

OPEN FILE ENVELOPE SERIES

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ENV 8179 DME 12/86

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EN SR file t Envelope front

LIST OF CORE LOGGED AND SAMPLED front

WELL FORMATION(8) FEET

Kirby 1 Toolachee, Epsilon 73

Burley 1 Toolachee, Epsilon, 80

Burley 2 Toolachee, Epsilon, 80

하다. 내내내내 하고 많은 사랑 먹니!	J	
WELL	FORMATION(S)	FEET
Kirby 1	Toolachee, Epsilon	
Burley 1	Toolachee Eparton	73
Burley 2	Toolachee, Epsilon,	80
됐다는 기가 되어 들었다. 가는 말을	Patchawarra	
→Big Lake 1	Toolachee	52
Big Lake 2	Toolachee	187
→Big Lake 3	Epsilon	172
Big Lake 5	Patchawarra	18°
一Big Lake 27	Patchawarra	66 "
-Big Lake 29	Patchawarra 1	49 ,,
₩Big Lake 31	Fatchawar 4	8
Dig Lake 34	Patchawa Pod	89
Jig Lake 35	Patchawarra	19
Moomba 1	THE THE LIMIT HELE TO A STREET	30
	Toplachee, Daralingie, Murteree, Patchawarra	Ina sitrana
Moomba 3	Toolachee, Daralingie	349
Moomba 4	Toplachee Daralingle	283
Moomba 5	Testualis	172
Magmba 6 at	Toolachee, Daralingie	74
1 (1 1 1 1 1 1 1 1 1	Toolachee, Patchawarra,	
Moomba 7	Daralingie Totalingie	391
√Moomba 8	Toplachee	1.93
Moomba 9	Toblachee, Daralingie	183
✓Moomba 10	Toolachee, Daralingie	271
Moomba 52	Toolachee, Daralingie	202
Moomba 53	Tdolachee	. 101
Marana 1	Toolachee, Daralingie	115
Kidman i	Toolachee	30
✓Kidman 2	Toolachee, Patchawarra	90
Fira 1	Toolachee	40
, Pīra Ž	Patchawarra	57
/Strzelecki i	Toolachee, Patchawarra	110
Strzelecki z	Toolachee, Patchawarra	198
	Toolachee	72
Strzelecki 5 Strzelecki 10	Toolachee	58
Strzelecki 10	Toplachee	117
		61
Marabooka 1	Toolachee 0	60
Daralingle 1	Patchawarra	86
Demaidment of	Toolachee	86
Daralingie 9	Patohawarra	
Daralingle 19	Patchawarra	5 <u>.</u> 5
Daralingie Z2 Toolachee 1	Patchawarra	
1. 四四年日16日 (十)	Patchawarra, Epsilon,	ent lengt til skelle. Littlet til
/Toolachee 3	Toolachee	97
	Fatchawarra	253
Toolachee 6 Toolachee 6	Fatchawarra	194 ^
Toolachee 8	Patchawarra	307
TUDIACHEE B	Patchawarra	ර්ර්
/Toolachee 9	Patchawarra	52
Tcolachee 12	Patchawarra	30
Toolachee 15	Patchawarra	27
Toolachee 18	Patchawarra	Zé
Toolachee 19	Patchawarra	28

WELL	FORMATION(B)	EEET
Toolachee 21	Patchawarra -	30
Della 3	Toolachee	104
Yapeni 1	Epsilon .	25
Pando 2	Epsilon	24
Murteree C-1	Toniachee	30
Lake Hobe 1	Eps11on	20
Pando North 1	Epsilon	29
Wancoocha 1	Epsilon, Patchawarra	115
Dullingari 1	Toolachee	17
Murteree 1	Toolachee	60
Eoxwood 1	Epsilon	8
Jarwonga 2	Epsilon .	28
√Dirkala 2	Epsilon	30
Kerna 1	Epsilon	33
Coochilara 1	Epsilon, Patchawarra	74
Mudlalee 1	Toolachee	27
[™] Brumby 1	Patchawarra	152
Diichee 1	Patchawarra	45
Kerna 1	Patchawarra	46
Munkarie 2	Patchawarra	48
Spencer 1	Toolachee	. <u>40</u>
	TOTAL	6,616

LIST OF WELLS FROM WHICH CUTTINGS HAVE BEEN SAMPLED

Toolachee 1 & 3 Toolachee East 1 Moomba 7 & 57 Strzelecki 10 Kidman 1 Kirby I Kirby 1
Burley 2
Dullingari 18 & 39
Wancoocha 2 & 4
Big Lake 26 & 33
Three Gueens 1
Marabooka 1
Namur 1
Daralingie 1 & 2
Spencer 1
Yalcumma 1
Lake Hope 1

Ġ.

NCPGG/NERDOG Gooper Basin Project OUTLINE OF ABASE 111+ DATABASES.

1. Introduction,

This document outlines the construction and use of the dBASE III+ files to be used for the storage of the large quantity of data which is being acquired during studies of the diagenesis of the Permian rocks in the Cooper Basin. A strict conformity with the structures given here is necessary to allow further manipulation and compilation of the various data.

Each well will have associated with it five data files containing information in the five topic areas listed below. Additional data files will be added in the future as topic areas are added, notably clay mineralogy, be added in the future as topic areas are added, notably clay mineralogy, seathodoluminescence, gamma-ray spectrometry, geophysical log data.

Topics:

- i. Thin section petrology.
- 2. Hand specimen description.
- 3. Core analysis
- 4. Scanning electron microscopy
- o, x=Ray diffraction

in addition there is a data file to contain important information about all the wells that you have worked on.

if you are unfamiliar with the dBASE III+ database package please take time to run through the tutorial provided with the software (about 2 hours).

2. Dreating the file structures.

Each of the six types of data file has a previously developed structure which determines the way the data is atored in the file. Each new file that you create must have a copy of that structure. These structures are located on a disk to be made available to you under the following names:

100 Loros 1-2-3 forunt

I. SECTION. DBF

2. GGLOG. DBF

3. CORAN. DBF

4. SEM. DBF

S. XRD.DBE

6. WELLDA A. DEF

Suppose, for example, you wish to create a core analysis data file called CWOICA.DBF (nomenclature of file will be explained later). Place the master disk in drive A: and a formatted disk in drive B: (For hard disk machines the drives may be C: and A: respectively). Make a copy of the required structure as follows:

AS COPY CORAN, DBF BICWOLCA, DBF

You are now ready to invoke the dBASE lift package.

Starting dBASE.

dBASE is usually invoked by the command DBASE, whereupon the software is loaded ready to go. Once you are in dBASE you have two modes of operation available:

the "dot prompt"
the ASSIST menus
and both Will be used by you.

The dot prompt is a dot (full stop) at the bottom of the screen and you get to it by pressing the Est key (several times if necessary), the ASSIST menu is entered by pressing the F2 key at the dot prompt. Try pressing these two keys alternately to verify this.

4. <u>Getting ready for data entry.</u>

Assume that we are to continue to create our core analysis file CNOICA, DBF. At the dot prompt type the following command:

·USE B: CWOICA ALIAS CORAN

This command has now loaded the empty file. Data is entered into this file by means of a form put on the screen; since this form is called CORAN we need the ALIAS part of the above command. We now have to load this form preparatory to using it, which we do by means of the ASSIST menus. Press F2.

Nenus Can be changed using the left and right arrow keys on the number pad. Choose the SET UP menu. Use the up and down arrow keys to highlight the various available choices. Highlight the FORMAT FOR SCREEN option and press the RETURN key. Highlight the disk drive with the master files (A:) and RETURN. You will see a list of the screen formats for the various data files. Highlight CORAN. FMT and press RETURN. You have just loaded the form for core analysis data entry.

5. <u>Enterino Data,</u>

Data is added at the end of a file using APPEND. This is the most usual way, but see later for inserting and editing. Our file is empty at present but we are about to change that.

Use left and right arrow keys to select the UPDATE menu, highlight the APPEND option (alright, alright, so it's already highlighted!) and press RETURN. If everything has gone to plan LO! and BEHOLD! up on the screen is a Fancy form for you to fill in. This form represents the first record in the database.

The cursor is sitting at the start of the first box (i.e. the first field) to be filled in on the form, in this case (and all others) this is the name of the exploration well the data is from, so you type this in, and proceed to the next box (well number). But there is a trap here for the unwary; if (as will certainly happen for some data) your entry fills the box completely, then the bell rings or hoots and the cursor automatically jumps to the next box; on the other hand if your entry only partially fills the box the you must proceed to the next box by pressing RETURN.

Histakes in data entry can be corrected at any time by using the rub-out or delete keys and retyping the entry. You can go back to a previous box using the arrow keys.

(

When the last box has been dealt with then you can proceed to the next form (record). After the last form has been filled in, finish by holding down the CTRL key while you press the END key. This tells the computer that the file is complete, whereupon it is transferred to disk.

You can now set up the next and subsequent database files in the same fashion using othe appropriate structure files and screen formats.

Hints and Tips.

Are you fed up with entering the same wellname and wellnumber in each record (e.g. CORKWOOD and Ol)? Go to the dot prompt and type:

"ISET FUNCTION 7 TO "CORKWOOD!" SET FUNCTION & TO "OII"

The semi-colon means ENTER, so it is not needed if the box is to be completely filled with data. When you now fill in your form simply press F7 and F8 at the wellname and number boxes respectively. You can do this for other data and function keys, but avoid changing F2 and F10.

If the reverse video used to highlight the field bokes on the input screen does not work well on your machine you can alter the format by the following (e.g.) at the dot prompt:

SET INTENSITY OFF SET DELIMITERS ON

This will then provide boxes bracketed with square brackets.

If your bell hoots annoy you, you can turn the bell off at the dot prompti

.SET BELL OFF

But be careful, since the audible warning is sometimes useful when you are not paying attention to the screen.

Editing data on File.

You can edit in one of two ways,

You can go back and change entries in the files at a later stage if

necessary. Follow the procedures outlined in section 4 above to set up the database file and its associated screen format.

using the EDIT option of the UPDATE menu using the BROWSE option of the UPDATE menu. Both methods have their advantages and disadvantages. Using EDIT you are presented with one record (screen form) at a time and you have to flip through to find the one you want using the PgDn and PgUp keys; this is OK if your files are reasonably short. The BROWSE option displays your file one record to a line but with several records on the screen simultaneously, making location of the one you want much easier tuse Pobn amnd Poup and the up and down arrow keys for navigation); however the screen is too narrow to show all fields for the records at once so you have to scroll through the fields horizontally using right and left arrow keys or, more quickly, waing the HOME and END keys.

In either case thoose the record and put the cursor at the beginning of the field want to alter (use HOME and END keys). Then overtype and/or delete (DEL key) the entry. Finish an editing session with the CTRL-END combination to make any changes permanent.

Deleting records requires two steps, tagging the record and rearranging the data file. In EDIT or BROWSE put the cursor in the unwanted record and press the CTRL-U combination to tag, then at the end of your editing session (after CTRL-END) choose PACK from the UPDATE menu and it's all done.

Donstructing Data Filenames.

To make it easy to identify and manipulate data files it is necessary to adopt a maming convention for files and to standardise wellnames and humbers within files.

Data filenames are constructed from three components of two characters each:

chars 1-2 (a contraction of the wellname chars 3-4 (the well number

chars 5-6 to code (c), the data type

The standardised wellnames and contractions are listed in appendix i. The well number is always two characters (e.g. 12, 03 iA, etc.). The data type godes are listed below:

thin section descriptions TŜ 60 geologic descriptions CA core analysis EM electron microscopy XR X-ray diffraction

Thus the core analysis data file for Corkwood I goest

CH + 01 + CA

CWOLCA, DBF yielding the full filenamer

Name the welldata file with WEL . + your first and last initials + serial number (e.g. WELBF1.DBC).

When each successive disk is nearly full make a copy for yourself and hand the original to Sally with a hard copy list of the files it contains; then start a new disk.

Notes for Filling Data Forms.

Entry forms are presented at the back of this document, which are largely melf-explanatory but additional information is included here

All depths are to be converted to loggers depths.

Where a list of choices is given select only from that list.

Well parameters.

0

Wellname must conform to the standard spelling in Appendix 1. Numbers must not be included.

Wellnumber must include two digits (e.g. 32, 03) in the first two spaces of the field and, optionally, a letter in the third space.

Latitude and longitude are entered as degrees minutes and seconds. The minus sign and the colons are already provided where required but all spaces must be filled, so include leading zeros when appropriate, papth conversions can be entered at will as long as the intention is clear up to a maximum of 80 characters. A series of entries of the form:

is suggested, where the first two numbers are the range and the last is the correction to go from drillers depths to loggers depth.

Cored sections will include a series of entries covering cored intervals. This may require compressing contiguous or near-contiguous sections into one entry.

Thin sections.

Sample number must be entered as four figures with leading zeros if required. The occasional three digits plus a letter will be accepted if it has already been used in a database, otherwise ascribe a new number. Formation codys are listed Appendix 2 and comprise the first four letters of the formation name. List of other minerals provides an opportunity to remark on minerals of interest not listed individually. The pointcount question is important since obviously such data is more precise than purely visual estimation.

Geological Descriptions Core or Cuttings.

These descriptions are of specimens for which other databases exist. Do not include all your core logging data.

Hydrocarbon presence can include both 0 for oil and 6 for gas if required.

Bedimentary structure codes are listed in Appendix 3.

Bedimentary environment codes are listed in Appendix 4.

Bedimentary environment codes are listed in Appendix 4.

For both these latter entry fields two-letter codes are to be entered, the separator colons are already provided and up to seven can be typed in. If the list provided does not provide the code you need, invent one (make sure it is unique) and tell everyone else so they can use it too.

Core Analysis

No special cumments

Electron Microscopy

Illite textures, carbonate types, and quartz overgrowths fields can have one or several entries chosen from the lists provided.

X-Ray Diffraction.

The illite/kaolin fraction is calculated in the usual way. (see Sally)

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			
WELLNAME ************************************	co	WELLINAME	co.
ALKOOMI	AK	Моомва Моктн	MN
ALWYN	Ąμ	MOOMBA SOUTH	MS
AROONA	AR	MODRARI	MR
BAGUNDI BARATTA	BD BT	MUDERA	MD
BARCOOLOO	BC BC	MUDLALEE	Y #
BATTUNGA	B0	MULGA	MG
BEANBUBI	ÉÉ	MUNIX	MM
BIALA	ΒĪ	MUNKARIE ** MURTEREE	MG MT
DIO LAKE	° BL	MURTEREE-A	MA
CODMXOC	BW	MURTEREE-G	MC
BRUMBY	ΕA	MUTEROOS	MÜ
BUCKINNA	BA "	MUTERDO S NAMUR	พพ
EURKE	DK:	NANTMA	MN
BURLEY	BM	NAPPACOONGEE	M=
BURRUNA CALAMIA/WEST	BR	NARCOONOWIE	NC
CHERNI	CL CH	NUNGEROO	NG
CUOCHILARA	CC	PADULLA	PU
CORKWOOD	CM	PANDO	₽Ŋ
COWAN	CO	FANDO NORTH	PN
DARALINGIE	DA	PANDUANNIE	芦 蕉
DELLA	DL.	FAXTON	FX
for the property	яa	PECKETA PERENTI	РK
DIFOHEE, DIFOHEE,	DC	FINNA	PT PA
D #LELI-HITH	TOK	FINTARI	F!Y
DULLINOARI	DU	, PIRA	ar in Time to the second of t
DULLINGARI NORTH	DN	POORAKA	ÞÔ
DUNCON	סמ	SPENCER	SF
FLY LAKE	FL.	TOMHTARTE	s.L ″
' FORTVILLE BARANJANIE	νή τα	STRZELECK.1	SZ
OGIDGEALFA	GD	ADMOWRAT	TW
NOWER	GY	THREE QUEENS	ar
GUrmA .	őŔ	THURAISINNA (ŢI¢
JENA	JN	TILPAREE	o <u>ir</u>
KALANNA	KL,	TINGA TINGANA	T
KARILLA	KA	TOOLACHEE EAST	TL TE
KEKNA	KE	TOPWEE	To To
EXITO	KT	ULANDI	UL
RERNA	KR	WANARA	WĀ
KERRINA	KI	WANCOOCITÀ	" WC:
KIDMAN	IKM .	MAUKATANNA	WK
KIDMAN NORTH	KN	WEENA	WN °
KIRBY KIWARRICK	KY	WILFINNIE	Mr.
KOBARI	F.W	WIRRARIE	WI
KUMBARIE	KO KB	MODITOO	MC)
LAKE HOPE	LH	WURDDFIE	ME
LEPINA	i,p	YALCUMMA	Υœ
LIMESTONE CREEK	Ľc	YAPENI	YP
L.OWANNA	Lali		
MANODICA	MX	가는 이번 보고를 보고하다 [기주문화]	
MANDORA	MY		
MARABOUKA	MO		
MARAKU	MZ		
MARANA	MV		
MCKINLAY	MK:	动图 克里诺克斯克斯克斯	
MCLEOD	ML.		
MERRIMELIA	ME		
MOOMBA	MB MI	선생하다 그 생활하는 것으로 없다.	
z sudult tadet	1367		

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CORMATION CODES

FORMATION	CODE
NAPPERMERRIT	NAPP
TOOLACHEE	TOOL
DARALINGIE	DARA
ROSENEATH	ROSE
CFS1LON .	EFST
MURTEREE	MURT
PATCHAWARRA	FATC
MERRIMELIA	MERR
TIRRAWARRA	TIRR
PRE-PERMIAN	PREP

(10)

U

SEDIMENTARY STRUCTURE CODES

CO SED. STRUCT,

MB MASSIVE BEDDING RX RIPPLE CROSS LAMINATION RC CLIMBING RIPPLES RR RIPPLE MARKS RI INTERFERENCE RIPPLES XF PLANAR CROSS-BEDDING XT TROUGH CROSS-BEDDING XL LOW ANGLE CROSS-BEDDING PB PLANAR BEDDING FC FLUTE CASTS LC LOAD CASTS FB FLASER BEDDING CH CHANNEL STRUCTURE SL SLUMP FL FINE LAMINATIONS OR ORGANIC/COAL STR./CLASTS CB CONVOLUTED BEDDING DW DEWATERING FEATURES SD SOFT SED. DEFORMATION MF MICROFAULTING TH TRAILS BU BURROWS RT ROOTS IM IMBRICATION DC DESSIGATION CRACKS ST STYLDLITES OR GRAVEL IC INTRACLASTS

SEDIMENTARY ENVIRONMENT CODES

0

SI

NCP65/NERDDC-Cooper Basin Project THIN SECTION DATABASE

(Fill all & spaces) (First 4 letters) WELL NUMBER: 99A SAMPLE NUMBER: XXXX FORMATION CODE: XXXX WELLMANE OR FIELDMANE: SXXXXXXXXXXXXXXXXXX LOGOEKS DEPTH (FEET): 99099.9 SAMPLE TYPE: X (D=Ottch, C=Core)

(P-Poorly, M-Moderatoly, W-Well, V-Very well Sorted) 66 × CRAIN SIZE (mm): SORTING:

CARBONATE: 99 %

FRACTURE POROSITY: 99 Z Was the composition determined by point counting (Y/N)? E. SECONDARY POROSITY: 99 Z PRIMARY POROSITY: 99 % SECONDARY PACIFICATION OF CONTRACT OVERGROWTHS VISIBLE? (Y/N): L

Structure for database: A:WELLDATA.dbf : 02/22/89 Number of data records: Date of lost update

ROSENEATH: 99999 MERRIMELIA: 99999

ROSENEATH:

IOOLACHEE: 99999 DARALINSIE: 99999 MURTEREE: 99999 PAICHAWARRA: 99999

Depths to formation tops. Loggers depth in feet: NAPPERWERK: 99999 TOOLACHEE. 99999 DARALINE EPSILON: 99999 MURTEREE: 99999 PAICHAMAR

PRE-PERMIAN: 99999

Depth Intervals of Cored Sections:

TIRRAWARRA: 99999

ASL): 999.9 TOTAL DEPTH (FEET): 99999 CELSIUS): 999 AFTER TIME (HOURS): 9999

NORTHING: 9999999

LONGITUDE: 999:99:99

MCPSG/NERDDC-Cooper Basin Project

WELL PARAMETER DATABASE

KELLY BUSHING ELEVATION (FEET ASL): 999,9 BOTTON HOLE TENPERATURE (DEG. CELSIUS): 99

A.M.G. Coordinates: EASTING: 999999

LATITUDE: -99:99:99

Character Character Type Field Name WELLNAME MELIN Field

Dac

WEGEN

Type

Character Character

Character Charactor Character Character

SAMPLETYPE

SAMPLE WELLIND

DEPTH

FORMATICAL GRAINSIZE

SORTING

Numerin

\$ 02/21/89

Structure for database: A:SECTION.dbf

Number of data records:

Date of last update Field Mane

Field

WELLHAME

D

חפת

Character Character Pumerin Muneric LONGITUDE LATITUDE MORTHING EASTING

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Character DEPTHOUN DARA 90 MM

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NCPGG/NERDDC-Cooper Basin Project CORE AMPLYSIS DATA BASE

FORMATION CODE: XXXX (First & letters) WELL NUMBER: 99A. (Fill all four spaces) LOGGERS DEPTH (FEET): 99999.9 SAMPLE NUMBER: XXXX

FORMATION CODE: XXXX (First 4 letters)

LOSSERS DEPTH (FEET) = 99999.9 FORMATION CODE:) SAMPLE, NUMBER: XXXX (FIII all four spaces)

SORTING CODE: X

(D=Ditch, C=Care)

GRAIN SIZE CODE: X SAMPLE TYPE: X

NCPGG/NERDOC-Cooper Basin Project

101

0

GEOLOGIC LOG DATABASE

PERMEABILITY (MILLIDARCYS): 9999.99 BULK DENSITY (GH/CC): 7,99

POROSITY (PERCENT): 99.9

CATION EXCHANGE CAPACITY (MED/GM): 99.9.

Dec

: 02/22/89

Character Character Character Character

Numeric

DEPTH. SAHPLE SAMPLETYPE

Character

WELLWAME

Dec

: 02/22/89

Number of data records: Date of last update : Field Field Name Type

WELLINAME

MELLING

Character Character Character Character Numeric Numeric Numeric

Numeric

Structure for database: A:CORAN.dbf

WELLIND

Type

Structure for database: A:66LOG.dbf

Number of data records: Date of last update Field Field Name 7 スアルーチント

Character Character Character

FORMATION HYDROCARD GRAINSIZE

NMANGHOO

NANE

Numeric

PERMEABLTY DEPTH SAMPLE FORMATION RULKDENS POROSITY

Total **

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Character

STRUCTURES ENVIRONMENT

** Total **

SORTING

Core

Audilysis

\$ 12

NCPG6/NERDDC-Cooper Basin Project X-RAY DIFFRACTION DATABASE desendesenteres. Well number: 99a WELLIAGHE OR FIELDHAME: XXXXXXXXXXXXXXXXXXX LOGGERS DEPTH (FEET): 99999.9

PURIDED RESERVE 9999.8 SAMPLE NUMBER: XXXX (FILL ALL 4 spaces)
LE TYFE: X (D-DIICH,C-CORE) PREPARATION: X (B-BULK,L-<10um,D-<2um) SAMPLE TYPE: X (D-DITCH, C-CORE)

MINERAL COMPOSITION CODES:

(D=Dowinant, C=Codowinant, S=Subdowinant, N=Winor, T=Tracs, A=Absent)
CUARTZ X KAGINITE X DICKIE X ILLIE/MUSCOVITE
AWERITE X CALSITE X DOLUMITE X FERRODOLOMITE PYROPHYLL ITE CHLORITE

× × × ILLITE/KAOLIN FRACTION: 99,99

OTHER (LIST): XXXXXXXXXXXXXXXXXXX

SIDERITE

MANGANDSIDERITE

HICROPOROSITY: 9 Average Fore Size Estimates in micrometres: OTHER FEATURES: XXXXXXXXXXXXXXXXXX SECONDARY: 999 PRIMARY: 959.

S=Siderite M=Mangano-siderite S=Subhedral A=Anhedral D=Drusey

R=Rhombohedral N=None evident

QUARTZ OVERGROWTHS: XXXXX E=Euhedral

QUARTZ SGLUTION EVIDENT? (YZN): L

F=Ferro-dolomite

(P=Platey, F=Fibrous, L=Lettuce)

KAOLIN SIZE (um): 999 ILLITE TEXTURES: XXX (P=Platey, F=Fibrous, L=FELDSPAR? (V/N): L CARBONATE TYPES: XXXXX A=Ankerite C=Calcite FELDSPAR SOLUTION EVIDENT? (Y/N): L D=Dalmite F=Ferro-do CARBONATE SOLUTION EVIDENT? (Y/N): L S=Siderite M=Mangano-

SAMPLE NUMBER: XXXX (FILL all 4 spaces)

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NGFGG/NERDDC-Cooper Basin Project

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ELECTRON MICROSCOPY DATABASE

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30 WAKEFIELD STREET, ADELAIDE, S.A. 5000

All correspondence should be addressed to The Executive Officer. 17 Level 19, 30 Wakefield St. Adelaide, S.A. 5000 Telephone 226 5500

REVISED

FOR SENRAC USE ONLY
PROJECT
NUMBER

/ G/ 87

APPLICATION FOR AN ENERGY RESEARCH GRANT

1989/90

PROJECT TITLE THE INFLUENCE OF THERMAL HISTORY AND FLUID MIGRATION ON POROSITY AND PERMEABILITY IN PERMIAN SANDSTONES: SOUTHERN COOPER BASIN

NAME OF APPLICANT DR. W.J. STUART

OFFICIAL USE ONLY

Date received

File No.



National Centre for Petroleum Geology and Geophysics

G.P.O. BOX 498, ADELAIDE, SOUTH AUSTRALIA 5001 Telephone; (08) 228 5493 Telex; UNIVAD AA89141 Telegraphic Address; UNIVAD Fax; (08) 224 0464

12 July, 1989

Mr. M.G. Day

Executive Officer

State Energy Research Advisory Committee

Level 19

30 Wakefield St., ADELAIDE, S.A. 5000

Dear Mr. Day,

Please find enclosed a revised application to SENRAC for 1990/1991 funding. The project was originally entitled 'Porosity and permeability in Permian sandstones: southern Cooper Basin'. Alterations to the proposed project have been made in response to a request from NERDDC to reduce the duration to two years with maximum funding from NERDDC of \$130,000.

To achieve the desired decreased in funding and timing it has been necessary to subdivide the original project. The modifications will allow the original aims to be achieved and both projects remain intimately related. Please find enclosed a copy of the revised NERDDC application.

In the original NCPGG submission, funds were requested from SENRAC for isotope work and several other items. The revised application to SENRAC requests funds for the isotope work (\$34,060), which substantially reduces the amount of funds sought from SENRAC. We consider that results of isotope analyses, when integrated with data from the NERDDC project, will have a significant impact on future exploration strategies.

Thank you for considering this revised application. If there are queries, I will forward additional information immediately.

Sincerely yours,

1

W.J. Stuart

CERTIFICATION OF CHIEF INVESTIGATOR(S)

IW	certify that	the informatio	n alveit in this	application inclu	dlad anii ettaalimaa	ts hereto is true and
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CERTIFICATION OF HEAD OF ORGANISATION

i I being the dui	ly appointed Head of the organisation, declare that:
	as proposed is acceptable to the organisation; and
(b) the salaries project.	s quoted for personnel are in accordance with our standard practice for this type of
Signature:	on an analysis of the control of the
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PART A: PROJECT AND BACKGROUND INFORMATION

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Name:	DR. W.J. STUART	en all se control di la control de la con
Designation:	DIRECTOR	aria manda aria da manda aria aria da manda aria aria aria da manda ari
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. PROJECT DESCRIPTION AND OBJECTIVES
(a) Project Description
The project is directly linked to the NERDDC funded study of porosity and permeability in Permian sandstones; southern Cooper Basin. The present study is concerned with the influence of thermal history and fluid migration on porosity and permeability.
Data acquisition represents the first stage of this project. i) Oxygen isotope analyses of authigenic quartz overgrowths, kaolin and illite will identify temperatures of crystallization for these minerals. When correlated with vitrenite reflectance data, the thermal history of the southern Cooper Basin can be ascertained. Samples for this work have already been characterised petrographically and are available in the NCPGG. ii) Geochronology based on K-Ar and Rb-Sr isotope studies will be performed on samples of detrital and authigenic illite. This information should provide a time framework for sedimentation in the basin and diagenetic alteration of illite. Samples selected will be the same as those for the oxygen isotope study. When results of the oxygen, K-Ar and Rb-Sr isotope studies are combined with carbonate isotope data already available in the NCPGG, it will be possible to identify the sources, direction and chemistry of fluid migration in the southern Cooper Basin.
The second major stage of the project will involve interpretation, integration and presentation of the results combined with the NERDDC project. Together with the final report, several papers will be submitted to journals and seminars will be held to disseminate the results to industry.
(b) Objectives
The overall aim is to identify the influence of thermal history and fluid migration on porosity and permeability in Permian reservoir sandstones of the southern Cooper Basin. Emphasis will be placed on the Toolachee, Epsilon and Patchawarra Formations. Based on results from the initial NERDDC project, the following specific aims will be addressed:
i) To estimate the temperatures and timing of authigenic mineral crystallization and hence the maximum depth of burial experienced by sediments. The thermal history of the basin can be determined from this information.
ii) To identify the source(s), direction and chemistry of fluid migration within the basin. This will provide a means of predicting zones of intense diagenetic alteration and possible diagenetic traps.
iii) To integrate this data with the NERDDC project and disseminate results of the combined projects to industry via a workshop, journal papers and presentations at conferences.
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	PROJECT SUPERVISOR	OTHER INVESTIGATORS		
	PROJECT SUPERVISOR	2	3	
Vame	W.J. STUART	B.B. FARROW	N.M. LEMON	
Designation I.	DIRECTOR	LECTURER	CONSULTANT	
Qualifications	B.Sc., M.Sc., Ph.D.	B.Sc., M.Sc.	B.Sc.(Hons), Ph.D.	
Business Address	NCPGG	SAIT (NCPGG	
	G.P.O. BOX 498	P.O. BOX 1	G.P.O. BOX 498	
	, ADELAIDE	INGLE FARM	ADELAIDE	
	S.A. 5001	S.A. 5098	S.A. 5001	
Telephone No.\	(08) 228 5493	(08) 343 3070	(08) 228 5323	
Average No. of days per month to be devoted to project	3	8	C). 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	
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9. OTHER SOURCES OF FUNDS (If grant approved)		\$ (estimate)	
YEAR	1990	1991	
Organisation's own funds*	8,000	8,000	
NERDDC	65,000	65,000	anatorio (de mandiale) de mandiale de la composición dela composición dela composición de la composición dela composición de la composición dela composición de la composición dela co
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Total.	78,000	73,000	

^{*}Exclude salary of Supervisor—see note 11.

PART B: ESTIMATED PROJECT EXPENDITURE REQUESTED AS A GRANT

(a) Project Staff Employees*	Full-time Annual Salary (\$)	Period to be emplo on project	oyed	Full-time man months equivalent on project	Estimated Cos \$
(i) Professionally Qualified			tianinphonone.	-	- Capataniatahan
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Total Percentage of Salary			Total	On-Costs	

11. PLANT, EQUIPMENT AND MATERIAL EXPENDITURE IN THE GRANT YEAR	Estimated Date of Purchase	Expenditure (include install.) (\$)		
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ESTIMATED TOTAL EXPENDITURE ON PLANT, EQUIPMENT, MA	<u>نخت محمد میں اس جی ا</u>	\$		

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12. OTHER EXPENDITURE IN THE GRANT YEAR (Details to be attached)	\$
(e) Computing Charges	1,000
(b) Travel BETWEEN ADELAIDE & CANBERRA (c) Other (Specify) SUBCONTRACTS (see attached sheet)	33,060
	1 21 525
ESTIMATED TOTAL OTHER EXPENDITURE	\$ 34,060

Calendar Year	1989	1989/		1990/		1992	
		Distributi	on by Six	Months (3eginning 1 July,	1 Januaryı	TOTAL \$
COST ITEM	1 July}	1 January	i Julyi	1 danuary1	, ouly		
Sale and Related Ext diture (item 10)					A comment		
Plant, Equipment and Materials (Item 11)						V-10-10-10-10-10-10-10-10-10-10-10-10-10-	
Other Expenditure (Item 12)		11,020	11,020	11,020	1,000		34,060

PART C: SUPPORTING DETAILS

Supporting details should be on pages of the same size as this form, attached to the application, and numbered consecutively.

18090

1. Management organisation

The project will be managed and co-ordinated in overall concept by Dr W.J. Stuart (Director, NCPGG). Specialists in isotope analyses from the Australian National University and AMDEL will be subcontracted to process the samples and provide professional interpretation of the results. Mr B. Farrow (Lecturer, SAIT) and Dr N. Lemon (Consultant, NCPGG) will be responsible for the integration of this data with diagenetic studies in the associated NERDDC project.

2. Major stages of the project. Stage 1 DATA AQUISITION Task a

Separation and running of oxygen isotope analyses to partially satisfy objectives i and ii. Clays will be prepared for isotope work by extracting a clay-size fraction. In the case of illite a less than 0.02 micron fraction will ensure that only authigenic illite is anlaysed. For kaolin samples the isotope work can be done on <2 micron fractions. This clay separation work will be subcontracted to CSIRO where the most up-to-date equipment is available. Quartz overgrowths must be separated from detrital grains by etching and fracturing.

Samples for oxygen isotope analyses will be selected from 8 wells scattered across the basin, and one sample taken from each of the 3 formations. In total there will be 72 samples for oxygen isotope analyses by Dr. A. Chivas at ANU. Preparation time is anticipated as 6 weeks, with an additional 7 weeks to run the samples. Results from quartz overgrowths should then be checked against fluid inclusion work which is currently being undertaken by Dr.Y. Bone from the Department of Geology and Geophysics, at the University of Adelaide.

Task b

Rb-Sr isotopic analyses on the 30 illite samples prepared for oxygen isotope work should establish the time of crystallization. This is the only possible means of establishing a time framework for the diagenetic sequence. Mr. M. Fanning at ANU, will be responsible for the Rb-Sr isotopic analyses. These results will be checked by running K-Ar isotopic analyses on selected samples. Dr. A. Webb from AMDEL has agreed to run the K-Ar isotopes. In total Rb-Sr and K-Ar anlayses should take approximately 8 weeks.

The results of task's a and b, combined with other data, such as vitrenite reflectance, will permit the completion of objectives I and II. This interpretation may take considerable time and the need for additional isotopic analyses could become

apparent. Sufficient time should be allowed for this eventuality,

Stage 2 FINAL REPORT AND INFORMATION DISSEMINATION

Preparation of final report, integrating data from all subsections of the study. Submission of manuscripts on various aspects of the project for journal publication. Presentation of results at relevant conferences and monthly meetings of PESA.

Furthermore, a workshop will be organised, for industry and academic personnel,

at which the results and implications of the project can be presented.

3. Market potential

Information gained from this project should be of substantial advantage to the petroleum industry. Factors controlling porosity and permeability, and their spatial distribution in the southern Cooper Basin will be clearly defined. This should demonstrate to industry the advantages of this type of research and encourage future funding.

Specific knowledge of diagenetic events in each major field of the southern Cooper Basin may help to explain production problems in some areas, for example Moomba #3. In the past information concerning diagenesis has been sporadic, but the results from this study will provide a thorough coverage of many important fields.

One question frequently asked during discussions with personnel from the

petroleum industry is the timing of diagenetic events, including hydrocarbon migration. This question will be answered through combined petrographic and

isotopic analyses.

In the past most drilling has aimed at structural traps. Once the direction and nature of fluid migration across the basin can be ascertained it may be possible to predict the location of diagenetic traps.

4 Technical, economic and other benefits

Significant benefit to industry from this project will be achieved by the prediction of favourable drilling sites, based on a knowledge of diagenesis, sedimentology and structure. New plays may be associated with combination stratigraphic-structural and diagenetic traps.

5 Industry links and business plan

Co-operation with Santos and the other Cooper Basin partners was established for the initial project. Communication will be maintained with industry, and the

exchange of knowledge encouraged.

Links are also being formulated with other Tertiary and government institutions. Collaborative work with CSIRO Division of Soils to undertake clay separation and Australian National University for isotopic analyses will significantly enhance human resources applied to this project.

6 Information dissemination

The major portion of funding for this aspect of the project has been requested in the NERDDC grant application. Information dissemination will be actively pursued via reports, journal publications, and seminars. Presentations at conferences, such as APEA, are another possible means of transferring information to industry which will be undertaken.

Anticipated cost of drafting and photography for papers and conferences is \$4000.

Production of final report \$3000.

A 2 day workshop for industry and academic personnel will be organised when the project is near completion. It is anticipated that at least 50 people would be invited to attend, with a high proportion of that total coming from industry. This workshop could be held in conjunction with the presentation of results on fluid inclusions by Dr. Y. Bone. Lectures would be designed so that the information was presented for specific fields, and as a whole for the southern Cooper Basin. Techniques involved would be clearly explained and ample time given for discussion. Participants would be given the opportunity to view thin sections, SEM samples, and XRD results, and the retrival and manipulation of the data base would be demonstrated so that future exploration could utilise this information. Clearly this type of practical experience is most successfully illustrated at a workshop.

Anticipated costs involved with the workshop would include:

		(\$)
	Reproduction of notes, maps and photographs @ \$50.00/set	2,500
2.	Return air fares for Dr Chivas and Mr Fanning from ANU to present the isotope results (current cost \$482 single return)	1,000
4.	Provision of morning and afternoon tea @ \$2.00/person Printing of invitations Welcoming reception @ \$12.00/person	200 50 <u>600</u>
n D	성이 취하는 경기를 가지 못했다. 이 후 성도 이번 경기 이렇게 되는 그리고 말한 것이다. 전에 어떤 경기에는 사고 있는 이번 그렇게 되는 이번 생각했다. 나는	\$4,350 350

The only portion of costing requested from SENRAC concerning information, dissemination is the air fares for the isotope specialists to attend and present results at the workshop.

7 Related research

Bibliography of significant publications.

<u> Isotopes - general</u>

- Eslinger, E. & Pevear, D. (1988) Clay minerals for petroleum geologists and
- engineers. SEPM short course 22.

 Longstaffe, F.J. (1983) Diagenesis 4. Stable isotope studies of diagenesis in clastic rocks. Geoscience Canada 10, pp.43-58.
- Williams, D.F., Lerche, I. & Full, W.E. (1988) Isotope chronostratigraphy: theory and methods. Academic press. 345p.

- Ayalon, A. & Lonstaffe, F.J. (1988) Oxygen isotope studies of diagenesis and pore-water evolution in the Western Canada sedimentary basin: evidence from the Upper Cretaceous Basal Belly River Sandstone, Alberta. J Sediment. Petrol. 58, pp.489-505.
- Eslinger, E.V., Savin, S.M. & Yeh, H-W (1979) Oxygen isotope geothermometry of diagenetically altered shales. In P.A. Scholle & P.R. Schluger (Eds.) Aspects of
- diagenesis. Soc. Eco. Paleon. Mineral. Spec. Pub. 26, pp. 113-124. Eslinger, E.V. & Yeh, H-W. (1986) Oxygen and hydrogen isotope geochemistry of Cretaceous bentonites and shales from the Disturbed Belt, Montana. Geochim. Cosmochim. Acta 50, pp.59-68.
- Land, L.S. (1984) Frio Sandstone diagenesis, Texas Gulf Coast. A regional isotopic study. In D.A. McDonald & R.C. Surdam (Eds) Clastic diagenesis. A.A.P.G. Mem. 37, pp.47-62.
- _ Lee, M. & Savin, S.M. (1985) Isolation of diagenetic overgrowths on quartz sand grains for oxygen isotopic analysis. Geochim, Cosmochim, Acta 49, pp497-501.
 - Longstaffe, F.J. (1984) The role of meteoric water in diagenesis of Shallow Sandstones: Stable isotope studies of the Milk River aquifer and gas pool, southeastern Alberta. In D.S. Medonald & R.C. Surdam (Eds) Clastic diagenesis A.A.P.G. Mem. 37, pp. 81-98.
 - Longstaffe, F.J. (1986) Oxygen isotope studies of diagenesis in the Basal Belly River Sandstone, Pembina I-Pool, Alberta. J. Sediment. Petrol. 56, pp.78-88.
 - Yeh, H-W. & Savin, S.M. (1977) Mechanism of burial metamorphism of argillaceous sediments: 3, O-isotope evidence. Geol. Soc. Amer. Bull. 88, pp.1321-1330.

Rb-Sr and K-Ar isotopes

Aronson, J.L. & Hower, J. (1976) Mechanism of burial metamorphism of argillaceous sediment: 2. Radiogenic argon evidence. *Geol. Soc. Am. Bull.* 87, pp.738-744.

Aronson, J.L. & Lee, M. (1986) K/Ar systematics of bentonite and shale in a contact metamorphic zone, Cerrillos, New Mexico. Clays & Clay Min. 34, pp.483-487. Bonhomme, M.G. (1982) The use of Rb-Sr and K-Ar dating methods as a strati-

Bonhomme, M.G. (1982) The use of Rb-Sr and K-Ar dating methods as a stratigraphic tool applied to sedimentary rocks and minerals. *Precambrian Research*, 18, pp.5-25.

Bonhomme, M.G. (1987) Type of sampling and comparison between K-Ar and Rb-Sr isotopic dating of fine fractions from sediments in attempt to date young

diagenetic events. Chem. Geol. 65, pp.209-222.

Clauer, N. (1979) A new approach to Rb-Sr dating of sedimentary rocks. In E. Jager & J.C. Hunziker (Eds) Lectures in isotope geology. Springer Verlag. pp. 30-51.

Glasmann, J.R., Larter, S., Briedis, N.A. & Lundegard, P.D. (1989) Shale diagenesis in the Bergen High area, North Sea. Clays & Clay Min. 37, pp.97-112.

Hower, J., Hurley, P.M., Pinson, W.H. & Fairbairn, H.W. (1963) The dependence of K-Ar age on the mineralogy of various particle size ranges in a shale. Geochim. Cosmochim. Acta 27, pp.405-410.

Lee, M., Aronson, J.L. & Savin, S.M. (1985) K/Ar dating of time of gas emplacement in Rotliegendes Sandstone, Netherlands. A.A.P.G. Bull. 69, pp.1381-1385.

Liewig, N., Clauer, N. & Sommer, F. (1987) Rb-Sr and K-Ar dating of clay diagenesis in Jurassic sandstone soil reservoir, North Sea. A.A.P.G. Bull. 71, pp.1467-1474.

Morton, J.P. (1985a) Rb-Sr evidence for punctuated illite/smectite diagenesis in the Oligocene Frio Formation, Texas Gulf Coast. A.A.P.G. Bull. 96, pp.114-122.

Morton, J.P. (1985b) Rb-Sr dating of diagnesis and source age of clays in Upper Devonian black shales of Texas. A.A.P.G. Bull. 96, pp1043-1049.

Perry, E.A. (1974) Diagenesis and the K-Ar dating of shales and clay minerals. A.A.P.G. Bull. 85, pp.827-830.

Perry, E.A. & Turekian, K.K. (1974) The effects of diagenesis on the redistribution of strontium isotopes in shales. *Geochim. Cosmochim. Acta* 38, pp.929-935. Thomas, M. (1986) Diagenetic sequences and K/Ar dating in Jurassic sandstones,

Central Viking Graben: effects on reservoir properties. Clay Min. 21, pp.695-710,

The proposed project will compliment related research by effectively utilising for the first time in Australia, methods developed for North Sea and Gulf Coast oil fields. In the past, isotopic analyses of clays and quartz have been applied to metamorphic terrains but rarely to sedimentary basins in Australia. Clearly isotopes have been utilised to great advantage elsewhere (e.g. Lee et al 1985) and since the technology is available in Australia these techniques should be applied for the benefit of the petroleum industry.

8 Progress with current grant

a) Expected total expenditure on current grant by scheduled completion date is \$39,000.

b) Summary of main project findings to date:
i. Porosity is best developed in well sorted, medium to coarse grained sediments of point bar sequences. These characteristics typify rocks where the proportion of illite is low and dickite is present rather than kaolinite, and significant amounts of other authigenic minerals are absent. Fine grained shoreline sands also have good porosity and permeability where silicification is minimal.

ii. Primary porosity has been partially preserved in some coarser clastics due to the introduction of an early quartz cement. Quartz overgrowths acted as a rigid framework to resist the effects of compaction. Secondary porosity is of importance where labile components (rock fragments, feldspars and carbonates) have been dissolved.

iii. Porosity and permeability are significantly reduced by detrital illite in fine grained flood plain and overbank deposits. Kaolinite formed due to the alteration of Kfeldspars and micas, and is the dominant kaolin mineral in finer grained clastics. Dickite precipitated from solution in coarser grained materials and is associated with high microporosity. Where microporosity is abundant sandstones provide targets for gas exploration when artificially or naturally fractured. Results indicate that total porosity values derived from petrophysical calculations are likely to overestimate effective porosity in rocks with a high proportion of kaolin minerals.

- iv. Distribution of authigenic minerals is partially depth related. Pyrophyllite and chlorite concentrate in the central Nappamerri Trough. The abundance of authigenic illite (less than 2 micron fraction) increases with depth in the Big Lake Field and possibly elsewhere.
- v. Diagenetic events probably occurred in the following paragenetic sequence. Micritic siderite precipitated from groundwaters in the vadose zone and was probably the earliest diagenetic event. Silicification occurred during at least two main phases. Some sandstones of the Toolachee Formation, show that a proportion of the quartz overgrowths developed prior to significant compaction and therefore are a relatively early event. Precipitation of quartz overgrowths probably continued through several other phases of diagenesis including the kaolinisation of feldspars and micas. In other areas, and finer grained rocks, where compaction occurred prior to precipitation of overgrowths, intense intergranular dissolution is abundant. Overgrowths were inhibited in many finer grained rocks by the present of detrial illite. Feldspars and micas were altered to kaolinite, liberating Si for the precipitation of quartz overgrowths; as the supply of Si decreased dickite was precipitated. Thus dickite formation postdates that of kaolinite, Alkaline conditions prevailed after the formation of large cuhedral quartz overgrowths causing their partial dissolution. Sparry carbonates were possibly precipitated during this period. Compositional variations in the carbonates are thought to be related to the chemistry of migrating fluids. Authigenic illites probably formed during periods of deeper burial when 7smeetite, kaolinite and K-feldspars were altered. The final diagenetic events are depth and temperature related, with the formation of clinochlore IIB and pyrophyllite. vi. Isotope work on the carbonates indicates the influence of meteoric waters and a cold climate.

c) Extent to which the original objectives have been achieved;
- in terms of the number of wells sampled the project has exceeded the original estimation.

- diagenetic factors controlling porosity and permeability have been identified, and their relationships to sedimentary facies assessed.

 basic well data generated from earlier exploration and development drilling has been examined.

quantification of the proportion of diagenetic silica in creating reservoirs of poor quality is in progress.

d) Difficulties encountered have been minimal. The only limitation has been a time constraint which will not permit full utilisation of the data base and construction of diagenetic maps.

e) Reasons why further support is considered necessary.

Results from the initial project are considered very promising, yet they can not be utilised by industry to their full potential without additional work. The initial project has clearly illustrated what additional information is required, personnel and equipment are available to continue the project, the background research has been thoroughly undertaken and even the samples in many instances are already available. Given sufficient time and resources to complete all the research outlined in this application, the potential predictive information concerning future drilling sites and secondary recovery from existing wells will be of vital economic assistance to the petroleum industry.

9. Sub-contracted Work Expenditure

Amdel has been chosen for the K-Ar dating because of the high standard of work produced by Alan Webb. It is not possible to undertake these analyses in the University. The rate of \$550 per sample is a commercially acceptable figure.

Oxygen isotope facilities are not available anywhere in South Australia and rather than try to set up facilities here it was decided to subcontract the work. The price of \$150/sample is very reasonable, considering other organisations are charging \$200. Dr Allan Chivas has considerable experience in oxygen isotope work, in particular he has worked on soils which are similar to the clay extracts and quartz which are

intended for anlayses in this project.

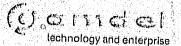
Rb-Sr isotope analyses on illites are probably the most difficult to obtain accurate results because of small sample size and problems of contamination. For these reasons it is essential that this work be done using a multiple collector mass spectrometer. The ANU laboratory has lower contamination than any other laboratory in Australia because it is new, and the mass spectrometer is capable of producing high precision results on small samples. The very low price of \$340/sample has been extended to the NCPGG as an indication of genuine interest in the success of this project.

The mineralogy section of the CSIRO Division of Soils has been chosen to

separate the clay fractions because of its expertise in clay analyses.

Please find attached documentary evidence from each subcontractor of the prices used in estimating costs.

Name of contractor	Brief description	Cost
AMDEL	K-Ąr DATING @ \$550/SAMPLE	11,520
ANU	OXYGEN ISOTOPES @ \$150/SAMPLE	10,800
ÀNU	Rb-Sr ISOTOPES @ \$340/SAMPLE	10,200
CSIRO	SEPARATION OF CLAY FRACTIONS @ \$10/SAMPLE	<u>. 540</u>
	TOTAL	\$33,060



Amdel Limited (incorporated in S.A.) 31. Flemington Street, Frewville, S.A. 5063

P.O. Box 114, Eastwood, S.A. 5063

Telephone: (08) 372 2700

Telex: AA82520 Facsimile: (08) 79 6623

19 April 1989

2 1 APR 1989

Dr W J Stuart National Centre for Petroleum Geology & Geophysics GPO Box 498 ADELAIDE SA 5000

Dear Dr. Stuart,

QUOTATION FOR K-Ar GEOCHRONOLOGY

In response to a request from Ms. S. Phillips, I wish to advise that our charges for K-Ar geochronology, on samples of illite prepared by your centre will be as follows:

Until 30 June 1989 : \$480 per sample After 30 June 1989 : \$550 per sample.

In addition, our charges for routine core analysis are :

Plug dr711/ing and plug trimming \$5,00 Extraction \$5.00 Helium indection porosity and air permeability \$55.00 Calculated grain density \$5.00 Total per plug \$70,00

We look forward to being of assistance to you in this matter.

Yours sincerely,

Man Well

Alan W Webb Senior Geochronologist Geological Services

AWW/bp

Cllices in Sydney, Melbourne, Perth, Brisbane, Canberta, Darwin, Townsville. Represented world-wide

RESEARCH SCHOOL OF EARTH SCIENCES THE AUSTRALIAN NATIONAL UNIVERSITY

INSTITUTE OF ADVANCED STUDIES • G.P.O. BOX 4, CANBERRA ACT 2601 TEL: 062-49-3406 • TELEX 62693 • PAX 062-474639

26 April, 1989

Dr W J Stuart
Director
National Centre for Petroleum Geology and Geophysics
GPO Box 498
Adelaide SA 5001

Dear Bill

I write in confirmation of a verbal agreement between Mark Fanning of RSES and Sally Phillips of the National Centre for PGG to the effect that RSES (Mark Fanning) is willing to carry out Rb-Sr analyses of thirty illite samples prepared by Sally Phillips at a cost of \$340 per sample. Included in this cost is an interpretation of the Rb-Sr systematics in the context of the overall data concerning the clay genesis.

Yours sincerely,

Malcolm McCulloch.

CS

The Australian National University Research School of Earth Sciences GPO Box 4, Canberra 2601, AUSTRALIA ne (062) 49 3406 Fax (062) 49 0738 Telex AA 62693 Telephone (062) 49 3406

Tol

Dr Bill Stewart

Director

Fax No.:

(08) 224 0464

From:

Allan R. Chivas

Group Leader

Environmental Geochemismy Group.

Date :

19 April, 1989

No. of pages:

Dear Bill

This is to confirm our willingness to undertake oxygen-isotope analyses of quartz and clay mineral separates for your proposed research project. I understand that analysis of up to 72 samples will be required. Our standard fee for this kind of work, involving oxygen extraction using bromine pentafluoride and mass spectrometric analysis of the extracted gas, is \$150 per sample. Approximately 10 to 15mg of each sample will be required.

ar chivair

Allan R. Chivas

#2.000



Walle Road, Urrorae, SA. Postal Audress: Private Bao No. 2, Glen Osmond, SA 5064 Telephone: (08) 274 9311, Telex: AA 82406, Fax: (08) 338 1636. Division of Soils

11-7-89

National Centre for petroleum Geology & Geophysics Mis S E Phillips The University of Adelaide GPO Box 498 ADELATOE 5000

Dear Sally

Particle size separations, XRFS analyses, CEC determinations We will undertake the analyses you have requested as follows!

200 core and ditch cuttings

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A Company of the Comp	nalvses.	by XRFS	Or 4 wh	 \$6,000
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- 11 *	-1 -1	"frad	tions	U P	13			40.00				14 5	Jan die	

\$9,710 TOTAL

Yours sincerely

Senior Principal Research Scientist Head of Mineralogy Group



30 WAKEFIELD STREET, ADELAIDE, S.A. 5000

All correspondence should be addressed to The Executive Officer, Level 19, 30 Wakefield St, Adelaide, S,A. 5000 Telephone 228 5500 FOR SENRAC USE ONLY
PROJECT
NUMBER

16/87

APPLICATION FOR AN ENERGY RESEARCH GRANT

1989/90

PROJECT TITLE POROSITY AND PERMEABILITY IN PERMIAN SANDSTONES: SOUTHERN COOPER BASIN

NAME OF APPLICANT... DR. W.J. STUART

OFFICIAL USE ONLY

Date received File No.

CERTIFICATION OF CHIEF INVESTIGATOR(S)

(IN	9 Certify that the late and	
CO	e certify that the information given in this application including any attachments hereto is true ar	ار اورود
(1)	gers, 사람이 되는 사람들은 경기에서 사용했습니다. 이번 이번 이번 보고 있는데 이번 이번 이번 사람들이 되었다. 그런데 아니는 사람들은 사람들이 없는데 모든데 되었다. 나는데 그런데 나는데 다른데 되었다.	na
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, -, , -, -, -, -, -, -, -, -, -, -, -, -, -,	Date:	1. 10.
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CERTIFICATION OF HEAD OF ORGANISATION

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Signature:	and the state of t					
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PART A: PROJECT AND BACKGROUND INFORMATION

ORGANISATION		
Names NATIO	NAL CENTRE FOR PETROLEIM C	EOLOGY AND GEOPHYSICS. (NCPGG)
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Postal Address:	G.P.O. BOX 498	
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(Artifelistiksen kertisjörgistransmistlatiss)	SOUTH AUSTRALIA	5001
PROJECT SUPER	14160n	
	DR. W.J. STUART	
	DIRECTOR	The state of the s
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PROJECT LOCAT		
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SUMMARY OF RE	EQUESTED FUNDS	
YEAR	SENHAC	OTHER SOURCES
YEAR 1990	SENRAC 15,839 !	95,283
YEAR	SENHAC	OTHER SOURCES 95,283 95,283 46,463 46,463 49,126

	N. C. C. Carlotte, C. C. Carlotte, C.	
.7.	PROJECT DESCRIPTION AND OBJECTIVES	
	PROJECT DESCRIPTION	0
3.5	Data acquisition represents the first stage of this project. Cathodoluminescence (CL) will be	meniniminalaninidah
A de	used (samples already held by NCPGG) to accurately determine the degree of silicification in	amamanamanamana
	reservoir sandstones. Clay fractions will be separated from samples and analysed by XRD and XRF to semiquantitatively determine the relative proportions of kaolin and illite. Based	
**********	on this data maps will be constructed demonstrating the distribution of authigenic silica and	
	clays. Samples of core, for which mineralogical data has already been obtained, will be	actaminism dymastinism i
i414-1411	placed in a gamma ray spectrometer and intensities of potassium-40, thorium-232 and	
ererept re	pronium-238 measured. This data can then be compared with gamma ray logs to assess the	granistration de la company
ajdje	relationship between netrophysical and mineralogical data. A collaboratory project with	all all free control of the control
i li i i i i i i i i i i i i i i i i i	CSIPO will determine whether shales between reservoir sandstones contain smeetite. Shale	
	samples will be analysed by XRD, SEM and transmission electron microscopy (TEM). These	anagarasaa ayalaayaanaa
	combined techniques permit full characterisation of clay minerals and the possible conversion	
intrair	of smectite to illite with depth. Core and cuttings will be logged, sampled and core plugs of taken where necessary from the Daralingie, Dullingari, Della and Mudera Fields. Samples	
	will be studied in thin section, by XRD, CL and SEM to ascertain the diagenetic history.	والتستيين والمقرية
	Results will be stored in the data base for correlation with other data. Oxygen isotope	
	analyses on authornic quartz overgrowths, kaolin and illite will identify temperatures of	manufuniinufullusianiniin
	arriging the for these minerals. When correlated with vitrenite reflectance data, the thermal	
(4)111ml	history of the southern Cooper Rasin can be ascertained. Geochronology based on K-Ar and	a
	Ph-Sr isotone studies will be performed on samples of detrital and authigenic illite. This	anang aparamental dalah
	Information should provide a time framework for sedimentation in the basin and diagencie	Laterana
	alteration of illite. When results of the oxygen, K-Ar and Rb-Sr isotope studies are combined	\$ 2
a.a.a.	with carbonate isotope data already available in the NCPGG, it will be possible to identify the	himma martification disconditional
	sources, direction and chemistry of fluid migration in the southern Cooper Basin,	
name	The second major stage of the project will involve interpretation, integration and presentation of the results. Together with the final report, several papers will be submitted to	Jelentralier Heistel aus der Verleit ist ist ist ist
	journals and seminars will be held to disseminate the results to industry.	
	그런 그 마음을 가지는 것은 아버가 하는 이 그의 어릴 것도 그렇게 들었다. 하는 그 생각이 있었는 어린 이를 다 하다고 하는데 하다.	
	OBJECTIVES The overall aim is to characterise factors controlling porosity and permeability in Permian	iciliani i proprio proprio de Ciliani
e mas	reservoir sandstones of the southern Cooper Basin. Emphasis will be placed on the	
	Toolachee, Epsilon and Patchawarra Formations. Based on results from the initial project, the	
	" following specific objectives will be addressed:	Herritanika di kangan di mateh di bi
ĺΥ.	마 네라이 네요. [2017년 1일 : 10 12년 12일 - 12일 : 10 12	or (millionianalanianianian
- missyl 6	" i) To construct diagenetic mans illustrating the degree of silicification and relative	
estron.	proportions of clay minerals in Permian sandstones. These maps will be vital to predicting	reprintarior era escriptor estander exceptore
	zones with good porosity and permeability.	
*******	ii) To test the relationships between gamma ray spectra and mineralogical/petro-physical farameters. If the natural gamma ray spectral log could be shown to be a useful interpretative	
22.000	fool then it would lower the uncertainties in formation evaluation for hydrocarbon reserve	aradarian amanamananan
	estimation and provide additional information for geological and petrophysical analysis.	
taren	iii) To determine whether silica in quartz overgrowths was derived from the transformation of	, <u>, , , , , , , , , , , , , , , , , , </u>
	smoothe to lilite in adjacent shale units and is a function of depth. This is important to	
1	predicting whether deeper drilling is feasible in the southern Cooper Basin.	
******	🔐 🕯 ÖĞİ - TÜNLER AN ALAN AN ALAN ELMEN ELMEN ELMEN AN ALAN MENDEN ELMEN ELME	kpiilii kapan eesat melista (eesan priis
1	vi) To utilise and expand the existing data base by pursuing diagenetic, sedimentological and	pentantratigarasen antiken Hibrar, ern
anifests.	"" etriciural studies in fields where more information is required to gain a better understanding	
	of the spatial controls on perosity and permeability.	dentification of the section of the
	v) To estimate temperatures and timing of authigenic mineral crystallization and hence the maximum depth of burial experienced by sediments. The thermal history of the basin can be	Harimanining arang and a same
****	maximum depin of durial experienced by sediments. The thermal history of the basin can be	
mac	determined from this information. vi) To identify the source(s), direction and chemistry of fluid migration within the basin.	Turnel stream to the Constitution
	This will provide a means of predicting zones of intense diagnetic afteration and possible	
10111	diagenetic traps,	Section of the sectio
	1003	B. artfordering and Artificial States
Speed	vii) To disseminate results of the project to industry via a workshop, journal papers and	landa eta eta eta eta eta eta eta eta eta et
Acces	presentations at conferences.	Wild to the Medical of the Control o

	PROJECT SUPERVISOR	OTHER INVESTIGATORS		
		2	3,	
Name	W.J. STUART	B.B. FARROW	N.M. LEMON:	
Designation	DIRÉCTOR!	LECTURER!	CONSULTANT	
Qualifications	B.Sc., M.Sc., Ph.D.	B.Sc., M.Sc.	B.Sc.(Hons), Ph.D.	
Business Address	NCPGG	SAIT J	NCPGG/	
	G.P.O. BOX 498	P.O. BOX 1	G.P.O. BOX 498	
	ADELAIDE	INGLE FARM	ADELAIDE	
	S.A. 5001	S.A. 5098	S.A. 5001	
Telephone No.	(08) 228 5493	(08) 343 3070	(08) 228 5323	
Average No. of days per month to be devoted to project	Martin Ma	anthuna din muandi and	S	
Prolonged absences	andagikayaanmak xarrir nisigi aratikaraniiaa. G	nemanalani)arkan(juganaran)tu)tankanikanikan V	iani - animanamanamanihinanamanamanamana 	
within the duration of the	gargiekuningen munikale om eintelandukteran saun munik	enturitariji teresi ili ililin proven enpulumini mara dibi.	opport from the second of the	
project.	(C)		ann an ann ann ann ann an ann an ann an	

마이 마니프, 이 15. 동안 교회에서 선생하는 일이 가능하네요. 현대는 기계를 하는 것이 하는데, 이번 10. 10. 10. 10. 10. 10. 10. 10. 10. 10.	T	\$ (estimate)	·
YEAR	1990	1991	1992
Organisation's own funds*	8,000	8,000	8,000
NERDDC	85,323	46,463	49,126
CSIRO/UNIVERSITY OF ADELAIDE	9,960	and conditions was fired a section of the	ti re constantini di periodori
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TOTAL	103,283	54,463	57,126

^{*}Exclude salary of Supervisor—see note 11.

PART B: ESTIMATED PROJECT EXPENDITURE REQUESTED AS A GRANT

(a) Project Staff Employees*	Full-time Annual Salary (\$)	Period to be employed on project	Full-time man months equivalent on project	Estimated Cos \$
(I) Professionally Qualified		L	ilanini allahamidan dakamada	A manifement of the manifest file.
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(II) Other		10	inparii ling aparii (aleriki ili pirii aparii (ili apa	
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	1	Total Salary Expenditu	re (excluding on-co	osts)
(b) On-Costs				
Items		Percentage of Annual Salary		
(i) Payroll Tax (ii) Workers Compensati (iii) Superannuation Conti (iv) Holiday Pay Loading (v) Long Service Leave (vi) Other (Specify)	tribution	quantitise determine province de la		
Total Percentage of Salar	У		Total On-Costs	<u> </u>

11. PLANT, EQUIPMENT AND MATERIAL EXPENDITURE IN THE GRANT YEAR	Estimated Date of Purchase	Expenditure (Include Install. (\$)
THIN SECTION PREPARATION (DEPT. GEOL. & GEOPHYSICS)	fluoring and the state of the	7,500
THIN SECTION PREPARATION OF THE TOTAL SECTION PREPARATION OF ADELAIDE)	petite (stationary street and stationary street	6,000
USE OF XRD & XRF (DEPT, GEOL, & GEOPHYSICS)		5,000
LABORATORY EQUIPMENT, CHEMICALS, FILM FOR SEM,	Accession and inchestions	6,745
CL AND T.S. WORK	Esting spreidsprending freezielden	alari ilisaridan darahan dalah mengana
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ન્યુપાલના માત્ર કરેલા કરેલા માત્ર કરતા કરતા કરતા કરતા છે. તેલા માત્ર કરતા કરતા કરતા કરતા કરતા કરતા કરતા કરત		ingan salintanakanakanakanakan
ત્રીમાં દુધ કર્યા ઉભાગોમાં સંસ્થારિક કર્યા કર્યા કર્યા કરવા છે. તેમાં કર્યા કરવા કરવા કરવા કરવા છે. તેમાં કરવા કરવા કરવા કરવા કરવા છે. તેમાં કરવા કરવા કરવા કરવા કરવા કરવા કરવા કરવા		
and the state of t	and an analysis and a state of the state of	\$ 25,245

^{*}Excluding Supervisor—see Note 11.

12. OTHER EXPENDITURE IN THE GRANT YEAR (Details to be attached)	\$
(a) Computing Charges	an <mark>andana</mark> anamanifinamaa
BETWEEN ADELAIDE & CANBERRA (b) Travel BETWEEN SAIT & NCPGG	2,800
INFORMATION DISSEMINATION (c) Other (Specify) SUBCONTRACTS	.11,350 37,520
HIRB OF TECHNICAL ASSISTANT	450
\hat{eta} estimated total other expenditure	\$ 52,120

Calendar Year	1989	1989/	/90	1990/	91	1992	
		Distribution by Six Months Beginning					TOTAL
COST ITEM	1 July	1 January	1 July	1 January	1 July	1 January	\$
Salary and Related Expenditure (Item 10)	v	9			n.		
Plant, Equipment and Materials (Item 11)		12,623	6,311	6,311	<i>b</i> '		25,245
Other Expenditure (Item 12)		1,608	1,608	19,643	19,643	9,618	52,120
TOTAL		14,231	7,919	25,954	19,643	9,618	77,365

PART C: SUPPORTING DETAILS

Supporting details should be on pages of the same size as this form, attached to the application, and numbered consecutively.

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PART C: SUPPORTING DETAILS

A Management organisation

The project will be managed and co-ordinated in overall concept by Dr W.J. Stilart (Director, NCPGG). Mr B. Farrow (Lecturer, SAIT) will supervise the operation and interpretation of data from the gamma ray spectrometer, the manipulation of results stored in the data base and integration with wireline log information. Dr N. Lemon (Consultant, NCPGG) is responsible for sedimentological interpretation, basin analysis and the supervision of students working on topics related to the project.

2. Major stages of the project, Stage 1 DATA AQUISITION

Task a

Selection and processing of core samples, by gamma ray spectrometry. Natural gamma ray spectral logs (NGS) yield information on the relative abundances of the naturally occurring radionuclides potassium-40, thorium-232 and uranium-238. The proportions of these elements reflect the clay mineralogy which is intimately associated with rock permeability and diagenesis. Clay mineralogical descriptions are available from the initial phase of this project and so interpretation of results from the gamma ray spectrometer can be relatively quickly assessed. Apparatus for low level gamma ray spectrometry has recently been assembled at the South Australian Institute of Technology. Tests have shown reliable results from drill core samples of between 2 and 5 kilograms when counted for a period of 24 to 48 hours. Thus three to four samples per week may be processed. A maximum of 100 samples will be run initially to allow suitable statistical analyses. A part-time technical assistant is required to load and unload the samples, so that Mr Farrow can process data. At 3-4 samples per week it will take approximately 28 weeks to process 100 samples. An additional period of approximately 10 weeks is required to interpret and compare the data to wireline logs. This work should complete objective if of the project.

Collaborative work with CSIRO to determine whether smeetite to illite transformation has occurred in shale units between the reservoir sandstones. This requires XRD, SEM, and TEM analyses and will be equitably divided between the NCPGG and CSIRO. Once the less than 2 micron fraction has been separated from 40 samples, the clays can be prepared as oriented samples for XRD and sedimented duto TEM grids. SEM work can be undertaken on freshly fractured chips. Estimated time framework to complete this task (which corresponds to objective iii) is as

2 weeks to separate the clay fraction for XRD and TEM. A part-time technical assistant should be employed to assist with this sample preparation.

3 weeks running and interpreting clay mineralogy

Depending on availability of machine time the SEM and TEM work will take approximately 3 weeks.

To construct maps showing relative proportions of kaolin and illite in each reservoir sandstone at least 50 samples from each formation would be analysed. Samples for this work are already available in the NCPGG. A technical assistant would separate clay fractions from the rocks and prepare them to be run as oriented XRD samples and for XRF (X-ray flourescence). Chemistry identified by the latter technique would allow a semiquantitative estimation of the proportions of clay minerals. Approximate time framework required to complete this task; Clay separation and XRD sample preparation 6 weeks. Running and interpreting XRD and XRF data would take 10 weeks. Construction and drafting of maps, 2 weeks.

Task d

CL work on 50 samples from each formation to construct maps showing the degree of silicification. Samples for this work are already in house and data can be combined with student results from additional fields (Task e). Once polished thin sections have been made (7 weeks) and photographed (5 weeks), the photographs can be measured and an estimate of the degree of silicification obtained (4 weeks). Compilation and drafting of maps will probably take 2 weeks.

Completion of task's c and d will achieve objective i.

Task e

Supervision of Masters and Honours students in the NCPGG who will undertake thesis work involving petrographic, sedimentological and structural descriptions of Permian reservoirs in the Dullingari, Daralingie, Della and Mudera Fields. This work can not commence until the students have finished their course requirements. Once cross plots from wireline log data have been constructed, core and ditch cuttings will be described and sampled. Samples will be analysed by XRD, SEM, CL and in thin section. Results will be entered into the data base where they can be utilised in conjunction with existing data to correlate factors controlling porosity and permeability. The completion of this task should satisfy objective vi.

Task f

Separation and running of oxygen isotope analyses to partially satisfy objectives vend vi. Clays separated in task c will be further prepared for isotope work by extracting a less than 0.02 micron fraction to ensure that the illite is authigenic. For kaolin samples the isotope work can be done on <2 micron fractions. Quartz overgrowths must be separated from detrital grains by etching and fracturing. Samples will be selected from 8 wells scattered across the basin, and one sample taken from each of the 3 formations. In total there will be 72 samples for oxygen isotope analyses. Preparation time is anticipated as 6 weeks, with an additional 7 weeks to run the samples. Results from quartz overgrowths should then be checked against fluid inclusion work.

Task g

Rb-Sr isotopic analyses on the 30 illite samples prepared for oxygen isotope work should establish the time of crystallization. These results will be checked by running K-Ar isotopic analyses on selected samples. In total Rb-Sr and K-Ar anlayses should take approximately 8 weeks.

The results of task's f and g, combined with other data, such as vitrenite reflectance, will permit the completion of objectives v and vi. This interpretation may take considerable time and the need for additional isotopic analyses could become apparent. Sufficient time should be allowed for this eventuality.

Stage 2 FINAL REPORT AND INFORMATION DISSEMINATION Task h

Preparation of final report, integrating data from all subsections of the study. Submission of manuscripts on various aspects of the project for journal publication. Presentation of results at relevant conferences and monthly meetings of PESA.

Furthermore, a workshop will be organised, for industry and academic personnel, at which the results and implications of the project can be presented.

3. Market potential

Information gained from this project should be of substantial advantage to the petroleum industry. Factors controlling porosity and permeability, and their spatial distribution in the southern Cooper Basin will be clearly defined. This should demonstrate to industry the advantages of this type of research and encourage future funding.

what dos and why

Diagenetic maps illustrating high and low concentrations of authigenic silica and clays will be useful in predicting the location of zones with good reservoir potential. This information will be further augmented by a knowledge of the source of silica. If smectite is being converted to illite in the shale units, with a consequent release of silica, then sandstones immediatedly adjacent to shales are more likely to be cemented.

Specific knowledge of diagenetic events in each major field of the southern Cooper Basin may help to explain production problems in some areas, for example Moomba #3. In the past information concerning diagenesis has been sporadic, but the results from this study will provide a thorough coverage of many important fields.

One question frequently asked during discussions with personnel from the petroleum industry is the timing of diagenetic events, including hydrocarbon migration. This question will be answered through combined petrographic and isotopic analyses.

In the past most drilling has aimed at structural traps. Once the direction and nature of fluid migration across the basin can be ascertained it may be possible to

predict the location of diagenetic traps.

Gamma ray spectrometry results will enhance knowledge of the relationship between rock composition and wireline logs (gamma ray). This could lead to better reservoir estimation.

4 Technical, economic and other benefits

Significant benefit to industry from this project will be achieved by the prediction of favourable drilling sites, based on a knowledge of diagenesis, sedimentology and structure. New plays may be associated with combination stratigraphic-structural and diagenetic traps.

Additional benefit will be realised when secondary recovery is attempted from wells in the study area. Detailed knowledge of clay mineralogy in these wells will allow the appropriate drilling mud composition to be selected to maximise recovery.

assist in production of hydrotabou

5 Industry links and business plan

Co-operation with Santos and the other Cooper Basin partners was established for the initial project. Communication will be maintained with industry, and the

exchange of knowledge encouraged.

Links are also being formulated with other Tertiary and government institutions. Collaborative work with CSIRO Division of Soils to undertake clay mineralogy and Australian National University for isotopic analyses will significantly enhance human resources applied to this project.

6 Information dissemination

Information dissemination will be actively pursued via reports, journal publications, and seminars. Presentations at conferences, such as APEA, are another possible means of transferring information to industry which will be undertaken.

Anticipated cost of drafting and photography for papers and conferences is \$4000.

Production of final report \$3000.

A 2 day workshop for industry and academic personnel will be organised when the project is near completion. It is anticipated that at least 50 people would be invited to attend, with a high proportion of that total coming from industry. This workshop could be held in conjunction with the presentation of results on fluid inclusions by Dr. Y. Bone. Lectures would be designed so that the information was presented for specific fields, and as a whole for the southern Cooper Basin.

Techniques involved would be clearly explained and ample time given for discussion. Participants would be given the opportunity to view thin sections, SEM samples, and XRD results, and the retrival and manipulation of the data base would be

demonstrated so that future exploration could utilise this information. Clearly this type of practical experience is most successfully illustrated at a workshop. Anticipated costs involved with the workshop would include:

	왕이 가는 사람들이 가는 것을 하는 것이 되었다. 사람들은 사용하는 것이 있다면 하는 것은 사용을 다 했다.	(\$)
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2. Return air fares for Dr Chiva from ANU to present th Courrent cost \$482 single	ie isotope resuits le return)	1,000
3. Provision of morning and aft \$2.00/person	ternoon tea @	200 50
4. Printing of invitations5. Welcoming reception @ \$12	2,00/person	<u>.600</u>
물리는 경기 가입을 살으면 됐다.	S subtotal	\$4,350
Total cost for information	on dissemination \$11,350	

7 Facilities available

The NCPGG has access to the following facilities which are vital to the successful completion of the project;

1 Lapidary for thin section preparation

2. Petrographic microscopes

3. Cathodoluminescence microscope

4. X-ray diffractometer

5. X-ray fluorescence spectrometer

6. 2 scanning electron microscopes with energy dispersive spectrometers.

7. High voltage transmission electron microscope with energy dispersive spectrometer.

8. Photographic and drafting facilities

9. Vax computer for storage and manipulation of data base

8 Related research Bibliography of significant publications.

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Rb-Sr and K-Ar isotopes

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The proposed project will compliment related research by effectively utilising for the first time in Australia, methods developed for North Sea and Gulf Coast oil fields. Use of cathocoluminescence to study the proportion of authigenic quartz cement and degree of compaction is innovative for Australia. Similarly the use of a gamma ray spectrometer to relate mineralogy and petrophysical logs has not been undertaken in Australia. In the past, alotopic analyses of clays and quartz have been applied to metamorphic terrains but rarely to sedimentary basins in Australia. Clearly isotopes have been utilised to great advantage elsewhere (e.g. Lee et al 1985) and since the technology is available in Australia these techniques should be applied for the benefit of the petroleum anastry. of the petroleum hidustry.

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9 Progress with current grant

a) Expected foul expenditure on current grant by scheduled completion date is \$39,000.

b) Summary of main project findings to date: i. Porosity is best developed in well sorted, medium to coarse grained sediments of point bar sequences. These characteristics typify rocks where the proportion of illite is low and diskite is present rather than kaolinite, and significant amounts of other authigenic minerals are absent. Fine grained shoreline sands also have good porosity

and permeability where silicification is minimal,

il. Primary porosity has been partially preserved in some coarser clastics due to the introduction of an early quartz cement. Quartz overgrowths acted as a rigid framework to resist the effects of compaction. Secondary porosity is of importance where labile components (rock fragments, feldspars and carbonates) have been

iii. Porosity and permeability are significantly reduced by detrital illite in fine grained flood plain and overbank deposits. Kaolinite formed due to the alteration of Kfeldspars and micas, and is the dominant kaolin mineral in finer grained clastics. Dickite precipitated from solution in coarser grained materials and is associated with high microporosity. Where microporosity is abundant sandstones provide targets for gas exploration when artificially or naturally fractured. Results indicate that total porosity values derived from petrophysical calculations are likely to overestimate effective porosity in rocks with a high proportion of kaolin minerals.

iv. Distribution of authigenic minerals is partially depth related. Pyrophyllite and chlorite concentrate in the central Nappamerri Trough. The abundance of authigenic illite (less than 2 micron fraction) increases with depth in the Big Lake Field and

possibly elsewhere. y. Diagenetic events probably occurred in the following paragenetic sequence. Micritic siderite precipitated from groundwaters in the vadose zone and was probably the earlisst diagenetic event. Silicification occurred during at least two main phases. Some sandstones of the Toolachee Formation, show that a proportion of the quartz overgrowths developed prior to significant compaction and therefore are a relatively early event. Precipitation of quartz overgrowths probably continued through several other phases of diagenesis including the kaolinisation of feldspars and micas. In other areas, and finer grained rocks, where compaction occurred prior to precipitation of overgrowths, intense intergranular dissolution is abundant. Overgrowths were inhibited in many finer grained rocks by the present of detrial illite. Feldspars and micas were altered to kaolinite, liberating Si for the precipitation of quartz overgrowths; as the supply of Si decreased dickite was precipitated. Thus dickite formation postdates that of kaolinite. Alkaline conditions prevailed after the formation of large euhedral quartz overgrowths causing their partial dissolution. Sparry carbonates were possibly precipitated during this period. Compositional variations in the carbonates are thought to be related to the chemistry of migrating fluids. Authigenic illites probably formed during periods of deeper burial when 7smectite, kaolinite and K-feidspars were altered. The final diagenetic events are depth and temperature related, with the formation of clinochlore IIB and pyrophyllite. vi. Isotope work on the carbonates indicates the influence of meteoric waters and a cold climate.

vii. A satistical method has been developed by which the permeability of Permian sediments may be estimated from wireline logs.

c) Extent to which the original objectives have been achieved;

- in terms of the number of wells sampled the project has exceeded the original estimation.

- diagenetic factors controlling porosity and permeability have been identified,

and their relationships to sedimentary facies assessed.

- basic well data generated from earlier exploration and development drilling has

- quantification of the proportion of diagenetic silica in creating reservoirs of poor quality is in progress.

d) Difficulties encountered have been minimal. The only limitation has been a time constraint which will not permit full utilisation of the data base and construction of diagenetic maps.

e) Reasons why further support is considered necessary.
Results from the initial project are considered very promising, yet they can not be utilised by industry to their full potential without additional work. The initial project has clearly illustrated what additional information is required, personnel and equipment are available to continue the project, the background research has been thoroughly undertaken and even the samples in many instances are already available. Given sufficient time and resources to complete all the research outlined in this application, the potential predictive information concerning future drilling sites and secondary recovery from existing wells will be of vital economic assistance to the petroleum industry.

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10. Sub-contracted Work Expenditure

Amdel has been chosen as the subcontractor for core plug analyses because this is the best and most efficient service available in South Australia. Amdel's close proximity to the core library leads to the successful co-operation between these two bodies. Since numerous core plugs have already been taken in the fields proposed for further study, it will not be necessary to take more than about 70 new plugs.

Amdel has also been chosen for the K-Ar dating because of the high standard of work produced by Alan Webb. It is not possible to undertake these analyses in the University. The rate of \$550 per sample is a commercially acceptable figure.

Oxygen isotope facilities are not available anywhere in South Australia and rather than try to set up facilities here it was decided to subcontract the work. The price of \$150/sample is very reasonable, considering other organisations are charging \$200. Dr Allan Chivas has considerable experience in oxygen isotope work, in particular he has worked on soils which are similar to the clay extracts and quartz which are intended for anlayses in this project.

Rb-Sr isotope analyses on illites are probably the most difficult to obtain accurate results because of small sample size and problems of contamination. For these reasons it is essential that this work be done using a multiple collector mass spectrometer. The ANU laboratory has lower contamination than any other laboratory in Australia because it is new, and the mass spectrometer is capable of producing high precision results on small samples. The very low price of \$340/sample has been extended to the NCPGG as an indication of genuine interest in the success of this project.

Please find attached documentary evidence from each subcontractor of the prices used in estimating costs.

Name of contractor	Brief description	Cost
ÁMDEL	CORE PLUGS (ø & k) @ \$70/SAMPLE	5,000
AMDEL	K-Ar DATING @ \$550/SAMPLE	11,520
ANU	OXYGEN ISOTOPES @ \$150/SAMPLE	10,800
ANU	Rb-Sr ISOTOPES @ \$340/SAMPLE	<u>10,200</u>
	TOTAL	37,520

RESEARCH SCHOOL OF EARTH SCIENCES THE AUSTRALIAN NATIONAL UNIVERSITY

INSTITUTE OF ADVANCED STUDIES • G.P.O. BOX 4, CANBERRA ACT 2601 TEL; 062 49 3406 • TELEX 62693 • FAX 062 474639

19 April, 1989

Dr Bill Stewart
Director
National Centre for Petroleum Geology & Geophysics
University of Adelaide
Box 498, GPO
Adelaide SA 5001

Dear Bill

This is to confirm our willingness to undertake oxygen-isotope analyses of quartz and clay mineral separates for your proposed research project. I understand that analysis of up to 72 samples will be required. Our standard fee for this kind of work, involving oxygen extraction using bromine pentafluoride and mass spectrometric analysis of the extracted gas, is \$150 per sample. Approximately 10 to 15mg of each sample will be required.

Yours sincerely,

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archiver

Allan R. Chivas Group Leader Environmental Geochemistry Group.



(17)



Amdel Limited (Incorporated in S.A.) 31 Flemington Street, Frewville, S.A. 5063

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19 April 1989

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Dr W J Stuart National Centre for Petroleum Geology & Geophysics GPO Box 498 ADELAIDE SA 5000

Dear Dr. Stuart,

QUOTATION FOR K-AF GEOCHRONOLOGY

In response to a request from Ms. S. Phillips, I wish to advise that our charges for k-Ar geochronology, on samples of illite prepared by your Centre will be as follows:

Until 30 June 1989 : \$480 per sample After 30 June 1989 : \$550 per sample.

In addition, our charges for routine core analysis are:

Plug drilling and plug trimming \$5.00 \$5.00 Extraction Helium injection porosity and air permeability \$55.00 \$55.00 \$55.00 \$70.00

We look forward to being of assistance to you in this matter.

Yours sincerely,

Man Webl

Alan W Webb Senior Geochronologist Geological Services

AWW/bp

Offices in Sydney, Wellbourne, Perth, Brisbane, Canberra, Darwin, Townsville, Represented world-wide

RESEARCH SCHOOL OF EARTH SCIENCES THE AUSTRALIAN NATIONAL UNIVERSITY

INSTITUTE OF ADVANCED STUDIES . G.P.O. BOX 4, CANBERRA ACT 2601 TEL: 062 49 3406 · TELEX 62693 · FAX 062 474639

26 April, 1989

Dr W J Stuart National Centre for Petroleum Geology and Geophysics GPO Box 498 Adelaide SA 5001

Dear Bill

I write in confirmation of a verbal agreement between Mark Fanning of RSES and Sally Faillips of the National Centre for PGG to the effect that RSES (Mark Fanning) is willing to carry out Rb-Sr analyses of thirty illite samples prepared by Sally Phillips at a cost of \$340 per sample. Included in this cost is an interpretation of the Rb-Sr systematics in the context of the overall data concerning the clay genesis.

Yours sincerely,

Malcolm McCulloch.

REFEREES

The following are suggested referees for the proposed project:

Mr. Terry Bair - SANTOS Ltd.

Mr. Bob Laws - SADME Dr. Mr. David Gravestock - SADME

SENRAC ASSESSMENT CHECKLIST

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PROJECT NO:

ASSESSMENT OFFICER:

NOTE: Answer to each of the following questions should be supported with relevant argument and background by way of concise attachments

\$		YES	NO	NOT RELEVANT	ATTACHMENT REFERENCEΩ
1. Do re	es the project address a priority S.A. search or development area?				
2. Is ⊕ im	there a detailed plan for plementation of the results?				
fr	there significant financial support om an industry or community user of e results?				
4. Ar	e there potentially significant users the results in S.A.				
5. (A) Has a first order cost-bunefit analysis been done relative to existing technology? IF NO	W.			
) Should SENRAC invest in such an analysis?				
(C	OR) Should SENRAC study the conditions under which economics would become more attractive?				
6. (A) Has assessment of relevant overseas or interstate work been done? IF NO				
(B) Should SENRAC invest in such an assessment?	6			
7. (A) Are relevant RDD programs in progress elsewhere in Aust. or overseas?	,			
(B	IF YES) Is it possible to join such a program? IF NO				
(c) Should SENRAC investigate the feasibility of commencing a cooperative program with workers elsewhere?				
8. (A) Is local expertise/infrastracture capable of executing the work?				
(b	IF NO) Should SENRAC set up a program to upgrade the local capability?				

PROJECT NO:

PRINCIPLE CONCLUSIONS:

RECOMMENDATIONS:

(A) GENERAL

(B) MAGNITUDE AND/OR DUPATION OF GRANT

COUNCIL-IN-CONFIDENCE

NATIONAL ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION COUNCIL

ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION PROJECTS

1987 APPLICATION FOR SUPPORT GRANT

FACTORS RELATING TO THE DEVELOPMENT OF POROSITY AND PERMEABILITY IN

PERMIAN SANDSTONES OF	THE SOUTHERN COOPER BASIN	araniananananananananananananananananana
The second secon	RSITY OF ADELAIDE	antananan-ramananan kataman
Applicant OrganisationTHE UNIVER		
Applications should be lodged with:	IMPORTANT	OFFICE USE ONLY
The Assistant Secretary Research Policy and Programs Branch Department of Resources and Energy Postal Address: G.P.O. Box 858 CANBERRA ACT 2601	Refer to reverse side of this page for background information. Original plus 9 copies of each proposal and supporting documentation are required. Il space on this form is	Dale received
Street Address: Room 415, Level 4 Jollmont Centre 65-67 Northbourne Ave CANBERRA CITY ACT 2601	insulticient, supply details on separate pages, Closing date for applications is 22 May 1987, Late applications Will not be	Application No.
Enquiries: Tel, 062-45 8548		(I) The war I cast and which were both
Enquiries: Tel. 062-45 8548 * Does not apply to revised versions of applications that were unsuinvited in December 1986. The closing date for such applications of the control of the con	UBLIC OFFICER/HEAD' OF ORGANIS	
i, being the duly appointed Public Officer/Head* (a) the information given in this application (b) the organisation has the basic facilities reprogram of activities set out in this application the salaries quoted for personnel are in the salaries applicable. In take of Universities and administration	of the organisation, declare that n, including any attachments hereto, is true equired for the project and, subject to being aw plication; and in accordance with the practice of this organ d Colleges of Advanced Education the application needs to	and correct in every particular; varded a granf, it will adhere to the hisalion. . be alphed by a senior officer of the beniral
HIBHATURI	PRATIL ROBINSTER	DATE 61.8.15.7

COUNCIL-IN-CONFIDENCE

NATIONAL ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION COUNCIL

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FACTORS RELATING TO THE DEVILOR.

LOSITY AND PERMEABILITY IN

PERMIAN SANDSTONES OF THE SOUTHERN COOPER BASIN

Applicant Organisation THE UNIVERSITY OF ADELAIDE

Applications should be lodged with

The Assistant Secretary Research Policy and Programs Branch Department of Resources and Energy Postal Address: G.P.O. Box 858 CANBERRA ACT 2501

Street Address! Room 415, Level 4 Jollmont Centre 65-67 Northbourne Ave CANBERRA CITY ACT 2601

Enquiries: Tel. 062-45 8548

IMPORTANT

Refer to reverse side of this

päge lor background information. Original plus 9 coples of each proposal and supporting documentation are regulred.

Il space on this form is Insufficient, supply delalis on separate pages.

Closing date for applications is 22 May 1987. Late applications will not be considered.

OFFICE USE ONLY

RANT

Date received

Application No.

* Does not apply to revised versions of applications that were unsuccessful in previous Coal Mine Safety Round or Additional Coal Round (Coal-only Round) which were both invited in December 1986. The closing data for such applications will be 19 June 1987.

CERTIFICATE OF PUBLIC OFFICER/HEAD' OF ORGANISATION

- I, being the duly appointed Public Officer/Head' of the organisation, declare that
 - (a) the information given in this application, including any attachments hereto, is true and correct in every particular;
 - (b) the organisation has the basic facilities required for the project and, subject to being awarded a grant, it will adhere to the program of activities set out in this application; and
 - (c) the salaries quoted for personnel are in accordance with the practice of this organisation.

"Delete whichever is not applicable. In case of Universities and Colleges of Advanced Education the application needs to be algred by a senior officer of the Cantilat

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PART A: PROJECT AND BUDGETARY INFORMATION

PROJECT Project Title	FACTORS RELATING TO THE DEVELO PERMEABILITY IN PERMIAN SANDST BASIN	ONES OF THE SOUTHERN COOPER					
CONTINUATION APPLICATIONS ONLY If thus application seeks continuation funding of a project cut isn'tly supported under the NERDAD Program, specify the current project number. (Relet paragraph 15 in Background Information Notes on	0 00						
reverse side of page 1)							
APPLICANT DRGANISATION , a Applicant organisation Other organisations involved should be listed as subconitaciots under item 13.							
b. Postal Address (i) Street of P.O. Box	GPO BOX 498.,						
(ii) Suburb o Cily	ADE(,A1DE						
(iii) State and Postcode	S.A. 5001 0						
c Peisonin CENTRAL ADMINISTRATION to whom collespondence should be directed	HUDSON Surname	MR. G. M. Title & Initials					
d Designation of person specified in 26.1	ASSISTANT REGISTRAR - RESEAR	H					
e. Administration Telephone No.	08 228_5551, AA_89141	31					
Central Administration Telex No. Division or Department of Organisation in which the project would be undertaken.	NATIONAL CENTRE FOR PETROLEU (NCPGG)	MGEOLOGYANDGEOPHYSICS					
PROJECT SUPERVISOR a. Principal Project Supervisor	STUART Suifiame	DR. W. J. Title & Initials					
PROJECT LOCATION Specify the location all which the majority of the work for which support is sought will be undertaken.	DEPARTMENT OF GEOLOGY AND GEOLOGY OF ADELAIDE	OPHYSICS					
B. SpecifyState Teffitory of 46	S.A.						
SUMMARY OF REQUESTED FUNDS a From date of approvation 1.2.86 (Rader paragraph 12 of Background Information	\$54,72\$						
Notet on teverse side of page 1) 5 1989	546,301 the	se amounts should be same as the totals of Is sought showh under					
6. 199 0	liet	n Son p. 8					
d forat	\$101,016						
6 NERDADPHOGRAM CLASSIFICATION							
Select from the list on the leverse side of page 1 the classification which best describes the technology and the project	net [0.1.03						

7. SUMMARY OF OLUCCTIVES, WORK PROGRAM AND IMPLEMENTATION Relate only to those espects of work for which funds are being sought in this application

(a) Objectives (Summarise those to be accomplished with the grant sought — Further details should be provided as nocessary under hem 16(a)). Petroleum exploration in the Cooper Basin is fast approaching a mature stage. For this reason, detailed petrographical studies in conjunction with petrophysical studies are required as a basis for future exploitation of petroleum reservoirs. To provide results which can lead to a substantial increase in petroleum reserves, the following objectives are proposed:

- The major objective of this project is to define the interaction of diagenetic factors, sedimentary processes and structural growth which reflect upon the quality of Permian sandstones in the Cooper Basin. This will explain why there is wide scatter of values in porosity-permeability cross-plots constructed for sandstones comprising the Patchawarra, Epsilon and Toolachee Formations.
- A secondary objective of this project is to define the diagenetic history of Permian sandstones as a function of depth, particularly in wells where secondary silicification and authigenic kaolinite affect adversely reservoir quality. It is important to study the influence of diagenesis on a subregional basis, because the same general rock units occur at different structural depths between the southern edge of the basin and the deep Nappermerri low.

The results of objectives 1 and 2 will provide industry with data to better exploit reservoirs in existing fields and new field discoveries. In addition, this research together with standard exploration techniques will also help to better define the prospectivity of less explored areas in the southern Cooper Basin. Further, the anticipated success of this project will lead to the application of these methods by industry to other hydrocarbon provinces.

- (b) Work Program (Brief summary of specific work which would be undertaken Further details should be provided as necessary under flem 16 (b)) The proposed project will complement stratigraphic and sedimentological studies of Permian sequences encountered in fields situated in the southern flank of the Cooper Basin plus data from deep wildcat wells in the main depositional axis of the basin - the Nappermerri low (see attachment). This will include the correlation of stratigraphic sequences penetrated by wells in conjuction with seismic profiles on a field by field basis. This study is in progress with students undertaking routine stratigraphic and structural analyses of available field data (See item 16b).
- An examination of available core data will be undertaken to ascertain the genesis of specific sandstones and for the selection of available sandstone plugs. Additional . 2 . core plugs will be collected as infill data for core analyses and petrophysical, SE"; and XRD studies.
 - Petrophysical and petrological data will be correlated with available porosity and permeability cross-plots. Cross-plots of porosity and permeability values will be generated via in-house Mincom Geolog Software. In addition, these data and cross-plots exhibiting log (Neutron, Sonic and Density) porosities will be correlated with 3. textural parameters obtained from petrographical methods. The interpretation of these data will take place during this stage of the project.
 - Preparation of displays which will exhibit genetic rock units and results obtained 4. from Item 3.
 - A series of maps will be prepared to illustrate diagenetic "facies", particularly those relating to depth of burial on a local and subregional scale. These maps will 5. be compared and interpretated with those exhibiting sandstone factos trends, isopach and basin structure.

7. SUMMARY OF DUJECTIVES, WORK PROGRAM AND IMPLEMENTATION (Continued)

The following intermalian is required to projects will potential for adoption by industry or leading to manufacture of equipment.

(c) What potential applications have been identified?

The methods and results are considered essential for a better understanding and exploitation of petroleum reservoirs in existing fields and the prospectivity of areas relatively unexplored in the Southern Cooper Basin. We foresee the application of these methods to hydrocarbon provinces located in several Australian onshore and offshore areas. In fact, most companies have both core and log porosity-permeability analyses of sandstone reservoirs, but the roles of sandstone genesis and diagenesis correlated with these reservoir data should provide important results for

(d) Detail links established willy industry and proposed plan for implementation

The proposed study area is the Cooper Basin

the exploration and exploitation of hydrocarbons.

Santos Ltd. will supply most research data including samples, cores, log suites, porosity-permeability cross-plots and well completion reports. This company together with Euso Australia Ltd. and the South Australian Oll and Gas Corporation (SAOGC) support the on-going operations of the National Centre (\$100.000/yr.).

(e) For projects involving development of new additionant, detail any plans of proposals for prototype and or follow on manufacture, including the extent of participality to Australian industry.

Major results will be published with expected companies' approval. We do not anticipate problems for publications because several theses, which have utilized company data; are on open file at the Department of Geology and Geophysics, University of Adelaide. National Centre Advisory Board members whose companies represent the majority of interest holders in the Cooper Basin have stressed the need for National Centre publications.

B. Explain why the work proposed is not likely to staff or, in the case of an existing project, be continued without the support of the grant sought.

Although industry and government have been extremely generous in financing the on-going operations of the National Centre, there is a need for outside assistance to complete this project. The National Centre Will require funds to operate SEM equipment, do core analyses and finance a research assistant to undertake personal research, help advise students and monitor research. The National Centre will provide one of its research staff who will collaborate with a staff member from the South Australian Institute of Technology. Another staff member who has been appointed as a Senior Lecturer in the Centre may also be available for research.

COUNCIL-IN-CONFIDENCE

D PHOLES BUPERVISORISI	PRINCIPAL SUPERVISOR	DIHER BU	r nvisors			
	Ust aupervisor's name given at 3(e)	(P)	(9)			
Name.	W. J. STUART	B, B, FARROW	N. M. LEMON			
Outlifeatons:	B.Sc., M.Sc., Ph.I.	B.Sc., M.Sc.	B.Sc. (Hons)			
Designation,	Director	Lecturer 0	Senior Teaching Fellow			
Business Address:	NCPGG GPO Box 498 ADELAIDE SA 5001	SAIT PO Box 1 INGLE FARM SA 5098	NOPGG GPO Box 498 ADELAIDE SA 5001			
Telephone No :	(OR) 228 5493	(08) 343 3070	(08) 228 5323			
How much time in working days per month as an average will the project supervisor devote to this project?	4 days	8 days	4 days			
Are any prolonged absences envisaged during the currency of this project which will altect its conduct?	No	NÖ	NO			
Is II proposed that salary costs for any of the project supervisors be claimed against the project? (If yes, please note guidelines under frem 11 on page 6)	NO G	ÑO	NO C			
Briefly builline felevant experience and any other major research projects being undertaken and for closely supervised by the project supervisors and their time demand. (Insert prefutes (2) and (3) and details it more than one project supervisor)	industry for a f most phases of p exploration proj Dallas Research	f the National Centre has worked with period of 18 years and is experienced in petroleum exploration. These include ojects worldwide, a period at Mobil's h Laboratory and four years involvement dies related to in the Cooper Basin.				
	well logging tec who will support logging techniqu considered neces	as 11 years experience chniques. He is a ver this project in the ues, and mathematical seary for the correlat bility values with tho	y capable researcher application of well algorithms ion of core			
	with basin analy sandstone diagen	nas 10 years experienc ysis studies. Mr. Lem nesis, instructing stu is also competent Wir	on is "mpetent in dents in this			

10 OTHER SUPPORT (directly associated with this project if grant approved of Burbacided external sources of funds for work directly associated with the project. Attach details of phanned expenditure by the applicant organisation and expenditure from approved or expected external sources of funds for work directly associated with the project. Attach details of any applications for support made to other granting schemes where a decision is still pending. Do not include any funds expected as a result of this application.

and petrographic technicles, and is an expert in syntectonic sedimentation.

A Albana secretaria de la cardina forma de la composition de la cardina			\$ (éstimáled)		
Organisation providing support	Nature of support	1988	1080	1650	
SANTOS, LTU , SAOGC	Samples, Cores, Core analysis,	engilisas spraifianies	*********************	-je-zelitatum	
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ESTIMATED PROJECT EXPENDITURE REQUESTED AS A GRANT

Council will consider all identifiable direct costs if it can be demonstrated that they are essential to the project.

Overheads, including administrative and any other costs which

can only be nominally allocated to the project on a proportion basis, may only be included in the case of non-profit fee-for-service organisations or consultants.

11, SALARY AND RELATED EXPENDITURE

Salary expenditure will be considered provided that it is not already paid by a public authority of by an organisation using Commonwealth of State funds. Support requested for project staff should not exceed the salary scales of conditions of the agency-tequesting the lunds and should show the official designation of the position (Engineer, Chemist, Technician, Leboratory Assir Not., etc.). Exclude employees engaged solely on fabrication of Innia and aquipment (costs of those should be included under flem 12 — "Plant, Equipment and Materials").

Bhow project employment on a full-time equivalent staff-months basis for each position. Include any anticipated leave.

General administrative overheads, where allowable, and appointment expenses should be specified under flem 14 — Travel, Computing and Other Expenditure.

(0)	Pio	ioci	Stalf

Désignation (Names II possible)	Full-(ime antiual salary (\$)	Period to be employed on project	Full-lime stall-months equivalent on	Estimated co
Research Fellow	27,859 0		project (incl. feave)	(\$)
ananise narangarannyandangarananananansaranan		1 1 88 6 1 1 89	12	27,859
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(b) Ori-Cosis		Total expenditure	VEN DE LA COMPANIE DE	56,969

0	n homs	Percentage of annual selary		
47 1 2 2 3 1 1 1 1 1 1 1 1 1 1	Payroll Tax	5		
	Workers' Compensation Insurance	1.4	나는 아니는 그 아니는 그들은 그들은 그리고 있다.	
(6)	Employers' Superannuation Contribution	14	[14] [44] 의 기계를 하고 된 것이 없었다면 되었다.	
(ív)	Holiday Pay Loading	1.35		
, (v)	Long Service Leave Allowance	2.5		
(v)	Others (specify)	**************************************		
Tola	Percentage of Salary	1.00.00		
		29,25	areco-no lelot	s 15,547
<u> </u>			ESTIMATED TOTAL SALARY EXPENDITURE (A + b)	

12 PLANT, EQUIPMENT AND MATERIALS Applicants are expected to have access to the basic facilities, including compilers, trivers, the proposed research is to be undertaken; provision for special facilities appellic to the project may be included in the application. Support may also be requested to bove: depreciation on Pens of plant e-equipment purchased for the project with the grantee's own funds. Depreciating sates shall be the same as those applying for taxation purposes. Provide defails including method by which depreciation was calculated, as an enachment specific to the project may be included in the application. Individual Plant and Equipment Items costing more than \$2000 per item should be apecified in the table items of Plant and Equipment costling more than \$10,000 become the property of the Commonwealth. Any installation costs should be included. In the case of equipment proposed for purchase, the cost of the equipment and installation should not be estimated but should be based on the latest prices which can be obtained from the supplier. Estimates for imported from of plant and equipment should be based on quoted prices including customs duly where applicable. Maintenance of plant and equipment used on the project will only be supported where it is an identificable direct cost. Include Insurance costs, if applicable, under hem 14 — Travel, Computing an Estimated: Estimated cost dale of (incl. Installation puichase * cosis) a, List frems of plant and equipment costing more than \$2000 per flam for the project (i) liems to be purchased (ii) Hems to be febricated in-house (include cost of malerials and labour) ...THIN ... SECTION ... PREPARATIONDEPARTMENT OF GEOLOGY & GEORHYSICS S.A.O.G.C. and W.M.C. USE OF SEM EQUIPMENT -- UNIVERSITY OF ADELAIDE SOUTH AUSTRALIAN INSTITUTE OF TECHNOLOGY (SENRAC) DRAFTING AND PREPARING OF REPORT 8,000 b. To al cost of plant, equipment and materials which cost less than \$2000 per flem č. Maintanance d. Depreciation on plant and equipment purchased to project by grantee with own funds ESTIMATED TOTAL EXPENDITURE ON PLANT, EQUIPMENT AND MATERIALS 8,000

13. CONTRACTED RESEARCH AND DEVELOPMENT EXPENDITURE

The grantee is responsible for all work carried out on the project. Where sub-contracts are proposed it is preferable if the organisation which will incur the ready expenditure under the proposed grant is the grantee. If this is not considered practicable, supporting reasons must be given for the arrangements but forward and the grantee will be required to ensure that the Commonwealth's interests are protected by placing conditions on the sub-contractor similar to those which the grantee accepts.

It should be noted that for major sub-contracts, the grantee may be required during the life of the project to provide itemised details of sub-contracted expenditure Defail any tasks essential to the project which it is proposed to sub-contract, providing sufficient details to enable Council to evaluate the sub-contracted tasks such details should be included as an attachment.

Name of contractor and period of contract	Brief description of tasks to be contracted out	Eslimated cost	
AMDEL	CORE PLUG EXTRACTIONS (SENRAC)		
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[일본] [일본 사람 학교 등 전 기계를 보고 있다.			
AMDEL	POROSITY - PERMEABILITY CORE ANALYSES	19,000	
\$	SENRAC \$14,000	a annument	
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	ESTIMATED TOTAL CONTRACT EXPENDITURE	A second of the control of the contr	

*Please supply details as an attachment.

14. TRAVEL, COMPUTING AND OTHER EXPENDITURE

a) Travel — Travel will only be supported if directly associated with the project including travel costs for staff engaged on the project incurred in using facilities at other control of the project incurred in using facilities at other control of the spency requesting the funds. The Council will not support favor to control or its against varyed to control or its expension of a proposal. Requests for overseas travel will not be considered unless the applicant has demonstrated that the travel is an integral and essential component of the project. Visits to seek general information (statu-of-the-art visits) will not be supported.

b) Computing Charges — Requests for funds to meet computing costs will only be considered where the costs are charged directly to the project. Funds requested to the employment of additional computing personner or for the purchase of

additional computing aquipment should be included in expenditure items 11 and 12 respectively.

c) Other:

- Onter:
appointment expenses: these will be considered for additional staff shown in liem 11. Wherever practicable personnel should be recruited from within Australia. If it is proposed to appoint staff from overseas, applicants will need to demonstrate why it is not possible to recruit suitable Australian presented, in such cases travel and removal expenses to Australia only will be considered.

 overheads; may only be included in the case of non-profit fee-for-service organisations of consultants.

Please supply an attachment giving details of funds sought and the basis on which estimates were made.	Estimated cost
6 TRAVEL RESEARCH FELLOW HIRED IN AUSTRALIA	700
b. COMPUTING CHARGES STAFF TRAVEL BETWEEN UNIVERSITY OF ADELAIDE AND S.A.	.1.T. 800
c. DTHER (SPECIFY)	
	manager of the state of the sta
ESTIMATED TOTAL OTHER EXP	PENDITURE \$ 500

15. TOTAL ESTIMATED PROJECT EXPENDITURE REDUESTED AS A GRANT

Unless otherwise specified by the applicant, the end of the last six month persenance shown for which funds are sought will be treated as the schoolied completive date of the grant should support be approved.

CALENDAH YEAR "	19	1968		1989		1990	
COST ITEM &	Date of Approval to	DISTRIBUTION BY SIX MONTHS BEGINNING				1 Total	
	30.6.88	1.7.89	1.1.89	1,7,89	1,1,90	1.7.90	- \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
SALARY AND RELATED EXPENDITURE (ITEM 11)	17,308	17,307	18,950	18,951			72,516
PLANT, EQUIPMENT AND MATERIALS (ITEM 12)	1,000	2,000	2,000	3,000			8,000
CONTRACTED H & D EXPENDITURE (1) (M 13)	6,000	10,000	3,000		**************************************		19,000
THAVEL, & NEPUTING AND OTHER EXPENDITURE (ITEM (4)	000	200	200	200			1,500
TOTAL	25,208	29,507	24,150	22,151			101,016

16(a) PROJECT OBJECTIVES

16.

Detailed examination of basic well data generated from earlier exploration and development drilling is expected to aid industry in the exploitation of existing fields and new field discoveries. The major objective of this NERDDC proposal is to qualify and quantify porosity and permusbility relationships of Permian reservoir sandstones occurring at various stratigraphic and structural levels with regard to assessing the influence of sedimentary depositional processes, structural growth and diagenesis.

Permian Toolachee sandstones within near stratigraphic proximity of one another exhibit a wide scatter of permeability values from of 0.1 to about 800 Md within a porosity range of 10 to 24% in fields such as Moomba and Big Lake. Much of this variation is probably shaliness which is partly due to the environment of deposition. In general, this was recognised by Porter and Crocker (1972) who correlated porosity and permeability values with two types of sandstones. More than two genetic types of sandstones, however, are now known e.g. point-bar, distributary, crevass splay, shoreline and delta front sandstones. For this reason, it is intended to re-examine core data and then subdivide the sandstones into genetic groups. These groups of sandstones will be correlated with porosity and permeability values based on core and log analyses. In contrast, Martin and Hamilton (1981) offered preliminary results that diagenesis is the main reason for variation in reservoir quality. We believe that it is important to research the roles of sedimentary processes, structural growth and diagenesis on a local and subregional basis. Another important problem to be solved is to quantify the role of diagenetic silith and kaolinization in rendering reservoirs of popy quality, particularly with depth. However, this important factor may also influence porosity and permeability values at shallower depths where shallness derived from sedimentary and compaction processes is thought to be the main problem in causing the wide scatter in porosity and permeability values observed in cross-plots.

We believe that much information can be gained by utilizing not only standard petrographic methods, XRD and well logging techniques but the SEM probe as well. The use of the SEM probe is expected to provide important information on the diagenetic versus depositional origin of clays, mineral definition and the degree of relative silicification. It will also provide meaningful data on factors relating to the degree and type of shaliness, the range of grain size, and the degree of sorting. All of these factors have probably influenced reservoir quality. SEM probe work will complement petrographic thin section and XRD analyses in providing an excellent combination for mineral identification. This project should provide important results which will aid industry in the exploitation of existing fields and exploration in selecting areas for future drilling.

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16(b) WORK PROGRAM

1. The work program will include the detailed lithological descriptions of numerous cores taken in the Patchawarra, Epsilon and Toolachee Formations penetrated by wells in fields located in the southern Cooper Basin (see attachment). A comprehensive review will be undertaken to integrate previous work related to Permian sandstone genesis and distribution in order to select wells from key areas for investigation. The National Centre has access to these data through theses, publications and company reports. In addition, internal and external graduate students are currently providing research on key areas such as Moomba-Big Lake, Brumbie-Munkarie, Toolachee and Dullingari and the Burley area in the Nappermerri low. Items two - five listed below deal with work procedures while item six is a time-table of the program plus budget expenditures.

Structural, facies and isopach mapping together with geological cross-sections and general core and ditch sample descriptions are not considered part of this proposal except to utilize the data when applicable. The National Centre has applied for an Australian Research Grant entitled "The Roles of Structural Growth, Basin Subsidence and Lake Levels on the Configuration of Permian Sandstones situated in the Cooper Basin, South Australia and Queensland". Although the results of this project are considered important to this NERDDC proposal, we do not believe that much overlap exists in research objectives, but the projects do complement each other. If we are unsuccessful with our ARGS application, this particular phase of research will continue.

- 2. Cores selected from key wells in the Moomba-Big Lake, Toolachee, and Dullingari fields together with Burley-1 will be prepared for petrological, SEM and XRD analyses. To provide essential information on genetic units new core-plugs will be taken to supplement our data base Sample collection will be taken at two foot intervals except where rock character requires less or greater detail. Additional core plugs, expected to number about 300 per year, will be submitted to AMDEL for porosity-permeability analyses.
- 3. SEM analyses of rough-cut thin sections, XRD analyses and normal petrographic thin sections will be interpreted utilizing essential information concerning the degree of shaliness, the range of grainsize, the degree of sorting and mineral identification. In addition, the degree of sandstone diagenesis, particularly the secondary overgrowths of silica and authigenic kaolinite, will be analyzed with regard to porosity and permeability analyses. Further, the percentage of void space will be estimated and compared to porosity values recorded from log analyses. We will utilize Mincom Geolog software to derive log porosities (cross-plots) and shaliness. We will compare the results between core and log analyses, but it is anticipated that research will be required to formulate new log algorithms for relating the two sets of analyses.
- 4. After each set of data are intercalated from items 1-3, displays will be prepared exhibiting log motif(s) character, core, log and core analyses, textural variations, and SEM micrographs.
- 5. Lithological, core and petrographic data will be interpreted taking into account sedimentary processes, structural growth and basin development. Local and subregional results will be supported by facies maps exhibiting sedimentary processes and diagenetic patterns. We

concur with Martin and Hamilton that the degree of diagenesis increases with depth of sandstone burial. This is the reason why we have selected fields with reservoirs at similar stratigraphic levels, and those that are situated at different structural depths in the flanks of the southern Cooper Basin, and in deep wells drilled in the Nappermerri "low. The Moomba field is interpreted as an intermediate in its basinal position and the results of this area will provide an important link to fields situated in marginal flank areas and the Nappermerri low.

6. The following discussion of the Work Program takes into account program phases and budget items:

1988

We will select two deep wells from the Moombo and Big Lake fields for analyses. These wells contain several genetic sandstone units which exhibit a variable degree of diagenesis with depth. The selection of these two field areas is important because Big Lake is located in a more marginal area of the basin and is a structure with documented structural growth during Permian time. In contrast, the Moomba field is a structural complex located more downbasin than Big Lake. We plan to have a brief feasability report by the end of the first six month period, to show briefly our preliminary results. During the third month of the first six month period, we will have interpreted the data so that a major phase of extracting core plugs and analyses can proceed for the field areas listed below:

Strzelecki Namur Wanara " Mudera Della Marabooka Daralingie

Kidman Munkarie Brumby

Kerna Pira Dilchee

Results of this phase will be presented in an interim report at the end of the first year. A total expenditure of \$54,615 will cover costs projected for the year 1988. The costs by category are shown in items 12-15.

1989

The project will proceed in 1989 with the infilling of additional well data from the fields listed above. We estimate that a total of 4000 thin sections and rough-cut sections will be interpreted during this project. It is stressed that not all field wells containing cores will be analyzed and interpreted during 1988 - 1989. Data from a number of field wells studied may be required to solve major problems which are not anticipated in this application. However, we will take immediate steps to inform NERDDC if results indicate that more detail is required for a particular field area. This in itself is important for industry to initiate studies The remaining five months in areas which warrant additional results. during 1989 will be devoted to the intercalation of interpreted results for report generation. The final report will clearly set out objectives and The bulk of the report will consist of petrographic, SEM, XRD log and core analysis and cross-plot displays with descriptions and results of fields investigated. In addition, various maps relating to diagenetic phases e.g. trends of the relative degree of silicification will be contrasted with available structure, isopach and facies maps. A total expenditure of \$46,301 is forecast for the year 1989. The greatest cost of \$37,901 Is for the salary of the Research Fellow.

17(a) PRÉVIOUS GRANTS

This is the National Centre's first application for funds to undertake the subject research.

17(b) RELATED RESEARCH

Research publications related to sedimentary process, atructural growth and basin development are extensive over the last 30 years. However, research related to diagenests has undergone very rapid growth during the last 10 to 12 years from purely a descriptive science towards a process orientated study. This has been stimulated by the recognition of the controls it has on the porosity and permeability of sandstones, particularly oil and gas field reservoirs. One of the most important papers was published during 1977 on the recognition and influence of authigenic clays in sandstones by Wilson and Pittman. During 1979 a number of important papers were published as a series of articles by the society of Economic Paleontologists and Mineralogists. Schmidt and McDonald wrote AAPG Course Notes Series 12 on secondary porosity. The growing importance of diagenesis was recognized by the AAPO with a major publication in 1984, (Memoir 37, Clastic Diagenesis), and by Geoscience Canada, who commissioned a series of articles for eventual publication in the same format as the popular Facies Models Reprint Series.

Although relevant publications appear in the U.S. and Canada literature, much confidential data remains in major oil corporation research laboratories, particularly in utilizing the SEM probe as an important old complementing standard petrographic and X-ray diffraction echniques. Based on personal experience with a major oil company this type of research is on-going and standard in assessing petroleum reservoir quality:

There are few published papers in Australia relating to research in the subject proposal. A paper was published by Martin and Hamilton (1981) on the "Diagenesis and Reservoir Quality, Toolachee Formation, Cooper Basin.

The results were derived from the data acquired from three wells. The results were derived from the data acquired from three wells. Although preliminary results indicate that mainly diagenesis of silica is the controlling factor limiting reservoir porosity and is the controlling factor limiting reservoir porosity values permeability, there are field areas where contoured porosity values show a similar pattern (highest average values in structural crestal areas) which coincide with isopach and factes maps (Delhi, unpublish areas) which coincide with isopach and factes maps (Delhi, unpublish anals). This relationship is a function of both structural growth and sedimentary process. For this reason, more local and subregional work is required to determine the influence of structural growth, sedimentary processes and diagenesis.

The research of NERDDC Project No. 820, which is currently in progress under the direction of D. Gravestock (South Australian Department of Mines and Energy), deals mainly with the mathematical analyses of sandstones comprising the Jurassic - Cretaceous part of the Eromanga sequence. In addition, he has gathered some information on core analyses relating to Permian sandstones located in the subsurface of the northern part of the Cooper Basin. If time permits, this information is available for research. The objectives of this application do not coincide with those of NERDC Project No. 820 because we are assessing geological factors which account for the variations of porosity and permeability in sandstones.

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18. TECHNOLOGY TRANSFER

The National Centre will submit relevant results in papers during the course of the project. We will concentrate initially on local journals for rapid technological transfer to interested organizations rather than to overseas journals which have long waiting lists. In addition, we will include the results in a case study to maintain a high standard of training for graduate students.

A short course dealing with the results of this project and diagenesis of sandstones relating to other areas will be offered for technologists in industry and government. We currently offer such courses both in-house and in participation with the Australian Mineral Foundation.

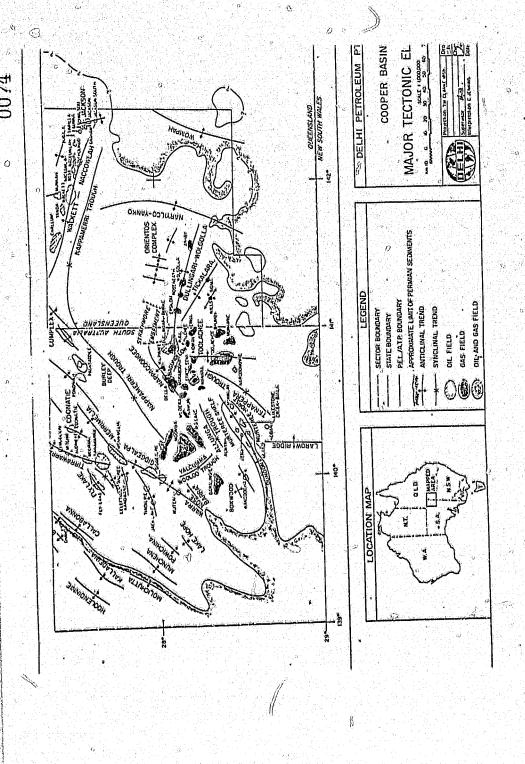
The National Centre will also present the results of this project to interested Exploration and Production Geology groups in industry. This is currently normal practice for other research subjects of interest. We will make every effort to present this package orally during various society meetings, and for interested groups in government and tertiaxy institutions.

The Department of Geology and Geophysics has audio-visual equipment which with be utilized for recording lectures pertaining partly to the methodology and results of this project. These will be made available to interested groups.

19. FACILITIES AVAILABLE

- 1. Computer facilities are available at both the University of Adelaide and the South Australian Institute of Technology (S.A.I.T.) for undertaking this project. Direct/terminal ties to VAX facilities are available to both Adelaide and S.A.I.T. mainframes. In addition, digitizing equipment is in place. Recently, the National Centre has received Mincom Geolog software for well logging techniques.
- 2. Both Scanning Electron Microscope (SEM) and energy dispersive X-ray (EDX) systems are available at the University of Adelaide and S.A.1.T. To aid in the identification of minerals EDX spectra can be obtained by the KEVEX 5000ux energy dispersive system. This and the use of available X-ray diffraction equipment and standard petrographic microscopes provide a strong suite of tools for interpretation.
- 3. Facilities exist for the preparation of standard, polished and roughcut thin sections at the University of Adelaide and S.A.I.T. Charges for thin sections are very competitive, and all equipment and chemicals are available.
- The National Centre will rely on AMDEL for extracting core plugs and porosity-permeability services.
- 5. Clerical Btal are available at the University of Adelaide and S.A.I.T. for interim and final report presentation.
- 6. Dr. V. Gostin and Dr. J. Jones who have expertise in the field of diagenesis have offered some of their time for critical discussions during the course of the project.

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SENRAC PROGRESS REPORT
14.12.88

FACTORS RELATING TO THE DEVELOPMENT OF

POROSITY AND PERMEABILITY IN PERMIAN SANDSTONES

IN THE SOUTHERN COOPER BASIN.

THE RESEARCHER: DR. W.J. STUART
NATIONAL CENTRE FOR PETROLEUM GEOLOGY AND GEOPHYSICS

GRANT EXPENDITURE \$8219.90

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SUMMARY

a) PROJECT OBJECTIVES:

- To identify how the interaction of diagenesis, sedimentary processes and structural growth have influenced reservoir quality in the Permian sandstones.
- ii. To ascertain the influence of depth of burial on the paragenetic sequence, particularly in wells where secondary silicification and authigenic kaolinite adversely affect reservoir quality.

b) MAIN FINDING AND CONCLUSIONS

Preliminary results indicate that porosity is best developed in well sorted, medium to coarse grained sediments of point bar sequences. This occurs in rocks where the proportion of illite is low and dickite is present rather than kaolinite, and no other authigenic minerals have developed. However, these results are tentative because of a lack of data from the fine grained shoreline sandstones which are also known to have good porosity and permeability. The latter sediments will be investigated in more detail next year.

A statistical method has been developed by which the permeability of Permian sediments may be estimated from wireline logs.

c) WORK PROGRAM DESCRIPTION

The work program proposed for 1988 involved the initial selection of wells from the Moomba and Big Lake' fields for analyses. Based on this data a major phase of core description and sampling was designed for the field areas listed below:

Namur Strzelecki Kidman Kerna Mudera Wanara Munkarie Pira Marabooka Della Brumby Dilchee Daralingie

Results of this phase were to be presented in an interim report at the end of the first year.

d) POTENTIAL FOR INDUSTRIAL APPLICATION

In the next phase of this project it is proposed that comparisons of maps of sandstone facies and mineralogy (clays and other authigenic minerals) will be constructed as a potential means of determining sites of good porosity and permeability.

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At this stage of the project it would be premature to make recommendations for industry. Once all the data has been gathered and maps constructed then it will be possible to provide some constructive guidelines for possible to provide some constructive guidelines for exploration both within existing, and possibly new

fields.

The preliminary results suggest that the integrated approach of this study is very beneficial to approach of this study is very beneficial to approach of this study is very beneficial to approach of this study is very beneficial to approach in the future.

Understanding the distribution of porosity and understanding the distribution of permeability and thus should be encouraged in the future.

3. PROJECT OF JECTIVES

The major objective of this study is to qualify and quantify porosity and permeability relationships of permian reservoir sandstones (occurring at various stratigraphic vid structural levels) to enable the stratigraphic vid structural levels) to enable the assessment of the influence of sedimentary depositional processes, structural growth and diagenesis.

Detailed examination of basic well data generated from earlier exploration and development drilling to enable the subdivision of the sandstones into genetic groups for comparison with porosity and permeability data.

To quantify the role of diagenetic silica and kaolin in creating reservoirs of poor quality, particularly with depth.

To combine standard petrographic methods, X-ray diffration (XRD) and well logging techniques with scanning electron microscopy (SEM) as a means of determining the detrital versus authigenic nature of aluminosilicates (clays) and the degree of silicification.

4. METHODOLOGY AND DESCRIPTION OF WORK UNDERTAKEN

1. DATA COLLECTION
The initial phase of the project involved the collection of data bases from industry and state collection of data bases from industry and state government organisations. These include; government organisations (k, Swi, CEC, porjsity) with a list of core analyses (k, Swi, CEC, porjsity) with corresponding well log values compiled by SADME.

· ...

microfiche copies of well completion reports for the wells in the above database.

a detailed list of core kept at the SADME core library.

a list of rock thin sections prepared and archived by
SAGASCO Resources Ltd.

2. CORE LOGGING AND SAMPLING

A total of 4,274 feet of core has been logged. The wells and formations are listed in Appendix A. It is apparent from this list that the number of fields now apparent from this list that the number of sields now being investigated has expanded from the original proposal for the project. The expansion has been proposal for the project. The expansion has been possible because of the contribution by Miss Sally Phillips and 4 post-graduate students. All the fields nominated in the proposal, plus some additional wells, will be logged and sampled by February 1989.

From the core, 450 samples have been taken and are in

From the core, 450 samples have been taken and are in the process of being analysed. In association with these the process of being analysed. In association with these the process of being analysed. In association with these the process of being analysed. In association with these the process have been taken for porosity and samples, 131 core plugs have been taken for process taken for process taken for process ampled and this information is available for the project.

419 sub-samples have been wet ground and run as powder pressings in the XRD to determine mineralogy.

400 sub-samples have been prepared as thin sections using araldite containing blue-dye to help in the characterisation of porosity types and the paragenetic sequence.

220 sub-samples have been photographed in the SEM with an EDS (Energy dispersive spectrometer) system to identify the authigenic versus detrital minerals.

22 sub-samples were prepared as polished thin sections, and 12 examined by cathodoluminescence to illustrate the proportion (\(\frac{\pi}{2} \) quartz overgrowths.

13 subsamples have been analysed for carbon and oxygen isotopes in an attempt to determine the nature and timing of the development of the carbonate minerals, in particular the siderite.

The cathodoluminescence and isotope work are additional to the work proposed for 1988 and are yielding very valuable information as to complexities in the paragenetic sequence and the degree of silicification.

3. GEOPHYSICAL ANALYSES
In the Toolachee, Moomba and Strzelecki Fields the
Correlation of stratigraphic sequences with well logs has
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correlated and cross plots of porosity and permeability
data have been generated. This work was scheduled for
1989.

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In addition a facility for low level gamma-ray spectrometry has been built at the South Australian Institute of Technology which will be used to analyse cores and cuttings to determine the presence of radioactive elements in the rocks. The radioactive elements may be related to diagenesis and thus assist in establishing directions of pore fluid movement across the basin.

PRELIMINARY FINDINGS AND CONCLUSIONS

I. MINERALOGY AND DIAGENESIS

The diagenetic events recognised within each of the producing reservoir sands of the Southern Cooper Basin, namely the Patchawarra, Epsilon and Toolachee Formations, are broadly similar. However, there are subtle differences between and within the formations which are apparent on a regional scale across the basin. The following diagenetic events have been identified as significant influences on porosity and permeability;

A. MECHANICAL COMPACTION

5.

Post-depositional mechanical compaction has reduced primary porosity to a limited extent in most samples. Compaction is evident from bent mica flakes, deformed lithic fragments, sutured grain contacts and stylolites (Plate. 1). Sutured grain contacts are not common and therefore the dissolution of quartz due to compaction is not thought to have significantly contributed to quartz overgrowths.

B. CHEMICAL ALTERATION

- 1. Quartz: Quartz overgrowths are very important in the reduction of porosity. Cathodoluminescence studies indicate that in most areas cementation occurred prior to compaction and that there may be at least 2 events during which quartz overgrowths developed (Plate 2). Quartz also occurs as a cement in isolated fractures through the rocks. Quartz overgrowths as seen in the SEM (Plate 2) are best developed in the coarser grained samples where some primary porosity is preserved. Many of the quartz overgrowths have been chemically etched (Plate 2) and are intergrown with kaolin. Illite and organic matter are seen as dust linings on the detrital quartz grains.
- 2. Raolin: Both kaolinite and dickite have been identified from XRD analyses. Dickite has a more cuhedral crystal habit and concentrates in the coarser grained rocks (Plate 3). SEM studies indicate that the kaolin has formed by 3 different processes;

the alteration of K feldspar has produced subhedral to anhedral kaolin with a honeycomb

texture.
ii) the alteration of mica (?biotite) results in

vermiform kaolin.
iii) growth from solution. At least 3 different sizes of kaolin (1-2um, 10-15um, and 30-40um) can be recognised within the one sample (Plate 3).

The succession of crystal sizes probably indicates sequential growth from solution as conditions became more favourable for dickite precipitation. The concentration of quartz and kaolin in these coarse grained samples suggests the rocks have been flushed by fresh water which removed all the elements less stable than Si and Al.

The jagged contact between kaolin and quartz overgrowths is thought to be a result of contemporaneous formation. The alteration of feldspar to kaolin releases an excess of silica which may be the source for the quartz overgrowths.

- 3. Tilite: this clay mineral is abundant in fine grained rocks where porosity and permeability are almost negligible. As a general trend where illite is more abundant than kaolin porosity is low regardless of grain size. Much of the illite appears to be detrital (Plate 4), it is also present as a replacement of feldspar (Plate 4), an alteration product of mica and rarely as an authigenic mineral (Plate 4). The abundance of authigenic illite is greatest in the Nappamerri Trough where depth of burial may be influencing its distribution.
- 4. Carbonate minerals: siderite, ankerite, dolomite and calcite have been recognised from XRD analyses. Siderite is the most abundant carbonate mineral present. handspecimen the siderite has a variety of forms, it occurs as bands up to several centimetres thick which markedly reduce porosity, as isolated blotches and as a pervasive cement forming the matrix of some rocks. The siderite (Plates 1 & 5) has a variety of crystal habits (rhombohedra, scalenohedra and anhedral micrite) and different compositions (Mg, Mn, Ca). These facts combined with the isotope data indicate that there may have been several periods when siderite formed. Siderite is frequently found adjacent to coals and shales where it may be an early precipitate in the diagenetic sequence. However, siderite also occurs in some coarse grained sands which are not associated with organic matter. is possible that this siderite has formed from solutions containing CO2, and Fe released by the alteration of biotite. Ankerite has only been identified from the southwestern margin of the basin. It occurs as euhedral rhombohedra which reduce porosity and only rarely appear to be partially dissolved. Minor amounts of dolomite and calcite have an irregular distribution across the basin. The calcite occurs as thin bands only a few centimetres thick which restrict porosity and permeability.
- 5. Chlorite: is present as clinochlore IIB which is Fe rich. It is most abundant in the middle of the

Nappamerri Trough where it occurs as euhedral rosettes and pseudohexagonal plates (Plate 5) that line and infill pores. The euhedral crystal habits indicate that the clinochlore has grown from solution. Samples with high chlorite contents typically have no siderite. The Fe was probably available in both systems but the supply of CO2 may have been limited. Traces of chlorite have also been identified at Moomba, Big Lake and in the Toolachee Field.

6. Pyrophyllite: is restricted to the deepest sediments in the Nappamerri Trough. It occurs as euhedral radiating plates (Plate 5) which completely infill pores. Various modes of formation have been described for this mineral but it is commonly associated with low grade metamorphism as a reaction between quartz and kaolinite. The mineral assemblage of pyrophyllite, clinochlore and muscovite and the absence of kaolinite in samples containing pyrophyllite indicate a low grade metamorphic origin is feasible. Clearly where low grade metamorphism has occurred liquid hydrocarbons are unlikely to be preserved.

C. HYDROCARBON MIGRATION

At least two phases of hydrocarbon migration have been recognised. The first phase is represented by blebs of bitumen which form dust linings on detrital quartz grains prior to the development of overgrowths. The second phase is represented by bitumen rinds lining pores after the development of quartz overgrowths. The presence of bitumen rims on some of these pores suggests that the hydrocarbons may have inhibited further diagenetic alteration.

PRELIMINARY CONCLUSIONS

Preservation of primary porosity and the dissolution of unstable components to form secondary oversized pores are the two most important types of porosity. However, there is some micro-porosity associated with the kaolin minerals. As a broad trend porosity increases towards the margins of the basin where secondary porosity is more important.

Based on the available data certain relationships have been identified between porosity, grain size and clay mineralogy:

1. Porosity generally increases with increases in grain size in several formations (Fig. 1) throughout the study area. However, this not the case in the Strzelecki area. In general, there is an upper limit to the trend as demonstrated by the poorly sorted, very coarse sands and gravels of the Patchawarra Formation at Big Lake which show a decline in porosity above the very coarse grain size.

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- 2. Good porosity is also broadly related to the relative proportions of illite and kaolin in the sediments. As the proportion of illite increases porosity declines (Fig. 2). This relationship fails where kaolinite, rather than dickite, is present in the coarser grained sediments. In these samples kaolinite is responsible for the reduction of porosity.
- 3. Only in some areas is there a direct relationship between crain size and the I/K ratio (Fig. 3). In these areas the amount of illite is greatest in finer grained sediments. In the Patchawarra Formation of the Toolachee Field, and the Toolachee and Daralingie Formations of the Moomba Field, grain size and illite/kaolin do not appear to be related. It is possible that some authigenic illite has developed in the coarser grained sediments at these sites.
- 4. Dickite, rather than kaolinite is the dominant clay in the coarser grained sediments of all formations (Fig. 4). However, in the fields around Strzelecki, dickite is associated with some of the silty deposits which suggests that porosity and permeability were initially good in this area allowing the formation of dickite from solution.
- 5. Depth of burial and high geothermal gradients in the Nappamerri Trough have favoured the growth of authigenic illite, clinochlore and pyrophyllite thus reducing porosity and permeability in this area.

In summary the preliminary results indicate that porosity is best developed in well sorted, medium to coarse grained point bar sequences. In these rocks the proportion of illite is low and dickite is present rather than kaolinite, and there are no other authigenic minerals. Fine grained sandstones of shoreline origin are also known to have well developed porosity and permeability e.g. the Daralingie sandstones in the Moomba and Big Lake fields. The diagenesis of these sandstones will be investigated during 1989, because of their origin these sediments could form stratigraphic and/or combination structural-stratigraphic traps.

II. WIRELINE LOGS

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A statistical method has been developed by which the permeability of permian sediments in the Cooper Basin may be estimated from four non-electric well logs namely gamma ray, bulk density, neutron porosity and sonic. The method is based on a detailed statistical analysis of core and log data made available by the S.A. Department of Mines and Energy. The probability that a particular value of a log correlates with a particular permeability is derived for each log from the data observed at a

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particular depth. These values are then combined together to determine the most probable permeability represented by the set of log values. A good correlation between estimated and measured permeabilities is achieved (Fig. 5). As further data is acquired the estimation algorithm is being further tested and refined, and attempts are being made to estimate other petrophysical parameters from the well logs.

The preliminary results of the wireline log study are significant. It may be possible to make good estimates of permeability in Permian sandstones without relying totally on expensive laboratory measurements.

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&. TECHNOLOGY TRANSFER ACTIVITIES

Two papers based on data from this project have been accepted for presentation and later publication, at the Cooper-Eromanga Basin Conference to be held in Adelaide in June 1989.

Titles of the Papers;

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- 1. Diagenetic alteration of Permian Reservoir Sandstones and the implications for development of porosity and permeability in the Nappamerri Trough, southern Cooper Basin.
- 2. Permeability estimation from well logs using probabilities.

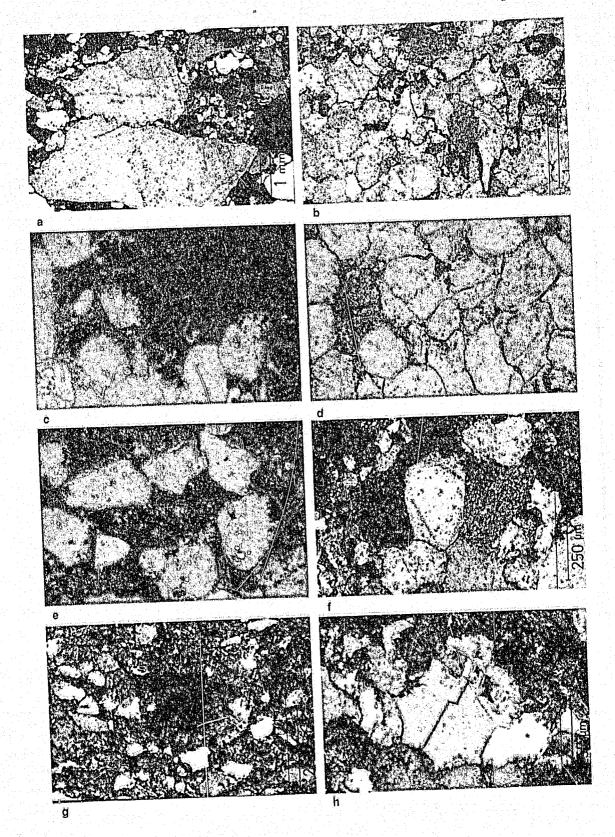
It is anticipated that several other papers for journals will be started in 1989. At least one of these papers will be concerned with the clay mineralogy of the reservoir sands. This paper will probably be written in conjunction with the CSIRO Division of Soils. A second paper on the carbonates will also be commenced in 1989.

In addition, the preliminary results of the project were presented at the NERDDC workshop on the Cooper-Eromanga Basin organised by SADME in March 1988. Recently an informal seminar was given for Santos (Appendix B) and other similar seminars are planned for 1989.

THIN SECTION AND CATHODOLUMINESCENCE MICROGRAPHS

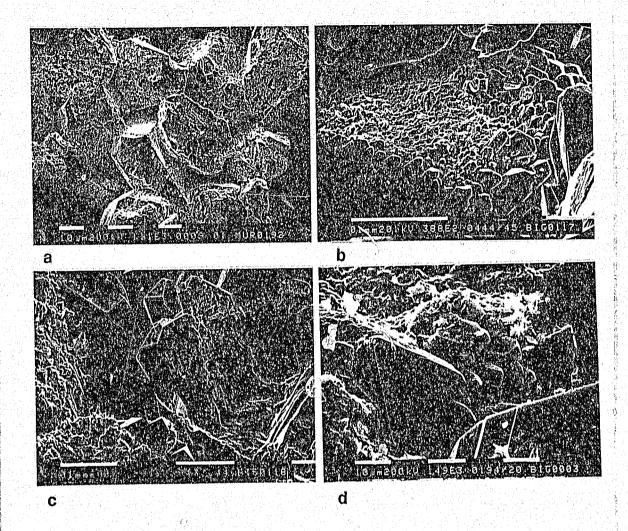
- a. Sutured grain boundary in a very poorly sorted sandstone provides evidence of mechanical compaction. Crossed nicols. Scale bar 1mm.
- b. Stylolites cross cutting a medium grained sandstone. Note the lack of porosity and the alteration of some grains to illite. Plane polarised light. Scale bar 1mm.
- the detrital grains are pale blue to cream in luminescence, whilst the overgrowths are brownish. The very bright blue is kaolin. Note that the detrital grains float in the cement, suggesting early cementation prior to compaction.
- d. Same field of view as (c) above in plane polarised light. The comparison demonstrates that the proportion of overgrowths is very difficult to detect in the optical microscope and only with further detailed CL work can the degree of silicification be correctly estimated.
- e. Cathodoluminescence micrograph in which zonation can be detected in the quartz overgrowths. This fact suggests that at least two phases of silicification have occurred in their development
- f. Thin section micrograph illustrating a rare dust lining separating a detrital quartz grain from the quartz overgrowth. The adjacent grain, which has been completely altered to illite indicates that feldspars were previously more abundant. Crossed nicols. Bar scale 250 µm.
- g. Micritic siderite blotch in a fine grained sandstone. Note the lack of quartz in the blotch which demonstrates either replacement or displacement of the quartz. On the right hand margin of the blotch euhedral crystals have developed. Siderite is also evident in the matrix of this sample. The brownish-red colour of the siderite indicates that it is oxidising to hematite. Crossed nicols. Bar scale 250 µm.
- h. Relatively unaltered rhombic siderite which is engulfing a quartz grain. Micritic siderite and illite occur in the matrix of the rock, significantly reducing any porosity and permeability. Crossed nicols. Bar scale 250 µm.

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SEM MICROGRAPHS OF QUARTZ OVERGROWTHS

- a. General view of medium grained sand with good porosity despite the presence of euhedral quartz overgrowths on some grains. These sands typically lack detrital clays.
- b. Euhedral quartz prisms developed on the margins of a detrital grain. Note the larger overgrowth on the adjacent grain. The smaller prisms demonstrate the selective and impaired development of overgrowths at specific sites.
 - c. In many of the coarse grained sands large euhedral quartz overgrowths have significantly reduced, but not occluded porosity. It is the preservation of some primary porosity in these samples despite the overgrowths which is of importance.
 - d. Euhedral quartz prisms and large overgrowths can also develop in finer grained rocks such as this example. However, the chances of preservation of primary porosity are much reduced because the pore spaces were initially very much smaller when compared to the coarser grained sediments.



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SEM MICROGRAPHS OF AUTHIGENIC KAOLIN MINERALS

- a. Two pores and the intervening throat, infilled with subhedral kaolin. If the kaolin had formed simply due to replacement of feldspar the pore throat would not have been filled. Note the jagged contact between the kaolin and the quartz.
- b. Kaolin and quartz overgrowths are commonly intergrown as in this example, due to their contemporaneous formation. The surface of the quartz overgrowth is covered in chemically etched V-shaped pits which possibly developed under more alkaline conditions associated with the precipitation of carbonate.
- c. Pseudohexagonal plates and books of kaolin are rarely seen growing between biotite sheets (arrow). When biotite alters to kaolin, Fe and K are released.
- d. Very small kaolin crystals (1-2 µm in diameter) engulfed by quartz overgrowths. Larger enhedral crystals of kaolin (10-15 µm) occur within the adjacent pore.
- e. In the same sample as (d) above, the kaolin is also vermiform and has a crystal size between 30 and 40 µm diameter. The euhedral morphology and large crystal size indicate that this dickite has grown from solution. It would appear that conditions became progressively more favourable for the precipitation of dickite after the initial intergrowth of small kaolin crystals with the quartz overgrowths.
- f. Ragged-edged vermiform kaolin of this type, permits some micro-porosity but is likely to reduce permeability.

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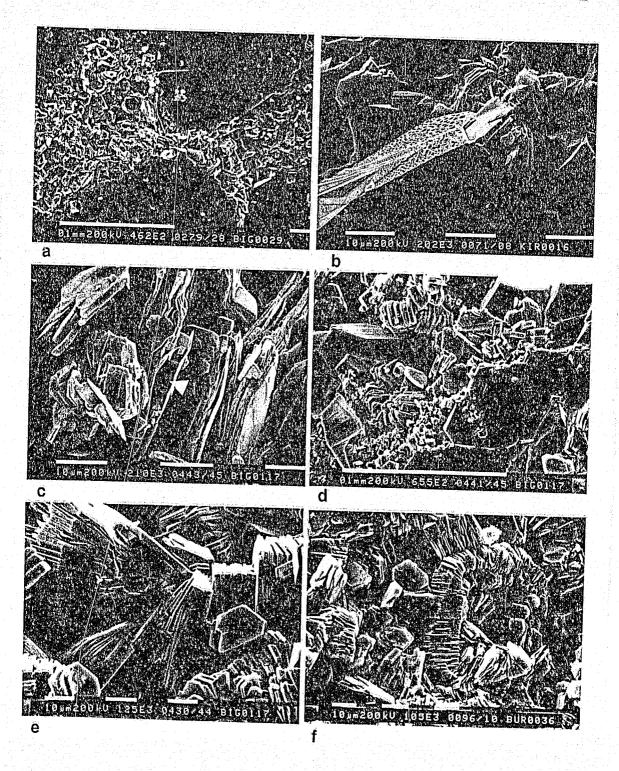
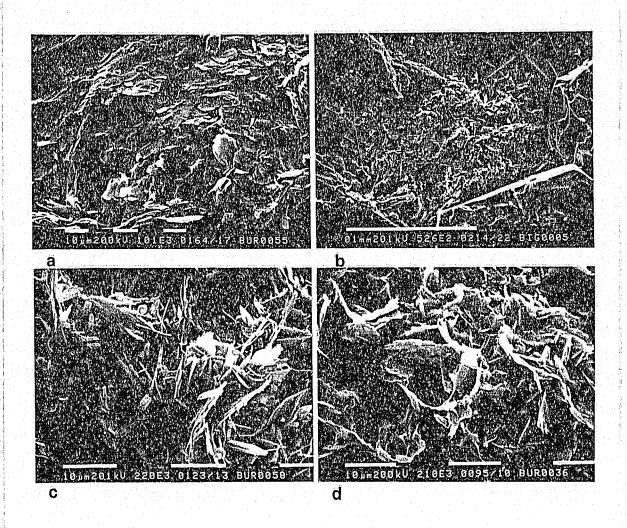


PLATE .

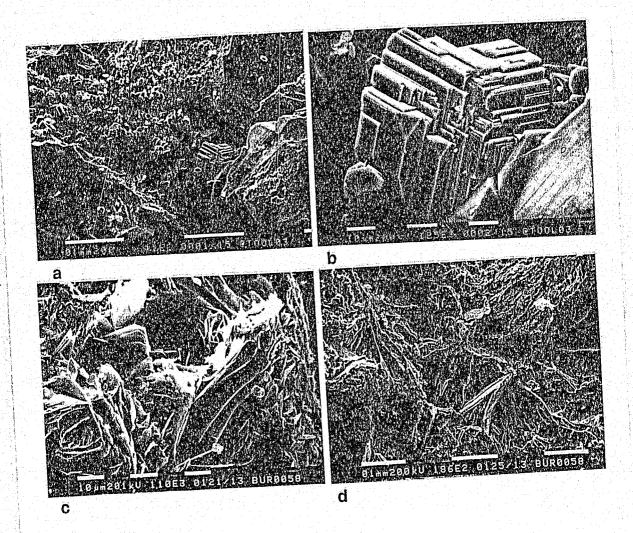
SEM MICROGRAPHS OF ILLITE

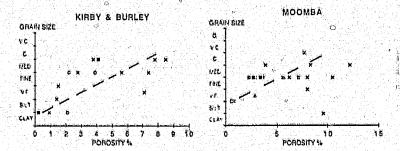
- a. Typically illite in fine grained rocks occurs as small, flat lying, closely packed platelets. In fine grained and silty sediments it is frequently difficult to see anything other than these platelets in the SEM. Clearly even micro-porosity is not likely to be associated with detrital illite.
- b. Illite also occurs as grain replacements as demonstrated from thin section (Plate 1 f) and this micrograph. The illite is less flat lying than in the detrital varieties.
- c & d. Rarely does illite occur in a fibrous form (d) or lettuce-like morphology (d) such as these examples. These clays are thought to be interstratified varieties of illite. Where illite is apparently authigenic it occurs as pore linings.

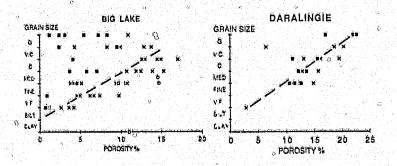


SEM MICROGRAPHS OF SIDERITE, CLINOCHLORE IIB AND PYROPHYLLITE.

- a. General view of a pore showing the partial infilling by kaolin and a euhedral rhombohedra of siderite. Clearly this is an oversized pore in relation to the size of the surrounding quartz grains.
- b. Enlargement of the siderite in (a) above. There is minor dissolution evident on the crystal, but in general rhombs of siderite are not etched.
- c. Rosettes and pseudohexagonal plates of clinochlore IIB. The chlorite occurs mainly as pore linings but has been observed as pore fillings. In both situations the euhedral nature of the crystals illustrates the authigenic origin of this mineral.
- d. Pyrophyllite totally fills the pore spaces in this sample. The soft nature of this mineral results in considerable damage during specimen preparation. Where pyrophyllite has been damaged, it is difficult, based on morphology alone, to discern it from platy illite. The absence of R in the EDS spectra is then more diagnostic.

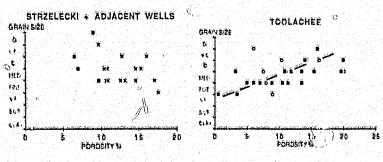






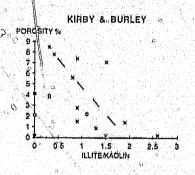
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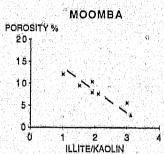
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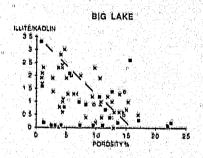


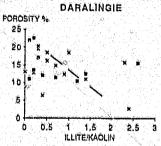
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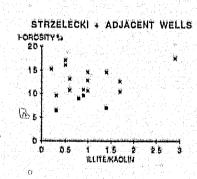
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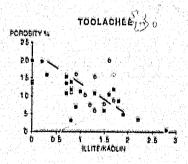










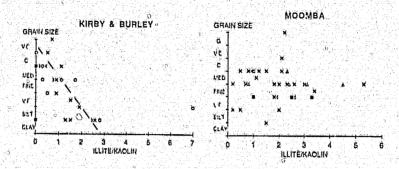


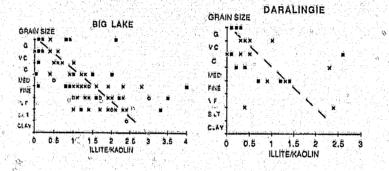
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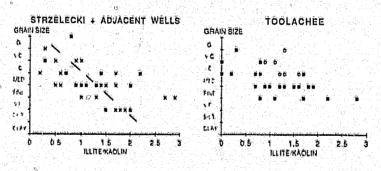
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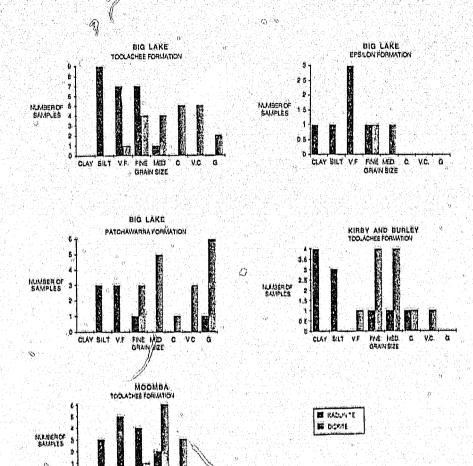
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FIGURE 4 THE RELATIVE PROPORTIONS OF DICKITE AND KAOLINITE FOR DIFFERENT GRAIN SIZES.

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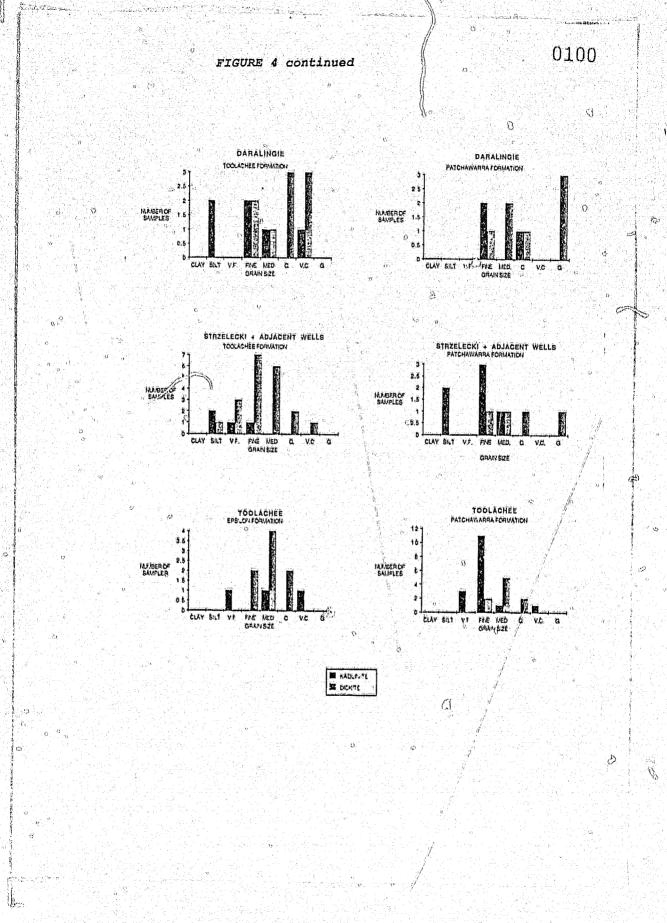
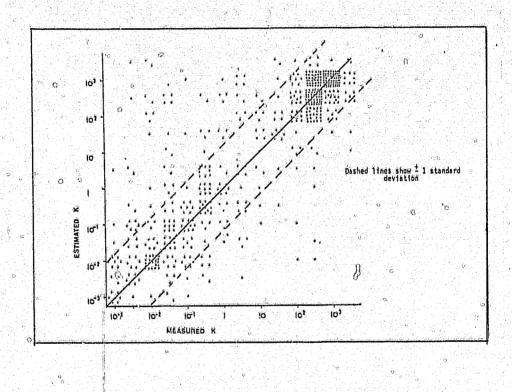


FIGURE 5 CROSSPLOT OF ESTIMATED VERSUS MEASURED PERMEABILITIES

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APPENDIX A

WEVI	FORMATION(S)	FEET
Kirly 1	Toolachee & Epsilon	
Burley 1	Toolachee & Epsiton	73
Burley 2	Toolachee, Epsilon &	80
	Patchawarra	
Big Lake 1	Toolachee	52
Big Lake 2	Toolachee	187
Big Lake 3	Epsilon	172 18
Dia Tales E	Patchawarra	66
Big Lake 27	Patchawarra	49
Dig nake 29	Patchawarra	8
prd hake 2T	Patchawarra	89∖
Big Lake 34	Patchawarra	19
Big Lake 35	Patchawarra	30
Moomba 1	Toolachee, Daralingie,	
그리고 말라는 이번 한다. 조리 없는	Murteree, Patchawarra	349
Moomba 3	Toolachee, Daralingie	283
Moomba 6	Toolachee, Patchawarra,	200
진빛 가장 등 생겼고 방까다 시민밖	Daralingie	391
Marana 1	Toolachee	30
Kidman 1	Toolachee, Patchawarra	90
Kidman 2	Toolachee	40
Pira 1	Patchawarra	57
Pira 2	Toolachee	53
Strzelecki 2	Toolachee	47
Strzelecki 5	Toolachee	58
Strzelecki 10 Strzelecki 15	Toolachee	18
Strzelecki 15	Toolachee	61
Strzelecki 16	Toolachee	60
Marabooka 1	Patchawarra *	88
Daralingie 1	Toolachee	86
Daralingie 9	Patchawarra	
Daralingie 19	Patchawarra	325
Daralingie 22	Patchawarra	
Tool chee 1	Patchawarra & Epsilon	73
Tpol/chee 3	Patchawarra	253
Tholachee 5	Patchawarra	184
Toolachee 8	Patchawarra	60
Toolachee 9	Patchawarra	52
Toolachee 12	Patchawarra	30
Toolachee 15	Patchawarra	27
Toolachee 18	Patchawarra	28
Toolachee 19	Patchawarra	2.8
Toolachée 21 Della 3	Patchawarra	30
Acria o	Toolachee	104
Yapeni 1	Epsilon .	25
Pando 2 Murteree C-1	Epsilon	24
Taba Dana 10	Toolachee	30
Lake Hope 1	Epsilon .	20
Pando North 1	Epsilon	29
Wancoocha 1	Epsilon & Patchawarra	119
Dullingari 1	Toolachee	17
Murteree 1 Boxwood 1	Toolachee	60
DOVADOR T	Epsilon	8

Appendix A continued

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WEI	Ъ	FORMATION (S		FEET
Tar	wonga 2	Epsilon/		28
Dir	kala 2	Epsilon"		30
	na 1 ″	Epsilon		33
	chilara 1	Epsilon	없다. 실어 경기를 하는 말이 있다.	34
Muc	llalee 1	Toolachee		29
Spe	ncer 1	Toolachee		40
			TOTAL 4	274
Q			흥미의 모든 일본 (하고) 의밀하면 하면	
O			그런 그는 그 생생님은 교육 가장을 하고 있었다.	

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Ref:3881x/25;JF:jl

15th December, 1988

Mr. W. Stuart, Director National Centre for Petroleum Geology and Geophysics Adelaide University North Terrace ADELAIDE S.A. 5000

Dear Bill

KEY CENTRE TOUR

On behalf of the Central Exploration Team, I would like to thank you, Andy, Yvonne and Sally for your time and effort in guiding us around the Centre. We all found the Fluid Inclusion and Diagenesis research results to be very interesting with immediate relevance to some of our exploration projects.

I hope that our explorationists can develop mutually beneficial contacts with research workers and students at the Centre.

Yours faithfully

Jim Frazer

cc : T.M. Barr

SENRAC PROGRESS REPORT 31.5.89

FACTORS RELATING TO THE DEVELOPMENT OF POROSITY AND PERMEABILITY IN PERMIAN SANDSTONES IN THE SOUTHERN COOPER BASIN.

THE RESEARCHER: DR. W.J. STUART
NATIONAL CENTRE FOR PETROLEUM GEOLOGY AND GEOPHYSICS

GRANT EXPENDITURE \$16,436.50

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	o (ˈajː// Page
1.	Project objectives 3
2.	Methodology and destyption of work undertaken 4
3.	Preliminary findings and conclusions 6
4.	Interim statement of expenditure 7
5.	Appendix A

1. PROJECT OBJECTIVES

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The major objective of this study is to qualify and quantify porosity and permeability relationships of Permian reservoir sandstones to enable assessment of the influence of sedimentary depositional processes, structural growth and diagenesis.

Detailed examination of basic well data generated from earlier exploration and development drilling to enable the subdivision of the sandstones into genetic groups for comparison with porosity and permeability data.

To quantify the role of diagenetic silica and kaolin in creating reservoirs of poor quality, particularly with depth.

To combine standard petrographic methods, X-ray diffraction (XRD) and well logging techniques with scanning electron microscopy (SEM) as a means of determining the detrital versus authigenic nature of clays and the degree of silicification.

2. METHODOLOGY AND DESCRIPTION OF WORK UNDERTAKEN

1. CORE LOGGING AND SAMPLING

Total core logged and sampled during the project is 6,614 feet. A total of 689 feet of core has been logged since the last progress report on 31.3.89. The additional wells and formations from which core has been logged, are listed in Appendix A. From this core, 30 samples have been taken; this brings the total number of samples to 624. Only 7 additional core plugs have been analysed by Amdel.

Future sampling will concentrate on cuttings from selected wells. Samples will be taken from all Permian stratigraphic intervals and analysed by the laboratory techniques used on core samples.

2. SAMPLE ANALYSES

- a) XRD, SEM and thin section descriptions have been completed for all samples.
- b) Isotopes: 30 samples are being prepared for carbon and oxygen isotope analyses of the carbonates. Samples containing abundant siderite have been selected from a variety of locations for analyses.

3. DATA BASE

All analytical results are being compiled into a data base using Dbase 3+. Files have been established which summarize the results from each analytical technique, and allow correlations. Relevant information from well completion reports concerning well locations and depths are also being entered into Dbase files. This process of entering analystical results into the data base is very time consuming, but considered essential for the success of the project.

4. CROSS-SECTIONS

Well tapes, generously made available by Santos, have been loaded onto the NCPGG Vax for the preparation of 3 major cross-sections across the southern Cooper Basin.

Line A-A' includes: Kirby #1, Burley #2, Moomba #7, Moomba #57, Big Lake #33, Yaleumma #1, Daralingie #1, Daralingie #2, Wancoocha #2, and Wancoocha #4. These represent wells located along the central axis of the Nappamerri Trough, from the depocentre to the flanks of the basin. Wancoocha #2 is updip from Wancoocha #4, and contrasts oil-saturated reservoirs to water wet sands in the Patchawarra Formation.

Line B-B' includes: Kidman #1, Strzelecki #10, Marabooka #1, Namur #1, Big Lake #26, Moomba #57, and Spencer #1.

Line C-C' includes: Kirby #1, Three Queens #1, Dullingari #39, Dullingari #18, Kidman #1, Toolachee East #1, Toolachee #1, and Toolachee #3.

A total of 18 cross-sections utilising gamma ray and sonic log signatures have been computer-generated and correlated. They encorporate available palynoidgical data, DST results and core information. The following sections were generated for each line of traverse:

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- i) A stratigraphic cross-section of the entire Permo-Triassic sequence (reference datum: top Nappamerri Formation/unconformity) to TD. This has enabled the establishment of a abroad framework for chronostratigraphic sedimentation within formations across the basin. Regional depositional trends are best discerned at this reduced scale.
- ii) A structural (subsea) cross-section of the entire Permo-Triassic sequence, highlightling the current structural position of the chronostratigraphic divisions and subdivisions distinguished.
- iii) A stratigraphic cross-section of the Nappamerri Formation (reference datum: top Nappamerri/unconformity) to the top of the Toolachee Formation.
- iv) A stratigraphic cross-section of the Toolachee and Daralingle Formations (reference datum; top Toolachee) to the top of the Roseneath Shale,
- v) A stratigraphic cross-section of the Roseneath Shale, Epsilon Formation and Murteree Shale Formation (reference datum: top Roseneath) to the top of the Patchawarra Formation.
- vi) A stratigraphic cross-section of the Patchawarra Formation (reference datum: top Patchawarra) to TD.

In addition, more detailed cross-sections, sand isopach, palaeogeographic and structure-contour maps are being constructed for the Toolachee, Moomba and Strzelecki Fields.

3. PRELIMINARY FINDINGS AND CONCLUSIONS

Since the previous report most effort has been directed towards entering results into data bases and construction of maps and cross-sections. Hence there are few new conclusions to report at this time. Interpretation of preliminary isotope results indicate that:

- i) Cold atmospheric waters derived from high palaeolatitudes were involved in carbonate cement precipitation as O¹⁸/O¹⁶ values (PDB) are invariably strongly negative (-13 to -22).
- ii) Some carbonate cements appear to have formed under fresh-water conditions possibly with the influence of microbial activity in near-surface environments. This is supported by weakly negative C13/C12 values.
- iii) Other carbonates are more strongly depleted in C¹³, implying a different source of carbon. Ther nogenic decarboxylation of organic matter at depth is considered partially responsible for this trend.
- iv) Some carbonates show intermediate trends between the two main categories, implying partial mixing of different carbon sources responsible for carbonate genesis. This could be explained, for example, by partial or complete recrystallisation of early formed carbonates at depth under the influence of thermogenic break-down of organic matter.

4. INTERIM STATEMENT OF EXPENDITURE

SENRAC GRANT (\$34,700 at 31,54;9)

EXPENDITURE 1988

ITEM	AMOUNT
SEM film	520.70
XRD analyses by CSIRO	527.00
SEM photography by Geolo SEM stubs & tweezers	ngy Dept. 2752.00 348.60
XRD analyses by Geology I	
dBase III+	410.00
SEM work at SAIT Report preparation	500.00 141.60
Toport Proputation	

SUBTOTAL \$8214.90

ITEM		Marine Section 1995	according the second control of	AMOU	MT	0	esterior.
Colour photoco	opy			258.00			i e-
SEM film				138.00			
Plastic vials			ν.	79.60		<i>(f)</i>	. To 1
CL comera SEM film	ing for the second seco			7,608.00			

SUBTOTAL \$8,221.60

TOTAL EXPENDITURE \$16,436.50

				IX		

	WELL		FORMAT	ION(S)			FEET
7	Moomba 9 Moomba 1	0	Toolachee Toolachee	, Daraling . Daraling	ie ie	O	271 202
	Moomba 5 Moomba 5	2	Toolachee Toolachee				. 101 <u>115</u>

TOTAL 689 FT

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INCOME

(\$1000)

		1986	1987	1988	1989	1990	1991	1992	1993
1.	CARRYOVER FROM PREVIOUS YEAR	100	215	317	282	220	48	(167)	(403)
2.	DEET	164	173	176	176	181	186	192	198
3.	SADME	75	125	50	25	Ŏ	Ō	ن • 0	Ō
4.	UNI.OF ADELAIDE	0	0	0	45	0	0	Ö,	0
5.	Industry	126	133	109	100	100	100	100	100
6.	înterest*	13	38	41	34	26	6	Ö	0
7.	Total,	478	684	693	662	527	340	125	(105)
8.	EXPENDITURE	253	367	411	442	479	506	528	557
	BALANCE (CARRYOVER)	215	317 {}	282	220	48	(166)	(402)	(661)
ė.	NCPGG INCOME				12	35	50	150	300
io.	BALANCE // (CÄRRYOVER)				232	62	(101)	(187)	(246)

The NCPGG had a carryover balance of \$282,000 from 1988 to 1989. 1. 2. DEET funds, are assumed for the years 1990 to 1993. These funds are pending expected DEET reviews of the NCPGG during the forth quarter of 1989 and 1991.

3. No funds can be expected from SADME after the year 1989.

Special Equipment item of \$45,000 from the University of Adelaide. These funds replace industrial funds spent on equipment during 1988 to accommodate Sierra software. Industrial funds are assumed based on 1988 donctions.

6. Interest is calculated at 12 percent on the balance carryover · funds from the previous year. 7. Total NCPGG income.

Expenditures are increased annually between 8 and 10 percent. 8.

Assumed NCPGG income through consulting services, research grants, etc.

Balance (carryover) is the result of adding in NCPGG income to items 1-6.

NATIONAL CENTRE FOR PETROLEUM GEOLOGY AND GEOPHYSICS

DIRECTOR'S REPORT

1988

NCPGG OPERATIONS

10th May, 1989

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INTRODUCTION

During the 1988 calendar year the National Centre for Petroleum Geology and Geophysics has made significant progress in the consolidation of a viable centre to train students and perform research for and on the behalf of the petroleum industry. The NCPGG Advisory Board (page 2) which are made up of noted professionals from industry, government and the participating institutions, again provided guidance and initiatives in matters relating to budget, curriculum and proposed research programs. Board meetings were held on 20th April, 19th August and 2nd December. Mr. J.G. Brown retired from Shell Australia Limited in late October, 1988 and Mr. J.P. Spicher kindly accepted an invitation by Vice-Chancellor K.M. Marjoribanks to take a seat on the Advisory Board. The smaller Centre Committee met previously to these meetings to expedite business.

The Centre is supported by grants from the Department of Employment, Education and Training (DEET), NERDDC and SENRAC together with donations from the State Government of South Australia and the petroleum industry have made this possible. The NCPGG is grateful to these agencies and organizations for their support.

The Centre was successful in attracting 17 students from both local and interstate institutions to take the 1988 NCPGG Petroleum Program. Most of our students obtained employment in organizations across the nation.

A solid foundation for research was established during 1988 because the Centre was successful in obtaining grants from both government and industry to work on projects which are applicable to the petroleum industry. To aid this research and the training of students, Sierra Geophysics Inc. made a substantial donation of state-of-the-art geophysical software to the Centre. The Centre was also instrumental in providing a forum for the meeting of staff from terdary institutions and petroleum companies by holding seminars, courses and workshops. Centre staff continued to visit institutions, petroleum companies and other organizations to present results of research and to inform the public of Centre operations.

The important accomplishments noted above result from the continuing pursuit of the Centre's three major objectives.

These are;

- 1. To train students for a career in petroleum exploration
- To conduct research on topics in petroleum geology and geophysics
- 3. To foster co-operation between the petroleum industry, academia and government

The following pages will review the Centre's 1988 achievements in more detail,

ADVISORY BOARD MEMBERS

Dr. J.D. Armstrong (Chairman)

Dr. S.B. Devine

Mr. B.R. Griffith

Mr. D.R. McDonald

Mr. D.I. McEvoy

Mr. C.R. Porter

Dr. P.E. Power

Mr. J.G. Brown

Mr. V.G. Swindon

Mr. J. Turner

Mr. T.R. Watts

Prof. K.M. Marjoribanks

Prof. J.F. Lovering

Prof. A.P. Meade

Prof. L.A. Frakes

Dr. W.J. Stuart

- Santos Ltd.

- SAGASCO Resources Limited

B.H.P. Petroleum

- Lasmo Oil Company Australia

- Esso Australia Ltd.

- Consultant

- Ampol Exploration Limited

- Shell Australia Limited

Consultant

 Woodside Offshore Petroleum Pty, Ltd.

 S.A. Department of Mines and Energy

 Vice Chancellor, University of Adelaide

 Vice Chancellor, Flinders University of South Australia

- Director, South Australian Institute of Technology

- University of Adelaide

Director, NCPGG

CENTRE COMMITTEE MEMBERS

9

Dr. J.D. Armstrong (Chairman)

Mr. T.R. Watts

Prof. L.A. Frakes

Dr. S.A. Greenhalgh

Dr. J.B. Jago

Dr. W.J. Stuart

- Santos Ltd.

 South Australian Department of Mines and Energy

- University of Adelaide

 Flinders University of South Australia

 South Australian Institute of Technology

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NCPGG

NCPGG CONTRIBUTORS 1988

FINANCIAL

COMMONWEALTH GOVERNMENT:

DEPARTMENT OF EMPLOYMENT, EDUCATION AND TRAINING (DEET)
NATIONAL ENERGY RESEARCH, DEVELOPMENT AND
DEMONSTRATION COUNCIL (NERDDC)

STATE GOVERNMENT OF SOUTH AUSTRALIA:

SOUTH AUSTRALIA DEPARTMENT OF MINES AND ENERGY (SADME) SOUTH AUSTRALIAN STATE ENERGY RESEARCH ADVISORY COMMITTEE (SENRAC)

INDUSTRY:

AMPOL EXPLORATION LIMITED
BHP PETROLEUM
CLIFTON HILLS PASTORAL COMPANY
ESSO AUSTRALIA LTD.
LASMO OIL COMPANY AUSTRALIA LIMITED
ORCA PETROLEUM N.L.
SAGASCO RESOURCES LIMITED
SANTOS LTD.
SHELL AUSTRALIA LIMITED
WESTERN MINING CORPORATION LIMITED

SERVICES, EQUIPMENT AND LITERATURE

AMPOL EXPLORATION LIMITED AUSTRALIAN MINERAL FOUNDATION BHP PETROLEUM BRIDGE OIL COMMONWEALTH SCIENTIFIC AND INDUSTRIAL ORGANIZATIONS ESSO AUSTRALIA LIMITED FLINDERS UNIVERSITY OF SOUTH AUSTRALIA FRED HAEBERLE GREG SWINDON KEN SEEDSMAN LEW OWENS MIKE RENNISON MINCOM PTY, LTD. PACIFIC OIL & GAS PTY, LTD. POSEIDON OIL PTY, LTD. SANTOS LTD. SCHLUMBERGER SCHLUMBERGER SHELL AUSTRALIA LIMITED SIERRA GEOPHYSICS INC. SOUTH AUSTRALIAN DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIAN INSTITUTE OF TECHNOLOGY TEKTRONIX INC. UNIVERSITY OF ADELAIDE WESTERN MINING CORPORATION LIMITED WILTSHIRE GEOLOGICAL SERVICES WOODSIDE PETROLEUM WORLD OIL

1988 NCPGG ACTIVITIES

STUDENT RECRUITMENT AND EMPLOYMENT

The NCPGG's charter to serve the national interest requires it to recruit good students from throughout Australia. To this end, the Director and staff visited Tertiary institutions located in New South Wales, Queensland, South Australia, Tasmania and Victoria to inform staff and students about the NCPGG Petroleum Program. In addition, presentations were made on specific research topics e.g. 'Hydrocarbon Plays Related to Ancient Submarine Fans'. As a result, the Centre recruited 17 students, as shown in Table 1.

TABLE 1

1988 NCPGG STUDENTS

HONOURS	PREVIOUS INSTITUTION	EMPLOYMENT/ STATUS
CHEDID, Rachid	Tulsa, U.S.A.	Unplaced
DUCKETT, Ashley	Western Aust.	SAGASCO RESOURCES LIMITED
GIULIANO, Michael	R.M.I.T.	SANTOS Ltd.
HILLOCK, Peter	Adélaide	WMC'LIMITED
JONES, Paul	Macquarie	Mineral Sands
LOELIGER, Marius	Adelaide	,—, overseas travel "
MENPES, Sandra	Adelaide	PACIFIC OIL & GAS PTY.
		LIMITED
MITCHELL, Trevor	Macquarie	Dropped out
RYAN, Peter	Adelaide	ESSO AUSTRALIA LTD.
SANSOME, Alan	Adelaide	SADME
YONG, Lee	Tulsa, U.S.A.	CSR PETROLEUM
TRUPP, Mark	R.M.I.T.	SHELL AUSTRALIA LIMITED
ZAUNBRECHER, Michelle	Darling Downs	BHP PETROLEUM

MASTERS (in progress)

ALSOP, David	Sydney
	S.A.I.T.
MILLER, Lisa	New South Wales
THOMAS, Allan	Adelaide :

It is important to note that 12 of 13 B,Sc.(Hons.) students successfully completed the 1988 Petroleum Program. The 400 per cent increase in the number of Honours students from three during 1987, to 12 during 1988 is significant. The remaining four 1988 students are continuing their research as a partial requirement for Master Degrees. In addition, several students continue their research 'part-time' while working in the petroleum industry.

The success of the NCPGG Petroleum Program is attested to by the number of 1988 students who have obtained employment in the petroleum industry. The excellent employment record of the NCPGG students shows that industry recognizes the quality and distinctiveness of the training offered by the Centre. This record and the industrial training program are important factors in drawing students to the Centre.

The NCPGG refined its Petroleum Program during 1988 by adding courses entitled 'Drilling Operations', 'Effective Negotiations' and 'Field Days at Moomba'.

The objective of the course in Drilling Operations was to familiarise students with both onshore and offshore drilling technology (see Attachment A). The Centre believes that it is essential for students to have an understanding of this technology in order to make informed interpretations of well data and because many students will be involved first hand in wellsite work once they are employed.

The course on Effective Negotiations is intended as an additional aid to improve students' communication skills. This course, in addition to oral exams and research presentations, helps prepare students for presentations to management. The positive effect of this training was demonstrated when students delivered brief presentations of their research work to industry at a meeting held on 2nd December, 1988. Centre staff also informally discussed with students issues such as business and personal ethics, company policies concerning confidentiality of data, and management expectations of employees. In addition, the Centre advised students on conduct at employment interviews and preparation of a Curriculum Vitae.

The NCPGG field program was expanded to include a five day trip to the Moomba Field area. During this trip students visited three operational drilling rigs, a Seismograph Service seismic crew and the Schlumberger workshop. Santos Ltd. made this trip possible and provided lectures related to the Moomba plant and Tirrawarra gathering facilities. Personnel from the above companies made this trip an instructional and me, able experience for Centre students.

Several organisations provided funds and facilities for students to attend the six-week industrial experience program. The NCPGG is grateful to the organizations who participated in this program (Table 2).

TABLE 2

INDUSTRIAL PROGRAM PARTICIPANTS

AMPOL EXPLORATION LIMITED
BRIDGE OIL LTD.
ESSO AUSTRALIA LTD.
ORCA PETROLEUM
PACIFIC OIL & GAS PTY, LIMITED
POSEIDON OIL PTY, LIMITED
SAGASCO RESOURCES LIMITED
SANTOS LTD.
SHELL AUSTRALIA LIMITED
SOUTH AUSTRALIAN DEPARTMENT OF MINES AND ENERGY
WESTERN MINING CORPORATION LIMITED

RESEARCH

A 1988 objective was to acquire funds to accelerate research in the Centre. The Centre achieved this goal by obtaining grants from NERDDC, SENRAC, CSIRO and the petroleum industry. The NCPGG is working closely with the Cooper Basin consortium of companies who have made their data available to staff and students in the following projects:

Factors relating to the development of porosity and permeability in Permian Sandstones of the Southern Cooper Basin - NERDDC, SENRAC, SANTOS Ltd., CSIRO and WESTERN MINING CORPORATION.

Application of thin bed seismics to hydrocarbon exploration in the Cooper/Eromanga Basins ENRAC and SANTOS Ltd.

Results to date relating to these projects are encouraging and publications are expected during 1989 and 1990.

The NCPGG was instrumental in the submission of two NERDDC applications for the year 1989. NERDDC approved the following projects during the forth quarter of 1988:

Sparse Array Triaxial Seismic Imaging of Hydrocarbon Reservoirs Flinders University

Enhancement of Onshore Seismic Data - NCPGG

The State Government of South Australia ranked seismic studies one of its tor-four priorities for research during 1988. The Centre was the recipient of funds from SENRAC for seismic studies related to the Enhancement of Onshore Seismic studies. The late Professor Ray Sengbush from the Colorado School of Mines provided initial input into this project. Although it has been delayed by the need to seek a new Chief Investigator, the project is expected to recommence during mid 1989.

The paper "The influence of structural growth and other factors on the configuration of fluvial sandstones, Cooper Basin" was presented at the 1988 APEA Conference in Brisbane. Mr. A. Thomas, a current Masters student, presented this paper and his performance was a credit to the Centre. A paper entitled 'A methodical approach to critical well re-evaluation' by R.J. Willink was accepted by APEA for the 1989 Conference in Hobart.

The Honours and M.Sc. theses by Centre students also form a substantial body of research work. A bibliography is given in Attachment A. This research is related to many aspects of petroleum exploration and the industry has freely provided data from many Australian basins for student projects.

Sierra Geophysics Inc., which is located in Kirkland, Washington, made a very substantial donation of geophysical and geological software to the NCPGG during late 1988. A press release received during early 1989 outlines the reasons for this donation (Attachment B). Sierra has a reputation for setting the standard in industry for geophysical and geological software. The Centre is the first recipient of donated interpretation software (2DI) from Sierra to a tertiary institution worldwide. This software provides is an important research tool, and enables valuable 'hands on' training to be given to students. Its donation is an excellent demonstration of the Centre's distinctiveness in education and research.

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CO-OPERATIVE VENTURES

The Centre facilitated the meeting of representives from academia, industry and government via Advisory Board Meetings, workshops and courses. Over 130 participants attended lectures and workshops presented by Professor Peter Vail, the 1988 Esso Distinguished Lecturer. Professor Vail is a world authority on Sequence Stratigraphy. The Centre also hosted Professor Noel James from Queens University, Ontario, Canada. Professor James is well known for his research on carbonate sedimentology and diagenesis in relation to reservoir quality and the formation of hydrocarbon traps. In addition, the Centre hosted three seismic workshop courses which were presented in association with the joint ASEG/SEG international conference and exhibition in February, and a further workshop on Advanced Exploration Techniques was presented by Dr. Mike Badley in July.

The Director of the NCPG accepted an invitation from Dean Donald W. Gentry to visit the Colorado School of Mines (CSM); at Golden, Colorado. Academic staff at CSM stressed interest in staff exchanges. Discussions were also held with Dr. G.R. Ohme concerning the possibilities of a cooperative venture with the University of Queensland. As a result, a field trip is being planned for M.Sc. slydchis at the Centre to study modern carbonates on the Great Barrier Reef. A target date for this course was set for October, 1989.

Nick Lemon and Andy Mitchell (Centre staff), in a co-operative venture with the Australian Mineral Foundation, made use of their expertise in providing industrial courses in Structure and Seismic Sundgraphy, respectively. The previously mentioned NERDDC project on diagenesis of Permian sandstone in the Cooper Basin is also being pursued as a joint venture between soft of NCPGG and the South Australian Institute of Technology.

STAFF

The Centre during 1988 had five full-time professional staff who undertook the bulk of the lecturing and project supervision. Four have worked for major oil companies (Mobil, Esso, Shell and BHP), with a combined total of 44 years of industrial experience between them. Staff from the following institutions and the petroleum industry presented courses for the Centre (page 7 and Attachment A) and/or helped supervised Centre students doing research in their particular fields of interest.

Dr. R.J. Willink resigned from the Centre in December 1988 to become exploration manager for SAGASCO Resources Limited. He has been replaced by Dr. John Warren. Dr. Warren is a South Australian who comes to the Centre from the University of Texas. His numerous publications form a significant contribution to the industry and he has consulted for major petroleum companies in the United States and Middle East.

STAFF

NCPGG

Dr. W.J. Stuart Mr. N.M. Lemon Mr. A.B. Mitchell Dr. R.J. Willink Ms. S.E. Phillips

Director
Petroleum Geologist
Senior Lecturer-Geophysics
Petroleum Geologist
Research Officer

THE UNIVERSITY OF ADELAIDE

Prof. L.A. Frakes
Prof. D.M. Boyd
Dr. B.M. McGowran
Dr. V.A. Gostin
Dr. P.R. James
Dr. G. Korvin
Dr. D.M. McKirdy
MsFS. Stojanovic

Professor
Professor
Reader
Senior Lecturer
Senior Lecturer
Senior Lecturer
Lecturer
Lecturer
Museum Curator

THE FLINDERS UNIVERSITY OF SOUTH AUSTRALIA

Prof.C.C. von der Borch Dr. S.A. Greenhalgh

Professor Reader

THE SOUTH AUSTRALIAN INSTITUTE OF TECHNOLOGY

Dr. J.B. Jago Mr. B.B. Farrow Senior Lecturer Senior Lecturer

QUEENS UNIVERSITY (ONTARIO, CANADA)

Prof. N. James

Professor

INDUSTRY

S

Mr. J. Bowler, Mr. A. Clark Mr. D. Crowe Mr. M. Rennison Mr. M. Wiltshire Mr. G. Woods Ms. B. Youngs Consultant
Shell Australia Limited
AMF
Consultant
Wiltshire Geological Services

Santos Ltd. SAGASCO Resources Ltd.

"NCPGG FINANCES

) INCOME

The grand total income shown on page 10 amounts to a total of \$693,317. After expenditures amounting to \$411,469, the Centre had a carryover balance of \$281,848 from 1988 to 1989. These funds provide a cushion for the possibility of financial shortfalls because Centre staff and operations are mainly supported by donations and grants.

The NCPGG received 1988 installments on research grants from various organizations. These funds amounted to a total 6. \$118,175 and are shown separately from other donations because the reporting of expenditures is required by each agency.

EXPENDITURES

The NCPGG 1988 expenditures amounted to a total of \$411,469 (page 11). The detail relating to these expenditures is shown in Attachment C.

Expenditures exceeded the projected 1988 budget (\$400,745) by \$10,724. The Centre had an overrun of \$9,725 in expenditures relating to the category Research/Training. This overrun was partly due to the increase in consultant's fees from \$5,000 to \$10,000 for teaching two sessions of the course 'Formation Evaluation' to Centre students. This resulted from an increase in 1988 student numbers. In the same category, this increase in student numbers also impacted on transportation and accommodation costs which amounted to a total of \$3,600 for the Flinders-Moomba field trip.

Expenditures related to the Business category exceeded the 1988 budget by \$9,544. This variance is related partly to expenditures for Mr. A. Thomas, an NCPGG student, to present a paper at the 1988 APEA conference in Brisbane and Mr. A.B. Mitchell for a trip to the Colorado School of Mines to consult with Prof. Ray Sengbush concerning the Centre's 1988 NERDDC seismic submission. In addition, there was an increase in advertising costs to acquire staff and attract students to the Centre (see Attachment C).

In order to attract students to the Centre, a total of \$16,500 was expended for student scholarships. The Director sought additional funds from the petroleum industry to cover this expense. It is important that interstate students applying to the Centre, particularly those at the B.Sc. (Hons.) level, have stifficient funds to provide for living expenses in Adelaide while undertaking the petroleum program.

The expenditures related to other categories are near or below the 1988 budget or those additional funds approved by the Advisory Board for equipment.

INTANGIBLE COSTS

In preparation of a major review of the NCPGG by the Department of Employment, Education and Training during the forth quarter of 1989, it is important to provide this organization with intangible costs by the tertiary institutions and industry. These costs are shown on page 12 for the year 1985 to 1988. The NCPGG appreciates the contributions made from the institutions and petroleum industry to the Centre. In particular, the Director would like to acknowledge the help of the University of Adelaide in providing the administrative umbrella for the Centre.

1988 NCPGG INCOME

경우 경기 보는 경기 보다 하는 것이 되었다. 그는 사람들은 사람들이 되었다. 그런 그리고 있는 것은 그리고 있는 것이 되었다. 그런 것은 것은 것은 것은 것은 것은 것은 것은 것은 것은 것은 것 	9
COMMONWEALTH (DEET)	176,500
STATE GOVERTMENT OF SOUTH AUSTRALIA: SOUTH AUSTRALIAN DEPARTMENT OF MINES & ENERGY	50,000
INDUSTRY:	
AMPOL EXPLORATION LIMITED BHP PETROLEUM ESSO AUSTRALIA LTD. LASMO OIL COMPANY AUSTRALIA LIMITED SAGASCO RESOURCES LIMITED SANTOS LTD. SHELL AUSTRALIA LIMITED WESTERN MINING CORPORATION LIMITED EARNED INCOME	5,000 10,000 10,000 1,500 20,000 50,000 5,000 7,500 41,103
TOTAL INCOME	376,603
CARRYOVER FROM 1987 TO 1988	316,714
GRAND TOTAL INCOME	693,317
LESS 1988 TOTAL EXPENDITURES	411,469
NET INCOME CARRYOVER FROM 1988 TO 1989	281,848
RESEARCH GRANTS*	
PERMIAN SANDSTONE STUDY, COOPER BASIN (NERDDC*, SENRAC*, CSIRO & WESTERN MINING CORPORATION)	62,775
THIN BED SEISMIC STUDY (SENRAC)	5,400
ENHANCEMENT OF ONSHORE SEISMIC DATA (SENRAC)	50,000
	118,175
* ACTUAL FUNDS RECEIVED DURING 1988	

1988 NCPGG EXPENDITURES*

	\$ 1988 BUDGET	\$ ACTUAL*
SALARIES	260,945	258,702
EQUIPMENT	72,500	72,104
RESEARCH/TRAINING	31,000	40,725
BOOKS	4,000	3,189
BUSINESS: TRAVEL MAINTENANCE ENTERTAINMENT	18,750	28,294 11,286 12,266
OFFICE EXPENSES	7,700	4,742 4,479
VEHICLE (V)	6,000 👵	3,976
TOTAL	400,745	411,469

For deniled expenses to explain variances see Attachment C.

SPECIAL ITEM: SCHOLARSHIPS

INCOME:

	CLAREMOI CLIFTON H	III I S PAST	ODAT CO	MPANY		3,500 4,500
	ORCA PETI SENRAC FU	ROLEHM N.	Y			6,000 2,500
TOT	ÄL	16 (17)			(16,500
EXP	ENDITURE:					1 (20) - 구구 경 중국 (20) 2 (19)
¢x.	SCHOLARS	HIPS				16 500

INTANGIBLE COSTS (1985 - 1988)

INDUSTRY		₅₎ \$K
Student Industrial Program		200
Advisory Board Meetings		150
Lecturers		, 60
Donations: Periodicals & Books		<u>,50</u> ,°
• TOTAL		460
institutional overheads	9	, 1 ² .
UNIVERSITY OF ADELAIDE		
Housing of Centre		<i>:</i> 720
Dept, spec. staff (DM)		. 150
Dept. staff (teaching & supervision)	D p	. 60
Equipment		<u>45</u>
TOTAL		975
FLINDERS UNIVERSITY OF SOUTH AUS	<u>TRALIA</u>	
Housing of Centre 9		. 13
Dept, staff (teaching)		n a 40
» Équipment		<u> 15</u>
TOTAL		68
THE SOUTH AUSTRALIAN INSTITUTE O	F TECHNOLOGY	
Dept. staff (supervision)		5.
Equipment °		5
A C	병생하고 하는 사람들이 되었다. 참 집 하는 사람이 하고 있다.	1)
GRAND TOTAL		1,513

ATTACHMENT A

NATIONAL CENTRE 1988 CURRICULUM

oposton i Vermala Li Estada e	als Massal		
SESSION 1 - (5 weeks: 1st February - 5	Lecturer	Days	
		Geop	Geol
Structure	Lemon/James	5 7	5
Organic Geochemistry	McKirdy	5	
Field Excursion	Lemon/Willink	1	5 1
Petrophysical Logs & Patterns	Willink	4	4
Applied Petrophysics	Bowler 🔪	5 3	5
Sandstone Reservoirs	Willink/Lemon/Gostin	. 3	3
Study Days		4	4 5 3 4 3
Assessment		3	3
		30 .	30
a Total		3 U ,	,50
SESSION 2 - (12 weeks: 14th March -	27th May)		
SESSIOI 2- (12 Weeks, 1-til villei)			
Seismic Acquisition and			
Processing c	Mitchell	하다 속하는 사람	5
Seismic Signal Analysis	Korvin	9	
Seismic Processing	Korvin	5 9	÷
Seismic Interpretation	Mitchell	9	9 3
Applied Palaeontology	McGowran/Stojanovic/		3
일 보장이는 제고 되었다. 그는 하면 방문의 얼마를 받았다.	Woods		-1/a
Australian Phanerozoic	시시 시프리아 아마 나라를 모양을 했다.		
Evolution	Frakes	. 2	2
Carbonates: Diagenesis/	네 경기 : 그리고 있는데 하는데 하는데 되었다.	ä	<i>"</i>
Reservoirs	James Willink/Rennison/	3 4	3 6
Drilling Operations	Wiltshire		, Ч
Regional Geophysics	Boyd	2	2
Remote Sensing/Image			- T
Processing Processing	Lemon/Stuart	2	2 1
Effective Negotiations	Crowe	1	1
Exploration Strategies and	사이트 시작하는 사람들이 모르는 것이		
Economics	Youngs	2 7 3	2
Study Days		7	11
Assessment		3	″ 3
이 가게 하는 사람들이 되었다면 하는데 하는데 없었다.	그렇게 목표 목표를 보내고 있다. 이 물		4 9
0		49	49
SESSION 3 - (7 weeks: 30th may - 15th	n July)		
Field Camp (Flinders Ranges)	Lemon	ij	7
Field Days (Moomba)	Stuart/Clark	. 5	5
Seismic Acquisition	Greenhalgh el at	8	
Seismic Stratigraphy	Mitchell/		
	von der Borch	8	8
Case Studies	Stuart	4	4
Study Days			8 .
Assessment		3	3
			
SHERICALLY IN THE SHIP TOTAL OF	L. Xuemuk	35	35
SESSION 4 - (6 weeks: 18th July - 26th	n /xugust)		
Industrial work experience	하는 말 하고 하는 것이 나를 들어 있다고?	30	30
industrial work experience			
Grand Total		144	144
성 경기 인계 경기 및 사용성 및 기계 전혀 되었습니다. 성명성 전기 및 기계 및 기계 및 기계 및 기계 및 기계 및 기계 및 기계 및			

1000

115

COMPLETED THESES

ARNOT, L.B. 1986 - A geoseismic interpretation of the Early Permain Epsilon Formation truncation at the Daralingic Unconformity in the Kidman Complex, Cooper Basin, South Australia. (Hons.)

BROWNE, M.V. 1987 - A sedimentary and structural evaluation of the Fly Luke-Brolga field, Cooper Basin, South Australia, (Hons.)

CHEDID, R. - A study of Bennett Field, Surat Basin, Queensland, (Grad. Dip.)

DUCKETT, A.K. 1988 - Sequence stratigraphy outlining the depositional history of the Barrow Group Sub-basin, Northwest Shelf, Western Australia. (Hons.) (confidential until Nov. 25, 1990)

GIULIANO, M.F. 1988 - The geology and hydrocarbon potential of the Pedirka Basin, South Australia and Northern Territory. (Hons.)

GRASSO, C.A. 1986 - Palaeogeography of Permian sediments of the Munkarie and Brumby gas fields in the Cooper Basin utilizing genetic sequences of strata. (Hons.)

HILLOCK, P.M. 1988 - The petrophysics of the Nita Formation, Central Canning Basin, Western Australia. (Hons.) (confidential until Nov. 25, 1990)

JONES, P.J. 1988 - Diapir recognition and history from seismic, Arkaringa Basin, South

KENNEDY, S. 1988 - A study of the Patchawarra Formation in the Tirrawarra field, Cooper Basin. (M.Sc.)

LOELIGER, M. 1988 - Diagenesis of sandstone reservoir rocks in the Upper Roper Group of the Proterozoic, McArthur Basin, Northern Territory. (Hons.) (confidential until Nov. 25, 1990)

MENPES, S.A. 1988 - Mesozoic structural evolution of the Merrimelia area, Southern Cooper-Eromanga Basin, South Australia. (Hons.)

O'CLERY, M.D. 1986 - The Mesozoic geological evolution and regional hydrocarbon potential of the Northwest Shelf of Alistralia. (Hons.)

RYAN, P.J. 1988 - Structural development in the Northern Drummond Basin, Queensland. (Hons.)

SANSOME, A. 1988 - Review of the reservoir sands, Parchawarra Formation, in the Daralingie field area, Southern Cooper Basin, South Australia. (Hons.)

SMITH, M.J. 1987 - Facies interpretation and genetic unit mapping of the Epsilon Formation in the Toolachee field area, Southern Cooper Basin, South Australia. (Hons.)

STOCKMANN, J.E. 1987 - Seismic stratigraphy of the Tertiary sediments in the Dampier Subbasin and on the Rankin Platform, Northwest Shelf, Western Australia. (Hons.) (confidential until Nov. 25, 1989)

TRUPP, M.A. 1988 - Reservoir development within the Waare Formation, Port Campbell Embayment, onshore Otway Basin, Victoria. (Hons.)

YONG, L. - A geological study of the Basal Jurassic Sandstones in the Grafton Range Field, Surat Basin, Queensland, (external M.Sc.)

ZAUNBRECHER, M.B. 1988 - Hydrocarbon source potential of the Upper Roper Group, McArthur Busin, Northern Territory, (Hons.) (confidential until Nov. 25, 1990)

SUBMITTED THESES

CHAMBERLAIN, W.B. 1988 - A study of the post-Eocene development of the Bass Basin, Southeast Australia. (M.Sc.)

THOMAS, A.D. 1988 - Structural analysis of the Southwest Cooper Basin in Northeast South Australia, (M.Sc.)

THESES IN PROGRESS

ALSOP, D.B. - The effects of diagenesis and factes distribution on reservoir quality in the Permian sandstones of the Toolachee gas field, Cooper Basin, South Australia. (M.Sc.)

CARROLL, P.G. - The structural evolution and influence on sedimentation of the hydrocarbon-prone Gldgealpa-Merrimelia-Innaminka trend, Cooper Basin, South Australia. (external M.Sc.)

ELEFTHERIOU, J. - Diagenetic influences on reservoir quality of the Strzelecki-Kidman-Kerna area, Cooper Basin, South Australia, (M.Sc.)

HUDSON, G.R.T. - An investigation of near-surface geochemical exploration techniques for hydrocarbons. (part-time M.Sc.)

LUCAS, G.E. - Tau-P processing of triaxial seismic data. (M.Sc.)

MILLER, L.V. - Multivariate statistical analyses applied to the delineation of reservoir facies from seismic data. (M.Sc.)

NURTON, C.J. - The application of threshold pressure data in the study of Cooper-Eromanga Basin cap-rock seals. (external M.Sc.)

OLDIIAM, A.C. A seismic stratigraphic analysis of the Permian section in the Patchawarra East block, Cooper Basin, South Australia (part-time M.Sc.)

SIFFLEET, P.B. - Attenuation estimates for the Cooper Basin using vertical seismic profile data. (external M.Sc.)

SCHULZ-ROJAHN, J.P. - Modes of origin, evolution, and controls of Permian sandstone reservoirs, Cooper Basin, South Australia, (Ph.D.)

THOMAS, A.P. - Diagenetic alteration of certain arenaceous and argillaceous units of Jurussic to Permian age in the Moomba field, Southern Cooper Basin, South Australia. (M.Sc.)

THORNTON, D.A. - Structural and stratigraphic development of a genetic unit Within the Devonian sequence, Barbwire Terrace, Canning Basin, Western Australia. (part-time M.Sc.)

WEEDEN, R.J. - Regional analysis of the Mirbella Dolomite, Canning Basin, Western Australia, (external M.Sc.)

Sierra

FOR IMMEDIATE RELEASE: January 19, 1989

For more information, please contact:
Susan Fink
Edelman Public Relations
One Greenway Plaza
Suite 700
Houston, Texas 77046
(713) 623-2666

Sierra Geophysics/donates \$90,000 of software to National Centre for Petroleum Geology and Geophysics in Australia

HOUSTON--Sierra Geophysics, Inc. today announced that the company is donating \$90,000 (USD) of licenses in Sierra exploration software to the National Centre for Petroleum Geology and Geophysics (NCPGG) in Adelaide, Australia.

"This donation represents Sierra's support for and recognition of the outstanding work the NCPGG does in training students for a career in petroleum exploration," said Barry Lewing, Sierra Asia-Pacific account manager. In addition, we'll be looking to the NCPGG to assist us with benchmarks and industry projects that would be worthwhile educational opportunities for their students."

Lewine said that Sierra plans to make additional constions of licenses to NCPGG as the company's business develops in Australia. "We want to enhance our support to NCPGG by providing more software for instruction and research as our business in the country grows," he said.

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Donation & Add One

Sierra is donating to the Centre licenses for four products!

- o 2DI: 2-D seismic interpretation software;
- o MIMIC: geologic modeling and mapping software;
- o QUIKLOG, seismic well-log analysis software;
- o QUIKDIG: digitizing software.

"We will be utilizing Sierra's software for teaching, research and demonstration of projects as part of our continuing program to foster cooperation between the petroleum industry, academia and the government," said Bill Stuart, Ph.D. who is director of NCPGG.

The NCPGG was initiated, by funding from the federal government for a key Centre in late 1985 and it is strongly supported by the state government of South Australia and the petroleum industry. The Centre involves the University of of Adelaide, The Flinders University of South Australia and The South Australian Institute of Technology.

"The Centre is a prime training ground for future staff or those companies in the petroleum industry and has an aggressive seismic research program," said John Armstrong, Ph.D. chairman of the NCPGG Advisory Board and general manager of exploration for Santos Ltd. "Certainly, this contribution by Sierra will help the Centre to enhance our programs and provide the most advanced technology for teaching and research and development projects."

-more-

Donation

Sierra is the only supplier of hardware-independent software for modeling, interpretation and seismic processing. The company is headquartered in Kirkland, Washington and has offices in Houston, Texas; London, England; Calgary; Alberta; and Washington D.C.

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C'ALGARY HERALD
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AMERICAN OIL & GAS REPORTER
ASIAN OIL & GAS
AUTOMATED GRAPHICS ENTERPRISES
BUSINESS & INDUSTRY
CANADIAN CLINICAL LAB
CSEG RECORDER
DRILLING CONTRACTOR
EDMONTON JOURNAL
GEOBYTE
GEOLOGICAL MAGAZINE
GEOLOGY

GEOPHYSICS: THE LEADING EDGE

REUTERS
SEATTLE POST INTELLIGENCE
SEATTLE TIMES
THE ASSOCIATED PRESS
THE ENERGY REPORT
THE NEW YORK TIMES
THE OFFSHORE RIG NEWSLETTER
THE OIL DAILY
THE OILMAN
THE SUN OESERVER
UNITED PRESS INTERNATIONAL
WALL STREET JOURNAL
WORLD OIL

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HOUSTON CHRONICLE
HOUSTON POST
INTERNATIONAL OIL NEWS
JOURNAL OF CANADIAN PETROLEUM TECHNOLOGY
JOURNAL OF PETROLEUM GEOLOGY
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KPRC-AM BADIO
KPRC, CHANNEL 2
KTRH-AM RADIO
KTRK, CHANNEL 13
MID CONTINENT OIL WORLD
NATIONAL OIL JOURNAL
NOROIL
NOROIL
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OFFSHORE DATA SERVICES
OIL & GAS AUSTRALIA
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OIL & GAS NEWS
OILWEEK
PETROCONSULTANTS INTERNATIONAL OIL LETTER
PETROCONSULTANTS INTERNATIONAL

PETROLEUM ENGINEER INTERNATIONAL PETROLEUM INFORMATION PETROLEUM MANAGEMENT PETROMIN ASIA PLATT'S OILGRAM NEWS

PETROLEUM COMPUTING

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ATTACHMENT C

1988 NCPGG EXPENDITURE

3	ΑL	A.	RI	ES	65	
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20.0	1000	100				

PROFESSIONAL STAFF		
Net salary	Carrie Early	
Superannua tion	211,518.69	
Payroll tax	22,054.07	
Workers compensation	9,140.77	新花风风 医环状
R. Sandhuak / anuma	2,571.49	
R.Sengbush (SENRAC FUND	S) 13,189.02 c	R
		232,096.0
CLERICAL STAFF		
Net salary		J. 7 D. 12 (4)
Superannuation	22,532.72	ก
Payroll tax	370.94	
Workers compensation	1,126.64	
compensation	315.16	

- SERVICES (STUDENTS) Net salary 7,843.22 Payroll tax 392.16 Workers compensation 25.64 Pacific Oll & Gas income* 6,000.00 CR

2,261.02 TOTAL SALARIES EXPENSE 258,702.48

Student Industrial Program

EQUIPMENT Hardware

Tapes for Dec Micro	22 22
Webster Castasta	80.00
KANTARI MELLINISTE	25.00
Minigavita Head at	47.50
Carter phone terminal	50.00

DEC Hardware/sofeware 825.00 maintenance - 22/7/88 4,000.00 - 28/7/88 2,000.00 - 27/10/88 1,090.00 Industry equipment 5.00 Vax installation 178.04

Tektronix equipment and Graphics terminai 34,169.17 Install Miczovax II 22,500.00 industry equipment 455.00 Merlin tape 16:80 Aussia duct 86.77 Install memory Webster

71,604.28 - Software Lopatin package 500.00 500.00

4,676.00

TOTAL EQUIPMENT EXPENSE

72,104.28

14,614.30

24,000.00

2,110.18

40,724.48

0

RESEARCH/TRAINING

	建设建设门的国际信息		
- Tead			
Lo	og Evaluation	Courses 10	,000.00
F)	Inders-Moomb	a V	
	fieldtrip		,500.00
C	rbonate Lect	ure(N.James)	562.70
D:	cilling Lectu	re	
	(Rennison)		650.00
o Ti	ravel - Willi	amson O	
	(Lecture)	흥분인 전혀 감고했다	474.00
F	uji Video tap	es (P.Vail)	236.00
À	MF - Carbonat	e video	191.60

- Training/Scholarships 8,000.00 8,000.00 Flinders 8,000.00 Adelaide 8,000.00

- Student Excursions
Travel - Stuart 185.60
Travel - Thomas 100.00
Vehicle use 83.75
Travel - Lemon 277.81
Travel - Willink (Moomba) 342.82
Accomodation (Moomba)
- Students and staff 1,100.00

Accomodation (Moomba)
- students and staff 1,100.00
Travel - Willink 20.20

TOTAL RESEARCH/TRAINING EXPENSE

<u>BODKS</u> 3,188.90

BUSINESS

USINESS	-	
Travel		
W.J. Stuart	/	
- recruisment	1,136.06	
- Adel-M≱1	322.00	11
- Adel-Manberra	/454.00 🔩	
- NWS Sym.//	724.00	
	1	2,636.06
# # # # # # # # # # # # # # # # # # #		
A.B. Mitchell		
A.B. Mitchell - CSM (airfare)	4,068.85	
- Selemia Conference	454.00	
		4,522.85
N.M. Lemon		2.2
-/Conference Canberre		706.50
y.J. Willink /		
/- APEA	642.00	
// Adel-Mel	322.00 724.00	
/ - NWS Sym.	724.00	1,688.00
		1,000,00
A.D. Thomas		610.00
= APEA		810.00
A.K. Duckett		
A.K. Duckett - Perth-Adelaide	513.00	
- Adelaide-Perth	544.00	
- Adelaide-Pertif	534.00	1,057.00
Petrol	얼마 얼마 하를 받는	65.29
~		
TOTAL TRAVEL EXPENSE		11,285.70
- Maintenance		
o /		
W.J. Stuart		
- recruitment	1,573.88	
- NCPGG (ASEG Conf.)	617.00	
- NWS Sym. (reg. & exp.)	337.00	그 내용 보다 보냈다.
- APEA Conference	345.00	
- AIP Conference	80.00	
- Yorke Pen. (N.James)	79.05	5 651 65
	<u></u>	3,031.93
A.B. Mitchell		1,079.70
- CSM		
R.J. Willink	69.80	
	346.00	
- APEA Conference	189.31	
- APEA (exp.)	324.00	
- NSW Sym. (reg. & exp.)	297.00	
		1,226.11
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
A.D. Thomas		
- APEA (reg.)	310.00	
- APEA (accom.)	243.00	
- APEA (exp.)	142.85	
나보다 되는 경기를 받았다면 하는 경기 때문	paramontonia.	695.85

L.A. Yong		
- Adel-Acquinas		105.00
Advertisements		4,712.61
Brochures	다양성학생년 공기기자	2,576.00
Subscription) Yang	284.48
Other Items		1,295.82
P.Vail Workshop expense		1,148.56
TOTAL MAINTENANCE EXPENSE		16,156.07
Less Income from	9	
	90.00	
	600.00	
	100.00	
	100.00	
	100.00	
	100.00	
	300.00	
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- Morgan - Leslie	50.00	
	550.00	
- SADME	50.00	
- SADME	50.00	
	250.00	
	100.00	
- SANTOS .1,	000.00	
- SADME	100.00	AVA.
	<u>an and and a</u>	3,890,00
NET MAINTENANCE EXPENSE		12,266.07
	2	\
= <u>Entertainment</u>		
Annual Student Functions	*	
- New students - Company representative	ä	484.15
(Luncheons)		2,586.57
		[기본 회원 등이 원인 글로마
NCPGG X'mas party		1,600.00
NCPGG X'mas party Other Items (petty cash)		1,600.00 70.90
Other Items (patty cash)	WSE	70.90
Other Items (petty cash)	WSE	70.90

0.00

4,479.18

OFFICE EXPENSES		
- Printing		
P.Vail Course	308.70	
Envelopes	24.95 134.55	
Other items	134+33	468.20
- Postage		255.28
- Stationery		1,490.56
- Courier		344.86
- Accommodation - R.Sengbush	173.12	
Rent - R. Sengbush	1,000.00	
R.Sengbush (SENRAC FUNDS)	1,173.12 CR	0.00

1,420.28 Petty cash

3,976.38 VEHICLE

TOTAL OFFICE EXPENSE

411,469.09 TOTAL NCPGG EXPENDITURE - 1988