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CRAYFISH SUBGROUP BIOSTRATIGRAPHY PROJECT FINAL REPORT

by

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DEPARTMENT OF MINES AND ENERGY RESOURCES
SOUTH AUSTRALIA

REPORT BOOK 94/33

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A. Rowett

A new subdivision of the *Foraminisporis wonthaggiensis* Zone (Helby *et al*, 1987) of the Early Cretaceous Crayfish Group sediments of the Otway Basin is proposed. Seven zones are identified from the palynological data and three from the dispersed cuticle. The reference biozonations were initially produced from detailed sampling of core, sidewall core and cuttings of Katnook 2 and modified on the basis of information obtained from thirteen wells selected by project sponsors.

The palynological biozonation was successfully identified in all wells, resulting in correlations being made along three transects through the Basin. These correlations were supported by the dispersed cuticle information when available. The dispersed cuticle biozonation was identified in several wells.
More detailed sampling of the selected and numerous additional wells is recommended to further refine these biozonations.

INTRODUCTION

The establishment of the Katnook 2 palynological and disperse cuticle reference biozonations for the *Foraminisporis wonthaggiensis* Zone (Helby et al 1987) and Lower *Cyclosporites hughesii*, Upper and Lower *F. wonthaggiensis* zones (Morgan 1993) were achieved in Stage One. The aim of this the final stage of the project has been to produce palynological and dispersed cuticle biozonations over the same spore/pollen interval in eleven wells selected by project sponsors (Figure 1) and correlate with the reference biozonations.
Sufficient palynological data was obtained from all wells to produce a recognisable profile with all or part of the reference biozonation identified. Correlation within the Crayfish Group has therefore focused on these profiles.

A modification was made to one palynological zone (Zone 4) in the reference biozonation based on this information. The dispersed cuticle data was less complete with less than half of the seven profiles produced considered acceptable. The use of small cutting samples in the analysis of many of the wells prevented the recovery of enough material to produce truly representative dispersed cuticle trends. The dispersed cuticle profiles produced for each well have been examined and zones assigned. In all instances the assigned zones correspond to the related palynological zones.

The fourteen wells have been linked in three transects across the Basin (Figure 2). The longest transect links seven wells in the Penola Trough from the offshore wells Troas 1 and Crayfish 1 in the west, through Katnook 2 to the Victorian wells of Bus Swamp 1 and Casterton 1 in the east. A second, shorter transect through the Penola Trough links Reedy Creek 1 and Laira 1 with Katnook 2. The other transect runs approximately north - south linking Robertson 1 and Sawpit 1 through the three Katnook wells with Ladbroke Grove 1. For ease of interpretation and presentation the resultant palynological correlations are displayed in these transects (Appendix 1).

SAMPLE ANALYSIS

Katnook 1, Katnook 3; Ladbroke Grove 1, Sawpit 1, Robertson 1, Laira 1, Reedy Creek 1, Crankshaft 1, Lake Hawdon 1, Crayfish 1, Troas 1,
Stratigraphic Information
Stratigraphic Unit: Crayfish Group.
General Location: South-east South Australia.
Geological Province: Otway Basin.
Mapsheet 1:250 000: Penola.
Bus Swamp 1, Casterton 1.
Stratigraphic Information

Stratigraphic Unit: Crayfish Group.
General Location: South-west Victoria.
Geological Province: Otway Basin.
Mapsheet 1:250 000: Hamilton.

Palynological Analysis
Laboratory technique: Standard with Acetylation and 129m and 10m sieves.
Microscope used: Photomicroscope III.
Palynomorphs counted: 300-350 in each sample.

Dispersed cuticle Analysis
Laboratory technique: HF treatment followed by Standard Cuticle Preparation (Rowett & Christophel 1990, Rowett & Sparrow 1994). Alternative procedure employed, collection at Heavy Liquid Stage in palynological analysis.
Microscope used: Laboval 4 (Zeiss) Research Microscope.
Dispersed Cuticle counted: All or 1000 in each sample.

RESULTS

Analysis of the palynological and dispersed cuticle data of Katnook 2 resulted in the production of two reference biozonations, both of which were defined in the February Progress Report (Rowett 1994) and are repeated below. The palynological scheme was the most detailed with six zones identified, with three zones recognised for the dispersed cuticle (Figure 3).
Katnook 2 Palynomorph Profile (Progress Report Figure 1, 1994)
ZONE 6: 1858.7m - 1876.3m
ZONE 5: 1876.3m - 1935.0m
ZONE 4: 1935.0m - 2868.76m
ZONE 3: 2868.76m - 2872.2m
ZONE 2: 2872.2m - 2907.5m
ZONE 1: 2907.5m - 3045.0m

ZONE 1

The least well defined zone marking the base of the sampling interval. The single sample shows no major trends other than the dominance of *Cyathidites australis* which is reversed with the related *C.minor* for Zone 2 upwards. It is the only Zone where *C.minor* records a frequency of <10%.

ZONE 2

This is defined on the basis of high *Cyathidites minor*, and *Osmundacidites wellmanii* frequencies with *Retitriletes* spp. and bisaccate pollen common. *R.austroclavatidites* and *Alisporites similis* are the major contributors, respectively. A mid-zone decline in abundance is characteristic of *C.australis* and *A. similis* corresponds to a peak (>30%) in *O. wellmanii*. Although a minor component *Foraminisporis wonthaggiensis* records its highest frequency for the entire sequence.

ZONE 3

A narrow zone dominated by *Osmundacidites wellmanii* and gymnosperms, particularly bisaccate grains. The former species is most abundant at the top of the Zone, the latter at the base of the Zone. *Cyathidites minor* and *Baculatisporites comaumensis* are common. The *Retitriletes* spp., *Neoraistrickia* spp. and bisaccate pollen decline in abundance towards the top of the zone, whereas the trisaccate pollen show an overall increase in frequency. *Foraminisporis wonthaggiensis* rare.

ZONE 4

The largest Zone in the sequence is defined on the basis of high frequencies of *Cyathidites minor*, *Osmundacidites wellmanii* and gymnosperm pollen with *C.australis* and *Baculatisporites comaumensis* well represented. A decline in abundance of *O. wellmanii* (<10%) near the middle of the zone corresponds to increases in *B. comaumensis* (>15%) and trisaccate grains (>18%). *Retitriletes* spp., *Neoraistrickia* spp. and Stereisporites *antiquasporites* are minor components. Trisaccate grains are the main contributor to the gymnosperm component.

ZONE 5

This zone is defined by the codominance of *Cyathidites minor* and *Osmundacidites wellmanii* with *C.australis* and *Baculatisporites comaumensis* common. *Retitriletes* spp., *Ceratosporites equalis*, *Classopollis chateaunovi*, *Neoraistrickia* spp., *Stereisporites antiquasporites* and gymnosperm pollen are minor contributors.

ZONE 6

This zone is defined on the basis of high frequencies of *Cyathidites minor*, *C.australis* and gymnosperm pollen with *Osmundacidites wellmanii* common. *C.minor* and *C.australis* and *O. wellmanii* are most abundant near the top of the Zone whereas gymnosperm pollen records its highest frequencies (combined) near the base of the Zone. *Neoraistrickia* spp., *Retitriletes* spp., *Classopollis chateaunovi* and *Ceratosporites equalis* are minor components. The gymnosperm component is dominated by bisaccate grains. *Pilosisporites notensis* is confined to this zone.
Katnook 2 Dispersed cuticle Profile (Progress Report Figure 2, 1994)
ZONE 3: 1858.7m - 1876.3m
ZONE 2: 1876.3m - 2865.0m

ZONE 1: 2865.0m - 3045.0m

ZONE 1

This zone is defined by the high frequencies of DM310A and DM310B with DM327 and DM309 common and DM328 well represented near the top of the Zone. DM308, DM311, DM318 and DM338 are minor contributors. DM338 is confined to the zone.

ZONE 2

This broad zone is defined on the basis of high frequencies of DM310A and DM310B with DM398 common and DM308, DM311, DM318 and DM325 minor contributor. DM311 and DM325 define the upper and lower limits of the zone respectively. Several rare cuticle types are confined to the zone.

ZONE 3

The youngest zone is defined by the high frequencies of cuticle types DM310A, DM310B and megaspores *Pyrobolospora hexapartita* and unknown Megaspore II with DM311 common. DM308, DM309, DM318 and DM327 are minor contributors with the gymnosperm cuticles DM319 and DM340 confined to the zone.

The analysis of the palynofloras of the other selected wells resulted in a modification to ZONE 4 of the reference biozonation of Katnook 2 (Figure 4).

The recognition of a consistently occurring change in frequency in a number of key palynomorph groups/species, primarily *Cyathidites minor, C.australis, Osmundacidites wellmanii* and Total Gymnosperm in the identified Zone 4 of the wells prompted its division.

The two new zones are identified as Zone 4a and Zone 4b and defined over the following interval.

Zone 4a: 1935.0m - 2117.5m.

Zone 4b: 2117.5m - 2868.76m.

Zone 4b is defined by an overall gradual decline in frequency of *C.minor*, *C.australis* and *O.wellmanii* from the base to the top of the zone. This trend negatively corresponds to an increase in the overall abundance of gymnosperm pollen, particularly in the occurrence of trisaccate grains. The peak in gymnosperm abundance occurs at the top of the zone.

Zone 4a is defined by more or less a reversal of the trends recognised in Zone 4b. There is an overall increase in *C.minor*, *C.australis* and *O.wellmanii*, the trend being more pronounced in the latter two species, which again negatively corresponds to an overall decline in gymnosperm abundance.

KATNOOK 1

Core, Cuttings

Sample Interval 1893.0m - 2312.5m.

Palynological and dispersed cuticle profiles produced (Figure 5).

Palynological Profile

Three spore/pollen zones recognised, upper Zone 4b, Zone 4a and lower Zone 5.

Zone 5: Top unknown - 1894.0m.

1894.0m - 2130.0m Samples Not Taken.

Zone 4a: 2130.m - 2167.5m.

Zone 4b: 2167m - Base unknown.

The profile infers there have been reductions in the thickness of both Zones 4a and 4b compared to Katnook 2, but this may be the result of the sampling procedure. It is possible that Zone 4a extends further up the sequence into the overlying unsampled interval in which case the Zone may be as thick, if not thicker than Zone 4a in Katnook 2. Similarly the unsampled interval below Zone 4b may well extend the zone deeper in which case it may be of an equivalent thickness to that in Katnook 2. Additional sampling in these intervals is therefore required to improve the limits of these zones.

Dispersed cuticle Profile

One dispersed cuticle zone recognised, Near the top of Zone 2.

Zone 2: Top Unknown - 1894.0m

1894.0m - 2130.0m Samples Not Taken

Zone 2: 2130.0m - Base unknown.

KATNOOK 3

Core. Sample Interval 2859.1m - 2921.8m.

Palynological and dispersed cuticle profiles produced (Figure 6).

Palynological Profile

Two spore/pollen zones recognised, Zone 3 and Lower Zone 4b.

Zone 4b: Top unknown - 2906.9m.

Zone 3: 2906.9m - 2921.8m.

Katnook 3 has a very short profile. It was decided to sample only core as there was little from the equivalent interval available in the other Katnook wells. Over the interval Zone 3 was identified and the very base of Zone 4b. More extensive sampling would probably produce a similar biozonation to that of Katnook 2.

Dispersed cuticle Profile
One zone recognised.
Near the top of Zone 1: 2859.1m - 2921.8m.

LADBROKE GROVE 1
Core, Cuttings. Sample Interval 1835.0m - 3115.23m.
Palynological and dispersed cuticle profiles produced (Figure 11).

Palynological Profile
Four spore/pollen zones recognised, base of Zone 2 up through Zones 3, 4b and to upper Zone 4a.
Zone 4a: Top unknown - 1977.5m.
Samples Not Taken 1977.5m - 2132.5m.
Zone 4b: 2132.5m - 2568.0m.
Zone 3: 2568.0m - 2590.0m.
Samples Not Taken 2590.0m - 2721.3m.
Zone 2: 2721.3m - 3115.23m.

Ladbroke Grove 1 has a biozonation similar to that of Katnook 2. The major difference is a thickening of Zone 2. Zones 4a and 4b appear similar in thickness to those in Katnook 2, but additional sampling will be required to locate the actual depth of the boundary between them. This may result in an expansion upwards (younger upper limit) of Zone 4b, which would be more characteristic of Katnook 2 or an expansion downwards (older lower limit) of Zone 4a, which would produce a broader zone than present in Katnook 2.

Dispersed cuticle Profile
Two dispersed cuticle zones recognised, upper Zone 1 and base Zone 2.
Zone 2: Top unknown - 2245.0m.
Zone 1: 2245.0m - base unknown.

SAWPIT 1
Cuttings only. Sample Interval 1250.0m - 2265.0m.
Palynological profile only (Figure 16).

Palynological Profile
Four spore/pollen zones recognised, Zone 2, Zone 3, Zone 4b and part of Zone 4a.
Zone 4a: Top unknown - 1287.5m.
Samples Not Taken 1287.5m - 1497.5m.
Zone 4b: Top unknown - 1880.0m.
Zone 3: 1880.0m - 2032.5m.
Zone 2: 2032.5 - 2180.0m.
Samples Not Taken 2180.0m - 2265.0m.
Zone 2: 2265.0m base unknown.

The biozonation represented in Sawpit 1 is somewhat different to that of Katnook 2 with an expanded Zone 2 and Zone 3, a slightly narrower Zone 4b and a very narrow Zone 4a. A large unsampled interval between the top of Zone 4b and base of Zone 4a made it difficult to locate a more accurate boundary. Additional sampling will either provide a younger upper limit to Zone 4b or an older lower limit to Zone 4a.

ROBERTSON 1
Core, Cuttings. Sample Interval 846.5m - 1579.3m.
Palynological and dispersed cuticle profiles produced (Figure 15).

Palynological Profile
Four spore/pollen zones recognised. Upper Zone 4b, lower Zone 4a, upper Zone 4a, Zone 5 and most of Zone 6.
Zone 6: Top unknown - 993.0m.
Zone 5: 993.0m - 995.0m.
Zone 4a: 995.0 - 996.3m.
Samples Not Taken 996.3m - 1323.2m.
Zone 4a: 1323.2 - 1335.4m.
Zone 4b: 1335.4m - base unknown.

Robertson 1 overall sequence appears to be more condensed but does extend up into the lower *C.hughesii* (Morgan 1993). This is marked by Zone 6, which appears to be thicker than that found in Katnook 2. The top of the Upper *F.wonthaggiensis* Zone (Morgan 1993) is identified by a very narrow Zone 5. Zone 4a also appears very narrow but additional sampling of the overlying unsampled interval could well extend the upper limit of the zone. Zone 4b is the thickest, extending to the lower sampling limit. Overall it is a less extensive biozonation and only at the top are the zones of a comparable thickness to those of Katnook 2.

Dispersed cuticle Profile
Two dispersed cuticle zones recognised, upper Zone 2 and lower Zone 3.
Zone 3: Top unknown - 993.0m.
Zone 2: 993.0 - base unknown.

TROAS 1
Cuttings only. Sample Interval 2345m - 3372m.
Palynological profile only (Figure 17).

Palynological Profile
Four spore/pollen zones recognised, Zone 4a, Zone 4b, Zone 3 and Zone 2.

Zone 4a: Top unknown - 2526.0m.
Zone 4b: 2526.0m - 2802.0m.
Samples Not Taken 2802.0m - 2922.0m.
Zone 3: 2922.0m - 3105.0m.
Samples Not Taken 3105.0m - 3282.0m.
Zone 2: 3282.0m - base unknown.

The distinctive features of the Troas 1 biozonation are the absence of the younger zones, i.e. Zone 6 and Zone 5, and a thicker Zone 3.
Additional sampling of the unsampled intervals overlying Zones 3 and 2 respectively could alter the zones significantly. It is possible that the older Zones 3 and 2 could be much thicker with both zones having younger upper limits. It is equally possible that Zones 4b and 3 could have older lower limits. or that Zone 3 have both a younger upper and older lower limit. The latter possibilities would substantially increase the thickness of Zone 3, thus altering the biozonation significantly.

CRAYFISH 1
Core samples only. Sample Interval 1407.1m - 3195.4m.
Palynological and dispersed cuticle profiles produced (Figure 10).

Palynological Profile
Four spore/pollen zones recognised, Zone 4a, Zone 4b, Zone 3, Zone 2.
Zone 4a: Top unknown - 1859.1m.
Samples Not Taken 1859.1m - 2170.0m.
Zone 4b: 2170.0m - 2467.6m.
Zone 3: 2467.6m - 2770.4m.
Samples Not Taken 2770.4m - 3195.4m.
Zone 2: 3195.4m - base unknown.

The biozonation of Crayfish 1 appears similar to that of Troas 1 with Zone 4a occurring at the top of the sequence and Zones 4b and 3 of similar thickness. Additional sampling of the unsampled intervals overlying Zones 4b and 2 is needed to confirm the boundary between Zones 4a and 4b and Zones 3 and 2 respectively. More detailed sampling is also required below Zone 2 to confirm its lower limit.

Dispersed cuticle profile
Two dispersed cuticle zones recognised, Zone 2 and top of Zone 1.
Zone 2: Top unknown - 1859.1m.
Barren Interval 1859.1 - 2471.3m.
Zone 1:.2471.3m - 2770.0m. Base unknown.
Samples Not Taken 2770.0m - 3195.4m.

LAKE HAWDON 1
Cuttings only. Sample Interval 603.7m - 1896.3m.
Palynological and dispersed cuticle profiles produced (Figure 13).

Palynological Profile
Three spore/pollen zones recognised, Zone 6, Zone 4a and Zone 4b.
Zone 6: Top unknown - 612.8m.
Samples Not Taken 612.8m - 1277.3m.
Zone 4a: 1277.3m - 1804.9m. Note: sampling intervals > 100m through zone.
Zone 4b: 1804.9m - 1896.3m.

The biozonation of Lake Hawdon 1 must be considered tentative. The lack of detailed sampling has made it difficult to assign zones within the Upper and Lower *F.wonthaggiensis* Zones. Zones 4a and 4b have tentatively been assigned but it would probably be more appropriate at this time to have a Zone 4. More detailed sampling through the sequence is required if an accurate biozonation is to be produced for this well.

Dispersed cuticle Profile
Two dispersed cuticle zones recognised, Zone 3 and Zone 2.
Zone 3: Top unknown - 612.8m.
Samples Not Taken 612.8m - 1277.3m.
Zone 2: 1277.3m - base unknown.

CRANKSHAFT 1
SWC, Cuttings, processed from R. Morgan, Sample Interval 1592.5m - 2520.0m.
Palynological Profile only (Figure 9).

Palynological Profile
Four spore/pollen zones recognised, Zone 6, Zone 4a, Zone 4b and Zone 3.
Zone 6: Top unknown - 1602.5m.
Zone 4a: 1602.5m - 1895.0m.
Samples Not Taken 1895.0m - 2110.0m.
Zone 4b: 2110.0m - 2149.0m.
Zone 3: 2149.0m - 2182.5m.
Samples Not Taken 2182.0m - 2520.0m.

A more detailed sampling of the Upper and Lower *F.wonthaggiensis* Zones is required for Crankshaft 1. Zone 4a has a known upper limit, but the boundary between it and Zone 4b needs to be determined. Zone 3 has been identified but its lower limit is unknown and will therefore require further sampling.

BUS SWAMP 1
SWC, Core, Sample Interval 845.0m - 1790.0m.
Palynological and dispersed cuticle profiles produced (Figure 7).

Palynological Profile
Five spore/pollen zones recognised. Zone 6, Zone 5, Zone 4a, Zone 3 and Zone 2.
Zone 6: Top unknown - 982.0m.
Zone 5: 982.0m - 1026.0m.
Samples Not Taken 1026.0m - 1145.0m.
Zone 4a: 1145.0m - 1325.0m.
Barren Interval 1325.0m - 1406.0m.
Zone 3: 1406.0m - 1509.83m.
Zone 2: 1509.83m - 1515.0m.
Samples Not Taken 1515.0m - 1785.23m.
?Zone 2: 1785.23m - 1790.0m.

The biozonation produced for Bus Swamp 1 is interesting in that while Zones 6, 5, 4a, 3 and 2 are represented, Zone 4b is absent. A barren interval exists between Zones 3 and 4a. Zones 6, 5 and 4a appear comparable to those in Katnook 2 but with additional sampling the latter zone is likely to become thicker with the determination of a younger upper limit. Zone 2 will probably be found to extend to a greater depth with additional sampling.

Dispersed cuticle Profile
Two dispersed cuticle zones recognised. Zone 3 and Zone 1.
Zone 3: 845.0m - 982.0m.
Barren Interval 982.0m - 1509.83m.
Zone 1: 1509.83m - 1515.0m.
Sample Not Taken 1515.0m - 1785.23m.
?Zone 1 1785.23m - 1790.0m.

CASTERTON 1
Core, Cuttings, Sample Interval 1374.0m - 2091.0m.
Palynological and dispersed cuticle profiles produced (Figure 8).

Palynological Profile
Three spore/pollen zones recognised. Zone 4b, Zone 3 and Zone 2.
Zone 4b: 1374.0m - 1460.0m.
Zone 3: 1460.0m - 1499.0m.
Samples Not Taken 1499.0m - 1607.0m.
Barren 1607.0m.
Sample Not Taken 1607.0 - 1710.0m.
Zone 2: 1710.0m - 1713.0m.
Sample Not Taken 1713.0m - 1953.0m.
?Zone 2: 1953.0m - 2062.0m.

The Casterton 1 biozonation shows an interesting contrast to Bus Swamp 1 in that Zone 4a is not present at the top of the sample interval. Sampling further up in the sequence is required to determine whether this zone can be delimited. Additional sampling is also needed to confirm the boundary between Zones 2 and 3. Extending the overall sampling interval (up and down through the sequence) would be useful in this well.

Dispersed cuticle Profile
Two dispersed cuticle zones recognised, lower Zone 2 and upper Zone 1.
Zone 2: 1374.0m - 1499.0m.
Barren Interval 1499.0m - 1713.0m.
Samples Not Taken 1713.0m - 1953.0m.
Zone 1: 1953.0m - base unknown.

REEDY CREEK 1
Cuttings only. Sample Interval 1675.0m - 2592.5m.
Palynological profile produced (Figure 14).

Palynological profile
Five spore/pollen zones recognised, Zone 6, Zone 5, Zone 4a, Zone 4b and Zone 3.
Zone 6: 1675.0m - 1707.5m.
Zone 5: 1707.5m - 1752.5m.
Zone 4a: 1752.5m - 1805.0m.
Zone 4b: 1805.0m - 1925.0m.
Zone 3: 1925.0m - 1987.5m.
Sample Not Taken 1987.5m - 2592.5m.

The biozonation for Reedy Creek 1 shows five significantly narrower zones, particularly Zones 4a and 4b, than those in Katnook 2. There is a large unsampled interval below Zone 3 which with additional sampling may determine the presence of the older Zone 2.

LAIRA 1
SWC residues only, processed by R. Morgan.
Sample Interval 1916.5m - 2897.0m.
Palynological profile produced (Figure 12).

Palynological profile
Six spore/pollen zones recognised, Zone 6, Zone 5, Zone 4a , Zone 4b, Zone 3, and Zone 2.
Zone 6: Top unknown - 1936.0m.
Zone 5: 1936.0m - 1938.5m.
Zone 4a: 1938.5m- 2204.0m.
Zone 4b: 2204.0m - 2630.0m.
Zone 3: 2630.0m - 2677.0m.
Samples Not Taken 2677.0m - 2838.0m.
Zone 2: 2838.0m - 2897.0m.

The Laira 1 biozonation is very similar to that of Katnook 2. There is a slight thinning of the overall *F.wonthaggiensis* Zone but Zones 6, 5, 4a, 4b, 3, and 2 are present and proportionally the same as in Katnook 2.

DISCUSSION

As the first detailed palynological and dispersed cuticle study of the Crayfish Group the project has made significant progress in developing a suitable biostratigraphic correlation scheme for the Early Cretaceous sediments of the Otway Basin.

The processing procedures used and developed for the analysis of Katnook 2 plant fossils made it possible to produce palynological and dispersed cuticle reference biozonation for the *F.wonthaggiensis* Zone (Helby et al 1987) and Lower *Cyclosporites hughesii*, Upper and Lower *F. wonthaggiensis* Zones (Morgan 1993).

The detailed sampling produced excellent palynological profiles in which well defined trends enable six zones being recognised. The dispersed cuticles were less definitive, due to variable yields, with only three zones established. The reason seen for this was primarily sample size but cuticle preservation in cuttings and a lack of good core were contributing factors.

The aim of the project was to erect a correlation biozonation that would provide greater subdivision within the Crayfish Group than is available with the palynological correlation schemes of Helby et al (1987), APG Consultants - Eromanga/Surat terminology and Morgan (1993). The most recent scheme developed by Morgan was an improvement in this regard by dividing the long ranging *Foraminisporis wonthaggiensis* Zone (Valanginian - Aptian) into the Upper and Lower *F. wonthaggiensis* Zones. The Upper *F. wonthaggiensis* Zone appears to be identified on the consistent occurrence of *Cicatricosisporites (mega)australiensis*, *Triporoletes reticulatus* and *Foraminisporis wonthaggiensis*, with the oldest occurrence of the two former species defining the base. *Retitriletes watherooensis* and *Microfasta evansii*, the algal acritach, are also common. These palynomorphs appear to be rare or absent in the Lower *F. wonthaggiensis* Zone.

The Lower *F. wonthaggiensis* Zone is characterised by a generally lower diversity in palynomorphs with oldest *Dictyotosporites speciosus* defining the base.

The quantitative approach taken with this project has divided the zonation further.

A comparison between the proposed palynological scheme and Morgan's for Katnook 2 shows an interesting relationship (Figure 3). The boundary marking the upper limit of the Upper *F. wonthaggiensis* Zone lies at the same level as the upper limit of Zone 5, which lithologically marks the unconformity between the Windermere Sandstone and Crayfish Group. The boundary between the Upper and Lower *F. wonthaggiensis* Zones lies at approximately the same level as the boundary between Zones 4a and 4b. Overall the Upper *F. wonthaggiensis* Zone is represented by two zones, Zones 5 and 4a, and the Lower *F. wonthaggiensis* Zone is represented by four zones, i.e. most of Zone 4b, as well as Zones 3, 2 and 1.

It is interesting to note in comparing the dispersed cuticle and palynological biozonation that some boundaries are also shared. In the dispersed cuticle scheme the unconformity is marked by the boundary between Zones 3 and 2, this corresponds to the boundary between Zones 6 and 5 in the palynological scheme. The dispersed cuticle Zone 2 is equivalent to Zones 5, 4a, and 4b of the palynological scheme and its boundary with Zone 1 is at almost the same level as the top of the palynological Zone 3. The fact that a number of these boundaries occur at the same level suggests a possible environmental and/or ecological influence. Additional palaeoecological research should be undertaken to investigate this relationship.

Whilst the palynological data have allowed further subdivision of the *F.wonthaggiensis* Zone and made correlation possible along the three designated transects (A-A', B-B', C-C'), the dispersed cuticle data could not. Where dispersed cuticle data were obtained the resultant profiles provide sufficient detail for zones to be identified and in doing so complement the palynological biozonation. A number of very distinctive cuticle types were identified that appeared to be biostratigraphically important but in the absence of much larger data sets could not be considered at this point in time. For the dispersed cuticles to achieve the same level of biostratigraphic significance as the palynomorphs, more cuticle must consistently be recovered from samples. To do this it will be necessary in future to obtain larger

samples, preferably core/swc or cuttings of 50gm - 100gm in weight.

In conclusion the subdivision of the *F. wonthaggiensis* Zone (Helby *et al*. 1987) based on pollen and spores and dispersed cuticle has been achieved. The seven palynological zones have been successfully employed in the correlation of the Crayfish sediments in the selected wells. The application of the dispersed cuticle biozonation was not as successful but it did confirm the palynological interpretations.

Although the biozonations are preliminary, the results, from the palynological biozonation at least, do indicate that with some refinement and additional research the scheme will prove valuable in the correlation of the Cretaceous sediments of the Otway Basin.

FUTURE RESEARCH

To refine the existing biozonations some additional sampling should be undertaken in some of the previously sampled wells, especially Katnook 3, Lake Hawdon 1, Crankshaft 1 and Sawpit 1. In addition all other onshore wells with Crayfish Group need to be sampled

To assess the value of dispersed cuticle biozonation further, a re-examination of the sampling and processing procedures employed with the aim to improve yields should be undertaken. A detailed dispersed cuticle study of Casterton 1, which is reported to be rich in plant material, would assist in this regard. A resampling programme to target specifically plant-rich horizons should be undertaken.

A detailed study of the *Cicatricosisporites australiensis* Zone (Helby *et al* 1987) and Upper C.*australiensis* Zone (Morgan 1993) should be undertaken. In the majority of the wells studied the base of the *F.wonthaggiensis* Zone remains undefined, by extending the study into the *C.australiensis* Zone this will be possible as well as providing a new biozonation for the *C.australiensis* Zone. Palynological and dispersed cuticle biozonations may provide further subdivision of the Upper and Lower *C.australiensis* Zones recognised by Morgan (1993).

Crayfish 1 and Troas 1, the two offshore wells studied in the project appear to have similar palynological profiles It would therefore be useful to determine whether this relationship extends throughout the offshore part of the Basin.

With the successful subdivision of the Early Cretaceous sediments in the Otway Basin it would be most useful to extend the study into Duntroon Basin where a very thick Early Cretaceous sequence exists.

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Morgan, R. 1993. in Alley, N.F. compiler of Otway Basin Jurassic - Late Cretaceous Palynological Zonal Nomenclature Chart. Dept. Mines & Energy, South Australia. Unpubl.

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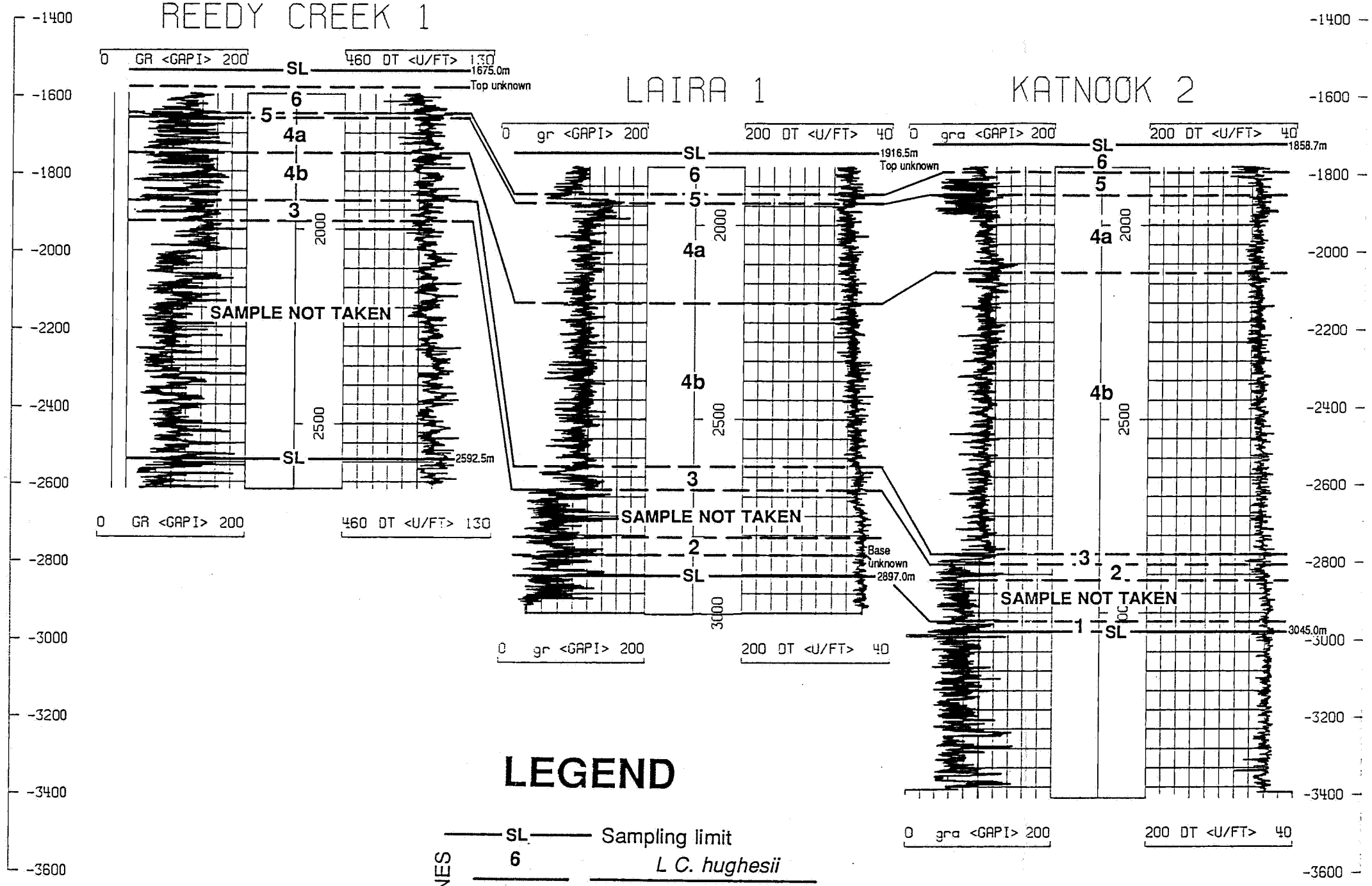
Rowett, A.I. and Sparrow, A.D. 1994. Multivariate analysis of Australian Eocene dispersed cuticle floras: influence of age, geography and taphonomy on biozonation. Review of Palaeobotany and Palynology 81: 165 -183.

APPENDIX 1

Ladbroke Grove 1 to Robertson 1 Transect.

Troas 1 to Casterton 1 Transect.

Reedy Creek 1 to Katnook 2 Transect



LEGEND

SL — Sampling limit

PALYNOLOGICAL ZONES

6 — *L C. hughesii*

5 — *F. Wonthaggensis*

4a

4b

3

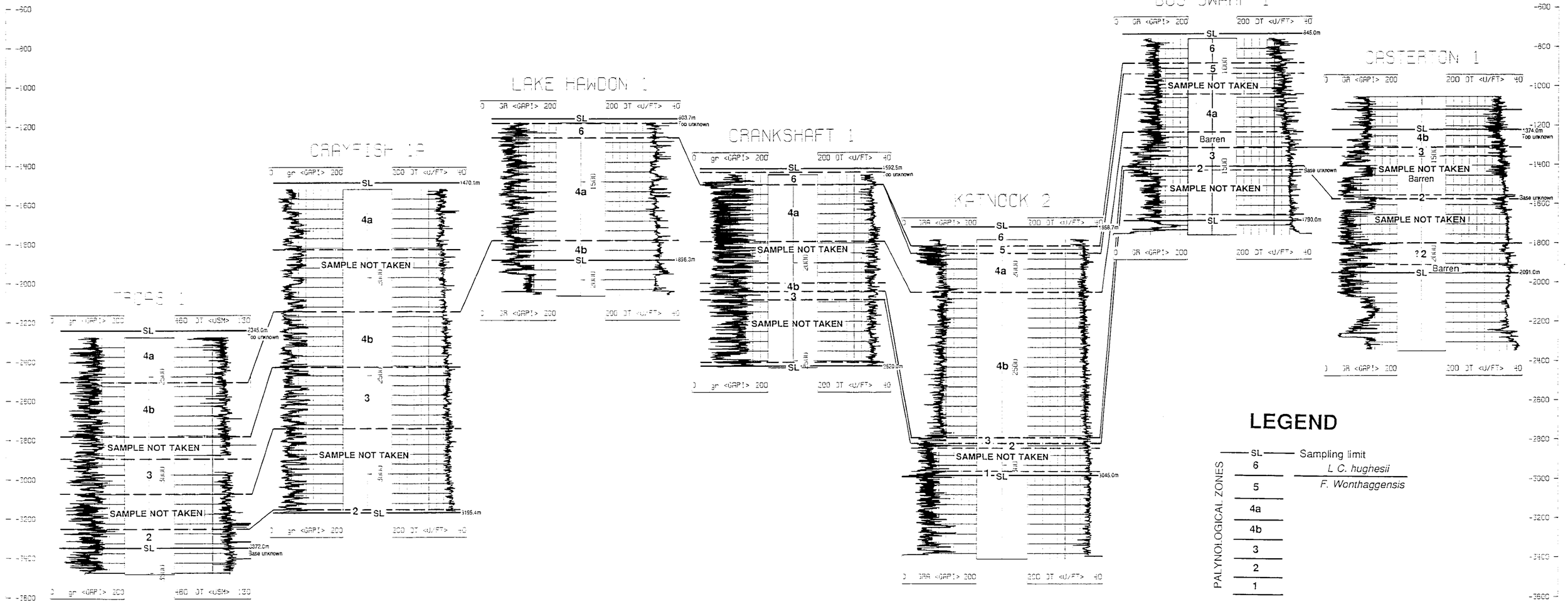
2

1

CRAYFISH SUBGROUP BIOSTRATIGRAPHY - OTWAY BASIN

REEDY CREEK 1 TO KATNOOK 2 TRANSECT

MESA 94-I293



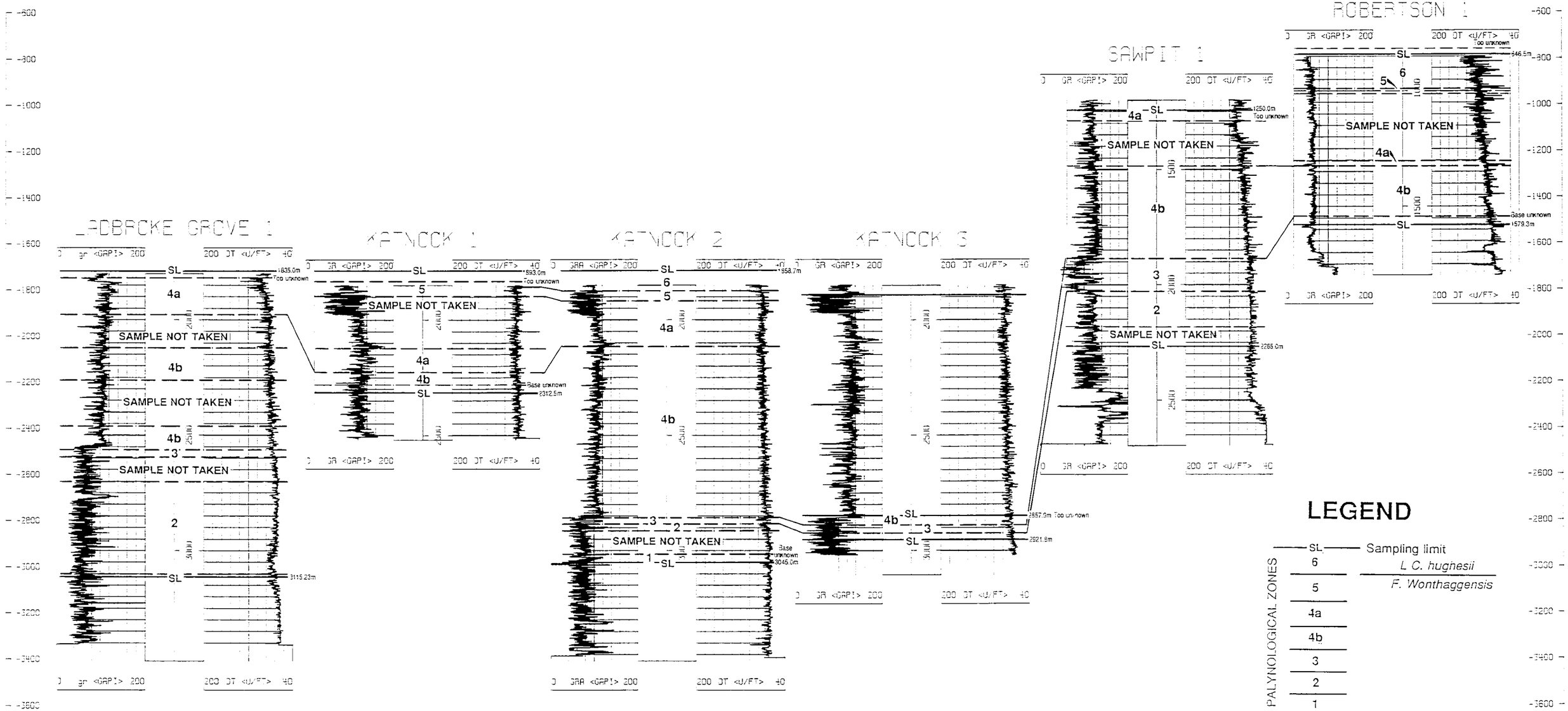
LEGEND

CRAYFISH SUBGROUP BIOSTRATIGRAPHY - OTWAY BASIN

LADBROKE GROVE 1 TO ROBERTSON 1

TRANSECT

MESA 94-1295



CRAYFISH SUBGROUP BIOSTRATIGRAPHY - OTWAY BASIN

TROAS 1 TO CASTERTON 1 TRANSECT

MESA 94-1294

APPENDIX 2

SPORE/POLLEN SPECIES LIST

1 = *Alisporites grandis*
2 = *Alisporites similis*
3 = *Baculatisporites comaumensis*
4 = *Callialasporites* spp.
5 = *Ceratosporites equalis*
6 = *Cicatricosisporites australiensis*
7 = *Classopollis chateaunovi*
8 = *Cyathidites minor*
9 = *Cyathidites australis*
10 = *Cyclosporites hughesii*
11 = *Dictyotosporites speciosus*
12 = *Foraminisporis wonthaggiensis*
13 = *Foraminisporis asymmetricus*
14 = *Microcachryidites antarcticus*
15 = *Neoraistrickia truncatus*
16 = *Neoraistrickia trichosa*
17 = Total *Neoraistrickia* spp.
18 = *Osmundacidites wellmanii*
19 = *Pilosisporites notensis*
20 = *Podocarpidites ellipticus*
21 = *Retitriletes australoclavatidites*
22 = Total *Retitriletes* spp.
23 = *Stereisporites antiquasporites*
24 = *Trisaccites variabilis*
25 = Bisaccate spp.
26 = Trisaccate spp.
27 = Total Gymnosperm spp.

APPENDIX 3

SAMPLING DATA

Katnook 1

1893m..... core
1893.99m..... core
1894m..... core
2122.5m..... cutting
2130m..... cutting
2132.5m..... cutting
2140m..... cutting
2147.5m..... cutting
2157.5m..... cutting
2165m..... cutting
2167.5m..... cutting
2177.5m..... cutting
2182.5m..... cutting
2190m..... cutting
2195m..... cutting
2200m..... cutting
2205m..... cutting
2212m..... cutting
2222.5m..... cutting
2230m..... cutting
2232.5m..... cutting
2235m..... cutting
2245m..... cutting
2255m..... cutting
2265m..... cutting
2267.5m..... cutting
2275m..... cutting
2282.5m..... cutting
2292.5m..... cutting
2305m..... cutting
2312.5m..... cutting
2317.5m..... cutting
2322.5m..... cutting

Katnook 2

1858.7m.....core
1861.7m.....core
1863.1m.....core
1864.25m.....core
1864.6m.....core
1866.87m.....core
1868.1m.....core
1869.8m.....core
1870.98m.....core
1872.7m.....core
1873.55m.....core
1874.4m.....core
1876.3m.....core
1917.5m.....cutting
1920m.....cutting
1935m.....cutting
1940m.....cutting
1980m.....cutting
1995m.....cutting
1997.5m.....cutting
2007.5m.....cutting
2010m.....cutting
2030m.....cutting
2057.5m.....cutting
2087.5m.....cutting
2117.5m.....cutting
2120m.....cutting
2142.5m.....cutting
2180m.....cutting
2240m.....cutting
2295m.....cutting
2327.5m.....cutting
2382.5m.....cutting
2440m.....cutting
2500m.....cutting
2555m.....cutting
2635m.....cutting
2660m.....cutting
2685m.....cutting
2835m.....cutting
2868.76m.....core
2869.82m.....core
2870.25m.....core
2871.3m.....core
2871.6m.....core
2871.75m.....core
2872.2m.....core
2872.38m.....core
2872.8m.....core
2873.25m.....core
2873.9m.....core
2874.4m.....core
2874.9m.....core
2875.5m.....core
2907.5m.....cutting
3045m.....cutting

Katnook 3

2857.9m..... core
2859.1m..... core
2862.38m..... core
2871.35m..... core
2872m..... core
2873.97m..... core
2878.39m..... core
2892.5m..... core
2906.9m..... core
2899.1m..... core
2907.8m..... core
2908.1m..... core
2910.25m..... core
2912.5m..... core
2921.8m..... core

Bus Swamp 1

845m .....swcore
913m .....swcore
957m .....swcore
977m .....swcore
982m .....swcore
1026m .....swcore
1145m .....swcore
1190m .....swcore
1325m .....swcore
1406m .....swcore
1445m .....swcore
1509.83m .....core
1515.83m .....core
1785.23m .....core
1790.06m .....core

Casterton 1

1374m..... core
1376m..... core
1420m..... cutting
1460m..... cutting
1496m..... core
1499m..... core
1607m..... core
1710m..... core
1713m..... core
1953m..... core
2062m..... core
2064m..... core
2089m..... core
2091m..... core

Crankshaft 1

1592.5m .....cutting
1602.5m .....cutting
1638.5m .....swcore
1785m .....cutting
1895m .....cutting
2110m .....cutting
2149m .....cutting
2182.5m .....cutting
2520m .....swcore

Crayfish 1

4822' ..... core
5016' ..... core
5008' ..... core
5553' ..... core
5582'3" ..... core
5588' ..... core
6095' ..... core
6098' ..... core
7117' ..... core
7123' ..... core
8093'9" ..... core
8106' ..... core
8636'9" ..... core
9087' ..... core
10481' ..... core

Ladbroke Grove 1

1835m .....cutting
1865m .....cutting
1977.5m .....cutting
2132.5m .....cutting
2245m .....cutting
2257.5m .....cutting
2470m .....cutting
2568m .....core
2579.3m .....core
2587.6m .....core
2590m .....core
2721.3m .....core
2765m .....cutting
2902.5m .....cutting
2960m .....cutting
3115.23m .....core

Laira 1

Lake Hawdon 1

1916.5m ..... swcore
1934m ..... swcore
1936m ..... swcore
1938.5m ..... swcore
1945m ..... swcore
2074.5m ..... swcore
2204m ..... swcore
2457m ..... swcore
2569.5m ..... swcore
2630m ..... swcore
2677m ..... swcore
2838m ..... swcore
2897m ..... swcore

1980' ..... cutting
2010' ..... cutting
4190' ..... cutting
4280' ..... cutting
4920' ..... cutting
5400' ..... cutting
5920' ..... cutting
6220' ..... cutting

Reedy Creek 1

1675m ..... cutting
1707m ..... cutting
1715m ..... cutting
1752.5m ..... cutting
1777.5m ..... cutting
1790m ..... cutting
1805m ..... cutting
1822.5m ..... cutting
1842.5m ..... cutting
1925m ..... cutting
1960m ..... cutting
1987.5m ..... cutting
2592.5m ..... cutting

Robertson 1

846.5m ..... core
848.0m ..... core
990.0m ..... core
990.5m ..... core
991.5m ..... core
993.0m ..... core
994.8m ..... core
995.0m ..... core
995.3m ..... core
996.3m ..... core
4340' ..... cutting
4360' ..... cutting
4380' ..... cutting
5180' ..... cutting

Sawpit 1

1250m ..... cutting
1272.5m ..... cutting
1287.5m ..... cutting
1497.5m ..... cutting
1582.5m ..... cutting
1642.5m ..... cutting
1782.5m ..... cutting
1827.5m ..... cutting
1837.5m ..... cutting
1867.5m ..... cutting
1880m ..... cutting
1965m ..... cutting
2032.5m ..... cutting
2097.5m ..... cutting
2180m ..... cutting
2265m ..... cutting

Troas 1

2345m ..... cutting
2355m ..... cutting
2397m ..... cutting
2418m ..... cutting
2481m ..... cutting
2526m ..... cutting
2568m ..... cutting
2640m ..... cutting
2700m ..... cutting
2778m ..... cutting
2802m ..... cutting
2922m ..... cutting
2979m ..... cutting
3105m ..... cutting
3282m ..... cutting
3372m ..... cutting

100184AR.CDR

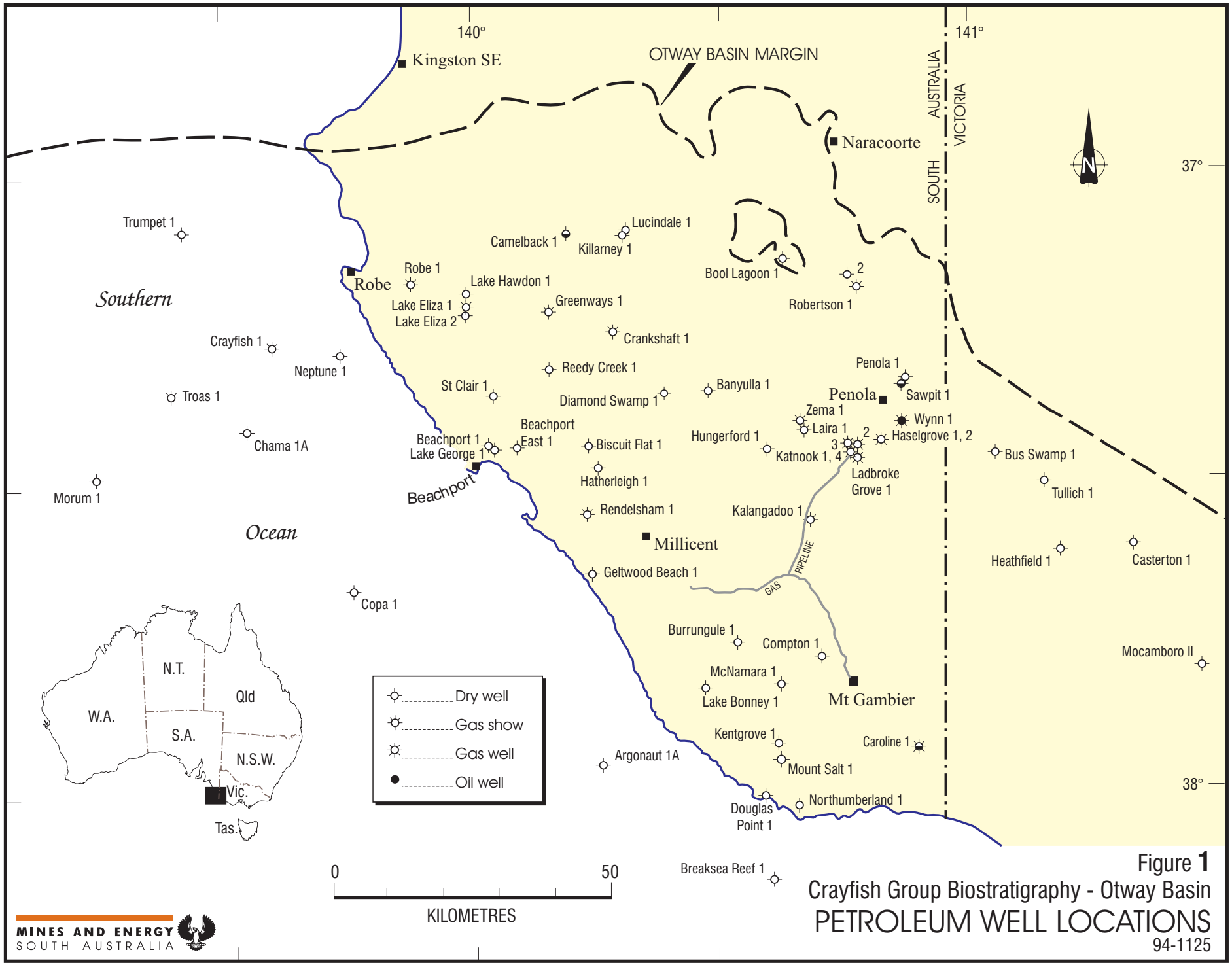


Figure **1**

Crayfish Group Biostratigraphy - Otway Basin

PETROLEUM WELL LOCATIONS

94-1125

CD-TOJO 6164AR

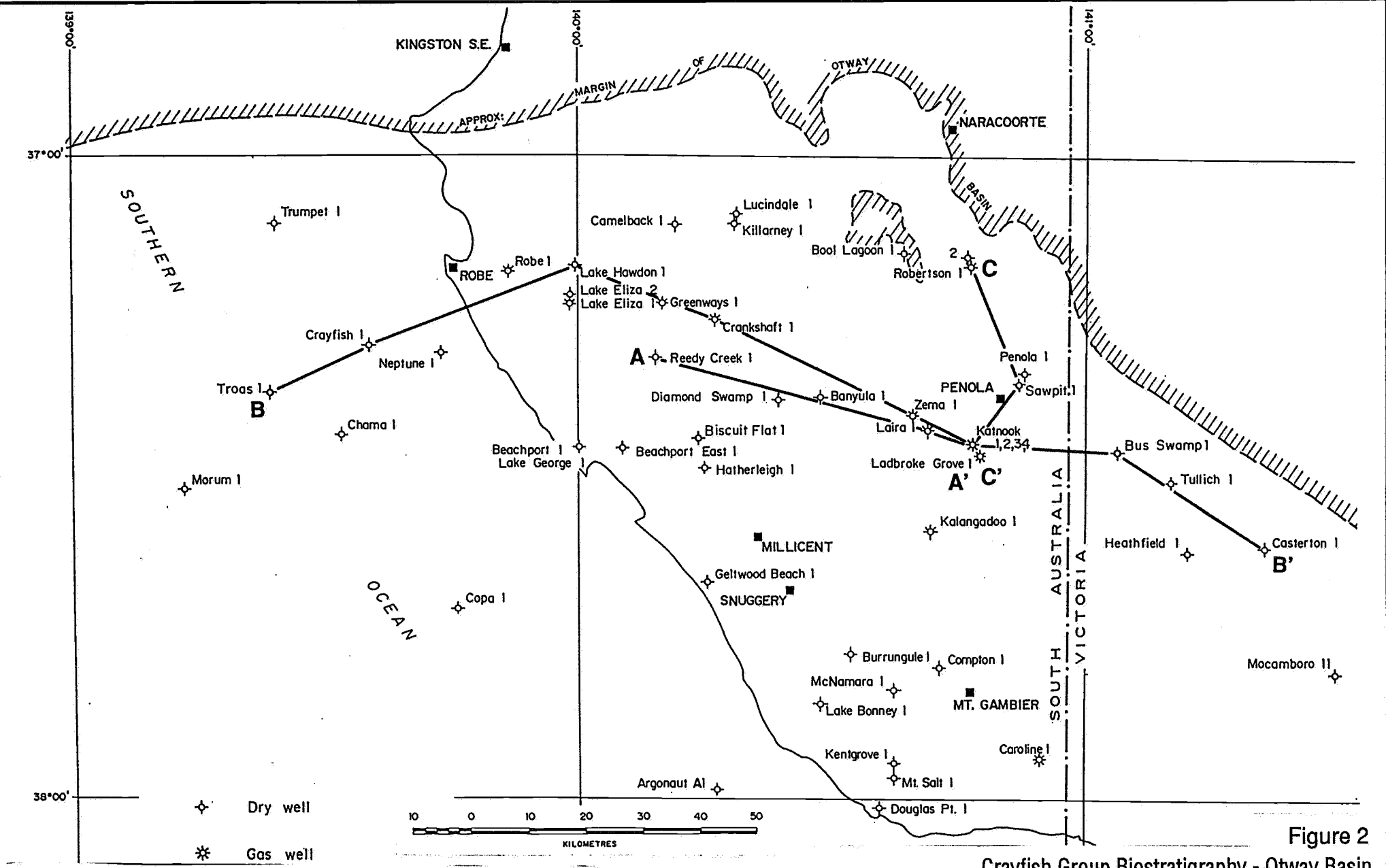


Figure 2

Crayfish Group Biostratigraphy - Otway Basin

PALYNOLOGICAL TRANSECT LOCATIONS

94-1126

MINES AND ENERGY
SOUTH AUSTRALIA

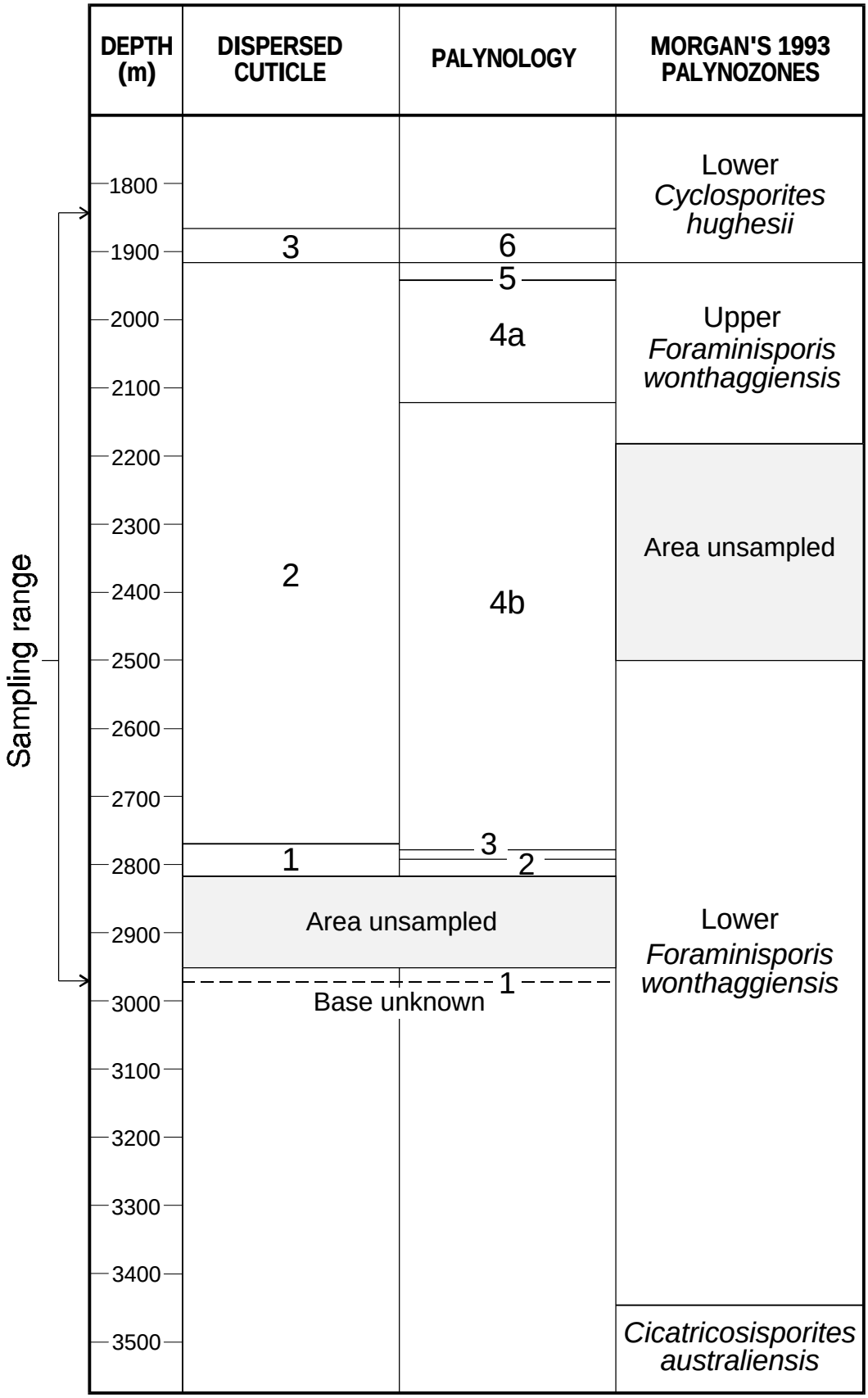


Figure 3

Crayfish Group Biostratigraphy - Otway Basin

DISPERSED CUTILE & PALYNOLOGICAL ZONE COMPARISON - KATNOOK 2

94-1127

MINES AND ENERGY SOUTH AUSTRALIA

CD-TOJO 6164AR

KATNOOK 2

% of total palynoflora

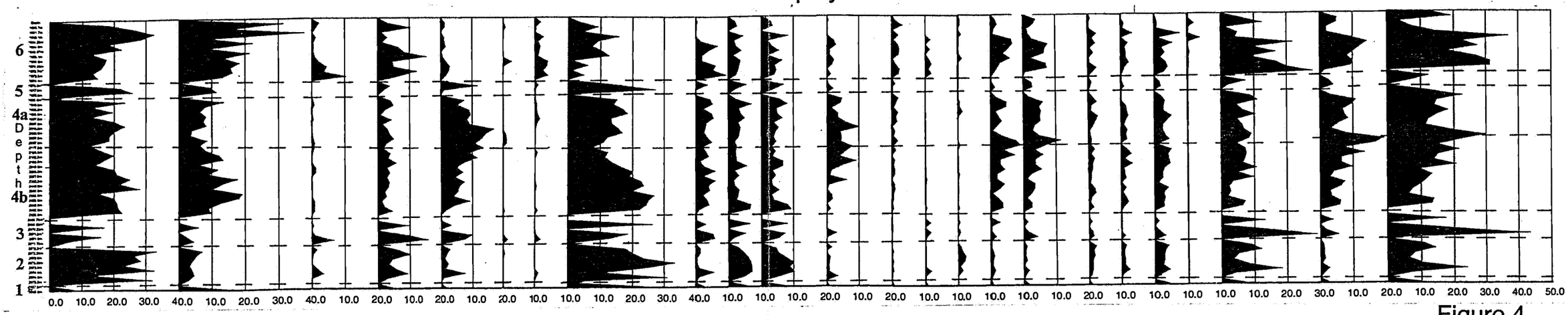
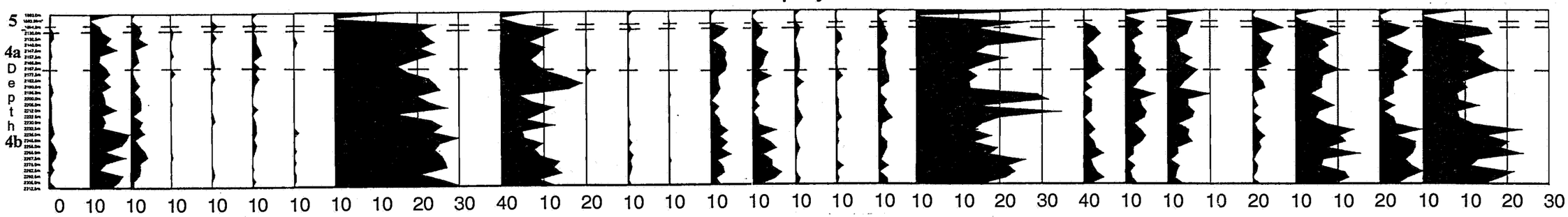


Figure 4

KATNOOK 1

% of total palynoflora



KATNOOK 1

% of dispersed cuticle flora

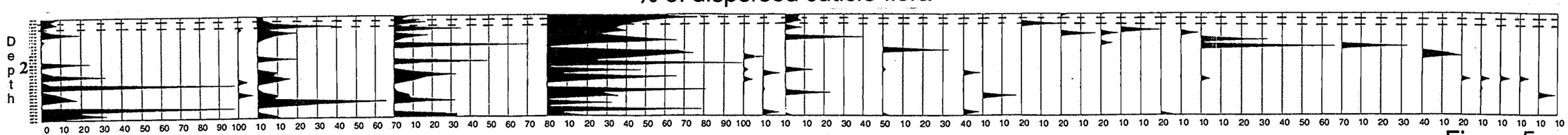


Figure 5

Crayfish Group Biostratigraphy - Otway Basin

KATNOOK 1 and 2

PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

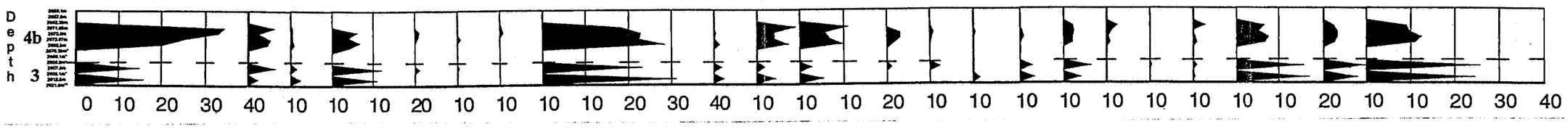
94-1128

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

KATNOOK 3

% of total palynoflora



KATNOOK 3

% of dispersed cuticle flora

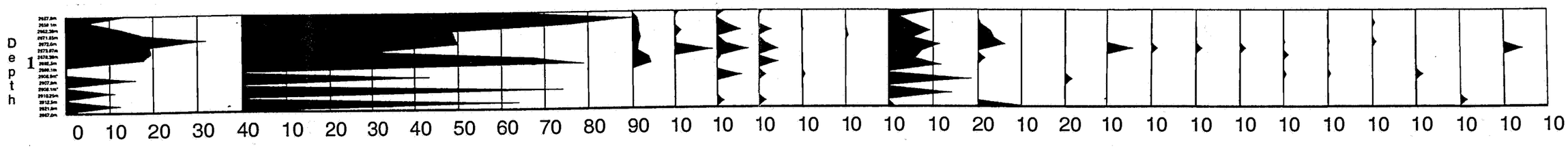


Figure 6

Crayfish Group Biostratigraphy - Otway Basin

KATNOOK 3

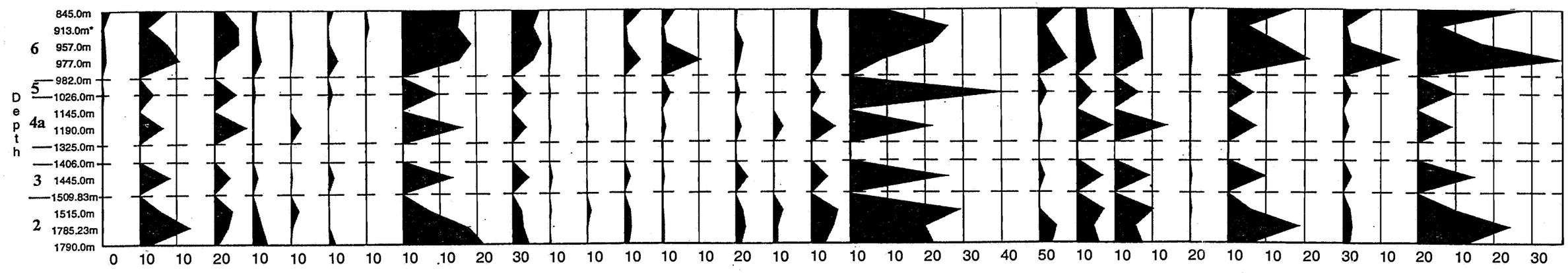
PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

94-1129

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

BUS SWAMP 1
% of total palynoflora



BUS SWAMP 1
% of dispersed cuticle flora

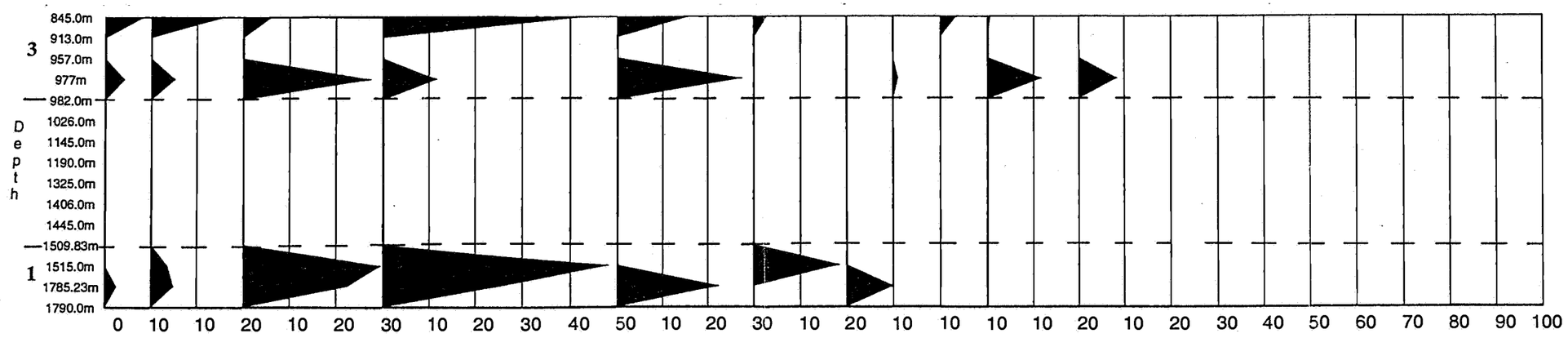


Figure 7

Crayfish Group Biostratigraphy - Otway Basin

BUS SWAMP 1

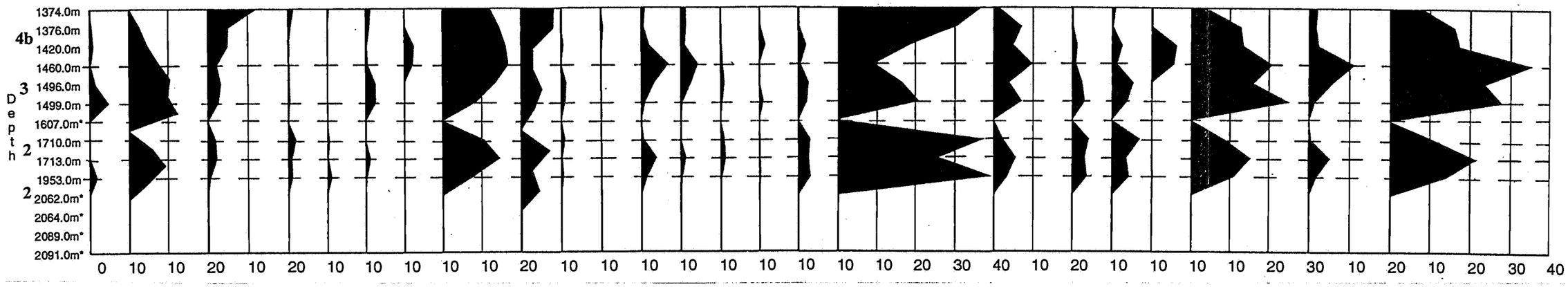
PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

94-1130

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

CASTERTON 1
% of total palynoflora



CASTERTON 1
% of dispersed cuticle flora

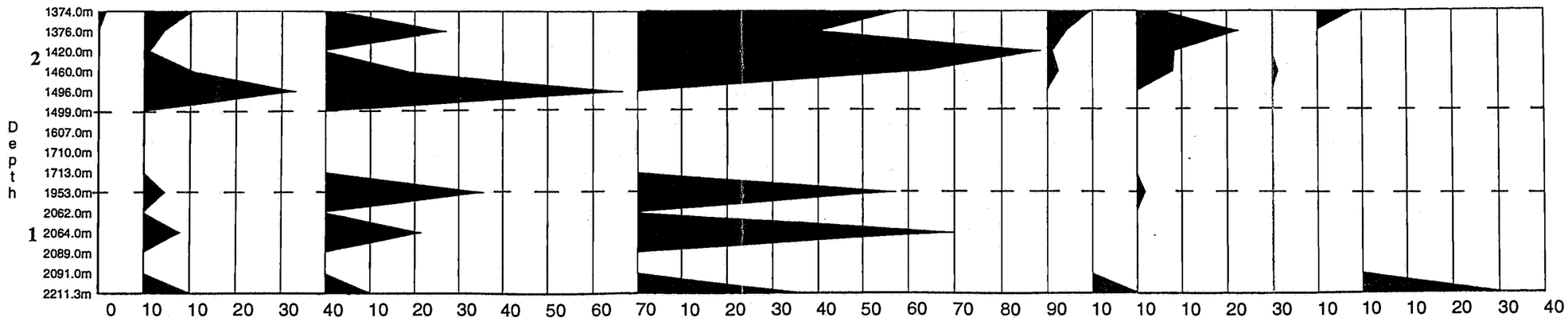


Figure 8

Crayfish Group Biostratigraphy - Otway Basin

CASTERTON 1

PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

94-1131

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

CRANKSHAFT 1
% of total palynoflora

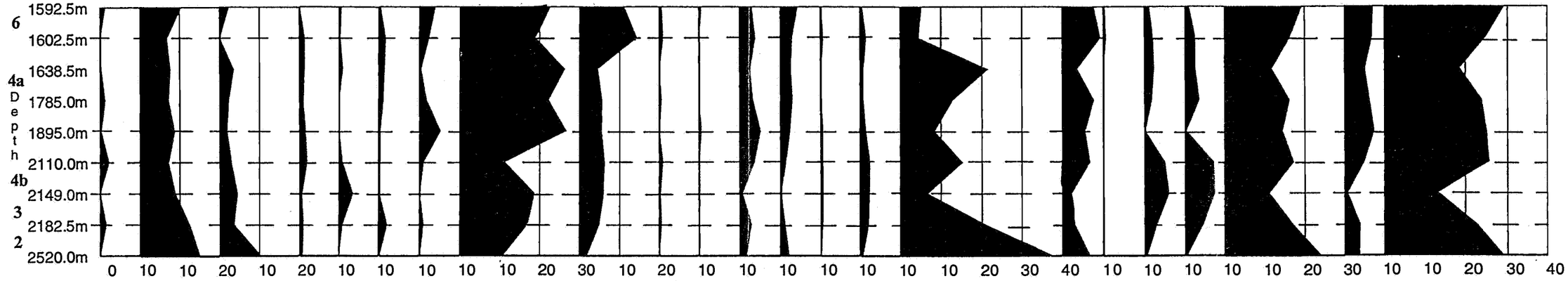


Figure 9

Crayfish Group Biostratigraphy - Otway Basin

CRANKSHAFT 1

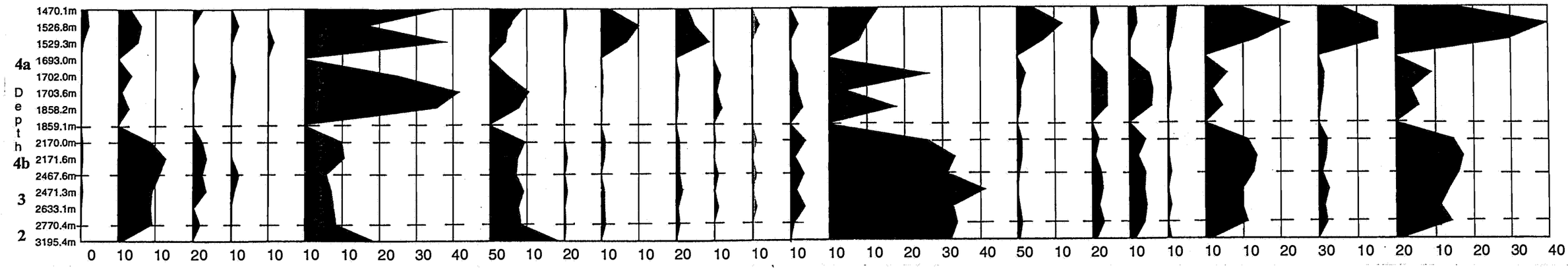
PALYNOLOGICAL PROFILE

94-1132

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

CRAYFISH 1
% of total palynoflora



CRAYFISH 1
% of dispersed cuticle flora

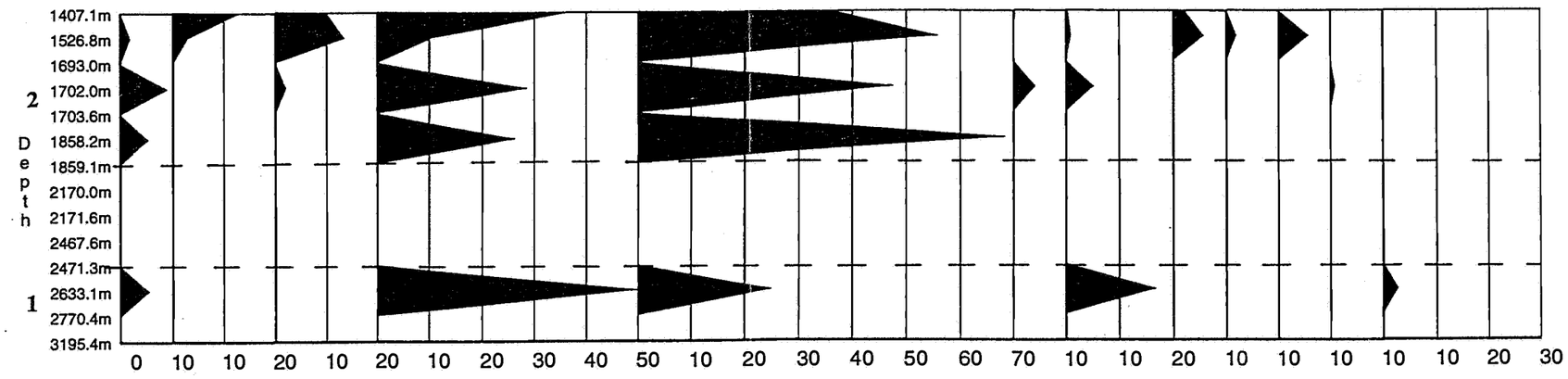


Figure 10

Crayfish Group Biostratigraphy - Otway Basin

CRAYFISH 1

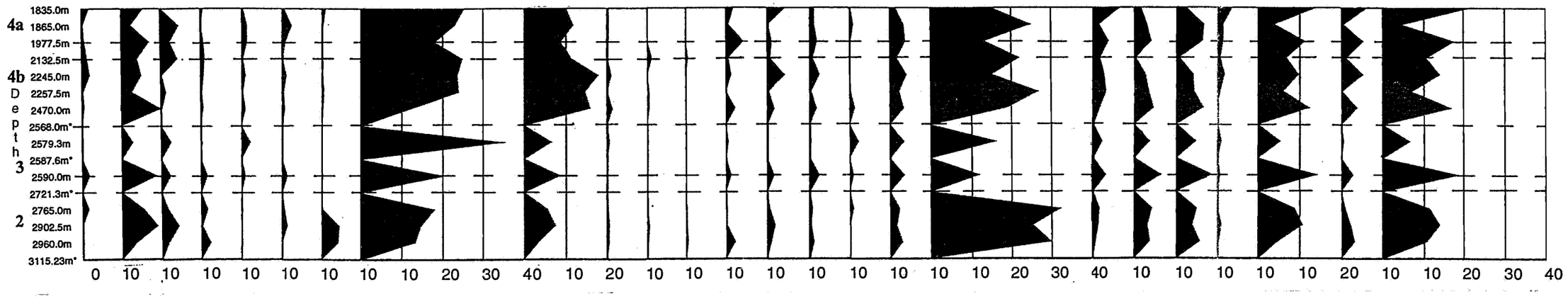
PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

94-1133

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

LADBROKE GROVE 1
% of total palynoflora



LADBROKE GROVE 1
% of dispersed cuticle flora

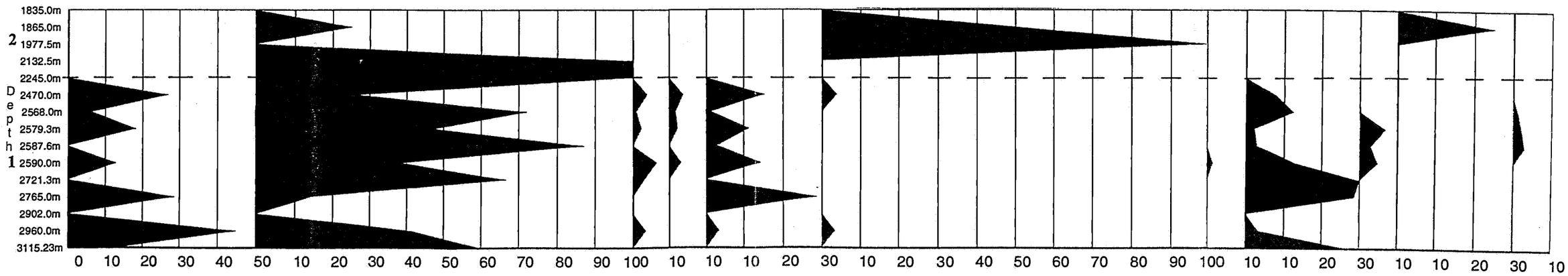


Figure 11

Crayfish Group Biostratigraphy - Otway Basin

LADBROKE GROVE 1

PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

94-1134

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

LAIRA 1

% of total palynoflora

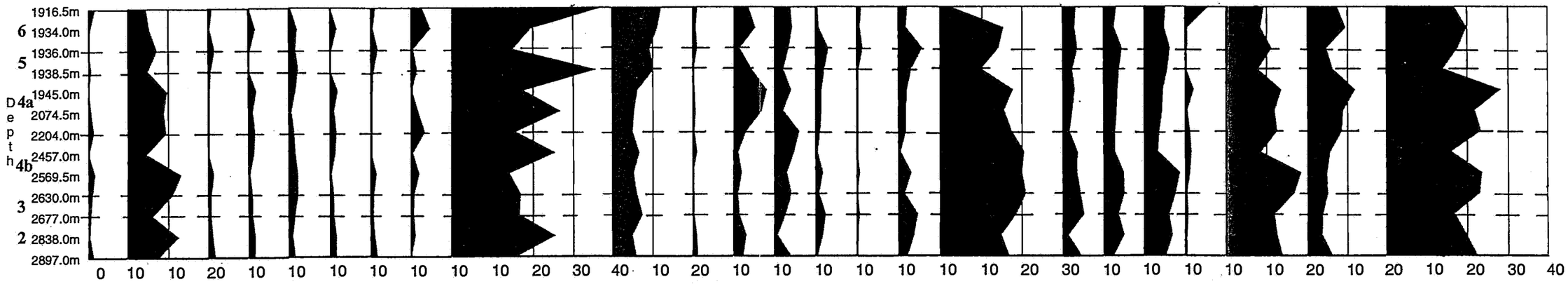


Figure 12

Crayfish Group Biostratigraphy - Otway Basin

LAIRA 1

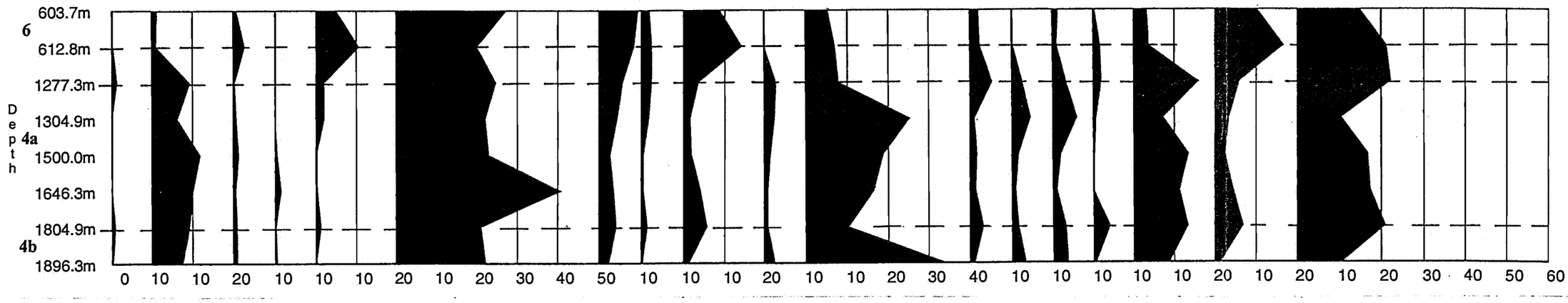
PALYNOLOGICAL PROFILE

94-1135

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

LAKE HAWDON 1
% of total palynoflora



LAKE HAWDON 1
% of dispersed cuticle flora

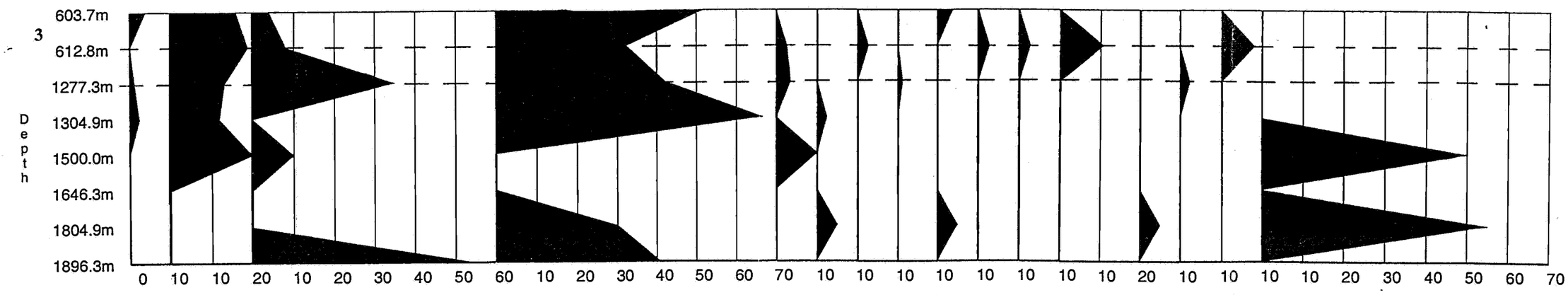


Figure 13

Crayfish Group Biostratigraphy - Otway Basin

LAKE HAWDON 1

PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

94-1136

MINES AND ENERGY
SOUTH AUSTRALIA

CD-TOJO 6164AR

REEDY CREEK 1
% of total palynoflora

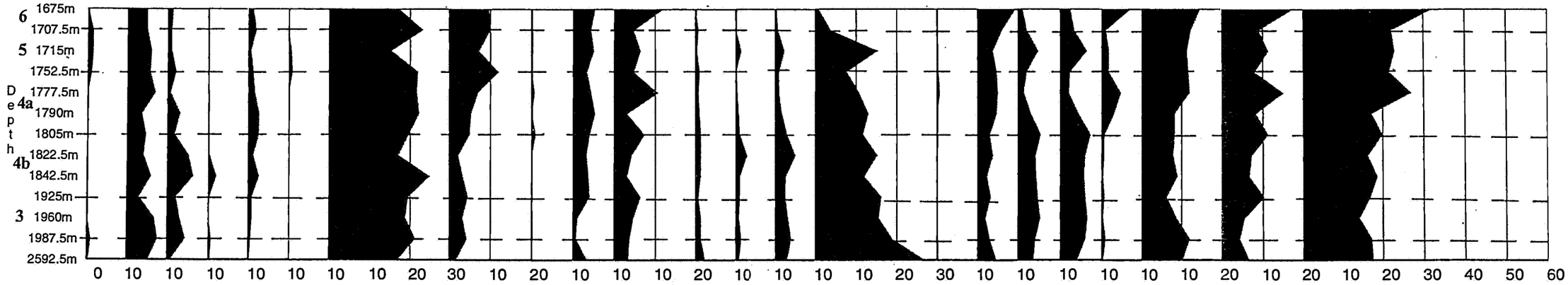


Figure 14

Crayfish Group Biostratigraphy - Otway Basin

REEDY CREEK 1

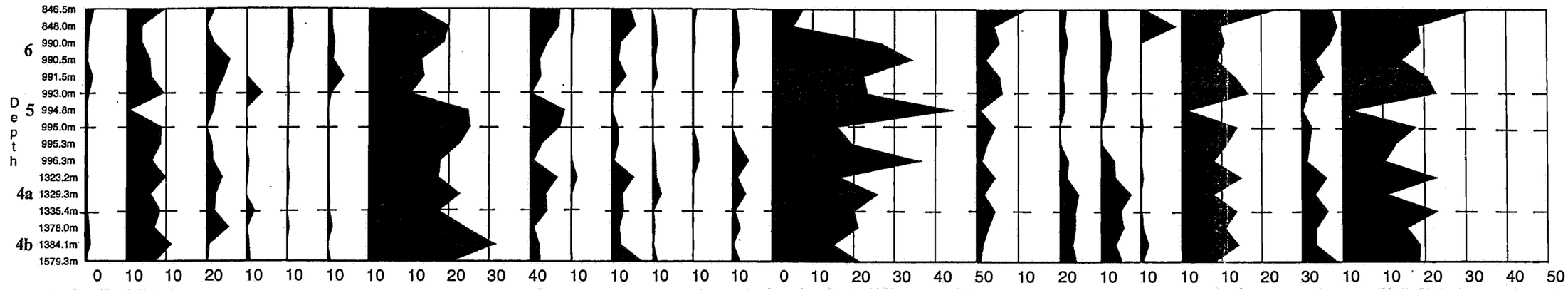
PALYNOLOGICAL PROFILE

94-1137

MINES AND ENERGY
SOUTH AUSTRALIA

GD-TOJO 6164AR

ROBERTSON 1
% of total palynoflora



ROBERTSON 1
% of dispersed cuticle flora

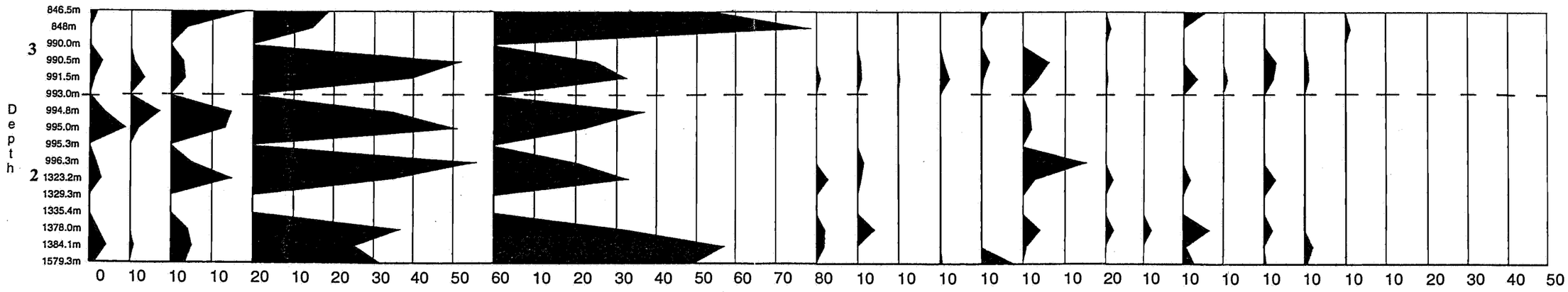


Figure 15

Crayfish Group Biostratigraphy - Otway Basin

ROBERTSON 1

PALYNOLOGICAL & DISPERSED CUTICLE PROFILES

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SAWPIT 1
% of total palynoflora

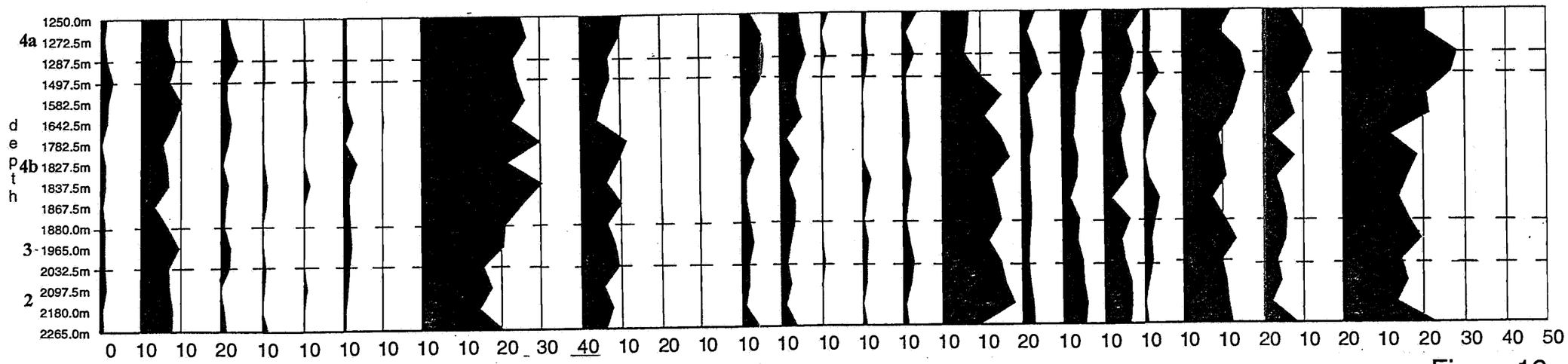

Figure 16

TROAS 1
% of total palynoflora

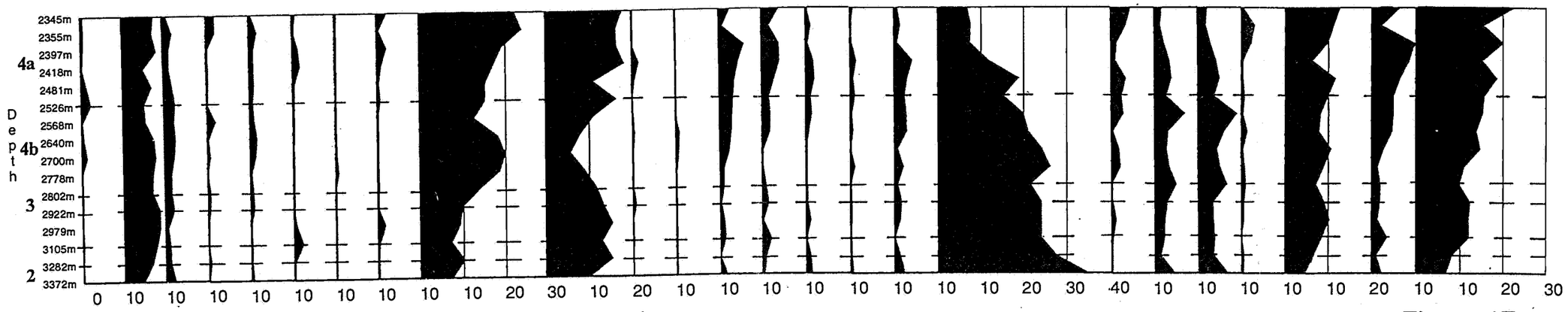

Figure 17

Crayfish Group Biostratigraphy - Otway Basin

SAWPIT 1and TROAS 1

PALYNOLOGICAL PROFILES

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