 31.0
18	12	25	50	3.814E+05	7.945E+05	0.480	7.1	0.89	118.0 ± 41.6
20	36	112	50	1.144E+06	3.560E+06	0.321	31.6	0.80	79.2 ± 15.3
22	13	18	60	3.443E+05	4.767E+05	0.722	4.2	0.93	176.7 ± 64.5
24	4	3	80	7.945E+04	5.959E+04	1.333	0.5	0.40	322.5 ± 246.5
27	17	35	100	2.701E+05	5.562E+05	0.486	4.9	0.80	119.4 ± 35.4
28	35	31	100	5.562E+05	4.926E+05	1.129	4.4	1.73	274.1 ± 68.1
29	25	19	60	6.621E+05	5.032E+05	1.316	4.5	0.94	318.4 ± 97.3
31	21	33	70	4.767E+05	7.491E+05	0.636	6.7	1.40	155.9 ± 43.8
33	13	26	100	2.066E+05	4.132E+05	0.500	3.7	1.18	122.8 ± 41.9
34	47	107	80	9.336E+05	2.125E+06	0.439	18.9	0.17	108.0 ± 19.2
	414	744		4.639E+05	8.338E+05		7.4		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 41.485 with 19 degrees of freedom
P(chi squared) = 0.2 %
Correlation Coefficient = 0.815
Variance of SQR(Ns) = 2.03
Variance of SQR(Ni) = 4.89
Age Dispersion = 28.025 %

Ns/Ni = 0.556 ± 0.034
Mean Ratio = 0.673 ± 0.074

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.282E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 136.6 ± 9.2 Ma
CENTRAL AGE = 142.7 ± 13.7 Ma

GC582-7 APATITE

IRRADIATION G586
SLIDE NUMBER 6
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	13	13	30	6.886E+05	6.886E+05	1.000	6.1	0.49	244.0 ± 96.0
4	6	16	60	1.589E+05	4.238E+05	0.375	3.8	1.08	92.6 ± 44.4
5	11	15	60	2.913E+05	3.973E+05	0.733	3.5	1.32	179.8 ± 71.6
6	39	501	70	8.853E+05	1.137E+07	0.078	100.9	0.00	19.3 ± 3.3
7	6	61	60	1.589E+05	1.616E+06	0.098	14.3	0.00	24.4 ± 10.5
8	9	53	45	3.178E+05	1.872E+06	0.170	16.6	0.00	42.1 ± 15.2
9	147	325	45	5.191E+06	1.148E+07	0.452	101.8	0.12	111.5 ± 11.5
10	18	78	30	9.534E+05	4.132E+06	0.231	36.6	0.04	57.1 ± 15.0
	249	1062		9.892E+05	4.219E+06		37.4		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 125.535 with 7 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.608
Variance of SQR(Ns) = 10.55
Variance of SQR(Ni) = 49.08
Age Dispersion = 70.826 %

Ns/Ni = 0.234 ± 0.016
Mean Ratio = 0.392 ± 0.116

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.286E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 58.0 ± 4.4 Ma
CENTRAL AGE = 77.3 ± 21.2 Ma

GC582-8 APATITE

IRRADIATION G586
SLIDE NUMBER 7
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
4	0	17	60	0.000E+00	4.502E+05	0.000	4.0	0.12	0.0 ± 0.0
6	2	4	9	3.531E+05	7.063E+05	0.500	6.2	0.00	123.5 ± 107.0
7	22	89	50	6.992E+05	2.829E+06	0.247	25.0	0.63	61.3 ± 14.7
8	11	52	30	5.827E+05	2.754E+06	0.212	24.4	0.41	52.5 ± 17.5
10	2	256	30	1.059E+05	1.356E+07	0.008	119.9	0.00	1.9 ± 1.4
11	24	30	40	9.534E+05	1.192E+06	0.800	10.5	0.93	196.4 ± 54.1
12	10	19	70	2.270E+05	4.313E+05	0.526	3.8	1.36	129.9 ± 50.9
13	4	42	36	1.766E+05	1.854E+06	0.095	16.4	0.00	23.7 ± 12.4
14	6	40	30	3.178E+05	2.119E+06	0.150	18.7	0.07	37.3 ± 16.4
15	2	13	80	3.973E+04	2.582E+05	0.154	2.3	0.00	38.2 ± 29.1
18	34	49	30	1.801E+06	2.595E+06	0.694	23.0	0.29	170.7 ± 38.4
19	58	66	30	3.072E+06	3.496E+06	0.879	30.9	0.03	215.5 ± 39.3
20	5	10	36	2.207E+05	4.414E+05	0.500	3.9	0.09	123.5 ± 67.7
21	6	7	40	2.384E+05	2.781E+05	0.857	2.5	1.03	210.2 ± 117.1
22	6	5	16	5.959E+05	4.966E+05	1.200	4.4	0.42	292.5 ± 177.3
23	2	11	50	6.356E+04	3.496E+05	0.182	3.1	0.78	45.2 ± 34.8
	194	710		4.840E+05	1.771E+06		15.7		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 177.490 with 15 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.099
Variance of SQR(Ns) = 3.82
Variance of SQR(Ni) = 12.45
Age Dispersion = 79.350 %

Ns/Ni = 0.273 ± 0.022
Mean Ratio = 0.438 ± 0.091

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.289E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 67.8 ± 5.8 Ma
CENTRAL AGE = 86.0 ± 19.5 Ma

GC582-9 APATITE

IRRADIATION G586
SLIDE NUMBER 8
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	14	75	25	8.899E+05	4.767E+06	0.187	42.1	0.24	46.5 ± 13.6
4	3	8	30	1.589E+05	4.238E+05	0.375	3.7	1.11	93.1 ± 63.1
5	8	21	21	6.054E+05	1.589E+06	0.381	14.0	0.01	94.5 ± 39.4
6	1	7	40	3.973E+04	2.781E+05	0.143	2.5	0.01	35.6 ± 38.1
7	1	24	30	5.297E+04	1.271E+06	0.042	11.2	0.04	10.4 ± 10.6
	27	135		2.939E+05	1.469E+06		13.0		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 6.425 with 4 degrees of freedom
P(chi squared) = 17.0 %
Correlation Coefficient = 0.872
Variance of SQR(Ns) = 1.44
Variance of SQR(Ni) = 5.86
Age Dispersion = 20.786 % (did not converge)

Ns/Ni = 0.200 ± 0.042
Mean Ratio = 0.225 ± 0.067

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass . . .
Rho D = 1.292E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 49.8 ± 10.6 Ma
CENTRAL AGE = 50.3 ± 12.3 Ma

GC582-10 APATITE

IRRADIATION G586
SLIDE NUMBER 9
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	12	19	100	1.907E+05	3.019E+05	0.632	2.7	1.14	156.4 ± 57.8
4	16	24	80	3.178E+05	4.767E+05	0.667	4.2	0.50	165.0 ± 53.4
	28	43		2.472E+05	3.796E+05		3.3		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 0.012 with 1 degrees of freedom
P(chi squared) = 91.2 %
Correlation Coefficient = 1.000
Variance of SQR(Ns) = 0.14
Variance of SQR(Ni) = 0.15
Age Dispersion = 0.000 % (did not converge)

Ns/Ni = 0.651 ± 0.158
Mean Ratio = 0.649 ± 0.018

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.296E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 161.2 ± 39.4 Ma
CENTRAL AGE = 161.2 ± 39.4 Ma

GC582-11 APATITE

IRRADIATION G586
SLIDE NUMBER 10
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	6	6	20	4.767E+05	4.767E+05	1.000	4.2	0.98	246.5 ± 142.5
4	13	15	40	5.164E+05	5.959E+05	0.867	5.2	1.89	214.2 ± 81.4
5	11	12	90	1.942E+05	2.119E+05	0.917	1.9	0.94	226.3 ± 94.7
6	14	16	40	5.562E+05	6.356E+05	0.875	5.6	0.43	216.2 ± 79.4
7	3	5	20	2.384E+05	3.973E+05	0.600	3.5	0.52	149.0 ± 108.9
9	4	7	16	3.973E+05	6.952E+05	0.571	6.1	0.65	142.0 ± 89.1
11	7	6	30	3.708E+05	3.178E+05	1.167	2.8	0.56	286.7 ± 159.7
13	9	10	40	3.575E+05	3.973E+05	0.900	3.5	1.18	222.3 ± 102.3
17	1	7	70	2.270E+04	1.589E+05	0.143	1.4	0.00	35.8 ± 38.3
19	16	21	60	4.238E+05	5.562E+05	0.762	4.9	1.19	188.7 ± 62.8
	84	105		3.133E+05	3.917E+05		3.4		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 4.667 with 9 degrees of freedom
P(chi squared) = 86.2 %
Correlation Coefficient = 0.918
Variance of SQR(Ns) = 0.94
Variance of SQR(Ni) = 0.64
Age Dispersion = 0.000 % (did not converge)

Ns/Ni = 0.800 ± 0.117
Mean Ratio = 0.780 ± 0.090

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.299E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 198.0 ± 29.5 Ma
CENTRAL AGE = 198.0 ± 29.5 Ma

GC582-13 APATITE

IRRADIATION G586
SLIDE NUMBER 11
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
5	81	66	70	1.839E+06	1.498E+06	1.227	13.1	0.36	302.0 ± 50.8
8	23	11	70	5.221E+05	2.497E+05	2.091	2.2	0.21	506.4 ± 186.2
10	43	28	24	2.847E+06	1.854E+06	1.536	16.2	0.33	375.7 ± 91.9
13	25	14	28	1.419E+06	7.945E+05	1.786	7.0	0.26	434.9 ± 145.7
14	34	21	20	2.701E+06	1.669E+06	1.619	14.6	0.38	395.5 ± 110.3
15	47	29	35	2.134E+06	1.317E+06	1.621	11.5	0.33	395.9 ± 94.2
18	121	98	50	3.846E+06	3.115E+06	1.235	27.3	0.40	303.8 ± 42.2
19	19	11	36	8.387E+05	4.855E+05	1.727	4.2	0.22	421.1 ± 160.0
20	29	13	30	1.536E+06	6.886E+05	2.231	6.0	0.20	538.8 ± 180.5
21	52	34	60	1.377E+06	9.005E+05	1.529	7.9	0.26	374.2 ± 83.2
23	78	38	16	7.747E+06	3.774E+06	2.053	33.0	0.38	497.4 ± 99.4
24	36	31	50	1.144E+06	9.852E+05	1.161	8.6	0.31	286.1 ± 70.6
25	123	78	100	1.955E+06	1.239E+06	1.577	10.8	0.29	385.5 ± 56.9
36	49	21	40	1.947E+06	8.343E+05	2.333	7.3	0.44	562.6 ± 147.6
28	6	4	24	3.973E+05	2.648E+05	1.500	2.3	0.37	367.2 ± 237.3
29	75	36	50	2.384E+06	1.144E+06	2.083	10.0	0.30	504.6 ± 103.3
30	98	47	30	5.191E+06	2.490E+06	2.085	21.8	0.34	505.0 ± 90.7
31	35	11	16	3.476E+06	1.092E+06	3.182	9.6	0.37	755.5 ± 262.0
32	36	14	20	2.860E+06	1.112E+06	2.571	9.7	0.31	617.3 ± 195.2
34	28	13	35	1.271E+06	5.902E+05	2.154	5.2	0.27	521.0 ± 175.5
	1038	618		2.052E+06	1.221E+06		10.7		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 23.976 with 19 degrees of freedom
P(chi squared) = 19.7 %
Correlation Coefficient = 0.936
Variance of SQR(Ns) = 5.14
Variance of SQR(Ni) = 4.19
Age Dispersion = 13.834 %

Ns/Ni = 1.680 ± 0.085
Mean Ratio = 1.865 ± 0.112

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.302E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 409.8 ± 23.9 Ma
CENTRAL AGE = 418.8 ± 28.6 Ma

GC582-14 APATITE

IRRADIATION G586
SLIDE NUMBER 12
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	10	19	100	1.589E+05	3.019E+05	0.526	2.6	1.55	131.6 ± 51.5
6	25	57	90	4.414E+05	1.006E+06	0.439	8.8	2.00	109.8 ± 26.5
7	20	42	100	3.178E+05	6.674E+05	0.476	5.8	0.97	119.2 ± 32.6
8	21	44	100	3.337E+05	6.992E+05	0.477	6.1	0.52	119.4 ± 31.9
9	8	10	40	3.178E+05	3.973E+05	0.800	3.5	0.73	199.0 ± 94.5
10	50	23	100	7.945E+05	3.655E+05	2.174	3.2	0.48	527.0 ± 133.6
11	10	31	100	1.589E+05	4.926E+05	0.323	4.3	0.21	81.0 ± 29.5
12	20	38	100	3.178E+05	6.038E+05	0.526	5.3	0.81	131.6 ± 36.5
14	9	22	70	2.043E+05	4.994E+05	0.409	4.4	0.18	102.5 ± 40.7
15	17	36	100	2.701E+05	5.721E+05	0.472	5.0	0.80	118.2 ± 34.9
16	9	27	100	1.430E+05	4.290E+05	0.333	3.7	0.20	83.6 ± 32.3
18	19	37	100	3.019E+05	5.880E+05	0.514	5.1	0.76	128.4 ± 36.4
21	9	13	100	1.430E+05	2.066E+05	0.692	1.8	0.88	172.5 ± 75.0
22	16	50	40	6.356E+05	1.986E+06	0.320	17.3	0.57	80.3 ± 23.2
23	12	36	100	1.907E+05	5.721E+05	0.333	5.0	0.72	83.6 ± 28.0
25	15	23	100	2.384E+05	3.655E+05	0.652	3.2	0.67	162.7 ± 54.2
27	9	19	70	2.043E+05	4.313E+05	0.474	3.8	0.76	118.5 ± 48.1
28	4	7	40	1.589E+05	2.781E+05	0.571	2.4	0.55	142.7 ± 89.6
29	7	19	50	2.225E+05	6.038E+05	0.368	5.3	1.21	92.4 ± 40.9
30	9	11	100	1.430E+05	1.748E+05	0.818	1.5	1.15	203.4 ± 91.6
	299	564		2.795E+05	5.272E+05		4.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 50.244 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.425
Variance of SQR(Ns) = 1.24
Variance of SQR(Ni) = 1.86
Age Dispersion = 37.752 %

Ns/Ni = 0.530 ± 0.038
Mean Ratio = 0.585 ± 0.090

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.306E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 132.5 ± 10.2 Ma
CENTRAL AGE = 131.1 ± 15.3 Ma

GC582-15 APATITE

IRRADIATION G586
SLIDE NUMBER 13
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	17	134	42	6.432E+05	5.070E+06	0.127	44.2	0.04	32.0 ± 8.3
4	92	69	40	3.655E+06	2.741E+06	1.333	23.9	0.00	329.1 ± 53.2
5	54	233	40	2.145E+06	9.256E+06	0.232	80.6	0.03	58.4 ± 9.0
6	12	16	100	1.907E+05	2.542E+05	0.750	2.2	0.07	187.2 ± 71.7
7	21	141	70	4.767E+05	3.201E+06	0.149	27.9	0.00	37.6 ± 8.9
8	4	3	15	4.238E+05	3.178E+05	1.333	2.8	0.02	329.1 ± 251.5
9	5	77	50	1.589E+05	2.447E+06	0.065	21.3	0.02	16.4 ± 7.6
	205	673		9.125E+05	2.996E+06		26.1		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 152.187 with 6 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.325
Variance of SQR(Ns) = 7.69
Variance of SQR(Ni) = 22.03
Age Dispersion = 94.522 %

Ns/Ni = 0.305 ± 0.024
Mean Ratio = 0.570 ± 0.215

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.309E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 76.7 ± 6.5 Ma
CENTRAL AGE = 96.3 ± 36.3 Ma

GC582-16 APATITE

IRRADIATION G586
SLIDE NUMBER 14
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	25	111	30	1.324E+06	5.880E+06	0.225	51.1	0.26	56.9 ± 12.7
4	4	38	50	1.271E+05	1.208E+06	0.105	10.5	0.16	26.7 ± 14.0
5	10	78	60	2.648E+05	2.066E+06	0.128	17.9	0.12	32.5 ± 10.9
6	0	30	50	0.000E+00	9.534E+05	0.000	8.3	0.02	0.0 ± 0.0
8	24	141	25	1.526E+06	8.962E+06	0.170	77.8	0.17	43.1 ± 9.6
10	0	17	40	0.000E+00	6.754E+05	0.000	5.9	0.05	0.0 ± 0.0
11	0	16	40	0.000E+00	6.356E+05	0.000	5.5	0.04	0.0 ± 0.0
12	0	34	40	0.000E+00	1.351E+06	0.000	11.7	0.00	0.0 ± 0.0
14	7	29	50	2.225E+05	9.217E+05	0.241	8.0	0.05	61.0 ± 25.7
15	11	200	40	4.370E+05	7.945E+06	0.055	69.0	0.01	13.9 ± 4.3
16	6	47	60	1.589E+05	1.245E+06	0.128	10.8	0.09	32.3 ± 14.0
17	15	101	70	3.405E+05	2.293E+06	0.149	19.9	0.22	37.6 ± 10.5
18	5	88	36	2.207E+05	3.884E+06	0.057	33.7	0.00	14.4 ± 6.6
19	27	221	36	1.192E+06	9.755E+06	0.122	84.7	0.47	30.9 ± 6.4
20	24	154	70	5.448E+05	3.496E+06	0.156	30.4	0.33	39.4 ± 8.7
21	13	77	80	2.582E+05	1.529E+06	0.169	13.3	0.17	42.7 ± 12.9
22	4	7	20	3.178E+05	5.562E+05	0.571	4.8	0.30	143.5 ± 90.0
23	1	17	50	3.178E+04	5.403E+05	0.059	4.7	0.39	14.9 ± 15.4
25	3	7	24	1.986E+05	4.635E+05	0.429	4.0	0.42	107.9 ± 74.5
26	1	103	40	3.973E+04	4.092E+06	0.010	35.5	0.00	2.5 ± 2.5
	180	1516		3.140E+05	2.644E+06		23.0		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 61.088 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.786
Variance of SQR(Ns) = 3.15
Variance of SQR(Ni) = 13.87
Age Dispersion = 54.404 %

Ns/Ni = 0.119 ± 0.009
Mean Ratio = 0.139 ± 0.033

Ages calculated using a zeta of 386.9 ± 6.9 for CN5 glass
Rho D = 1.312E+06cm-2; ND = 2033
Rho D interpolated between top of can; Rho D = 1.269E+06cm-2, ND = 998
bottom of can; Rho D = 1.316E+06cm-2, ND = 1035

POOLED AGE = 30.1 ± 2.5 Ma
CENTRAL AGE = 29.4 ± 4.7 Ma

8642-54 APATITE

IRRADIATION PT784
SLIDE NUMBER 4
COUNTED BY: HJG

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	294	330	60	7.786E+06	8.740E+06	0.891	78.3	0.32	216.9 ± 18.0
4	29	70	100	4.608E+05	1.112E+06	0.414	10.0	0.00	101.8 ± 22.6
5	24	68	100	3.814E+05	1.081E+06	0.353	9.7	0.01	86.8 ± 20.7
7	42	52	40	1.669E+06	2.066E+06	0.808	18.5	0.40	197.0 ± 41.1
8	226	179	100	3.591E+06	2.844E+06	1.263	25.5	0.88	305.3 ± 31.3
9	42	115	50	1.335E+06	3.655E+06	0.365	32.7	0.05	89.8 ± 16.3
10	106	179	80	2.106E+06	3.556E+06	0.592	31.8	0.18	145.0 ± 18.1
11	211	210	70	4.790E+06	4.767E+06	1.005	42.7	0.80	244.1 ± 24.4
12	3	32	36	1.324E+05	1.412E+06	0.094	12.6	0.03	23.2 ± 14.0
14	11	22	80	2.185E+05	4.370E+05	0.500	3.9	0.06	122.6 ± 45.4
17	82	98	40	3.258E+06	3.893E+06	0.837	34.9	0.30	204.0 ± 30.8
18	163	111	50	5.180E+06	3.528E+06	1.468	31.6	0.64	353.8 ± 44.2
19	102	186	40	4.052E+06	7.389E+06	0.548	66.2	0.12	134.4 ± 16.8
21	184	195	40	7.310E+06	7.747E+06	0.944	69.4	0.58	229.5 ± 24.1
22	60	161	60	1.589E+06	4.264E+06	0.373	38.2	0.00	91.6 ± 14.0
24	11	49	50	3.496E+05	1.557E+06	0.224	13.9	0.12	55.4 ± 18.5
26	53	181	60	1.404E+06	4.794E+06	0.293	42.9	0.08	72.1 ± 11.4
27	43	63	21	3.254E+06	4.767E+06	0.683	42.7	0.11	166.8 ± 33.2
28	125	142	100	1.986E+06	2.256E+06	0.880	20.2	0.64	214.4 ± 26.7
29	113	234	100	1.796E+06	3.718E+06	0.483	33.3	0.11	118.5 ± 13.8
	1924	2677		2.394E+06	3.331E+06		29.8		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 233.373 with 19 degrees of freedom
P(chi squared) = 0.0 %
Correlation Coefficient = 0.823
Variance of SQR(Ns) = 18.36
Variance of SQR(Ni) = 12.78
Age Dispersion = 49.885 %

Ns/Ni = 0.719 ± 0.021
Mean Ratio = 0.651 ± 0.080

Ages calculated using a zeta of 354.8 ± 6.3 for SRM612 glass
Rho D = 1.396E+06cm-2; ND = 5971

POOLED AGE = 175.6 ± 6.5 Ma
CENTRAL AGE = 147.2 ± 17.7 Ma

GEOTRACK

000235

APATITE FISSION TRACK ANALYSIS OF SAMPLES FROM THE WESTERN EROMANGA BASIN AND ERINGA TROUGH, AUSTRALIA

GEOTRACK REPORT #582A

Data Report Only

A report prepared for Mines and Energy South Australia

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February 1996

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000237

APATITE FISSION TRACK ANALYSIS OF SAMPLES FROM THE WESTERN EROMANGA BASIN AND ERINGA TROUGH, AUSTRALIA

Data Report Only

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GEOTRACK REPORT #582A

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1. Introduction

This data report (#582A) is intended as an addendum to Geotrack Report #582 which was prepared for Mines and Energy South Australia (MESA) and completed in December 1995.

This report contains Apatite Fission Track Analysis (AFTA®) data obtained from three samples from the **Western Eromanga and Eringa Trough** region, which were supplied by MESA. One sample is of Merrimelia Formation from the Weena-1 well and two samples are from outcropping units at the Dalhousie Anticline. One of the outcrop samples failed to yield any apatite suitable for analysis. Chlorine contents were measured in all grains in which AFTA parameters (ages or lengths) were determined. Vitrinite reflectance (VR) data from the Weena-1 well was also supplied by MESA for inclusion in this data report.

No interpretation of the AFTA or VR data is provided in this report, as requested.

2. Report structure

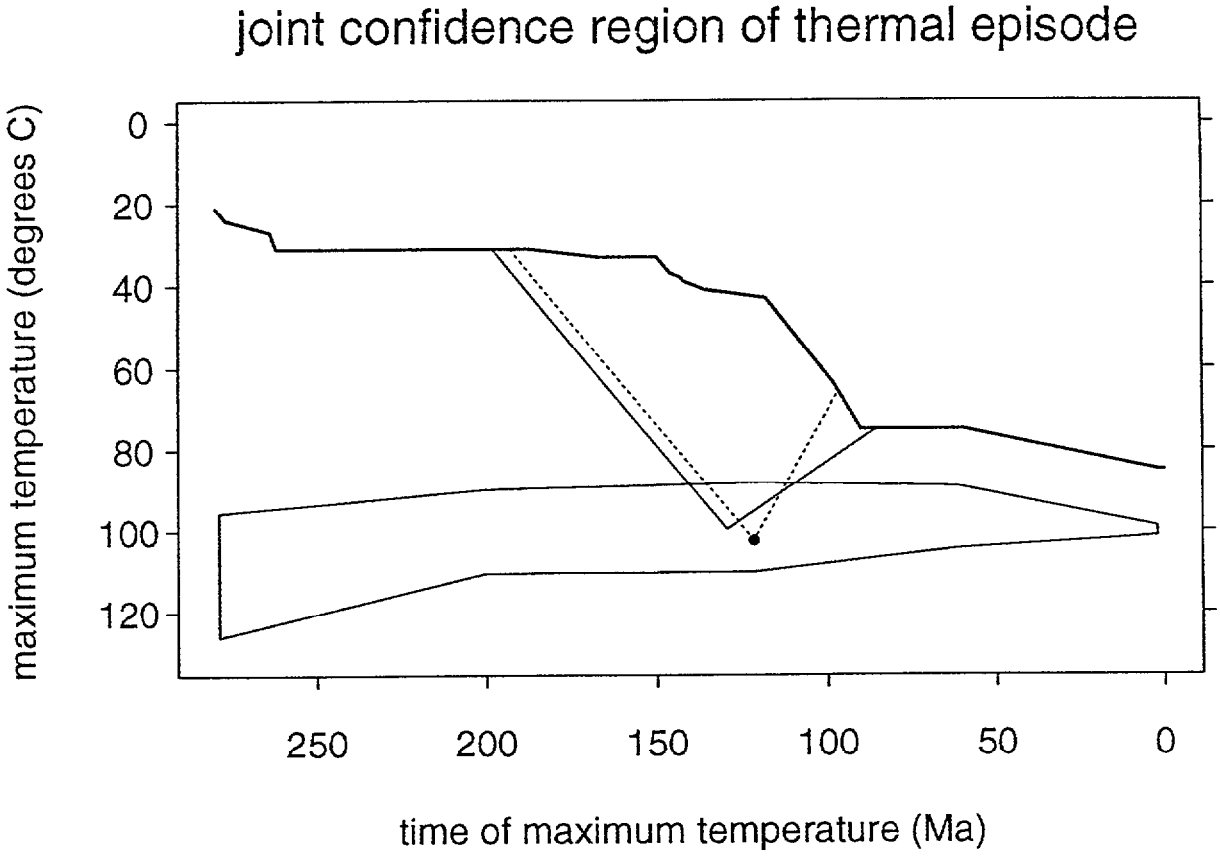
Data at the front of this report is divided into three parts. Graphical results of thermal history modelling of the AFTA and chlorine data are supplied in the first part. Summary files relating to the results of thermal history modelling are presented next. Finally, the Default Burial History as derived from the preserved stratigraphy in the Weena-1 well is displayed along with the VR data which are plotted with respect to depth. (Presentation of these data are as implemented by BasinMod™ (version 3.15), a software package of Platte River Associates.)

Sample details are discussed in Appendix A, together with the yields of detrital apatite obtained after mineral separation. Also shown in Appendix A, is a summary of the present temperature profile in the Weena-1 well. Sample preparation and analytical details are described in Appendix B, followed by presentation of all AFTA data, including raw track counts and fission track ages for individual grains. The presentation of data in the form of Tables and Figures throughout the report is discussed in detail in Appendix B.

PART ONE:

Graphical results of thermal history modelling of the AFTA and chlorine data

582-17


joint confidence region of thermal episode
maximum temperature (degrees C)
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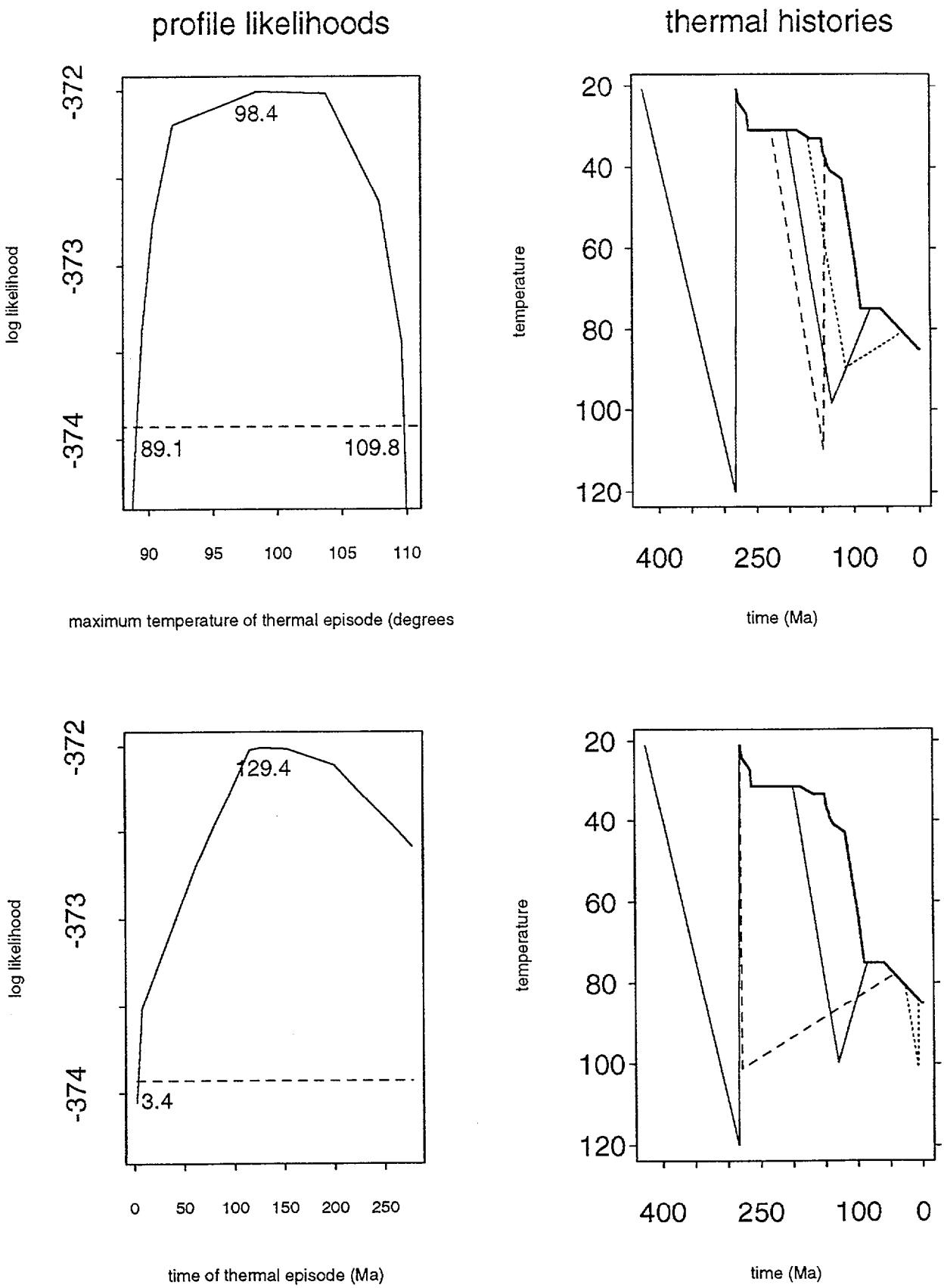
20
40
60
80
100
120
250
200
150
100
50
0
time of maximum temperature (Ma)

582-17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thermal histories
log likelihood
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-373
-374
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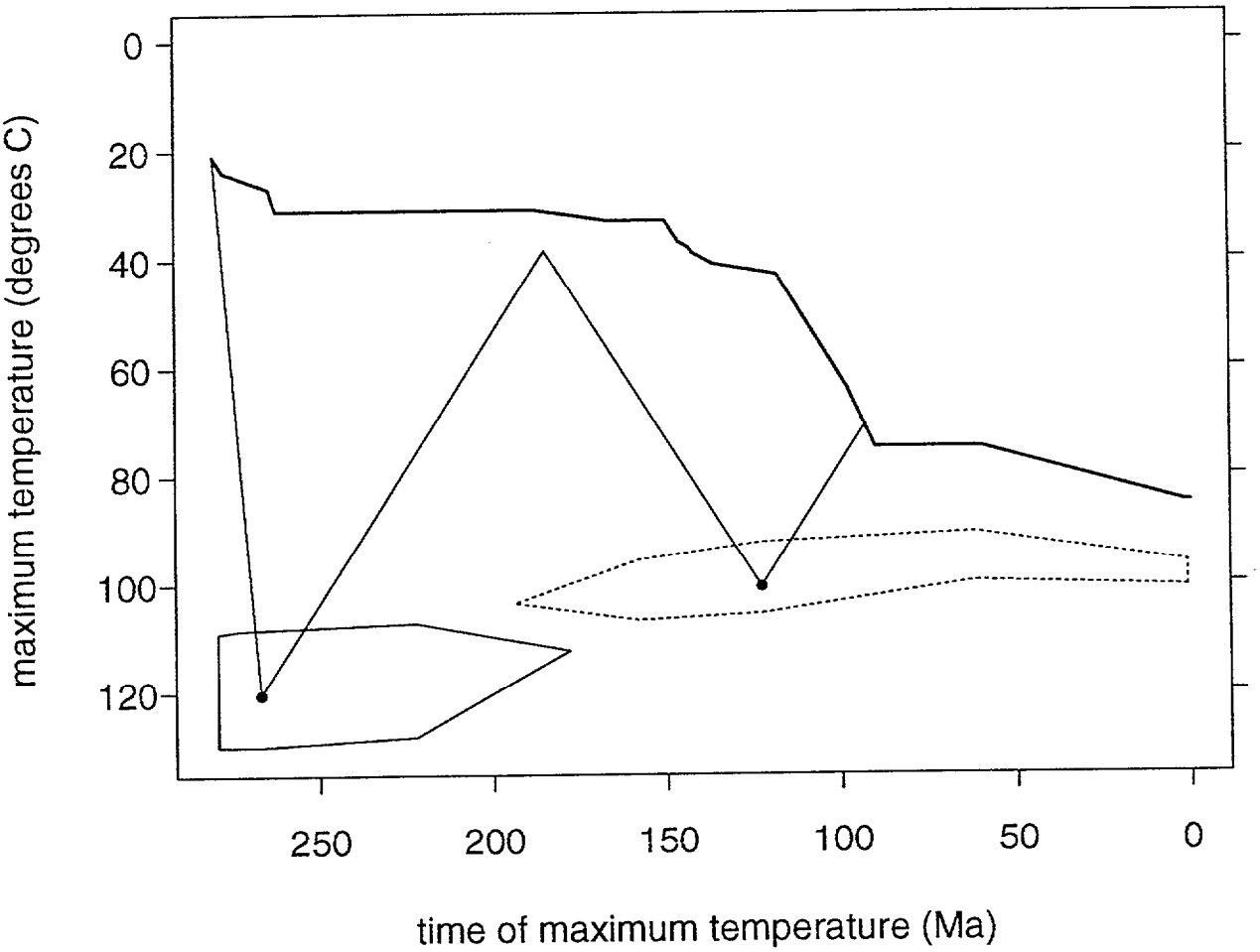
89.1
109.8
90
95
100
105
110
maximum temperature of thermal episode (degrees
temperature
20
40
60
80
100
120
400
250
100
0
time (Ma)
log likelihood
-372
-373
-374
129.4
3.4
0
50
100
150
200
250
time of thermal episode (Ma)
temperature
20
40
60
80
100
120
400
250
100
0
time (Ma)

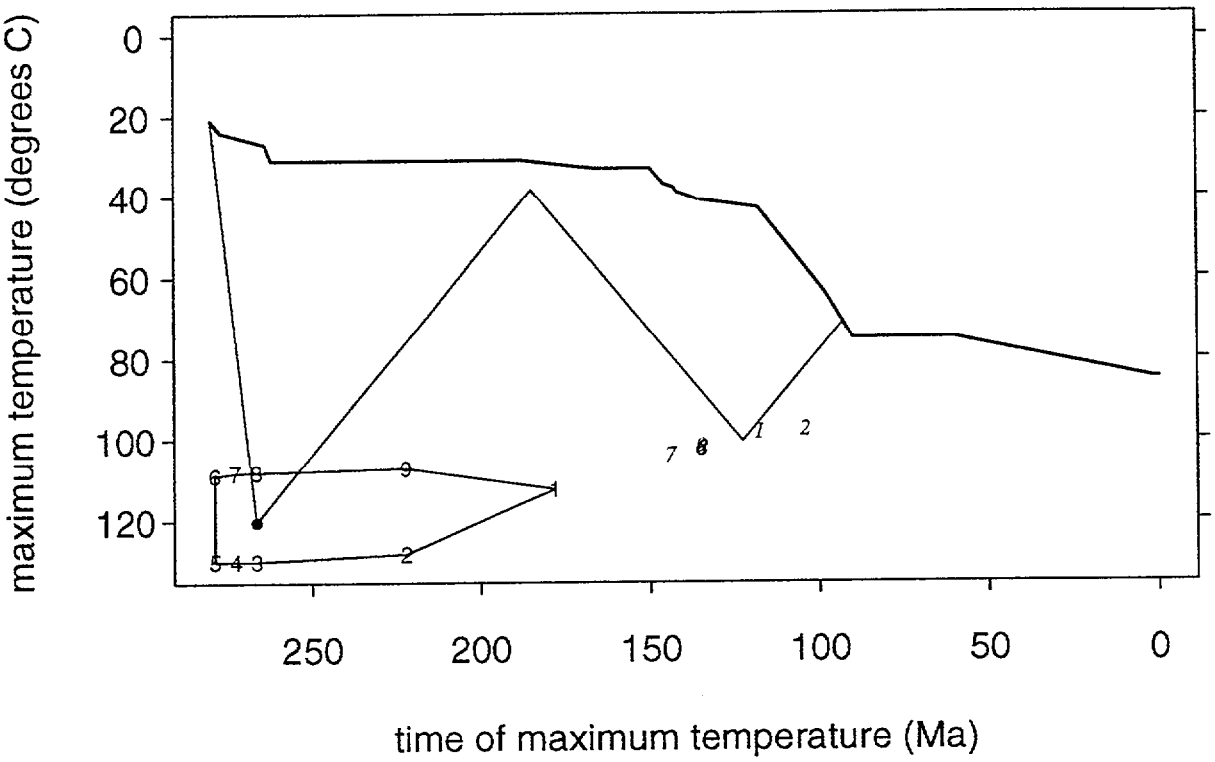
582-17

episodes 1 and 2

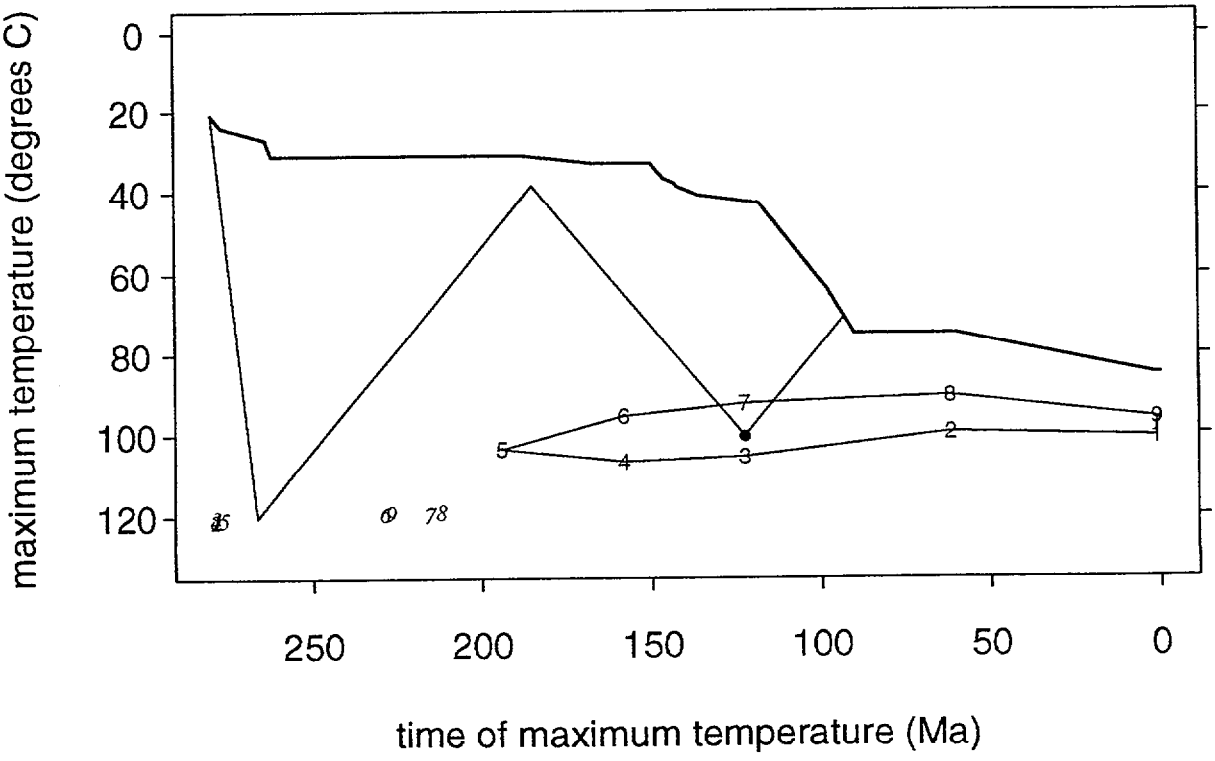


582-17

episode 1

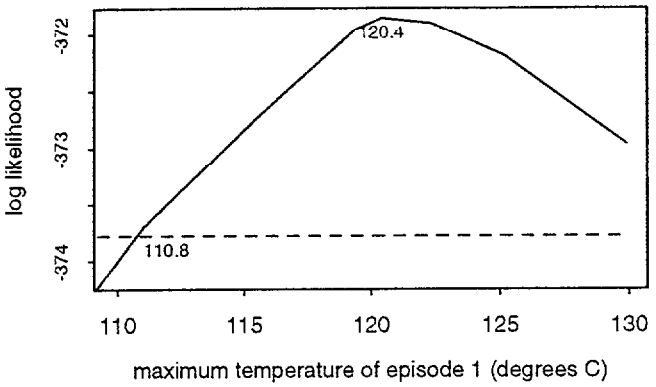


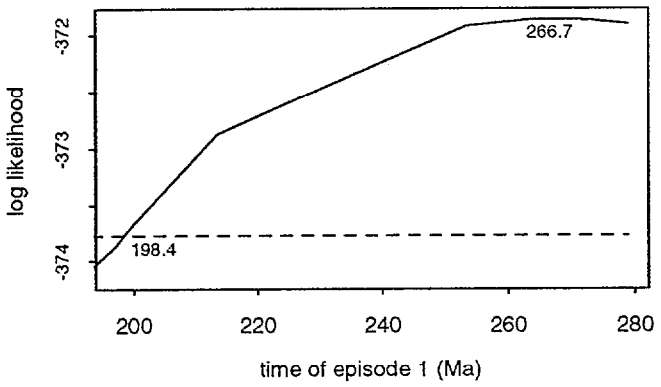
episode 2

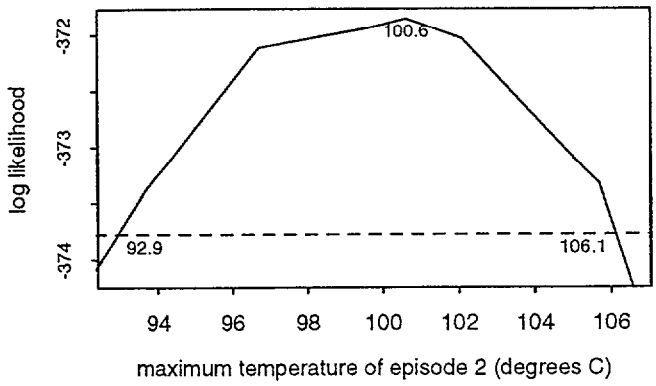


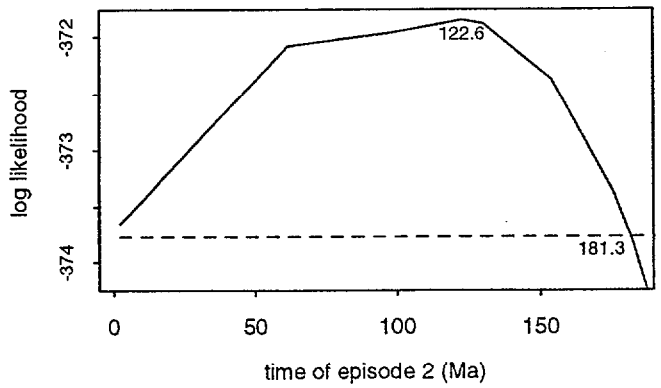
582-17

profile likelihoods

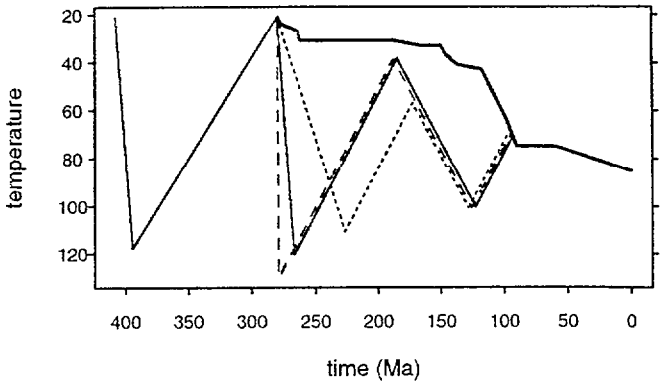


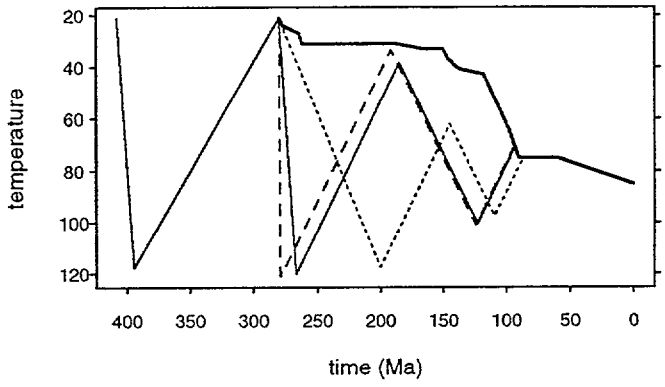


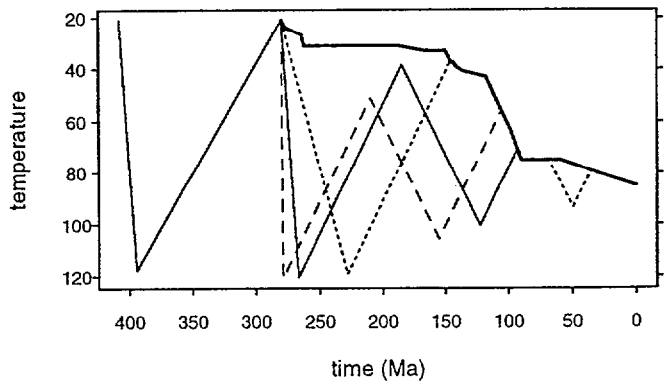


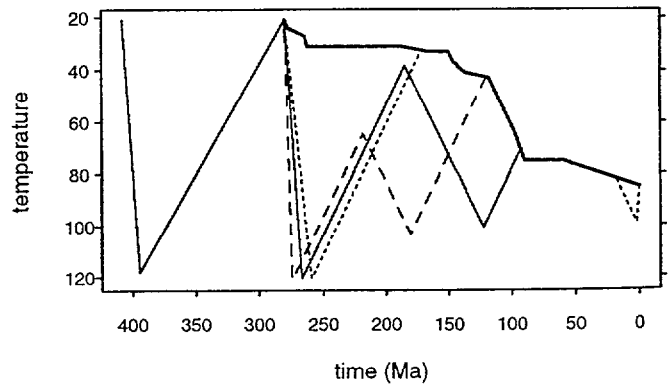


thermal histories

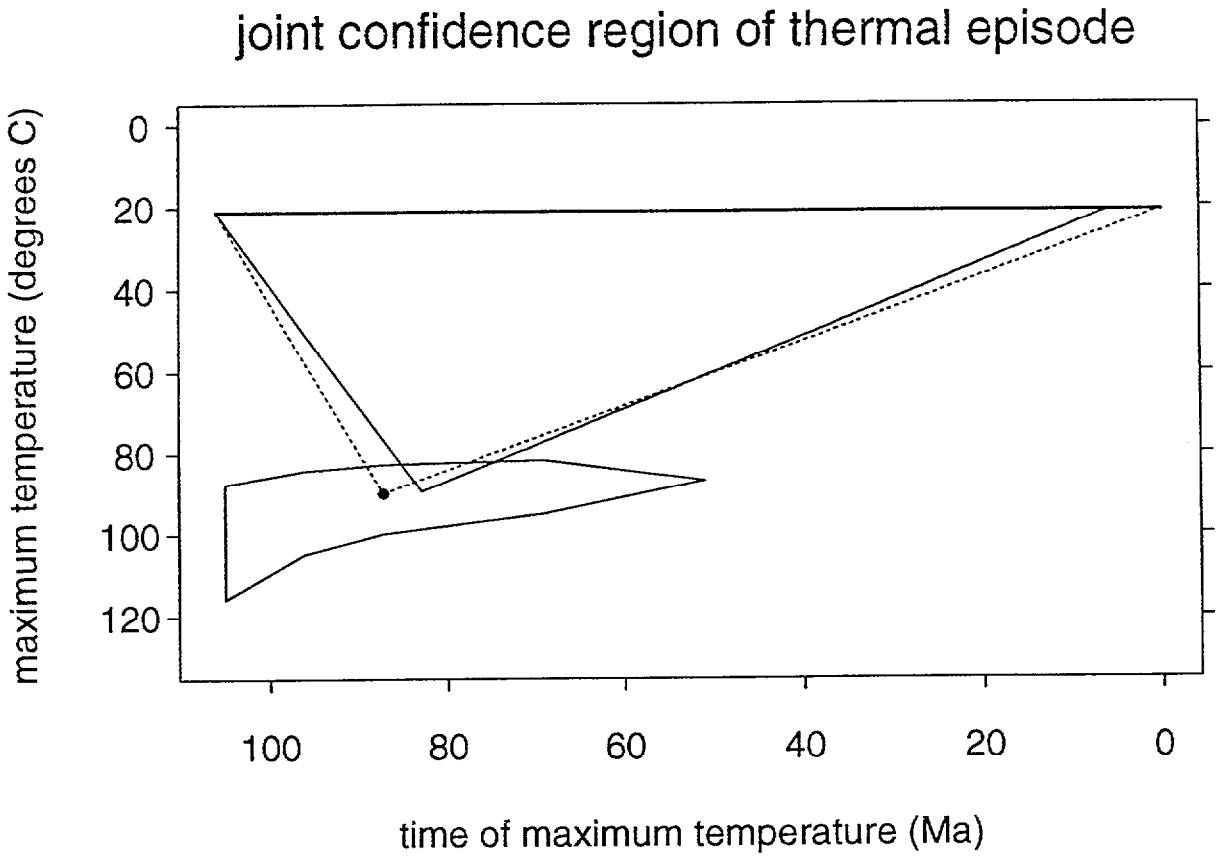






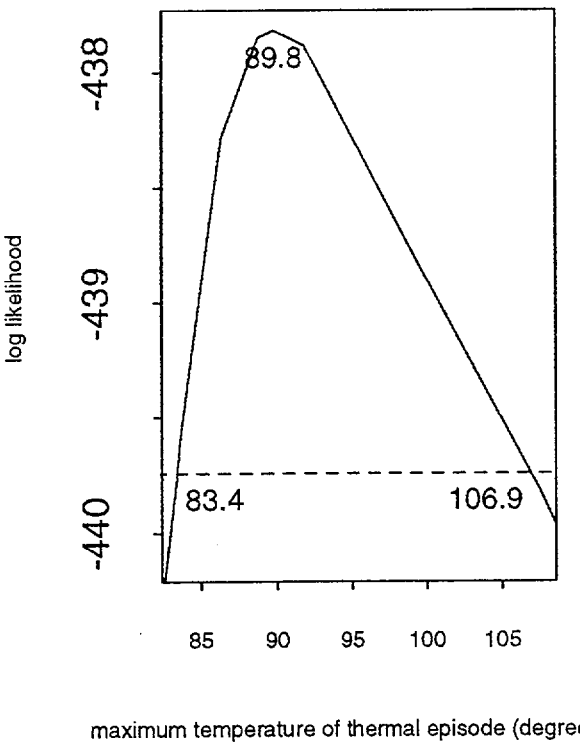


582-18

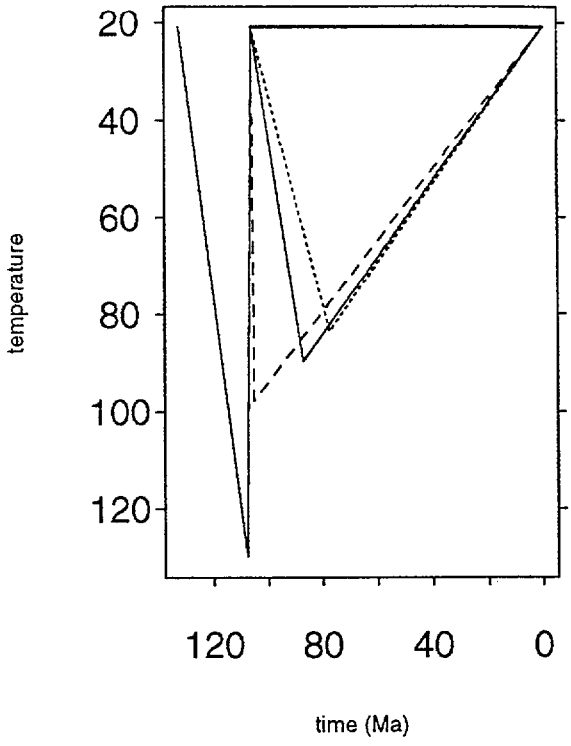

joint confidence region of thermal episode
maximum temperature (degrees C)
0
20
40
60
80
100
120
100
80
60
40
20
0
time of maximum temperature (Ma)

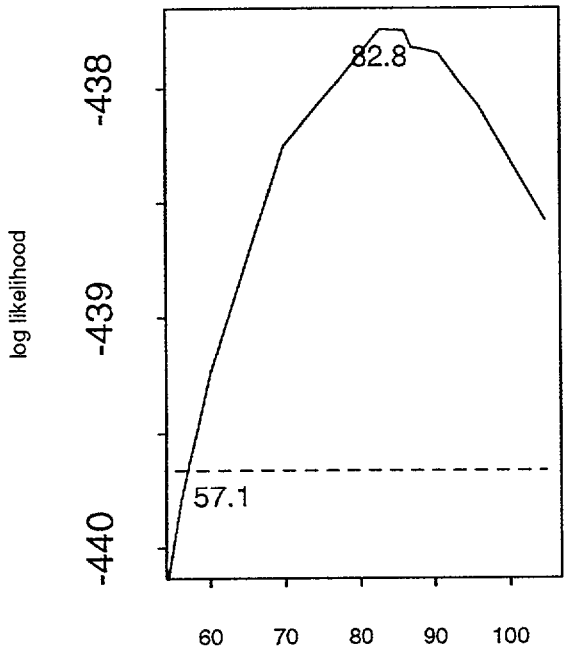
582-18

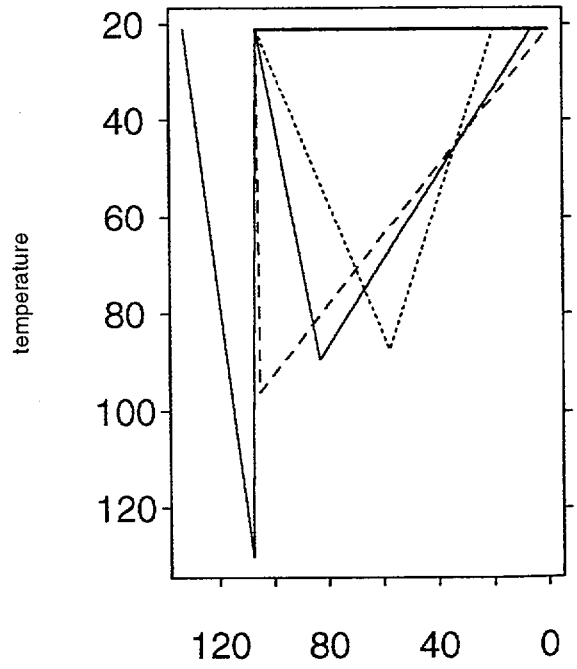
profile likelihoods



thermal histories

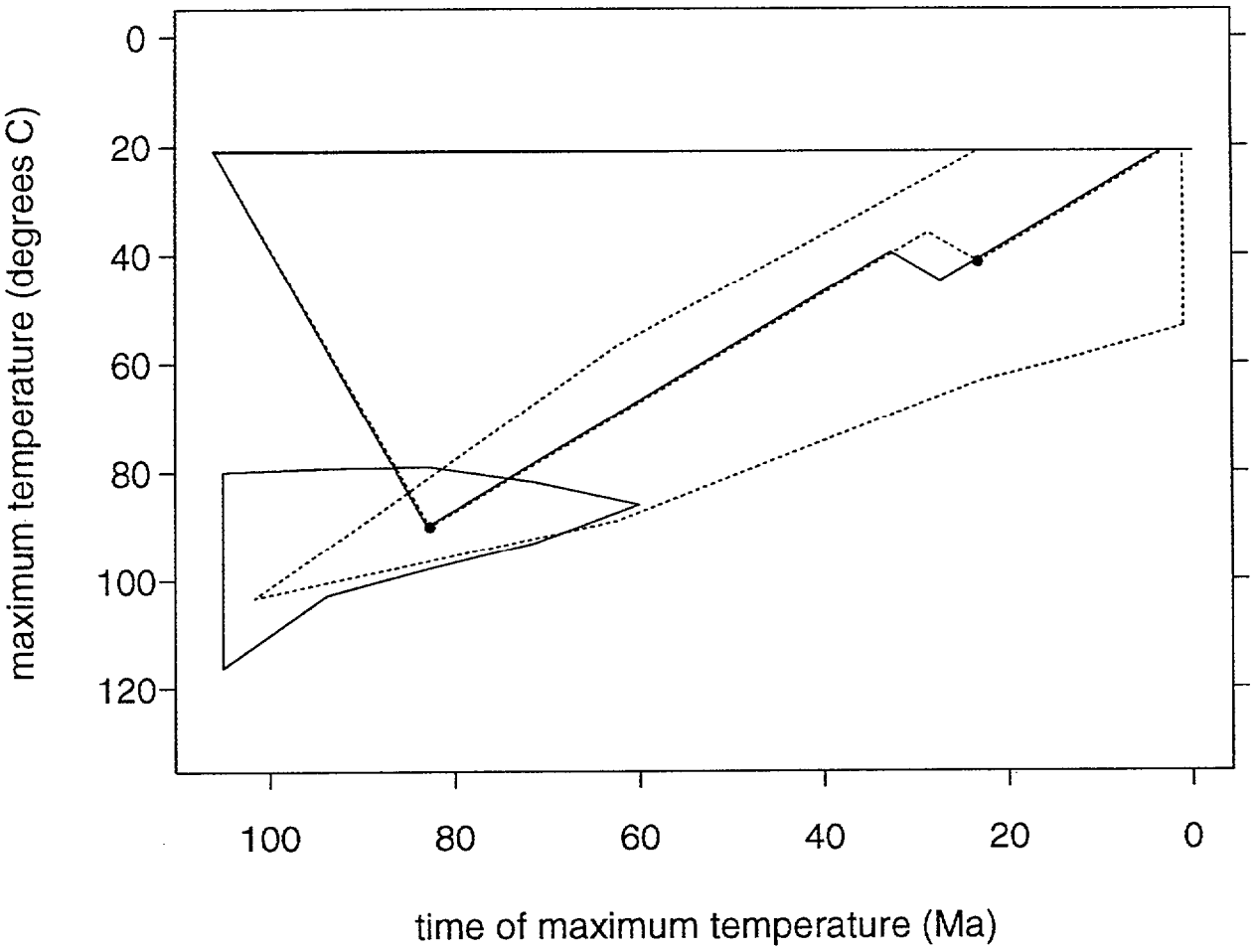






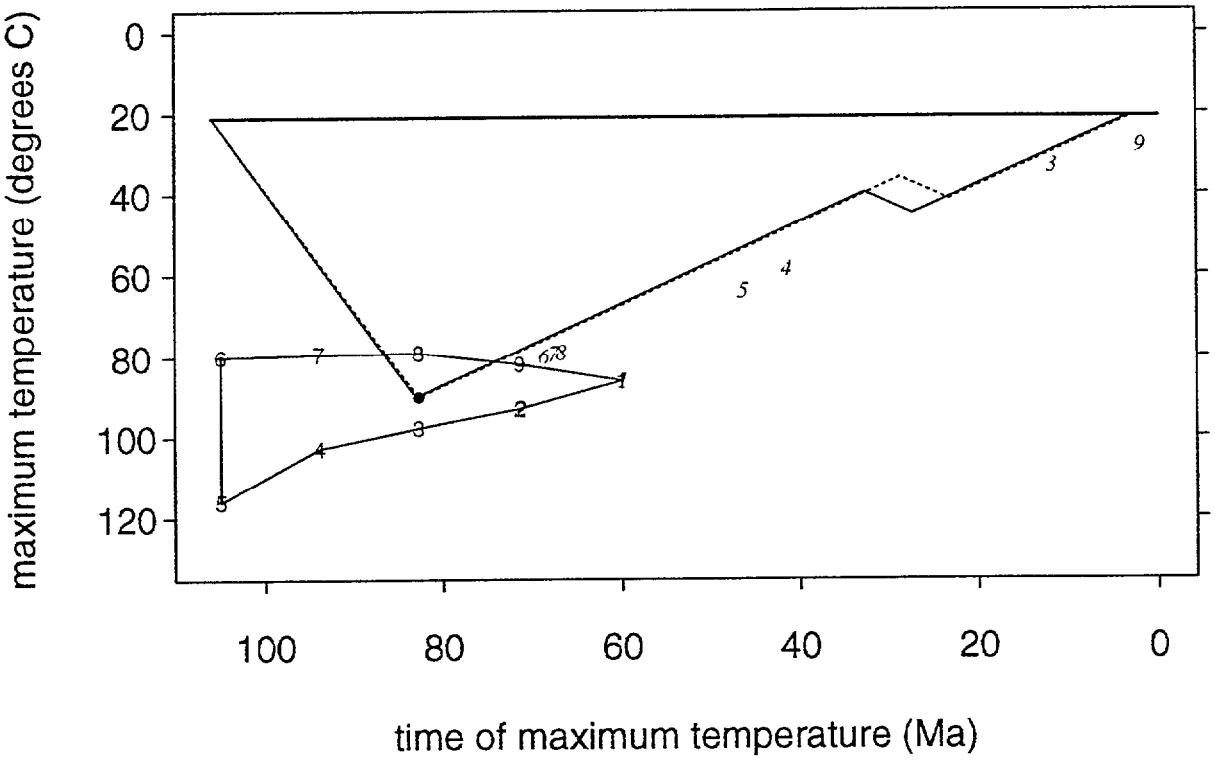
582-18

episodes 1 and 2

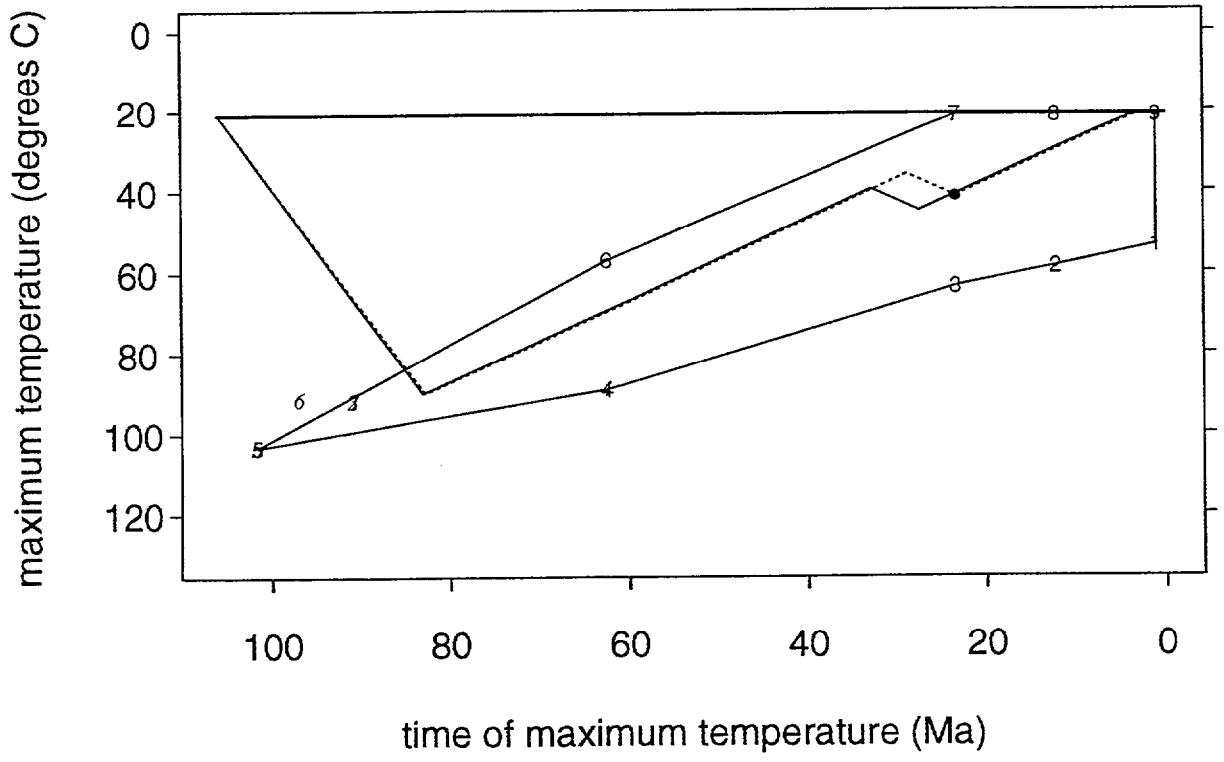


582-18

episode 1

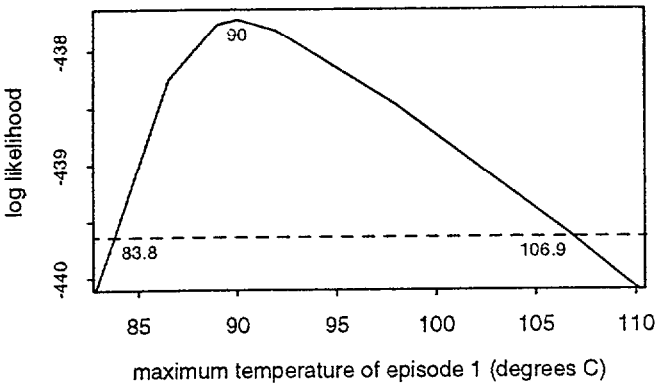


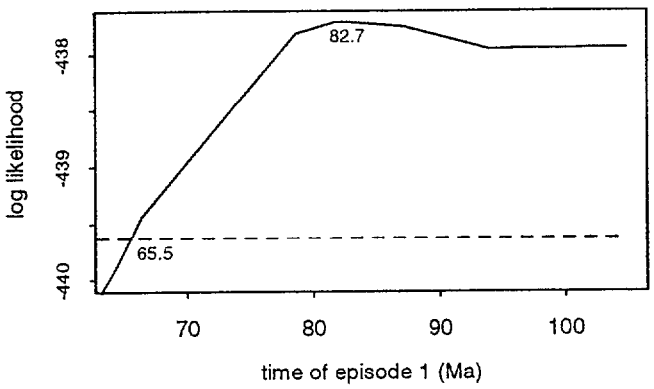
episode 2

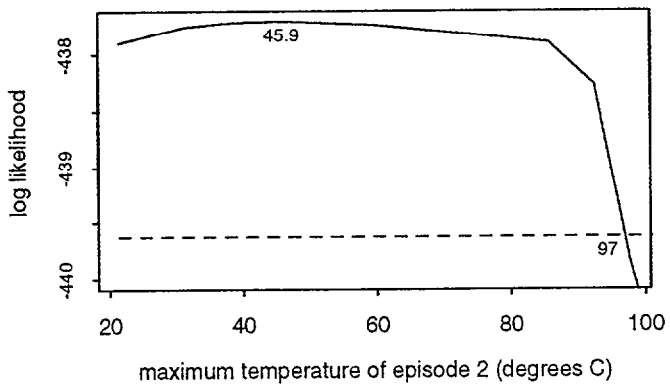


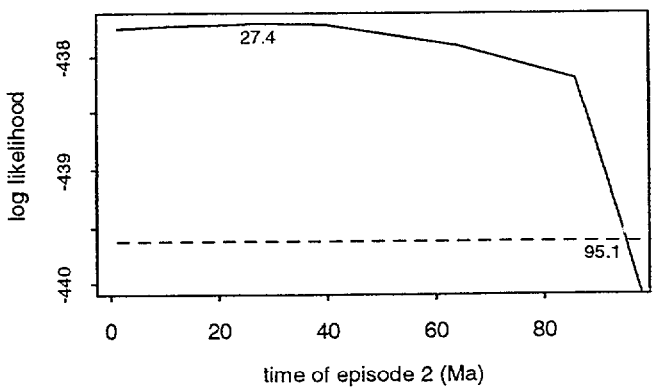
582-18

profile likelihoods

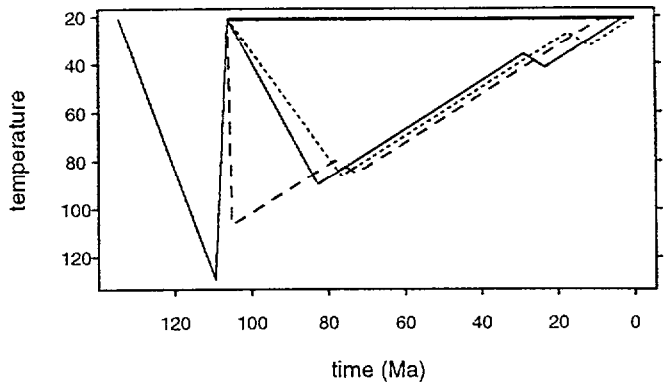


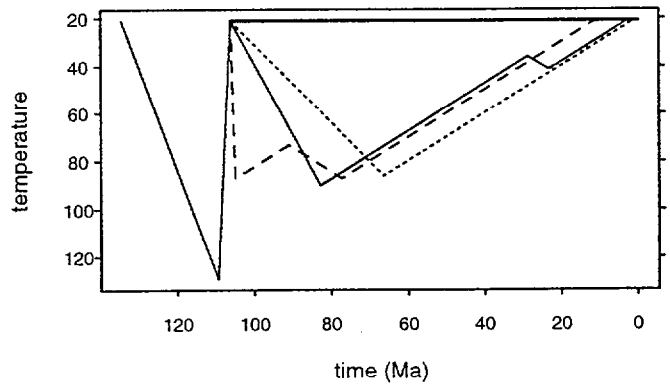


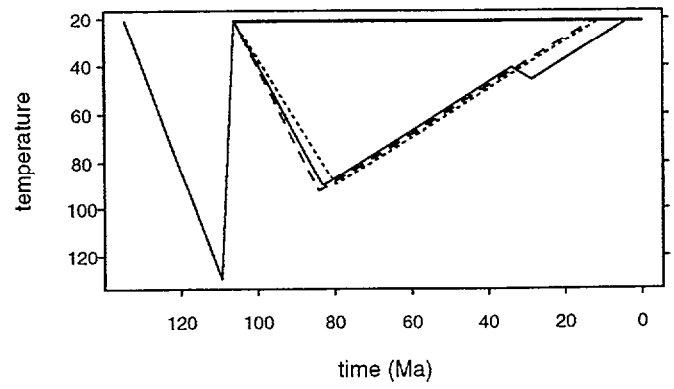


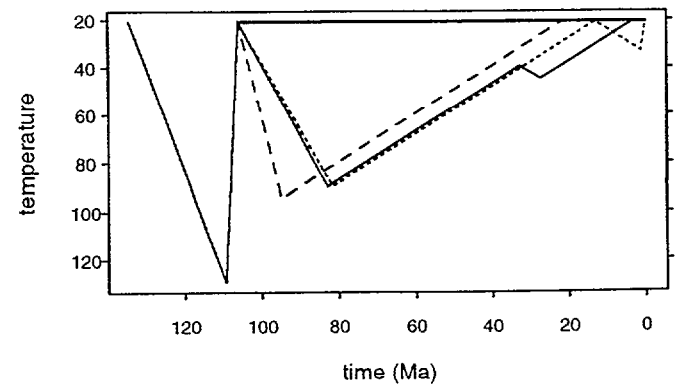


thermal histories









PART TWO:

Summary of thermal history modelling

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-17.cnn
file of lengths: 582-17.lng
zeta: 392.9117
rho d: 1.3234
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	17	0	Ma0	280.0	T0	21.0
		1	Ma1	277.0	T1	24.0
		2	Ma2	264.0	T2	27.0
		3	Ma3	262.0	T3	31.0
		4	Ma4	188.0	T4	31.0
		5	Ma5	167.0	T5	33.0
		6	Ma6	150.0	T6	33.0
		7	Ma7	148.0	T7	35.0
		8	Ma8	146.0	T8	37.0
		9	Ma9	143.0	T9	38.0
		10	Ma10	142.0	T10	39.0
		11	Ma11	136.0	T11	41.0
		12	Ma12	118.0	T12	43.0
		13	Ma13	98.0	T13	64.0
		14	Ma14	90.0	T14	75.0
		15	Ma15	60.0	T15	75.0
		16	Ma16	2.0	T16	85.0
		17	Ma17	0.0	T17	85.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-372.0150

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 1.4693

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	424.5	T0	21.0
		1	Ma1	283.7	T1	119.8
		2	Ma2	280.0	T2	21.0
		3	Ma3	121.6	T3	102.4
		4	Ma4	0.0	T4	85.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age
15	1	4	3	337.6	68.6
21	1	3	8	96.8	68.6
24	5	27	24	286.0	185.0
26	1	8	36	57.5	68.6
31	9	24	30	204.7	273.8
33	3	24	38	162.1	132.5
34	2	2	12	43.2	94.1
37	2	33	81	105.1	94.1
38	5	18	33	140.3	185.0
59	1	2	7	73.9	68.6
60	3	9	25	92.9	132.5
62	6	19	36	135.8	198.8

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

chlorine (%)

0.0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5

length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	33.99	0	33.75	0	0.00	0	32.52
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.01	0	0.00	0	0.00
4	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00
5	0	0.00	0	0.01	0	0.07	0	0.00	0	0.01
6	0	0.00	0	0.01	0	0.13	0	0.00	0	0.03
7	0	0.00	0	0.02	0	0.23	0	0.00	0	0.11
8	0	0.00	0	0.06	0	0.37	0	0.00	0	0.31
9	0	0.00	0	0.12	1	0.70	0	0.00	1	0.64
10	0	0.00	0	0.21	1	1.30	0	0.00	1	1.12
11	0	0.00	0	0.25	0	1.77	0	0.00	2	1.75
12	0	0.00	0	0.19	1	1.48	0	0.00	2	1.81
13	0	0.00	0	0.09	1	0.69	0	0.00	1	0.95
14	0	0.00	1	0.03	1	0.18	0	0.00	0	0.25
15	0	0.00	0	0.00	0	0.03	0	0.00	0	0.04
16	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	13.5	10.08	10.6	10.14	0.0	0.00	10.6	10.60
mu*:		2.36		3.25		4.59		0.00		6.45

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	30.49	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.01	0	0.00
7	0	0.02	0	0.00	0	0.00	0	0.01	0	0.00
8	0	0.09	0	0.00	0	0.00	1	0.02	0	0.00
9	0	0.23	0	0.00	0	0.00	0	0.04	0	0.00
10	1	0.46	0	0.00	0	0.00	0	0.10	0	0.00
11	1	0.75	0	0.00	0	0.00	0	0.22	0	0.00
12	0	0.82	0	0.00	0	0.00	0	0.30	0	0.00
13	0	0.47	0	0.00	0	0.00	0	0.21	0	0.00
14	0	0.13	0	0.00	0	0.00	0	0.07	0	0.00
15	1	0.02	0	0.00	0	0.00	0	0.01	0	0.00
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.5	10.81	0.0	0.00	0.0	0.00	7.5	11.11	0.0	0.00
mu*:		6.95		0.00		0.00		9.63		0.00

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-18.cnn
file of lengths: 582-18.lng
zeta: 392.9117
rho d: 1.3326
heating rate: 1.0000
curvature: 0.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	1	0	Ma0	106.0	T0	21.0
		1	Ma1	0.0	T1	21.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-437.8210

ML ESTIMATE OF THERMAL HISTORY

cooling rate: 0.6897

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	2	0	Ma0	132.5	T0	21.0
		1	Ma1	107.7	T1	130.0
		2	Ma2	106.0	T2	21.0
		3	Ma3	87.1	T3	89.8
		4	Ma4	0.0	T4	21.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age
3	10	13	30	112.5	108.0
4	10	3	6	129.6	108.0
5	2	6	16	97.4	91.0
6	6	4	7	147.9	95.3
9	3	6	20	78.1	92.1
13	5	3	3	256.6	94.3
14	7	3	6	129.6	99.6
16	10	15	38	102.5	108.0
17	10	7	20	91.0	108.0
18	10	11	23	124.0	108.0
21	8	10	29	89.6	103.5
22	7	4	6	172.2	99.6
23	4	9	16	145.6	93.2
24	6	3	16	48.9	95.3
28	10	8	26	80.1	108.0
29	10	8	8	256.6	108.0
30	9	4	8	129.6	107.5
32	8	1	4	65.1	103.5
33	10	2	6	86.7	108.0
36	10	8	39	53.5	108.0

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	18.87	0	18.83	0	0.00	0	18.49	0	17.92
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.02	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.08	0	0.01	0	0.00	0	0.00	0	0.00
9	2	0.22	0	0.05	0	0.00	0	0.02	0	0.01
10	0	0.44	0	0.14	0	0.00	0	0.19	0	0.12
11	1	0.75	0	0.26	0	0.00	0	0.69	0	0.55
12	0	1.13	0	0.39	0	0.00	2	1.26	2	1.23
13	3	1.60	1	0.53	0	0.00	2	1.68	3	1.75
14	3	2.06	1	0.69	0	0.00	1	2.13	3	2.19
15	0	1.80	1	0.61	0	0.00	4	1.95	1	2.02
16	0	0.77	0	0.27	0	0.00	0	0.89	0	0.94
17	0	0.13	0	0.05	0	0.00	0	0.16	0	0.17
18	0	0.01	0	0.00	0	0.00	0	0.01	0	0.01
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.7	12.85	13.5	12.95	0.0	0.00	13.3	13.18	12.8	13.28
mu*:		10.03		10.29		10.43		10.57		10.70

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	14.77	0	0.02	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.04
6	0	0.00	0	0.00	0	0.00	0	0.01	0	0.11
7	0	0.00	0	0.00	0	0.00	0	0.01	1	0.27
8	0	0.00	0	0.00	0	0.01	0	0.02	0	0.51
9	0	0.01	0	0.00	0	0.01	0	0.03	1	0.74
10	0	0.06	0	0.01	0	0.01	0	0.04	0	0.91
11	0	0.30	0	0.04	0	0.04	0	0.07	3	1.62
12	1	0.78	0	0.12	0	0.11	0	0.19	4	4.41
13	1	1.18	0	0.20	1	0.19	1	0.37	8	8.51
14	0	1.49	0	0.25	0	0.25	1	0.50	6	11.39
15	4	1.38	0	0.23	0	0.24	0	0.47	11	10.86
16	0	0.66	0	0.11	0	0.12	0	0.24	10	5.44
17	0	0.12	1	0.02	0	0.02	0	0.05	2	1.09
18	0	0.01	0	0.00	0	0.00	0	0.00	0	0.08
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	13.7	13.35	16.5	13.35	12.5	13.32	13.0	13.27	13.5	13.27
mu*:		10.82		11.33		11.77		12.24		12.29

****
* SUMMARY TABLE *
****

DATA + INPUT PARAMETERS

file of counts: 582-17.cnn
file of lengths: 582-17.lng
zeta: 392.9117
rho_d: 1.3234
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	17	0	Ma0	280.0	T0	21.0
		1	Ma1	277.0	T1	24.0
		2	Ma2	264.0	T2	27.0
		3	Ma3	262.0	T3	31.0
		4	Ma4	188.0	T4	31.0
		5	Ma5	167.0	T5	33.0
		6	Ma6	150.0	T6	33.0
		7	Ma7	148.0	T7	35.0
		8	Ma8	146.0	T8	37.0
		9	Ma9	143.0	T9	38.0
		10	Ma10	142.0	T10	39.0
		11	Ma11	136.0	T11	41.0
		12	Ma12	118.0	T12	43.0
		13	Ma13	98.0	T13	64.0
		14	Ma14	90.0	T14	75.0
		15	Ma15	60.0	T15	75.0
		16	Ma16	2.0	T16	85.0
		17	Ma17	0.0	T17	85.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-371.8585

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	8	0	Ma0	408.2	T0	21.0
		1	Ma1	394.4	T1	117.9
		2	Ma2	280.0	T2	21.0
		3	Ma3	266.7	T3	120.4
		4	Ma4	184.7	T4	38.5
		5	Ma5	122.6	T5	100.6
		6	Ma6	92.9	T6	71.0
		7	Ma7	90.0	T7	75.0
		8	Ma8	60.0	T8	75.0
		9	Ma9	2.0	T9	85.0
		10	Ma10	0.0	T10	85.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
15	1	4	3	337.6	68.4	2.4
21	1	3	8	96.8	68.4	0.5
24	5	27	24	286.0	171.1	1.9
26	1	8	36	57.5	68.4	-0.4
31	9	24	30	204.7	260.8	-0.9
33	3	24	38	162.1	126.2	1.0
34	2	2	12	43.2	95.2	-1.1
37	2	33	81	105.1	95.2	0.5
38	5	18	33	140.3	171.1	-0.7
59	1	2	7	73.9	68.4	0.1
60	3	9	25	92.9	126.2	-0.8
62	6	19	36	135.8	182.9	-1.1

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	0.00	0	40.32	0	38.32	0	0.00	0	35.90
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.01	0	0.00	0	0.00
4	0	0.00	0	0.00	1	0.02	0	0.00	0	0.00
5	0	0.00	0	0.01	0	0.06	0	0.00	0	0.01
6	0	0.00	0	0.01	0	0.12	0	0.00	0	0.02
7	0	0.00	0	0.03	0	0.21	0	0.00	0	0.09
8	0	0.00	0	0.06	0	0.37	0	0.00	0	0.26
9	0	0.00	0	0.12	1	0.71	0	0.00	1	0.58
10	0	0.00	0	0.21	1	1.31	0	0.00	1	1.09
11	0	0.00	0	0.25	0	1.79	0	0.00	2	1.79
12	0	0.00	0	0.19	1	1.49	0	0.00	2	1.88
13	0	0.00	0	0.09	1	0.70	0	0.00	1	0.99
14	0	0.00	1	0.03	1	0.18	0	0.00	0	0.26
15	0	0.00	0	0.00	0	0.03	0	0.00	0	0.04
16	0	0.00	0	0.00	1	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	0.0	0.00	13.5	10.08	10.6	10.18	0.0	0.00	10.6	10.68
mu*:		2.45		3.42		4.55		0.00		6.21

	chlorine (%) 0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	35.08	0	0.00	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.01	0	0.00
7	0	0.02	0	0.00	0	0.00	0	0.02	0	0.00
8	0	0.07	0	0.00	0	0.00	1	0.03	0	0.00
9	0	0.20	0	0.00	0	0.00	0	0.05	0	0.00
10	1	0.44	0	0.00	0	0.00	0	0.10	0	0.00
11	1	0.76	0	0.00	0	0.00	0	0.21	0	0.00
12	0	0.85	0	0.00	0	0.00	0	0.29	0	0.00
13	0	0.49	0	0.00	0	0.00	0	0.21	0	0.00
14	0	0.13	0	0.00	0	0.00	0	0.07	0	0.00
15	1	0.02	0	0.00	0	0.00	0	0.01	0	0.00
16	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.5	10.88	0.0	0.00	0.0	0.00	7.5	11.09	0.0	0.00
mu*:		6.64		0.00		0.00		9.54		0.00

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.9	1-10	7	6.23	-0.31
0.0-0.9	11-11	3	4.79	0.82
0.0-0.9	12-20	9	7.98	-0.36

chi-squared statistic for lengths: 0.9 with 3 groups
chi-squared statistic for counts : 15.0 with 12 grains
overall chi-squared statistic: 15.9 on 8 degrees of free

usual chi-squared statistic for counts : 23.3 on 11 degrees of freec

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax) OF THE THERMAL EPISODES

episode	time	Temp
1	266.66	130.00
1	266.66	108.27
1	279.00	130.00
1	279.00	108.99
1	272.83	130.00
1	272.83	108.39
1	272.83	120.75
1	222.34	128.31
1	222.34	107.27
2	122.60	105.64
2	122.60	92.44
2	1.00	100.89
2	1.00	96.25
2	61.80	99.79
2	61.80	90.67
2	61.80	97.15
2	158.23	106.81
2	158.23	95.69

SUMMARY TABLE

DATA + INPUT PARAMETERS

file of counts: 582-18.cnn
file of lengths: 582-18.lng
zeta: 392.9117
rho_d: 1.3326
heating rate 1: 1.0000
cooling rate 1: 1.0000
heating rate 2: 1.0000
cooling rate 2: 1.0000

DEFAULT HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
0	1	0	Ma0	106.0	T0	21.0
		1	Ma1	0.0	T1	21.0

LIKELIHOOD STATISTICS

number of fits + refits: 1

fit #	log likelihood
1	-437.7147

ML ESTIMATE OF THERMAL HISTORY

# intervals b	a	Time point	Time	Estimate	Temp.	Estimate
2	5	0	Ma0	134.4	T0	21.0
		1	Ma1	109.3	T1	129.5
		2	Ma2	106.0	T2	21.0
		3	Ma3	82.7	T3	90.0
		4	Ma4	28.7	T4	36.0
		5	Ma5	23.3	T5	41.4
		6	Ma6	2.8	T6	21.0
		7	Ma7	0.0	T7	21.0

AGE ESTIMATES

grain number	chlorine group	ns	ni	usual FT age	estimated age	standardised residuals
3	10	13	30	112.5	109.7	0.1
4	10	3	6	129.6	109.7	0.2
5	2	6	16	97.4	92.5	0.1
6	6	4	7	147.9	96.8	0.7
9	3	6	20	78.1	93.6	-0.4
13	5	3	3	256.6	95.8	1.3
14	7	3	6	129.6	101.2	0.4
16	10	15	38	102.5	109.7	-0.2
17	10	7	20	91.0	109.7	-0.4
18	10	11	23	124.0	109.7	0.3
21	8	10	29	89.6	105.1	-0.4
22	7	4	6	172.2	101.2	0.8
23	4	9	16	145.6	94.7	1.1
24	6	3	16	48.9	96.8	-1.1
28	10	8	26	80.1	109.7	-0.8
29	10	8	8	256.6	109.7	1.8
30	9	4	8	129.6	109.2	0.3
32	8	1	4	65.1	105.1	-0.4
33	10	2	6	86.7	109.7	-0.3
36	10	8	39	53.5	109.7	-1.9

OBSERVED AND FITTED LENGTH DISTRIBUTIONS

	chlorine (%) 0.0-0.1		0.1-0.2		0.2-0.3		0.3-0.4		0.4-0.5	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	18.89	0	18.81	0	0.00	0	18.47	0	17.85
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7	0	0.02	0	0.00	0	0.00	0	0.00	0	0.00
8	0	0.08	0	0.01	0	0.00	0	0.00	0	0.00
9	2	0.24	0	0.05	0	0.00	0	0.03	0	0.01
10	0	0.48	0	0.15	0	0.00	0	0.20	0	0.12
11	1	0.74	0	0.27	0	0.00	0	0.72	0	0.57
12	0	1.01	0	0.36	0	0.00	2	1.23	2	1.21
13	3	1.46	1	0.49	0	0.00	2	1.55	3	1.63
14	3	2.09	1	0.69	0	0.00	1	2.09	3	2.13
15	0	1.93	1	0.65	0	0.00	4	2.05	1	2.11
16	0	0.82	0	0.29	0	0.00	0	0.95	0	1.00
17	0	0.14	0	0.05	0	0.00	0	0.17	0	0.19
18	0	0.01	0	0.00	0	0.00	0	0.01	0	0.01
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	11.7	12.90	13.5	12.99	0.0	0.00	13.3	13.21	12.8	13.32
mu*:		10.06		10.30		10.45		10.59		10.72

chlorine (%)

	0.5-0.6		0.6-0.7		0.7-0.8		0.8-0.9		0.9-1.0	
length	obs	fit	obs	fit	obs	fit	obs	fit	obs	fit
0	0	14.71	0	0.02	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.01
5	0	0.00	0	0.00	0	0.00	0	0.00	0	0.04
6	0	0.00	0	0.00	0	0.00	0	0.01	0	0.11
7	0	0.00	0	0.00	0	0.00	0	0.01	1	0.27
8	0	0.00	0	0.00	0	0.01	0	0.02	0	0.51
9	0	0.01	0	0.00	0	0.01	0	0.03	1	0.74
10	0	0.06	0	0.01	0	0.01	0	0.04	0	0.91
11	0	0.32	0	0.04	0	0.04	0	0.07	3	1.66
12	1	0.78	0	0.12	0	0.11	0	0.20	4	4.47
13	1	1.11	0	0.19	1	0.18	1	0.36	8	8.20
14	0	1.44	0	0.24	0	0.24	1	0.48	6	10.97
15	4	1.44	0	0.24	0	0.24	0	0.48	11	11.10
16	0	0.70	0	0.12	0	0.12	0	0.25	10	5.75
17	0	0.13	1	0.02	0	0.02	0	0.05	2	1.17
18	0	0.01	0	0.00	0	0.00	0	0.00	0	0.08
19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
mean:	13.7	13.38	16.5	13.38	12.5	13.34	13.0	13.30	13.5	13.30
mu*:		10.84		11.35		11.79		12.26		12.31

CHI-SQUARED GOODNESS-OF-FIT STATISTICS

chlorine groups	length groups	observed	fitted	standardised residuals
0.0-0.2	1-13	7	5.33	-0.72
0.0-0.2	14-20	5	6.67	0.65
0.2-0.5	1-12	4	4.11	0.05
0.2-0.5	13-14	9	7.39	-0.59
0.2-0.5	15-20	5	6.50	0.59
0.5-0.9	1-13	4	3.76	-0.12
0.5-0.9	14-20	6	6.24	0.10
0.9-1.0	1-11	5	4.26	-0.36
0.9-1.0	12-12	4	4.47	0.22
0.9-1.0	13-13	8	8.20	0.07
0.9-1.0	14-14	6	10.97	1.50
0.9-1.0	15-15	11	11.10	0.03
0.9-1.0	16-20	12	7.00	-1.89

chi-squared statistic for lengths: 7.7 with 13 groups
chi-squared statistic for counts : 13.8 with 20 grains
overall chi-squared statistic: 21.5 on 26 degrees of free

usual chi-squared statistic for counts : 13.2 on 19 degrees of free

VERTICES OF CONFIDENCE REGION FOR (tmax,Tmax)
OF THE THERMAL EPISODES

episode	time	Temp
1	82.70	97.83
1	82.70	79.04
1	105.00	116.12
1	105.00	80.01
1	93.85	102.82
1	93.85	79.36
1	93.85	86.57
1	71.38	93.07
1	71.38	81.94
2	23.27	63.56
2	23.27	21.20
2	1.00	53.33
2	1.00	21.20
2	12.13	58.67
2	12.13	21.20
2	12.13	36.40
2	62.44	88.98
2	62.44	56.96

PART THREE:

Default Burial Histories derived from preserved stratigraphy in each well and VR data plotted with respect to depth

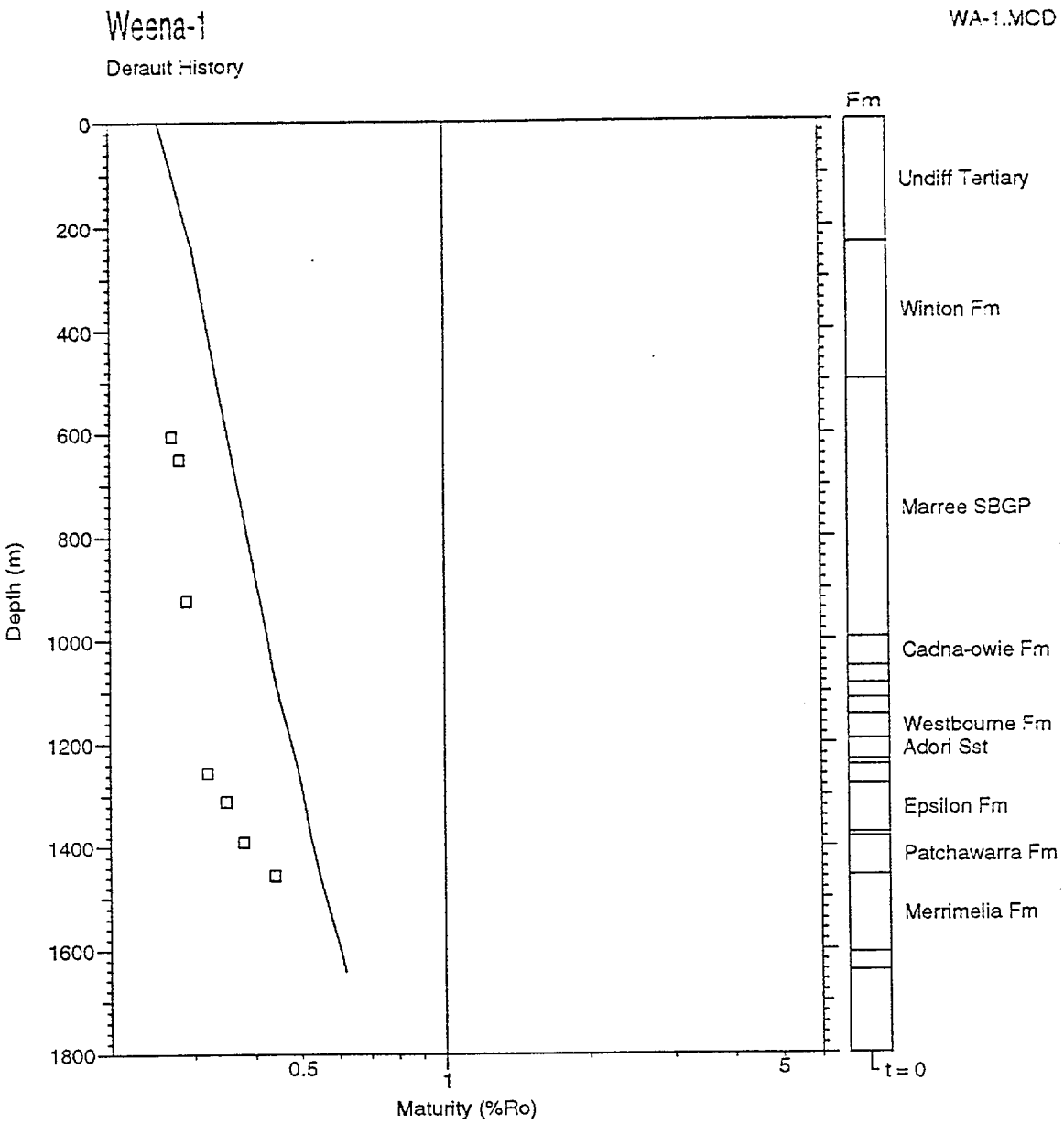


Figure 3.1: Vitrinite reflectance data (supplied by MESA) in the **Weena-1 well** plotted against depth (TVD) with respect to KB. The solid line shows the VR profile predicted from the Default Thermal History, i.e., the profile predicted if samples throughout the section are currently at their maximum temperatures since deposition.

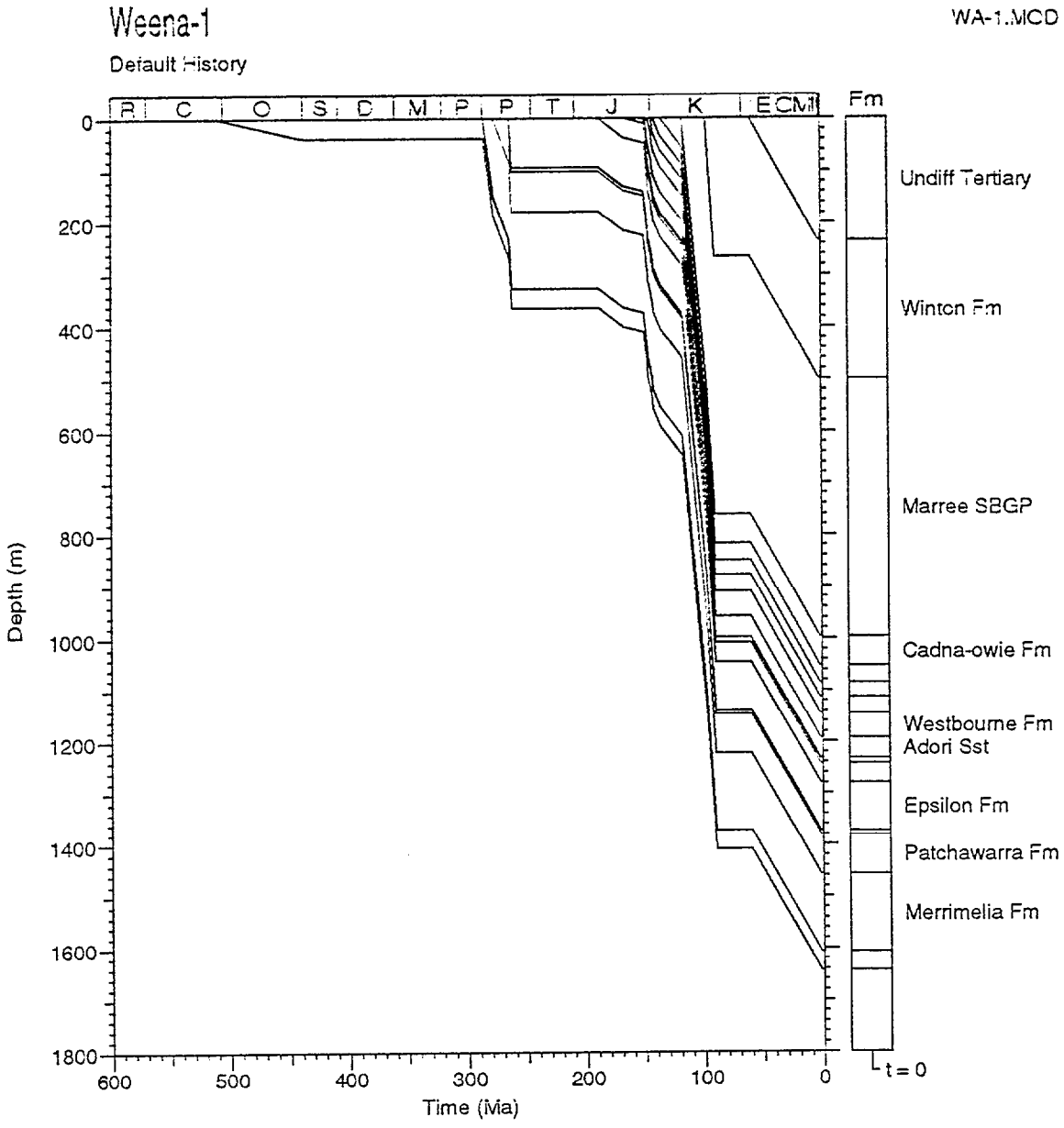


Figure 3.2: Default Burial History showing the history derived from the preserved stratigraphy in the **Weena-1 well.** This history, together with the present geothermal gradient of 42.5°C/km (Table A.3) and a surface temperature of 21°C, has been used to calculate the Default Thermal History, as used in Figure 3.1. Default parameters can be compared with observed AFTA and VR parameters to evaluate the degree of heating which is attributable to the present thermal regime, hence determine whether samples have been hotter in the past.

APPENDIX A

Sample Details

A.1 Apatite yields and quality

Three samples from the **Western Eromanga Basin and Eringa Trough** region were submitted for Apatite Fission Track Analysis (AFTA®) by Mines and Energy South Australia. Sample GC582-17 is from the Weena-1 well and samples GC582-18 and -19 are of outcrop from the Dalhousie Anticline.

The yields of detrital apatite obtained after mineral separation of the three samples were variable. Sample GC582-17 provided a fair yield, GC582-18 provided an excellent yield, but sample GC582-19 failed to yield any apatite suitable for analysis, as summarised in Tables A.1 and A.2.

All grains analysed are of average to high quality and contain good quality polished surfaces. Resulting AFTA data are reliable and should form the basis of a firm thermal history interpretation.

A.2 Stratigraphic details

Stratigraphic ages of each sample are summarised in Tables A.1 and A.2. Chronostratigraphic and chronometric (numerical) age information was supplied by Mines and Energy South Australia (MESA). Well stratigraphy for Weena-1 is summarised in Table A.4.

A.3 Present temperatures

In the application of any technique involving estimation of paleotemperatures, it is critical to control the present temperature, since estimation of maximum paleotemperatures proceeds from determining how much of the observed effect can be explained by the magnitude of present temperatures.

Uncorrected BHT temperatures and DST data were provided by MESA for the Weena-1 well, as summarised in Table A.3 and plotted with respect to depth in Figure A.1. The raw BHT data were adjusted using a simplified correction procedure adapted from the literature (Oxburgh and Andrews-Speed, 1981; Andrews-Speeds et al., 1984). In this procedure we increased the difference between the surface temperature and the

uncorrected BHT by 20% for uncorrected temperatures below 150°F (<66°C) and by 25% for temperatures above 150°F (>66°C). An estimate of 21°C was assumed for the present mean annual surface temperature.

A.4 Grain morphologies

Apatite grains in sample GC582-17 are characterised either by angular or sub-rounded forms. Most grains are small to moderate in size (roughly 40 to 100 μm). Grains are generally of average quality, though some grains are of poorer quality due to the presence of minor crystal dislocations.

Apatite grains in sample GC582-18 are characterised by angular to sub-rounded forms. Most grains are moderate in size (roughly 60 to 100 μm). Grains are generally of high quality, though some grains are of poorer quality due to the presence of minor crystal dislocations.

A.5 Apatite compositions

The annealing kinetics of fission tracks in apatite are affected by chemical composition, specifically the Cl content.

For this study, chlorine compositions were determined for all individual apatite grains in which fission track ages were determined. Chlorine contents were measured using a semi-automated Jeol JXA-5A electron microprobe equipped with three wavelength dispersive crystal spectrometers, with an accelerating voltage of 15KV and beam current of 25nA. The beam was defocussed to 20 μm to avoid the problems associated with apatite decomposition, which occur under a fully focussed 1μm - 2μm beam. The X-Y co-ordinates of apatite grains within the grain mount were transferred from the Autoscan Fission Track Stage to a file suitable for direct input into the electron microprobe. Pure rock salt (NaCl) was used as a standard for chlorine, which was the only element determined in each apatite grain. Count rates were converted to wt% Cl using an empirically determined correction factor. This allows for atomic number absorption and fluorescence matrix effects, which are normally calculated explicitly when analysing for all elements. Durango apatite (Melbourne University Standard APT151) was analysed at regular intervals throughout the analysis to monitor microprobe performance.

Using this approach, lower limits of detection for chlorine content have been calculated for typical analytical conditions (beam current, counting time, etc.), and are listed in Table A.5. Errors in wt% composition are given as a percentage and quoted at 1σ for chlorine determinations. A generalised summary of error values for various values of wt% chlorine is presented in Table A.6.

The measured range of chlorine content of apatites (both age and length grains) within each sample is shown in histogram format in Figures A.2a and b. Plots of single grain age versus weight % chlorine are shown in Figures B.5a and b. Chlorine contents appear in the fission track age summary sheets in Appendix B, and in Table B.3.

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Andrews-Speed, C.P., Oxburgh, E.R. and Cooper, B.A. (1984). Temperatures and depth-dependent heat flow in the South-western North Sea. *In:* , L.V. and Hobson, G.D. (eds.), The petroleum geology of the continental shelf of NW Europe, 3, 141-151.

Oxburgh, E.R. and Andrews-Speed, C.P. (1981). Temperatures and depth-dependent heat flow in the Western North Sea. *AAPG Bulletin*, 68, 1764-1781.

Table A.1: Details of AFTA samples and apatite yields - well samples from Western Eromanga - Eringa Trough (Geotrack Report #582A)

Sample number	Depth (m)	Sample type	Stratigraphic subdivision	Stratigraphic age (Ma)	Present temperature *1 (°C)	Raw weight (g)	Washed weight (g)	Apatite yield *2
Weena 1								
GC582-17	1516-1518 *(4975-4981')*	core	Merrimelia Fm	285.5-277	85	1360	583	Fair

*1 See Appendix A for discussion of present temperature data.

*2 Yield based on quantity of mineral suitable for age determination. Excellent: >20 grains; Very Good: ~20 grains; Good: 15-20 grains; Fair: 10-15 grains; Poor: 5-10 grains; Very Poor: <5 grains.

Note: All depths quoted are TVD with respect to KB.

Table A.2: Details of AFTA samples and apatite yields - outcrop samples from Western Eromanga - Eringa Trough (Geotrack Report #582A)

Sample number	Location	Stratigraphic subdivision	Stratigraphic age (Ma)	Raw weight (g)	Washed weight (g)	Apatite yield *1
Outcrop samples						
GC582-18	Dalhousie anticline	Coorikiana Sst	108-105	1490	333	Excellent
GC582-19	Dalhousie anticline	Cadna-Owie Fm	138-117.5	670	372	None

*1 Yield based on quantity of apatite suitable for age determination. Excellent: >20 grains; Very Good: ~20 grains; Good: 15-20 grains; Fair: 10-15 grains; Poor: 5-10 grains; Very Poor: <5 grains.

Table A.3: Summary of present temperature measurements - Western Eromanga - Eringa Trough wells (Geotrack Report #582A)

Ground surface (ft)	Ground surface (m)	Depth (log) (ft)	Uncorrected temperature (°F)	Uncorrected temperature (°C)	Time since circulation (hrs)	Depth (m)	Corrected temperature (°C)	Geothermal gradient (°C/km)
Weena 1								
0	0	4196	168	75.5	DST	1279		42.5
		5394	168	75.5	-	1644	90.7	

Quoted BHT values have been corrected by increasing the difference between sea bed temperature and measured BHT by 20% for measured temperatures <150°F (<66°C) and by 25% for temperatures >150°F (>66°C). A surface temperature of 21°C has been assumed.
*Measurement was not used in calculation of present geothermal gradient.
All depths quoted are with respect to KB, except where otherwise stated.

Table A.4: Summary of stratigraphy - wells from Western Eromanga - Eringa Trough (Geotrack Report #582A)

	Formation / Group	Age of Top (Ma)	Depth of Top (m)
Weena 1			
	Tertiary Undifferentiated	2	0
	Unconformity	60	235
	Winton Fm	90	235
	Marree SubGp	97.5	500
	Cadna-owie Fm	117.5	997
	Murta Fm	135.5	1052
	McKinlay Mbr	141.5	1085
	Namur Sst	143	1113
	Westbourne Fm	146	1145
	Adori Sst	148	1193
	Birkhead Fm	150	1233
	Hutton Sst	167	1243
	Unconformity	188	1280
	Epsilon Fm	261.5	1280
	Murteree Sh	263.5	1373
	Patchawarra Fm	264.5	1381
	Merrimelia Fm	277	1458
	Unconformity	285.5	1607
	Basement	440	1607
	Total Depth	510	1644

All depths quoted are with respect to KB, except where otherwise stated.

Table A.5: Lower Limits of Detection for Apatite Analyses (Geotrack Report #582A)

Element	LLD (95% c.l.)		LLD (99% c.l.)	
	(wt%)	(ppm)	(wt%)	(ppm)
Cl	0.01	126	0.02	182

Table A.6: Per cent errors in chlorine content (Geotrack Report #582A)

Chlorine content (wt%)	Error (%)
0.01	9.3
0.02	8.7
0.05	7.3
0.10	6.1
0.20	4.7
0.50	3.2
1.00	2.3
1.50	1.9
2.00	1.7
2.50	1.5
3.00	1.4

Errors quoted are at 1σ. See Appendix A for more details.

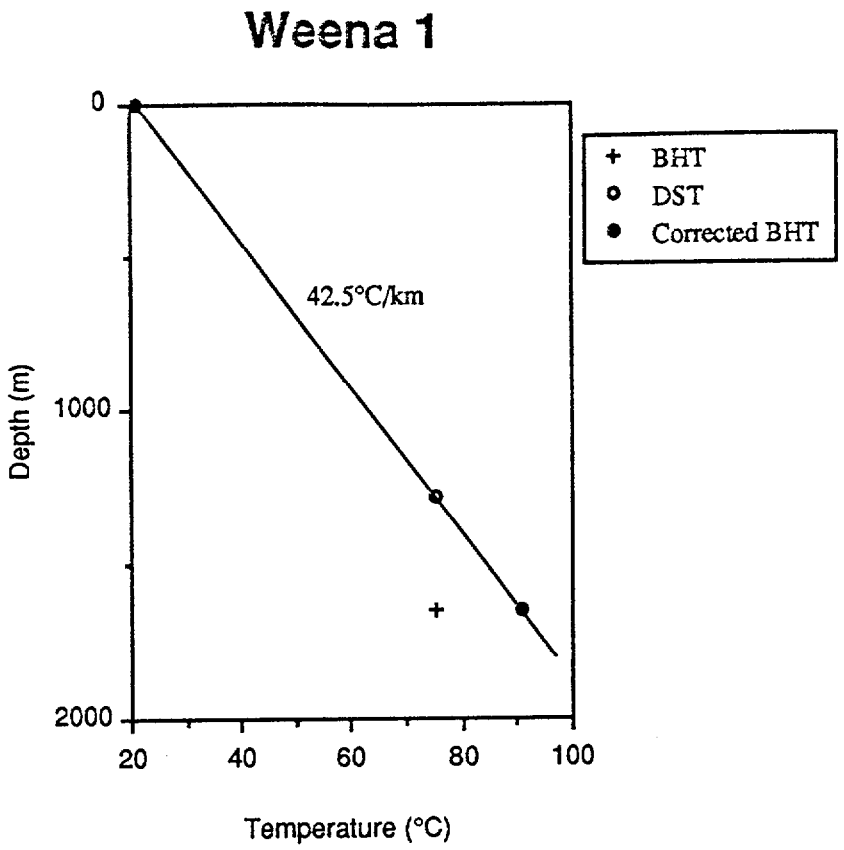


Figure A.1: Present temperature profile calculated for **well Weena 1, Western Eromanga - Eringa Trough.** See Table A.3 and Appendix A for more detail.

GC582-17

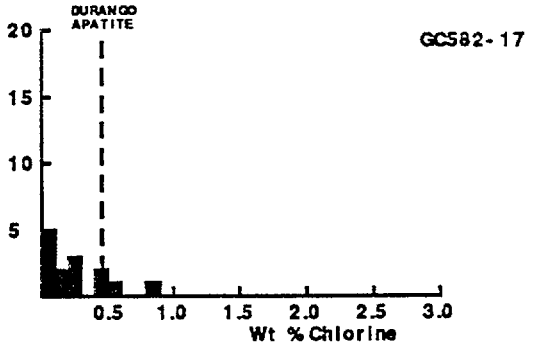
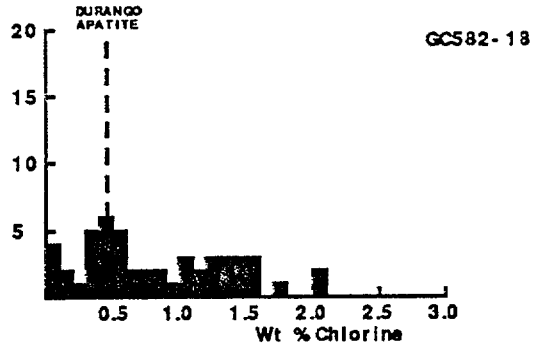


Figure A.2a: Distributions of chlorine content in samples from well Weena 1, Western Eromanga - Eringa Trough.

GC582-18



GC582-19

No Apatite

Figure A.2b: Distributions of chlorine content in **outcrop** samples from the **Western Eromanga - Eringa Trough.**

APPENDIX B

Sample Preparation, Analytical Details and Data Presentation

B.1 Sample Preparation

Core and outcrop samples are crushed in a jaw crusher and then ground to sand grade in a rotary disc mill. Cuttings samples are washed and dried before grinding to sand grade. The ground material is then washed to remove dust, dried and processed by conventional heavy liquid and magnetic separation techniques to recover heavy minerals. Apatite grains are mounted in epoxy resin on glass slides, polished and etched for 20 sec in 5M HNO_3 at 20°C to reveal the fossil fission tracks.

After etching, all mounts are cut down to 1.5 X 1 cm, and cleaned in detergent, alcohol and distilled water. The mounts are then sealed in intimate contact with low-uranium muscovite detectors within heat shrink plastic film. Each batch of mounts is stacked between two pieces of uranium standard glass which has been prepared in similar fashion. The stack is then inserted into an aluminium can for irradiation.

B.2 Experimental Details

Fission track ages

Fission track ages are calculated using the standard fission track age equation using the zeta calibration method (equation 5 of Hurford and Green, 1983), viz:

$$\text{F.T. AGE} = \frac{1}{\lambda_D} \ln \left[1 + \left(\frac{\zeta \lambda_D \rho_s g \rho_D}{\rho_i} \right) \right] \qquad \text{B.1}$$

where:
- λ_D = total decay constant of ^{238}U (= 1.55125 x 10^{-10})
- ζ = Zeta calibration factor
- ρ_s = Spontaneous track density
- ρ_i = Induced track density
- ρ_D = Track density from uranium standard glass
- g = A geometry factor (= 0.5)

Fission track ages are determined by the external detector method or EDM (Gleadow, 1981). The EDM has the advantage of allowing fission track ages to be determined on single grains. In apatite, tracks are counted in 20 grains from each mount wherever

possible. In those samples where the desired number is not present, all available grains are counted, the actual number depending on the availability of suitably etched and oriented grains. Only grains oriented with surfaces parallel to the crystallographic c-axis are analysed. Such grains can be identified on the basis of the etching characteristics, as well as from morphological evidence in euhedral grains. The grain mount is scanned sequentially, and the first 20 suitably oriented grains identified are analysed.

Tracks are counted within an eyepiece graticule divided into 100 grid squares. In each grain, the number of spontaneous tracks, N_S, within a certain number of grid squares, N_a, is recorded. The number of induced tracks, N_i, in the corresponding location within the mica external detector is then counted. Spontaneous and induced track densities, ρ_S and ρ_i, respectively, are calculated by dividing the track counts by the total area counted, given by the product of Na and the area or each grid square (determined by calibration against a ruled stage graticule or diffraction grating). Fission track ages may be calculated by substituting track counts, N_S and N_i, for track densities ρ_S and ρ_i in equation B.1, since the areas cancel in the ratio.

Translation between apatite grains in the grain mount and external detector locations corresponding to each grain is carried out using Autoscan™ microcomputer-controlled automatic stages (Smith and Leigh Jones, 1985). This system allows repeated movement between grain and detector, and all grain locations are stored for later reference if required.

Neutron irradiations are carried out in a well thermalised flux (X-7 facility; Cd ratio for Au ~98) in the Australian Atomic Energy Commission's HIFAR research reactor. Total neutron fluence is monitored by counting tracks in mica external detectors attached to two pieces of NBS standard glass SRM612 included in the irradiation canister at each end of the sample stack. In determining track densities in external detectors irradiated adjacent to uranium standard glasses, 25 fields are normally counted in each detector, and the total track count N_D is divided by the total area counted to obtain the track density ρ_D. The positions of the counted fields are arranged in a 5 X 5 grid covering the whole area of the detector. For typical track densities of between ~5×10^5 and 5×10^6 this is a convenient arrangement to sample across the detector while gathering sufficient counts to achieve a precision of ~±2% in a reasonable time.

A small flux gradient is often present in the irradiation facility over the length of the sample package (note that this developed only in late 1991, after extended refurbishment of the reactor, before which no detectable flux gradient was present). If a detectable gradient is present, the track count in the external detector adjacent to each standard glass is converted to a track density ρ_D and a value for each mount in the stack is calculated by

linear interpolation. When no detectable gradient is present, the track counts in the two external detectors are pooled to give a single value of ρ_D which is used to calculate fission track ages for each sample.

A Zeta calibration factor, ζ, has been determined empirically for each observer by analysing a set of carefully chosen age standards with independently known K-Ar ages, following the methods outlined by Hurford and Green (1983) and Green (1985).

All track counting is carried out using Zeiss(R) Axioplan microscopes, with an overall linear magnification of 1068 x using dry objectives.

For further details and background information on practical aspects of fission track age determination, see e.g. Fleischer, Price and Walker (1975), Naeser (1979) and Hurford (1986).

Track length measurements

For track length studies in apatite, the full lengths of 'confined' fission tracks are measured. Confined tracks are those which do not intersect the polished surface but have been etched from other tracks or fractures, so that the whole length of the track is etched. Confined track lengths are measured using a digitising tablet connected to a microcomputer, superimposed on the microscope field of view via a projection tube. With this system, calibrated against a stage graticule ruled in 2 μm divisions, individual tracks can be measured to a precision of ± 0.2 μm. Tracks are measured only in prismatic grains, characterised by sharp polishing scratches with well etched tracks of narrow cone angle in all orientations, because of the anisotropy of annealing of fission tracks in apatite (as discussed by Green et al., 1986). Tracks are also measured following the recommendations of Laslett et al. (1982), the most important of which is that only horizontal tracks should be measured. One hundred tracks are measured whenever possible. In apatite samples with low track density, or in those samples in which only a small number of apatite grains are obtained, fewer confined tracks may be available, and in such cases, the whole mount is scanned to measure as many confined tracks as possible.

Integrated fission track age and length measurement

Fission track age determination and length measurement are now made in a single pass of the grain mount, in an integrated approach. The location of each grain in which tracks are either counted or measured is recorded for future reference. Thus track length measurements can be tied to age determination in individual grains. As a routine procedure we do not measure the age of every grain in which lengths are determined, as

this would be much too time consuming. Likewise we do not only measure ages in grain in which lengths are measured, as this would bias the age data against low track density grains. Nevertheless, the ability to determine the fission track age of certain grains from which length data originate can be a particularly useful aid to interpretation in some cases. Grain location data are not provided in this report, but are available on request.

B.3 Data Presentation

Fission track age data

Data sheets summarising the apatite fission track age data, including full details of fission track age data for individual apatite grains in each sample, together with the primary counting results and statistical data, are given in the following pages. Individual grain fission track ages are calculated from the ratio of spontaneous to induced fission track counts for each grain using equation B.1, and errors in the single grain ages are calculated using Poissonian statistics, as explained in more detail by Galbraith (1981) and Green (1981). All errors are quoted as $\pm 1\sigma$ throughout this report, unless otherwise stated.

The variability of fission track ages between individual apatite grains within each sample can be assessed using a chi-squared (χ^2) statistic (Galbraith, 1981), the results of which are summarised for each sample in the data sheets. If all the grains counted belong to a single age population, then the probability of obtaining the observed χ^2 value, for ν degrees of freedom (where ν = number of crystals -1), is listed in the data sheets as $P(\chi^2)$ or P(chi squared).

A $P(\chi^2)$ value greater than 5% can be taken as evidence that all grains are consistent with a single population of fission track age. In this case, the best estimate of the fission track age of the sample is given by the "pooled age", calculated from the ratio of the total spontaneous and induced track counts in all grains analysed. Errors for the pooled age are calculated using the 'conventional' technique outlined by Green (1981), based on the total number of tracks counted for each track density measurement (see also Galbraith, 1981).

A $P(\chi^2)$ value of less than 5% denotes a significant spread of single grain ages, and suggests that real differences exist between the fission track ages of individual apatite grains. A significant spread in grain ages can result either from inheritance of detrital grains from mixed source areas (in sedimentary rocks), or from differential annealing in apatite grains of different composition, within a narrow range of temperature.

Calculation of the pooled age inherently assumes that only a single population of ages is present, and is thus not appropriate to samples containing a significant spread of fission track ages. In such cases Galbraith has recently devised a means of estimating the modal age of a distribution of single grain fission track ages which is referred to as the "central age". Calculation of the central age assumes that all single grain ages belong to a Normal distribution of ages with a standard deviation, σ, known as the "age dispersion". An iterative algorithm (as yet unpublished) is used to provide estimates of the central age with its associated error, and the age dispersion, which are all quoted in the data sheets. Note that this treatment replaces use of the "mean age" which has used been in the past for those samples in which $P(\chi^2)<5\%$. For samples in which $P(\chi^2)>5\%$, the central age and the pooled age should be equal, and the age dispersion should be less than ~10%.

Table B.1 summarises the fission track age data in apatite from each sample analysed.

Construction of radial plots of single grain age data

Single grain age data are best represented in the form of radial plot diagrams (Galbraith, 1988, 1990). As illustrated in Figure B.1, these plots display the variation of individual grain ages in a plot of y against x, where:

$$y = (z_j - z_o)/\sigma_i \qquad x = 1/\sigma_j \qquad \text{B.2}$$

and; z_j = fission track age of grain j
z_o = a reference age
σ_j = error in age for grain j

In this plot, all points on a straight line from the origin define a single value of fission track age, and at any point the value of x is a measure of the precision of each individual grain age. Therefore, precise individual grain ages fall to the right of the plot (small error, high x), which is useful, for example, in enabling precise, young grains to be identified. The age scale is shown radially around the perimeter of the plot (in Ma). If all grains belong to a single age population, all data should scatter between y = +2 and y = -2, equivalent to scatter within $\pm 2\sigma$. Scatter outside these boundaries shows a significant spread of individual grain ages, as also reflected in the values of $P(\chi^2)$ and age dispersion.

In detail, rather than using the fission track age for each grain as in equation B.2, we use:

$$z_j = \frac{N_{sj}}{N_{ij}} \qquad \sigma_j = \{1/N_{sj} + 1/N_{ij}\} \qquad \text{B.3}$$

as we are interested in displaying the scatter within the data from each sample in comparison with that allowed by the Poissonian uncertainty in track counts, without the additional terms which are involved in determination of the fission track age (ρ_D, ζ, etc).

Zero ages cannot be displayed in such a plot. This can be achieved using a modified plot, (Galbraith, 1990) with:

$$z_j = \text{arc sin}\sqrt{\left\{\frac{N_{sj}+3/8}{N_{sj}+N_{ij}+3/4}\right\}} \qquad \sigma_j = \frac{1}{2}\sqrt{\left\{\frac{1}{N_{sj}+N_{ij}}\right\}} \qquad \text{B.4}$$

Note that the numerical terms in the equation for z_j are standard terms, introduced for statistical reasons. Using this arc-sin transformation, zero ages plot on a diagonal line which slopes from upper left to lower right. Note that this line does not go through the origin. Figure B.2 illustrates this difference between conventional and arc-sin radial plots, and also provides a simple guide to the structure of radial plots.

Use of arc-sin radial plots is particularly useful in assessing the relative importance of zero ages. For instance, grains with $N_s = 0$, $N_i = 1$ are compatible with ages up to ~900 Ma (at the 95% confidence level), whereas grains with $N_s = 0$, $N_i = 50$ are only compatible with ages up to ~14 Ma. The two data would readily be distinguishable on the radial plot as the 0,50 datum would plot well to the right (high x) compared to the 0,1 datum.

In this report the value of z corresponding to the fission track age of each sample is adopted as the reference value, z_o.

Note that the x axis of the radial plot is normally not labelled, as this would obscure the age scale around the plot. In general labelling is not considered necessary, as we are concerned only with relative variation within the data, rather than absolute values of precision.

Radial plots of the single grain age data in apatite from each sample analysed in this report are shown in Figure B.3.

Smoothed probability distributions

The single grain ages within each sample are also shown in Figure B.3 in histogram form and also as smoothed probability distributions (Hurford et al., 1984). In constructing these distributions, each grain is represented by a normal probability curve with mean equal to the single grain age, standard deviation given by the error on the single grain age, and the contributions from all grains analysed in each sample are summed to produce the plotted curve. These distributions are generally not as informative as the radial plot

presentation of single grain age data as they convey little assessment of the relative precision of the fission track ages of different grains. However they can be useful for portraying the general form of the distribution of ages within a sample.

Track length data

Distributions of confined track lengths in apatite from each sample are shown as simple histograms in Figure B.4. For every track length measurement the length is recorded to the nearest 0.1 μm, but the measurements have been group into 1 μm intervals in the histograms in Figure B.4. Each distribution has been normalised to 100 tracks for each sample to facilitate comparison. A summary of the length distribution in each sample is presented in Table B.2, which also shows the mean track length in each sample and its associated error, the standard deviation of each distribution, and the number of tracks (N) measured in each sample. The angle which each confined track makes with the crystallographic c-axis is also routinely recorded, as is the width of each fracture within which tracks are revealed. These data are not provided in this report, but can be supplied on request.

B.4 A note on terminology

Note that throughout this report, the term "fission track age" is understood to denote the parameter calculated from the fission track age equation, using the observed spontaneous and induced track counts (either pooled for all grains or for individual grains). The resulting number (with units of Ma) should not be taken as possessing any significance in terms of events taking place at the time indicated by the measured fission track age, but should rather be regarded as a measure of the integrated thermal history of the sample, and should be interpreted in that light. Use of the term "apparent age" is not considered to be useful in this regard, as almost every fission track age should be regarded as an apparent age, in the classic sense, and repeated use becomes cumbersome.

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Table B.1: Apatite fission track analytical results - samples from Western Eromanga - Eringa Trough (Geotrack Report #582A)

Sample number	Number of grains	Rho D x10 ^{6} (ND)	Rho S x10 ^{6} (Ns)	Rho I x10 ^{6} (Ni)	Uranium content (ppm)	P(chi squared) (%)	Age dispersion (%)	Fission track age (Ma)
Weena 1								
GC582-17	12	1.323 (2129)	1.424 (173)	2.742 (333)	24	2	33	133.7 ± 13.1 *132.3 ± 19.2**
Outcrop samples								
GC582-18	20	1.333 (2129)	0.235 (128)	0.601 (327)	5	83	<1	101.7 ± 11.0
GC582-19			No apatite					

Rho S = spontaneous track density; Rho I = induced track density; Rho D = track density in glass standard external detector.
All track densities quoted in units of 1000000 tracks per square cm. Brackets show number of tracks counted.
Rho D and Rho I measured in mica external detectors; Rho S measured in internal surfaces.
* Central age, used where sample contains a significant spread of single grain ages—P(chi squared)<5%. Errors quoted at ±1 sigma.
Ages calculated using dosimeter glass CN5, with a zeta of 392.9±7.4 (Analyst: M. Moore)

Table B.2: Length distribution summary data - samples from Western Eromanga - Eringa Trough (Geotrack Report #582A)

Sample number	Mean track length (µm)	Standard deviation (µm)	Number of tracks (N)	Number of Tracks in Length Intervals (µm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Weena 1																							
GC582-17	10.75 ± 0.64	2.80	19	-	-	-	1	-	-	-	1	2	3	3	3	2	2	1	1	-	-	-	-
Outcrop samples																							
GC582-18	13.29 ± 0.20	1.83	86	-	-	-	-	-	-	1	-	3	-	4	9	20	15	21	10	3	-	-	-
GC582-19	No apatite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Track length measurements by M. Moore

Table B.3: AFTA Data in Compositional Groups - (Geotrack Report #582A)

Cl Wt %	Default fission track age* (Ma)	Measured fission track age (Ma)	Error in age (Ma)	P (χ 2)	Number of grains	Default fission track length* (μm)	Mean track length (μm)	Error in length (μm)	Std deviation (μm)	Number of lengths	Number of grains	Number of tracks in length interval (μm) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Weena-1																															
†582-17	186.8	132.3	18.8	2.0	12	11.1	10.7	0.6	2.8	19	7	0	0	0	1	0	0	0	1	2	3	3	3	2	2	1	1	0	0	0	0
0.0-0.1	153.1	81.3	22.7	16.0	4	9.7	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.1-0.2	178.7	97.1	19.4	25.0	2	10.2	13.2	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0.2-0.3	199.9	134.8	29.1	23.0	2	10.5	10.5	1.5	4.0	7	2	0	0	0	1	0	0	0	0	1	1	0	1	1	1	0	1	0	0	0	0
0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4-0.5	213.3	202.1	40.5	7.0	2	11.2	10.7	0.5	1.3	7	2	0	0	0	0	0	0	0	0	1	1	2	2	1	0	0	0	0	0	0	0
0.5-0.6	217.0	135.8	38.6	100.0	1	11.4	11.7	1.7	2.9	3	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.8-0.9	228.3	204.7	56.2	100.0	1	12.0	7.7	0.0	0.0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Outcrop																															
†582-18	105.8	101.7	10.8	83.0	20	14.7	13.3	0.2	1.8	86	40	0	0	0	0	0	0	1	0	3	0	4	9	20	15	21	10	3	0	0	0
0.0-0.1	103.9	0.0	0.0	0.0	0	14.5	11.8	0.7	2.1	9	3	0	0	0	0	0	0	0	0	2	0	1	0	3	3	0	0	0	0	0	0
0.1-0.2	104.2	97.4	46.7	100.0	1	14.5	13.2	0.5	0.8	3	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
0.2-0.3	104.5	78.1	36.4	100.0	1	14.5	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.3-0.4	104.8	145.6	60.8	100.0	1	14.6	13.3	0.4	1.2	9	5	0	0	0	0	0	0	0	0	0	0	0	2	2	1	4	0	0	0	0	0
0.4-0.5	105.1	0.0	0.0	0.0	0	14.6	12.9	0.3	1.0	9	6	0	0	0	0	0	0	0	0	0	0	0	2	3	3	1	0	0	0	0	0
0.5-0.6	105.3	99.9	37.2	20.0	3	14.7	13.6	0.6	1.5	6	3	0	0	0	0	0	0	0	0	0	0	0	1	1	0	4	0	0	0	0	0
0.6-0.7	105.6	150.9	71.9	76.0	2	14.7	16.7	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0.7-0.8	105.8	86.7	30.2	78.0	2	14.7	12.4	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0.8-0.9	106.1	129.6	79.4	100.0	1	14.8	12.8	0.7	1.0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
0.9-1.0	106.2	129.6	91.7	100.0	1	14.8	13.4	0.0	0.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1.0-1.1	106.2	0.0	0.0	0.0	0	14.8	14.3	0.7	1.3	4	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	0	0	0
1.1-1.2	106.2	0.0	0.0	0.0	0	14.8	12.4	0.8	2.5	10	2	0	0	0	0	0	0	1	0	0	0	1	2	2	1	2	1	0	0	0	0
1.2-1.3	106.3	112.5	37.4	100.0	1	14.8	13.7	0.5	1.7	13	3	0	0	0	0	0	0	0	0	0	0	1	1	4	1	1	4	1	0	0	0
1.3-1.4	106.3	79.7	21.0	11.0	2	14.8	13.7	0.7	1.6	5	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	1	0	0	0	0
1.4-1.5	106.4	91.0	40.0	100.0	1	14.8	14.3	0.5	0.9	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
1.5-1.6	106.4	100.4	28.7	85.0	2	14.8	14.2	0.8	2.0	6	2	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	0	1	0	0	0
1.6-1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.7-1.8	106.5	256.6	128.4	100.0	1	14.8	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.8-1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.9-2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.0-2.1	106.7	80.1	32.4	100.0	1	14.8	13.4	1.6	3.3	4	2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2	0	0	0	0

* Fission Track Age and Mean Track Length predicted from the Default Thermal History (i.e. if the sample has not been hotter in the past)

† Combined data for all compositional groups

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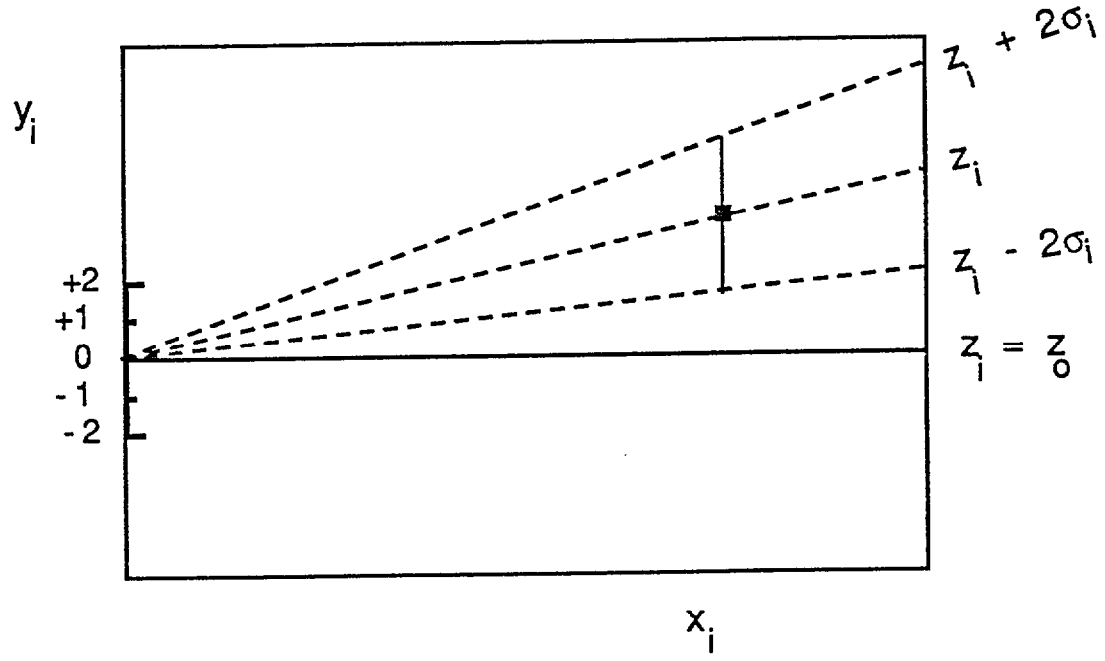
Estimates	z_i
Standard errors	σ_i
Reference value	z_o
Standardised estimates	$y_i = (z_i - z_o) / \sigma_i$
Precision	$x_i = 1 / \sigma_i$

PLOT y_i against x_i



Slope of line from origin through data point $= y_i / x_i$

$= \{(z_i - z_o)/\sigma_i\} / \{1/\sigma_i\}$

$= z_i - z_o$

Key Points:

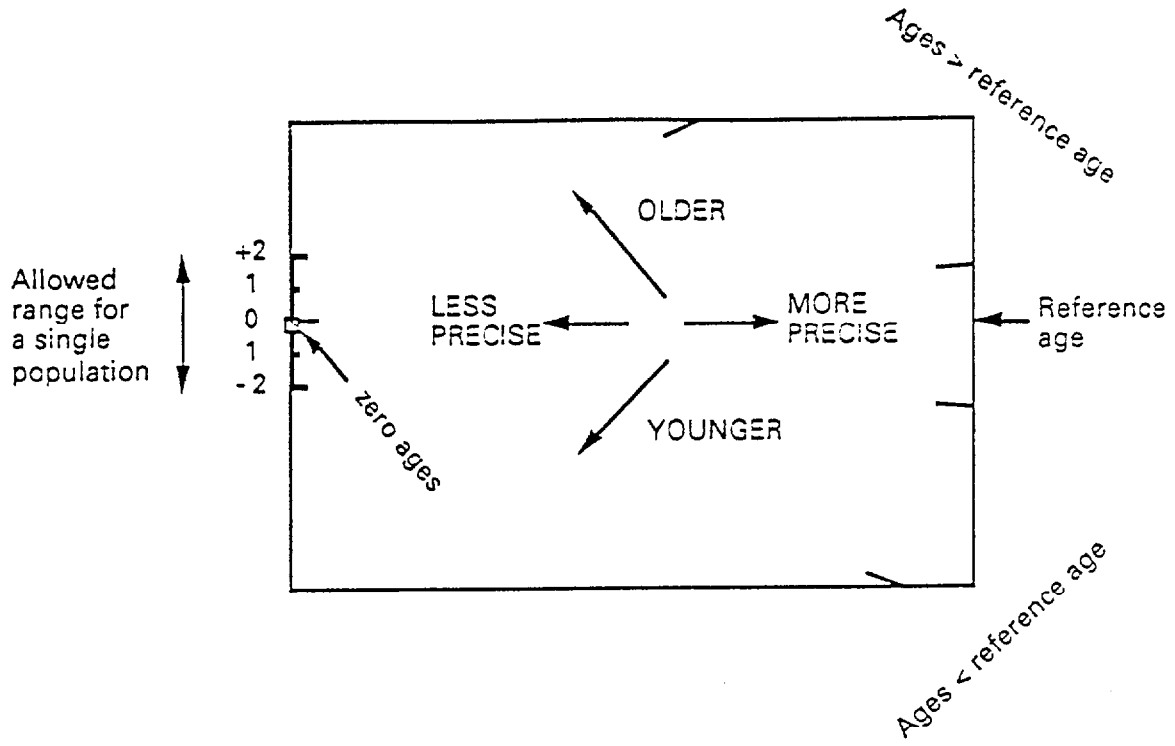
Radial lines emanating from the origin correspond to fixed values of z

Data points with higher values of x_i have greater precision.

Error bars on all points are the same size in this plot.

Figure B.1 Basic construction of a radial plot. In AFTA, the estimates z_i correspond to the fission track age values for individual apatite grains. Any convenient value of age can be chosen as the reference value corresponding to the horizontal in the radial plot. Radial lines emanating from the origin with positive slopes correspond to fission track ages greater than the reference value. Lines with negative slopes correspond to fission track ages less than the reference value.

Normal radial plot (equations B.2 and B.3)



Arc-sin radial plot (equations B.2 and B.4)

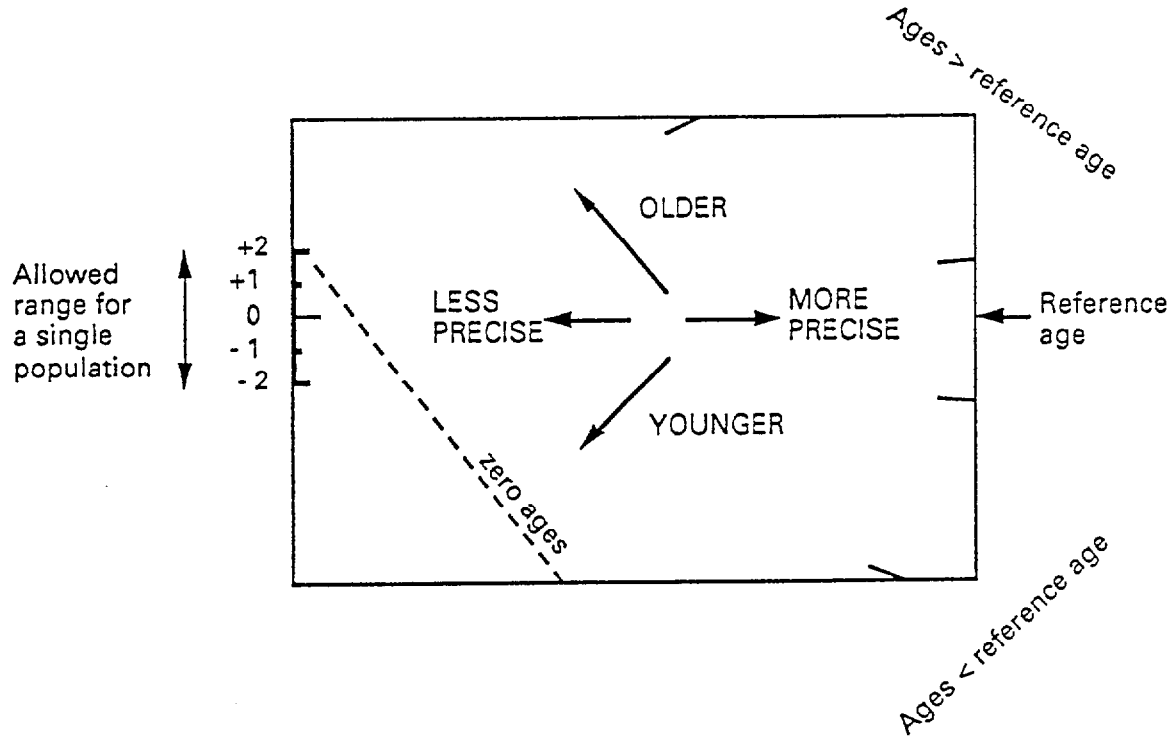


Figure B.2 Simplified structure of Normal and Arc-sin radial plots.

GC582-17

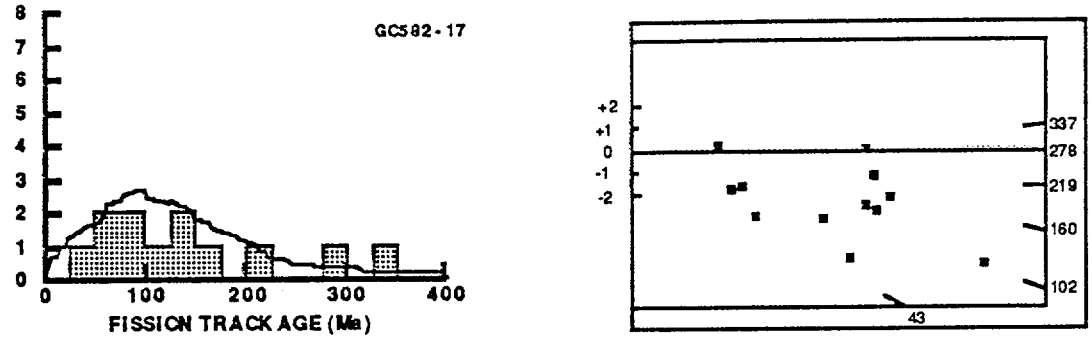
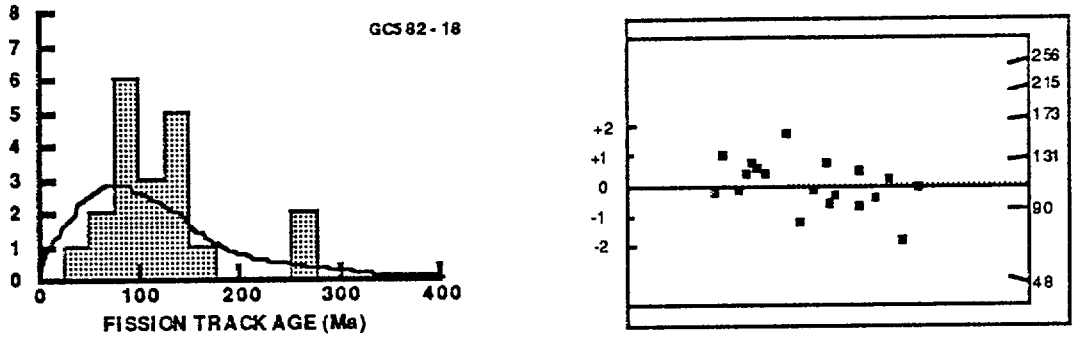


Figure B.3a: Single grain age figures for samples from **well Weena 1, Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC582-18



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No Apatite

Figure B.3b: Single grain age figures for **outcrop** samples from the **Western Eromanga - Eringa Trough.** The horizontal line or shaded area in the radial plot diagrams shows the stratigraphic age. See Appendix B for further details.

GC582-17

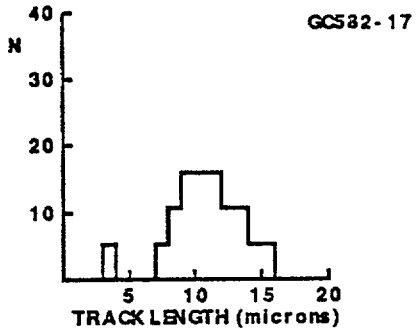
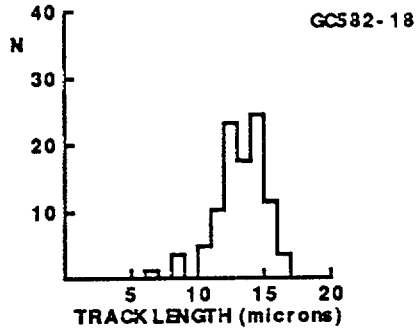


Figure B.4a: Distributions of confined track lengths in samples from well **Weena 1, Western Eromanga - Eringa Trough.**

GC582-18



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No Apatite

Figure B.4b: Distributions of confined track lengths in **outcrop** samples from the **Western Eromanga - Eringa Trough.**

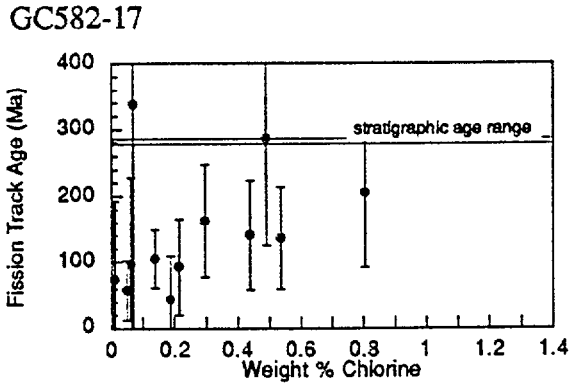

Figure B.5a: Plots of single grain age against weight percent chlorine for samples from well Weena 1, Western Eromanga - Eringa Trough.

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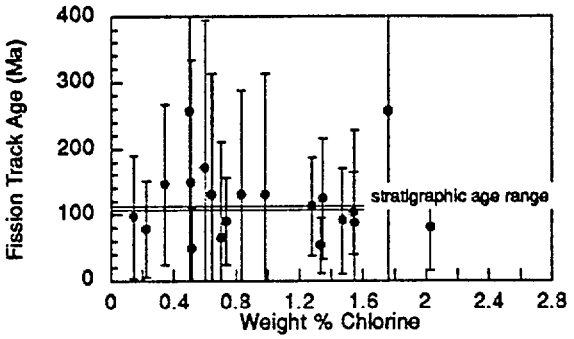

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Figure B.5b: Plots of single grain age against weight percent chlorine for **outcrop** samples from **Western Eromanga - Eringa Trough.**

Fission Track Age Data Sheets - Glossary

Ns	=	Number of spontaneous tracks in Na grid squares
Ni	=	Number of induced tracks in Na grid squares
Na	=	Number of grid squares counted in each grain
RATIO	=	Ns/Ni
U (ppm)	=	Uranium content of each grain (= U content of standard glass * $\rho i/\rho_D$)
Cl (wt%)	=	Weight percent chlorine content of each grain
RHOs	=	Spontaneous track density (ρs) = Ns/ (Na*area of basic unit)
RHOi	=	Induced track density (ρi) = Ni/ (Na*area of basic unit)
F.T.AGE	=	Fission track age, calculated using equation B.1
Area of basic unit	=	Area of one grid square
Chi squared	=	χ^2 parameter, used to assess variation of single grain ages within the sample
P(chi squared)	=	Probability of obtaining observed χ^2 value for the relevant number of degrees of freedom, if all grains belong to a single population
Correlation coefficient	=	Correlation coefficient between Ns and Ni
Variance of SQR(Ns)	=	Variance of square root of Ns values - should be ~ 0.25 for Poisson distribution; greater if additional variation present
Variance of SQR(Ni)	=	Variance of square root of Ni values - should be ~ 0.25 for Poisson distribution; greater if additional variation present
Age Dispersion	=	% variation in single grain ages - see discussion in text re "Central age"
Ns/Ni	=	Pooled ratio, total spontaneous tracks divided by total induced tracks for all grains
Mean ratio	=	Mean of (Ns/Ni) for individual grains
Zeta	=	Calibration constant, determined empirically for each observer
RhoD	=	Track density (ρ_D) from uranium standard glass (interpolated from values at each end of stack)
ND	=	Total number of tracks counted for determining ρ_D
POOLED AGE	=	Fission track age calculated from pooled ratio Ns/Ni. Valid only when $\chi^2 > 5\%$
CENTRAL AGE	=	Alternative to pooled age when $\chi^2 < 5\%$

GC582-17 APATITE

IRRADIATION G595
SLIDE NUMBER 1 and 2
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
15	4	3	30	2.119E+05	1.589E+05	1.333	1.4	0.07	337.6 ± 258.1
21	3	8	15	3.178E+05	8.475E+05	0.375	7.3	0.06	96.8 ± 65.6
24	27	24	12	3.575E+06	3.178E+06	1.125	27.4	0.49	286.0 ± 80.7
26	8	36	20	6.356E+05	2.860E+06	0.222	24.6	0.05	57.5 ± 22.5
31	24	30	9	4.238E+06	5.297E+06	0.800	45.6	0.80	204.7 ± 56.4
33	24	38	25	1.526E+06	2.415E+06	0.632	20.8	0.30	162.1 ± 42.5
34	2	12	8	3.973E+05	2.384E+06	0.167	20.5	0.19	43.2 ± 33.0
37	33	81	18	2.913E+06	7.151E+06	0.407	61.6	0.14	105.1 ± 21.9
38	18	33	8	3.575E+06	6.555E+06	0.545	56.5	0.44	140.3 ± 41.3
59	2	7	15	2.119E+05	7.416E+05	0.286	6.4	0.01	73.9 ± 59.3
60	9	25	12	1.192E+06	3.311E+06	0.360	28.5	0.22	92.9 ± 36.2
62	19	36	21	1.438E+06	2.724E+06	0.528	23.5	0.54	135.8 ± 38.7
	173	333		1.424E+06	2.742E+06		23.6		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 23.302 with 11 degrees of freedom
P(chi squared) = 1.6 %
Correlation Coefficient = 0.795
Variance of SQR(Ns) = 2.54
Variance of SQR(Ni) = 3.94
Age Dispersion = 33.109 %

Ns/Ni = 0.520 ± 0.049
Mean Ratio = 0.565 ± 0.104

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.323E+06cm-2; ND = 2129
Rho D interpolated between top of can; Rho D = 1.323E+06cm-2, ND = 1041
bottom of can; Rho D = 1.383E+06cm-2, ND = 1088

POOLED AGE = 133.7 ± 13.1 Ma
CENTRAL AGE = 132.3 ± 19.2 Ma

GC582-18 APATITE

IRRADIATION G595
SLIDE NUMBER 3
COUNTED BY: MEM

Current grain no.	Ns	Ni	Na	RHOs	RHOi	RATIO	U (ppm)	Cl (wt%)	F.T. AGE (Ma)
3	13	30	12	1.721E+06	3.973E+06	0.433	34.0	1.28	112.5 ± 37.5
4	3	6	50	9.534E+04	1.907E+05	0.500	1.6	0.98	129.6 ± 91.7
5	6	16	42	2.270E+05	6.054E+05	0.375	5.2	0.14	97.4 ± 46.7
6	4	7	60	1.059E+05	1.854E+05	0.571	1.6	0.51	147.9 ± 92.8
9	6	20	36	2.648E+05	8.828E+05	0.300	7.6	0.22	78.1 ± 36.4
13	3	3	45	1.059E+05	1.059E+05	1.000	0.9	0.50	256.6 ± 209.7
14	3	6	28	1.703E+05	3.405E+05	0.500	2.9	0.64	129.6 ± 91.7
16	15	38	24	9.932E+05	2.516E+06	0.395	21.5	1.54	102.5 ± 31.4
17	7	20	60	1.854E+05	5.297E+05	0.350	4.5	1.47	91.0 ± 40.0
18	11	23	50	3.496E+05	7.310E+05	0.478	6.3	1.35	124.0 ± 45.6
21	10	29	80	1.986E+05	5.760E+05	0.345	4.9	0.74	89.6 ± 33.0
22	4	6	40	1.589E+05	2.384E+05	0.667	2.0	0.60	172.2 ± 111.3
23	9	16	40	3.575E+05	6.356E+05	0.562	5.4	0.34	145.6 ± 60.8
24	3	16	40	1.192E+05	6.356E+05	0.188	5.4	0.52	48.9 ± 30.8
28	8	26	50	2.542E+05	8.263E+05	0.308	7.1	2.03	80.1 ± 32.4
29	8	8	28	4.540E+05	4.540E+05	1.000	3.9	1.76	256.6 ± 128.5
30	4	8	40	1.589E+05	3.178E+05	0.500	2.7	0.83	129.6 ± 79.4
32	1	4	40	3.973E+04	1.589E+05	0.250	1.4	0.70	65.1 ± 72.8
33	2	6	50	6.356E+04	1.907E+05	0.333	1.6	1.55	86.7 ± 70.8
36	8	39	50	2.542E+05	1.239E+06	0.205	10.6	1.34	53.5 ± 20.8
	128	327		2.351E+05	6.007E+05		5.1		

Area of basic unit = 6.293E-07 cm-2

Chi Squared = 13.211 with 19 degrees of freedom
P(chi squared) = 82.8 %
Correlation Coefficient = 0.827
Variance of SQR(Ns) = 0.59
Variance of SQR(Ni) = 2.03
Age Dispersion = 0.486 % (did not converge)

Ns/Ni = 0.391 ± 0.041
Mean Ratio = 0.463 ± 0.050

Ages calculated using a zeta of 392.9 ± 7.4 for CN5 glass
Rho D = 1.333E+06cm-2; ND = 2129
Rho D interpolated between top of can; Rho D = 1.323E+06cm-2, ND = 1041
bottom of can; Rho D = 1.383E+06cm-2, ND = 1088

POOLED AGE = 101.7 ± 11.0 Ma
CENTRAL AGE = 101.7 ± 11.0 Ma