Palynological evidence for Late Miocene – Early Pliocene deposits in the eastern Eucla Basin, South Australia

Liliana Stoian

Report Book 2003/23

Government of South Australia
MINERALS & ENERGY
PRIMARY INDUSTRIES AND RESOURCES SA

202068_001

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Geological Survey

October 2003

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Government of South Australia

MINERALS & ENERGY

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Preferred way to cite this publication
Stoian, L.M., 2003. Palynological evidence for Late Miocene - Early Pliocene deposits in the eastern Eucla Basin, South Australia. *South Australia. Department of Primary Industries and Resources. Report Book,* 2003/23.

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ABSTRACT

Palynological analyses of four cutting samples from NALARA NR 3 and NALARA NR 4 drillholes in the eastern part of the Eucla Basin show distinctive microfloristic assemblages. The samples from both drillholes are dated Late Miocene into Early Pliocene, *Monotocidites galeatus* Spore-Pollen Zone.

Depositional environment changed from non-marine, littoral to estuarine. Open woodland with Casuarina and eucalypts developed.

INTRODUCTION

Four cutting samples from NALARA NR 3 and NALARA NR 4 drillholes have been submitted for palynological analyses and dating by Jonathan Higgins, PhD candidate, University of Adelaide, as part of a collaborative Tertiary Palaeochannel Project initiated in 2000 between PIRSA, CRC LEME and University of Adelaide.

To date the preliminary results have been submitted to all the parties in order to assist in geological interpretation of the area, which may contain gold and other commodities of high economic interest for exploration companies.

Several report books and articles have been published by Baohong Hou, Neville Alley and Larry Frakes, including the palaeochannel mapping and developing several models for depositional environment in this area.

This report book will emphasize only the biostratigraphy, giving a detailed sample description, age, zone, depositional environment and palaeovegetation reconstruction. Comparisons with similar sediments of the same age from other parts of Australia complete the picture of Late Miocene-Early Pliocene vegetation and depositional environment, generally poorly investigated. This information has not been released in any of the previous studies.

The samples were processed using standard palynological processing undertaken in the PIRSA Mineral Resources Laboratory by Lyn Broadbridge. The distribution of the species, and four histogram charts showing the abundance of all taxa and selected species are listed in Appendixes 2–5.

LOCATION

NALARA NR 3 and NALARA NR 4 are situated in the Eucla Basin, CHILDARA map sheet (Fig. 1).

NALARA NR 3
Map Sheet: CHILDARA 1:250 000
Latitude: 31°23'34.82"S; *Longitude:* 134°21'9.89"E
MGA Zone: 53; *Easting:* 438463m; *Northing:* 6526661m
Maximum depth: 56 m.
Unit number: 5735-3

NALARA NR 4
Map Sheet: CHILDARA 1:250 000
Latitude: 31°22'9.85"S; *Longitude:* 134°21'14.91"E
MGA Zone: 53; *Easting:* 438581m; *Northing:* 6529278m
Maximum depth: 51 m
Unit number: 5735-4

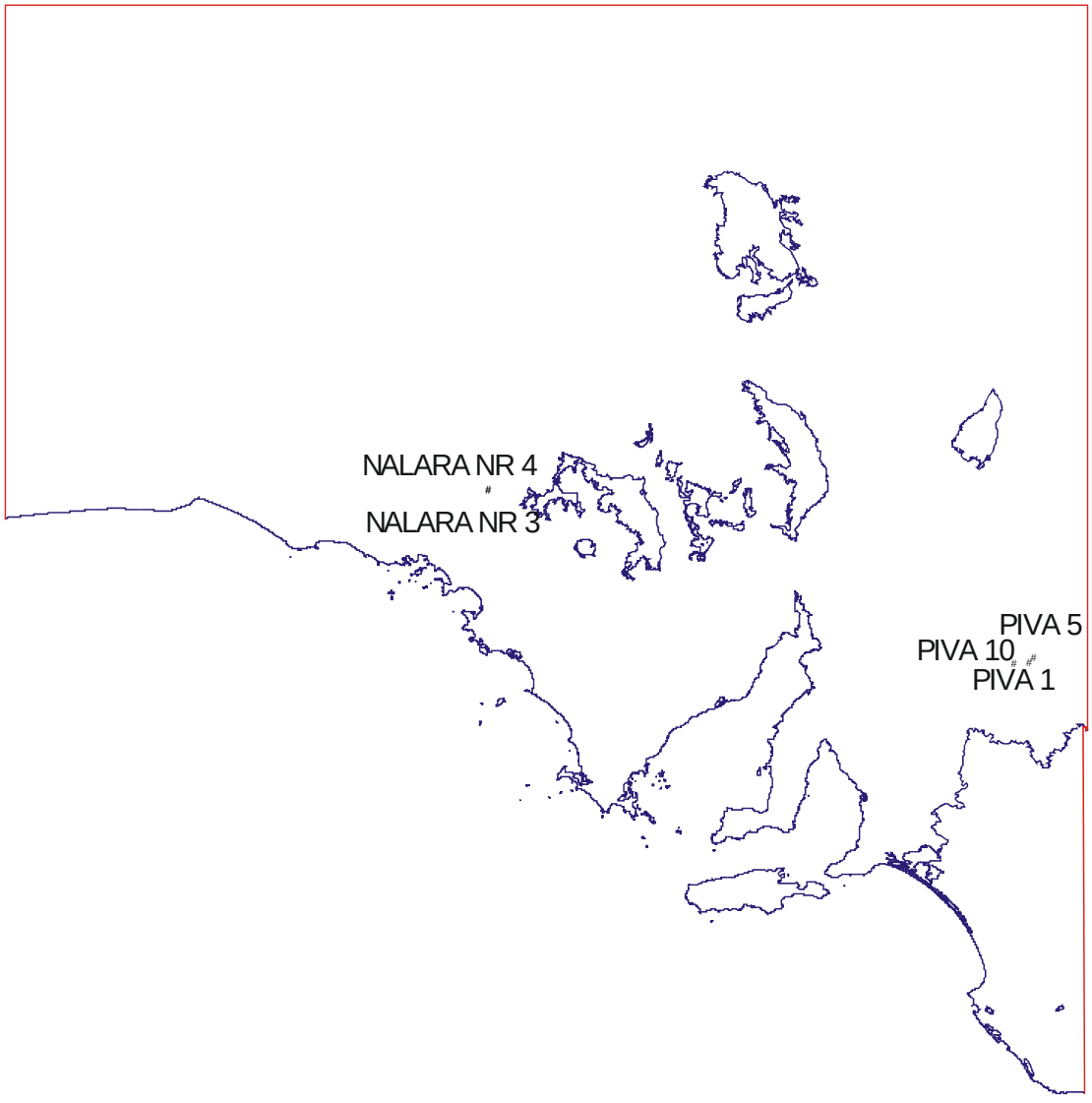


Figure 1 Location of the drillholes NALARA NR 3 and NALARA Nr 4, Eucla Basin, and other drillholes examined from the Murray Basin, South Australia. (202068–002)

GENERAL COMPOSITION OF PALYNOMORPHS AND DATING

The zonation diagram of Macphail (1999) is used for sample correlation and dating. Initially developed for the Murray Basin, this zonation can be confidently used in other areas. The age and relationships between spore–pollen zones is presented in Figure 2.

NALARA NR 3

Sample 12-14 m

Cuttings

R 504518 (rock sample number); S 1004 (slide number)

Good yield and preservation of the palynofloras.

Casuarinaceae (47%) dominate the assemblage with common Proteaceae (12%), frequent Myrtaceae (5%) and Asteraceae (5%) and less common Chenopodiaceae (3%) and spores (<1%).

Haloragacidites harrisii (47%) is the abundant taxon.

Proteaceae include *Triporopollenites chnosus* (11%), with rare *Proteacidites punctiporus, P. isopogiformis, Grevillea* ap. and *Hakea* sp.

Myrtaceae include *Myrtaceidites mesonesus* (3%), *M. eugeniioides* (2%) and rare *M. lipsis, M. eucalyptoides* and *M. verrucosus.*

Asteraceae include *Tubulifloridites antipodica* (4%) and rare *T. simplis.*

Chenopodiaceae are represented by *Chenopodipollis chenopodiaceoides* (3%).

Other taxa locally frequent include *Milfordia homeopunctata* (8%), *Graminidites psilatus* (4%), *Polyorificites oblatus* (3%), *Parsonsidites psilatus* (3%), while *Acaciapollenites myriosporites* (1%), *Ailanthipites mulleri* (1%), and *Rhoipites isoreticulatus* (1%) are all rare.

Other taxa present, in very low frequencies <1%, include *Haloragacidites myriophylloides, H. haloragoides, Malvacipollis spinyspora, Monotocidites galeatus, Periporopollenites polyoraus, P.demarcatus, Symplocoipollenites austellus, Rhoipites alveolatus, Rh. sphaerica, Rh. muehlenbeckiaformis* and *Tricolporites* spp.

Podocarpaceae, *Nothofagus* spp. and spores are absent.

Dinoflagellate cysts are present in low frequencies (2%) and include *Tectatodinium pellitum, Batiacasphaera hirsuta, Apteodinium australiense, Impagidinium* sp. and *Lingulodinium* spp.

The sample is dated Late Miocene-Early Pliocene and assigned to the *Monotocidites galeatus* Zone (Macphail, 1999) based on the presence of *Monotocidites galeatus* (very rare) in association with *Myrtaceidites lipsis, Tubulifloridites simplis, T. antipodica, Malvacipollis spynispora, Graminidites psilatus, Chenopodipollis chenopodiaceoides, Acaciapollenites myriosporites, Proteacidites isopogiformis, P. punctiporus, Rhoipites isoreticulatus* and *Rh. muehlenbeckiaformis.*

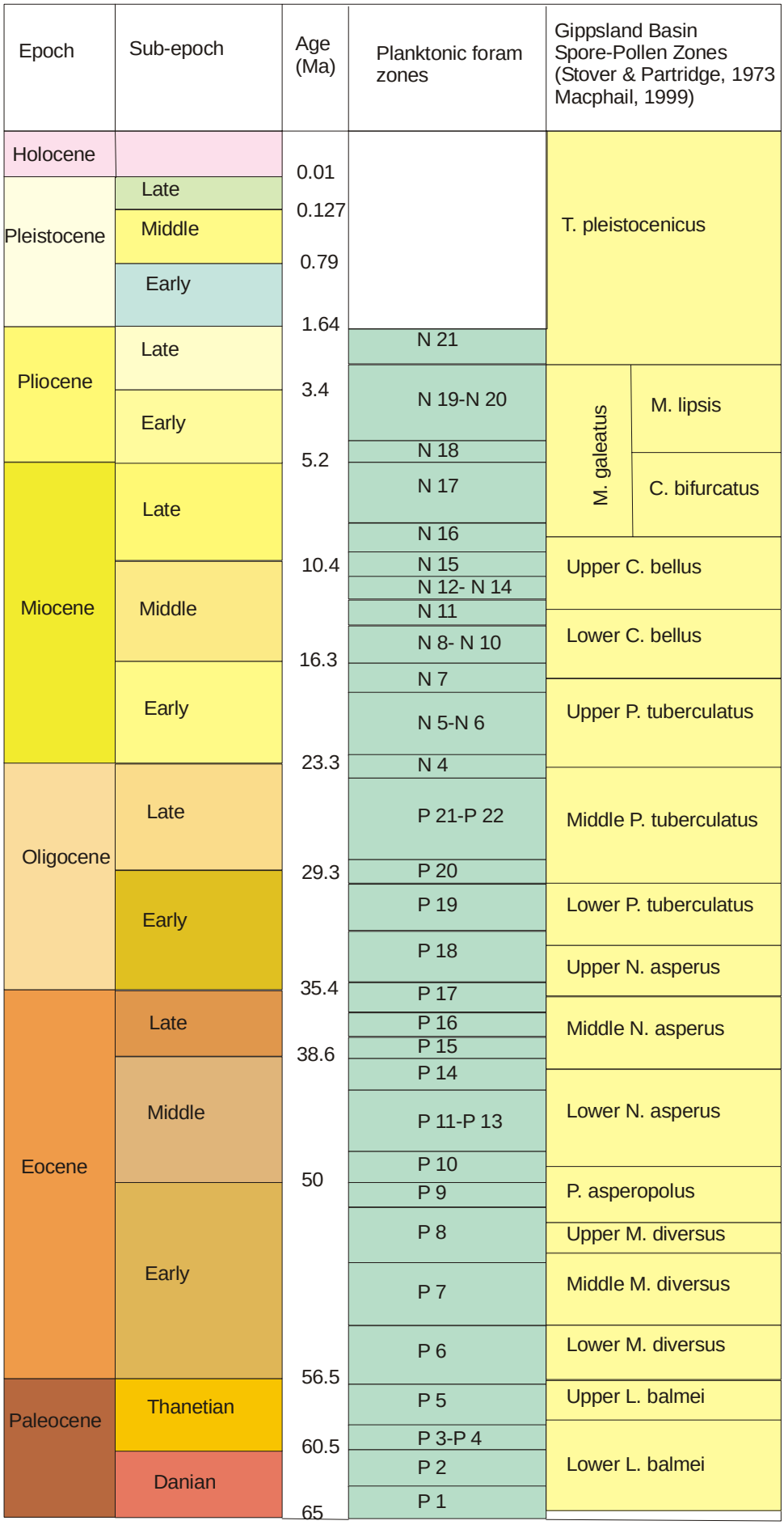


Figure 2 The age and relationship between spore-pollen zones in the Gippsland Basin and Murray Basin (after Stover & Partridge, 1973 and Macphail, 1999). (202068–003)

Sample 28-30 m

Cuttings

R 504517; S 1005

Good yield and preservation of palynofloras.

Casuarinaceae (58%) dominate the assemblage followed by Proteaceae (12%), Myrtaceae (3%), Asteraceae (3%), and Chenopodiaceae (2%).

Casuarinaceae include abundant *Haloragacidites harrisii* (54%) and rare *Casuarinidites cainozoicus* (2%).

Proteaceae include high frequencies of *Triporopollenites chnosus* (11%) and rare *Proteacidites isopogiformis, P. symphyonemoides, Grevillea* sp. and *Hakea* sp.

Myrtaceae are less frequent and include *Myrtaceidites mesonesus* (2%), *M. eugeniioides* (1%) and rare *M. eucalyptoides* and *M. verrucosus.*

Asteraceae are represented by *Tubulifloridites antipodica* (2%) and rare *T. simplis.*

Chenopodiaceae include *Chenopodipollis chenopodiaceoides* (2%).

Other taxa locally frequent include *Milfordia homeopunctata* (7%), *Parsonsidites psilatus* (3%), *Graminidites psilatus* (2%), *Rhoipites isoreticulatus* (2%), while *Rh. muehlenbeckiaformis* (1%) and *Haloragacidites trioratus* (1%) are all rare.

Taxa present in very low frequencies include *Acaciapollenites myriosporites, Monotocidites galeatus, Ailanthipites mulleri, Bysmapollis emaciatus, Milfordia spynispora, Periporopollenites polyoratus, P. demarcatus, Perisyncolpites pokornyi* and *Symplocoipollenites austellus.*

Podocarpaceae, *Nothofagus* spp. and spores are absent.

Dinoflagellate cysts (<1%) are very rare.

The sample is dated Late Miocene-Early Pliocene and assigned to the *Monotocidites galeatus* Zone (Macphail, 1999) based on the presence of *Monotocidites galeatus* (very rare) in association with *Tubulifloridites simplis, T. antipodica, Malvacipollis spynispora, Graminidites psilatus, Chenopodipollis chenopodiaceoides, Acaciapollenites myriosporites, Proteacidites isopogiformis, Rhoipites isoreticulatus* and *Rh. muehlenbeckiaformis.*

NALARA NR 4

Sample 10-12 m

Cuttings

R 504553; S 10026

Fair yield and good preservation of palynofloras.

Casuarinaceae (39%) dominate the sample with common Myrtaceae (19%), Proteaceae (10%) and Asteraceae (10%), and less common Chenopodiaceae (3%) and spores (1%).

Casuarinaceae include *Haloragacidites harrisii* (39%).

Myrtaceae are common and *Myrtaceidites parvus-mesonesus* (12%) is well represented with rare *Myrtaceidites lipsis* (2%), *M. eugeniioides, M. eucalyptoides* and *M. oceanicus* (all less than 1%).

Proteaceae include *Triporopollenites chnosus* (8%) and rare *Proteacidites punctiporus* and *Hakea* sp.

Asteraceae are represented by *Tubulifloridites antipodica* (5%) and *T. simplis* (5%).

Chenopodiaceae are less common and include *Chenopodipollis chenopodiaceoides* (2%).

Other taxa present in moderate frequencies include *Acaciapollenites myriosporites* (5%), *Milfordia homeopunctata* (3%) and *Gyropollis psilatus* (3%), with rare *Rhoipites muehlenbeckiaformis* (2%) and *Monotocidites galeatus* (1%).

Other taxa present include *Cupanieidites orthoteichus, Phyllocladidites mawsonii, Podocarpidites ellipticus, Perisyncolpites pokornyi, Rhoipites alveolatus,* and *Rh. isoreticulatus.*

Spores and Podocarpaceae are very rare, while *Nothofagidites* spp. and dinoflagellate cysts are absent.

The sample is dated Late Miocene-Early Pliocene and assigned to the *Monotocidites galeatus* Zone (Macphail, 1999) based on the presence of *Monotocidites galeatus* in association with *Myrtaceidites lipsis, Chenopodipollis chenopodiaceoides, Tubulifloridites simplis, T. antipodica, Proteacidites punctiporus, Rhoipites isoreticulatus* and *Rh. muehlenbeckiaformis.*

Sample 18-20 m

Cuttings

R 504554; S 10027

Good yield and preservation of palynofloras.

Casuarinaceae (52%) dominate the sample with common Proteaceae (12%) and Myrtaceae (9%), followed by Chenopodiaceae (4%), Asteraceae (2%) and spores (2%).

Casuarinaceae include abundant *Haloragacidites harrisii* (50%) and less frequent *Casuarinidites cainozoicus* (2%).

Proteaceae include high frequencies of *Triporopollenites chnosus* (11%) and rare *Proteacidites isopogiformis, P. punctiporus* and *Hakea* sp.

Myrtaceae include *Myrtaceidites parvus-mesonesus* (4%), *M. eucalyptoides* (3%), and rare *M. tenuis, M. eugeniioides* and *Eucalyptus spathulata.*

Chenopodiaceae include *Chenopodipollis chenopodiaceoides* (2%). Asteraceae are less common, ie. *Tubulifloridites antipodica* (1%) and *T. simplis* (1%).

Spores are rare.

Other taxa present in moderate frequencies include *Milfordia homeopunctata* (7%), *Acaciapollenites myriosporites* (4%) and *Gyropollis psilatus* (2%).

Rare taxa include *Graminidites psilatus, Monotocidites galeatus, Periporopollenites polyoratus, Polyorificites oblatus, Podocarpidites ellipticus, P. magnificus, Perisyncolpites pokornyi* and *Symplocoipollenites austellus.*

There are no *Nothofagidites* spp. and dinoflagellate cysts.

The sample is dated Late Miocene-Early Pliocene and assigned to the *Monotocidites galeatus* Zone (Macphail, 1999) based on the presence of *Monotocidites galeatus* in association with *Chenopodipollis chenopodiaceoides, Tubulifloridites simplis, T. antipodica, Proteacidites punctiporus, P. isopogiformis* and *Graminidites psilatus.*

DISCUSSION

Palynological analyses of four cutting samples from NALARA NR 3 and NALARA NR 4 drillholes indicate the same age, Late Miocene – Early Pliocene, correlative to *Monotocidites galeatus* Zone (Macphail, 1999).

This interval is dominated by Casuarinaceae (between 39% and 58%), with *Haloragacidites harrisii* the most abundant taxon in all samples.

Taxa consistently present in high-moderate frequencies in all samples include *Triporopollenites chnosus* (8-11%), *Milfordia homeopunctata* (up to 8%, usually between 3-7%), *Acaciapollenites myriosporites* (up to 5%), while the other taxa remain within 2-3% interval (ie. *Polyorificites oblatus*-3%, *Parsonsidites psilatus* –3%, and *Rhoipites* spp.-2-3%).

By this time, the vegetation of Australia changed, from *Nothofagus* dominated forest during Eocene-Oligocene, to open woodland dominated by Casuarinaceae, eucalypts and grasses. Low nutrient soils developed allowing Casuarinaceae, Chenopodiaceae and Asteraceae to become more prominent.

Open woodland with *Casuarina* was dominant in coastal areas along with non- *Eucalyptus* species, *Acacia*, Proteaceae, Chenopodiaceae, Asteraceae and Gramineae. Forest communities are more open and dry sclerophyllous forest and coastal communities are present on both sites.

Eucalyptus spathulata, found in one sample from NALARA NR 4, has a modern relative, which is a mallee, and is found in low-lying country, tolerating saline soils. The conditions become more arid and some species, including Araucariaceae and *Nothofagus* spp., disappeared from the landscape, while others survived and become more tolerant to ecological changes.

Samples from NALARA NR 4 have few grains of *Podocarpidites ellipticus* and *Phyllocladidites mawsonii* and few tree ferns, which are part of rainforest taxa, suggesting a warm climate and persistence of the rainforest until the end of Miocene in this area.

Samples from NALARA NR 3 contain few dinoflagellate cysts, suggesting a weak marine influence due to sea-level changes. An estuary developed near the site, but the extension of marine influence decreased towards NALARA NR 4. However the low nutrient soils been prevailed on both sites, where the same pattern in vegetation can be recognised.

The same vegetation pattern has been found in southwestern Australia, Lake Tay, which form part of a large Tertiary palaeodrainage system. *Casuarina* represents over 60% of the total count (Bint, 1981), while Proteaceae count is low. The vegetation here was open forest or woodland, with sclerophyllous shrub layer. Small amounts of *Nothofagus* species have been recorded.

On Eyre Peninsula palynological data for early to middle Pliocene suggests open vegetation with grass, Chenopodiaceae and Compositae (Truswell and Harris, 1982). *Casuarina* and Cyperaceae are locally abundant and *Eucalyptus* type is common. Podocarpaceae and *Nothofagus* spp. are rare.

In the Murray Basin, samples from PIVA 10, PIVA 5 and PIVA 1 drillholes indicate the presence of open forest, in which Myrtaceae, Araucariaceae and Casuarinaceae were prominent during Late Miocene-Early Pliocene (Stoian, 2002). Here the *Nothofagus*

dominated rainforest was replaced by open woodland and along coastal fringe some mangrove vegetation developed. The conditions on this site were dry, but Araucariaceae formed an important component of the vegetation together with Myrtaceae and Casuarinaceae, while in the Eucla Basin Araucariaceae are absent and only Casuarinaceae dominate the pollen spectra.

Data from Martin (1973, 1978) indicate that in the Murray Basin rainforest with *Nothofagus brasii* persisted until the end of Miocene, when it was replaced by vegetation dominated by *Casuarina* and Myrtaceae.

CONCLUSION

Samples from NALARA NR 3 and 4 drillholes are dated Late Miocene-Early Pliocene, *Monotocidites galeatus* Zone.

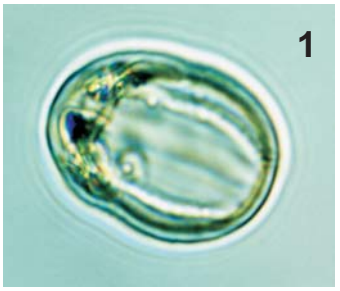
Reconstruction of the vegetation in Eucla Basin show distinct plant communities: *Casuarina*-*Eucalyptus* type-non-*Eucalyptus*-type-*Acacia*-Chenopodiaceae-Asteraceae-Proteaceae. The arid conditions prevailed and low nutrient, saline soils developed. There is a low marine influence throughout the sequence. Rainforest taxa are restricted to NALARA NR 4 site until the end of Miocene, when have been replaced by *Casuarina* dominated woodland. There are similarities in pollen spectra with other areas of Australia, but the climate in the Eucla Basin was more arid, and some species, consistently recorded in the similar deposits in the Murray Basin, are not found here. High frequencies of *Triporopollenites chnosus* have been recorded only in the Eucla Basin.

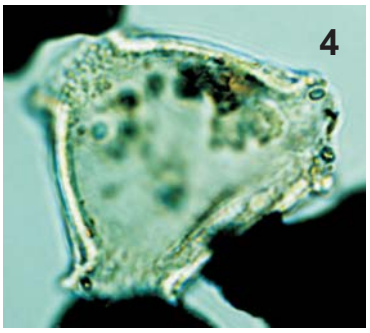
The work is currently in progress, more palynological data will be available to complete the picture of Late Miocene-Early Pliocene sediments in the Eucla Basin and allow better comparison with other sites palynologically investigated.

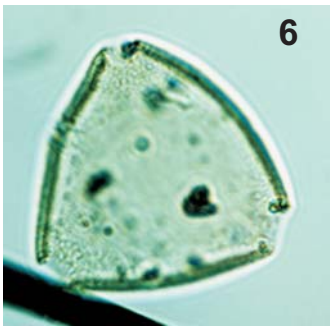
PLATE 1

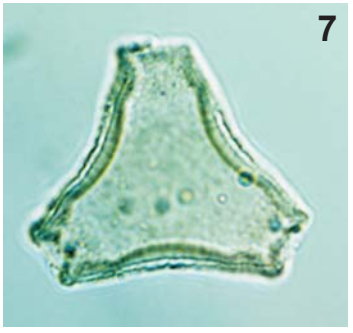
1 Monotocidites galeatus, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 13/105.2
2 Monotocidites galeatus, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 19/105.3
3 Haloragacidites haloragoides, slide S 10005, 28-30 m, NALARA NR 3, x800, 7.5/102.2
4 Hakeidites (Grevillea) sp., slide S 10005, 28-30 m, NALARA NR 3, x800, 23/118
5 Proteacidites punctiporus, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 4/100
6 Proteacidites punctiporus, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 10/102
7 Proteacidites sp., slide S 10005, 28-30 m, NALARA NR 3, x800, 6/97.3
8 Proteacidites symphyonemoides, slide S 10005, 28-30 m, NALARA NR 3, x800, 6.6/101
9 Milfordia homeopunctata, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 8/107.9
10 Malvacipollis spinyspora, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 6.7/102.8
11 Periporopollenites demarcatus, slide S 10005, 28-30 m, NALARA NR 3, x800, 15/100
12 Myrtaceidites verrucosus, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 4/100.5
13 Myrtaceidites lipsis, slide S 10004-2, 12-14 m, NALARA NR 3, x800, 23.2/105.8

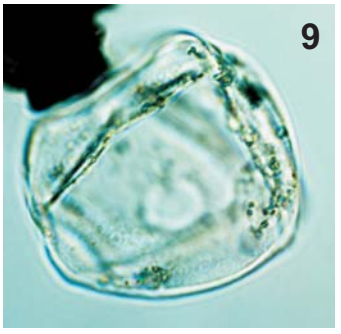
PLATE 1

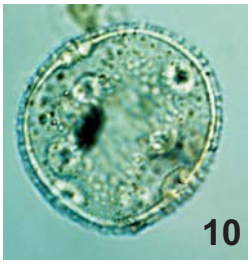


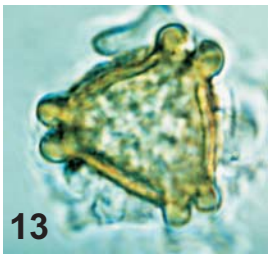












APPENDIXES

	NALARA NR 3		NALARA NR 4	
	12-14 m	28-30 m	10-12 m	18-20 m
Pollen and spores				
Acaciapollenites myriosporites	x	x	x	x
Ailanthipites mulleri	x	x		
Bluffopollis scabratus				x
Bysmapollis emaciatus		x		
Casuarinidites cainozoicus	x	x		x
Chenopodipollis chenopodiaceoides	x	x	x	x
Crotonipollis sp.	x			
Cupanieidites orthoteichus		x	x	
Cyathidites australis			x	x
Cyathidites subtilis				x
Ericipites crassiexinus	x			
Eucalyptus spathulata				x
Foveotriletes crater	x	x		x
Graminidites psilatus	x	x		x
Gyropollis psilatus	x	x	x	x
Hakeidites (Grevillea) sp.	x	x		
Hakeidites (Hakea) sp.	x	x	x	x
Haloragacidites haloragoides	x	x		
Haloragacidites harrisii	x	x	x	x
Haloragacidites myriophylloides	x			
Haloragacidites trioratus	x	x		
Laevigatosporites ovatus				x
Lymingtonia cenozoica		x		
Malvacipollis spinyspora	x	x		
Milfordia homeopunctata	x	x	x	x
Monotocidites galeatus	x	x	x	x
Myrtaceidites eucalyptoides	x	x	x	x
Myrtaceidites eugeniioides	x	x	x	x
Myrtaceidites lipsis	x		x	
Myrtaceidites oceanicus			x	
Myrtaceidites parvus-mesonesus	x	x	x	x
Myrtaceidites tenuis				x
Myrtaceidites verrucosus	x	x		
Nothofagidites heterus	x			
Parsonsidites psilatus	x	x		
Periporopollenites demarcatus	x	x		
Periporopollenites polyoratus	x	x		x
Perisyncolporites pokornyi		x	x	x
Peromonolites vellosus	x			
Phyllocladidites mawsonii			x	
Podocarpidites ellipticus			x	x
Polyorificites oblatus	x	x		x
Propylipollis minimus			x	
Proteacidites isopogiformis	x	x		x
Proteacidites punctiporus	x		x	x
Proteacidites symphyonemoides		x		
Rhoipites alveolatus	x	x	x	x
Rhoipites isoreticulatus	x	x	x	
Rhoipites muehlenbeckiaformis	x	x	x	

	NALARA NR 3		NALARA NR 4	
	12-14m	28-30m	10-12m	18-20m
Rhoipites sphaerica	x			
Symplocoipollenites austellus	x	x		x
Tricolpites discus	x			
Tricolporites leuros	x			
Triporopollenites chnosus	x	x	x	x
Tubulifloridites antipodica	x	x	x	x
Tubulifloridites simplis	x	x	x	x
Dinoflagellate cysts				
Apteodinium australiense	x			
Batiacasphaera hirsuta	x	x		
Impagidinium sp.	x	x		
Lingulodinium sp.	x			
Tectatodinium pellitum	x	x		
Reworked				
Callialasporites dampieri				x
Cicatricosisporites ludbrookiae				x
Podocarpidites multesimus				x

Drillhole Name : NALARA NR 3

Interval : 10m - 35m

Scale : 1:500

Chart date: 26 September 2003

Author: Liliana Stoian

Chart compiled by: Liliana Stoian

Mineral Resources, PIRSA
Adelaide, SA

Absolute abundance histograms

Depth

Chronostratigraphy

Period/Epoch

Spore-Pollen Zone

Zone

Samples

Pollen and spores

Dinoflagellate

Acaciapollenites myriosporites
Ailanthipites mulleri
Bysmapollis emaciatus
Casuarinidites cainozoicus
Chenopodipollis chenopodiaceoides
Cupanieidites orthoteichus
Foveotriletes crater
Graminidites psilatus
Grevillea sp.
Gyropollis psilatus
Hakea sp.
Haloragacidites haloragoides
Haloragacidites harrisii
Haloragacidites trioratus
Lymingtonia cenozoica
Milfordia homeopunctata
Milfordia spinyspora
Monotocidites galeatus
Myrtaceidites eucalyptoides
Myrtaceidites eugenioides
Myrtaceidites mesonesus
Myrtaceidites verrucosus
Periporopollenites demarcatus
Periporopollenites polyoratus
Perisyncolpites pokornyi
Personsidites psilatus
Polyoriticites oblatus
Proteacidites isopogiformis
Proteacidites symphyonemoides
Rhoipites alveolatus
Rhoipites isoreticulatus
Rhoipites muehlenbeckiaformis
Symplocoipollenites austellus
Triporopollenites chnosus
Tubulifloridites antipodica
Tubulifloridites simplis
Crotonipollis sp.
Ericipites crassiexinus
Haloragacidites myriophylloides
Malvacipollis spynispora
Myrtaceidites lipsis
Nothofagidites heterus
Parsonsidites psilatus
Peromonolites vellosus
Proteacidites punctiporus
Rhoipites sphaerica
Tricolpites discus
Tricolporites leuros
Batiacasphaera hirsuta
Impagidinium sp.
Tectatodinium pellitum
Apteodinium australiense
Lingulodinium sp.

10m
15m
20m
25m
30m
35m

Early Pliocene - Late Miocene

Monotocidites galeatus

14m S 10004

3m0 S 10005

202068-004

Figure A2 Histograms chart of all identified taxa grouped by categories.
Chart includes chronostratigraphy and pollen-spore zones showing the participation of all identified taxa (pollen, spores and dinoflagellate cysts) in reconstruction of the Late Miocene-Early Pliocene vegetation in the Eucla Basin, South Australia.

Drillhole Name : NALARA NR 3

Interval : 10m - 35m

Scale : 1:500

Chart date: 26 September 2003

Author: Liliana Stoian

Chart compiled by: Liliana Stoian

Mineral Resources, PIRSA
Adelaide, SA

Absolute abundance histograms of the main taxa

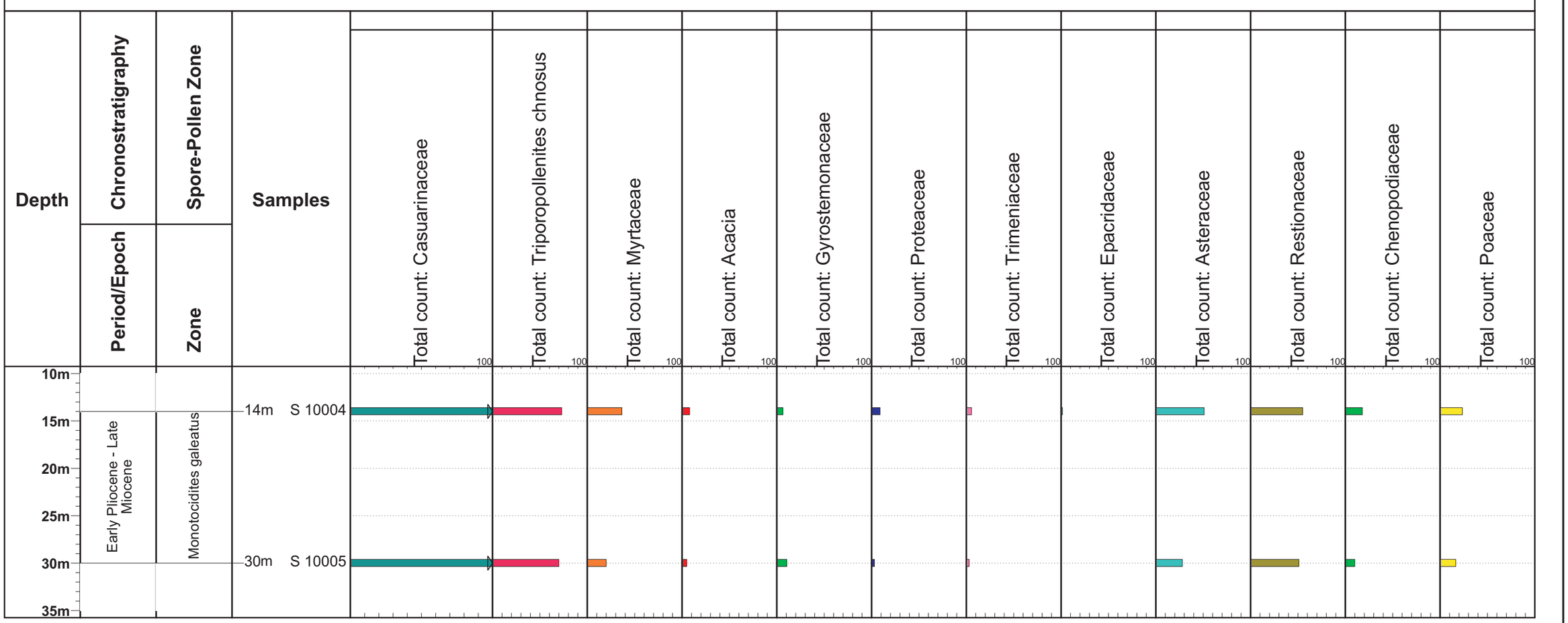


Figure A3 Histogram chart of the main taxa grouped by family level. Chart includes chronostratigraphy and pollen-spore zones showing the participation of the main taxa in reconstruction of the vegetation during the Late Miocene-Early Pliocene, Eucla Basin, South Australia. Only selected taxa have been included.

Drillhole Name : NALARA NR 4

Interval : 10m - 25m

Scale : 1:500

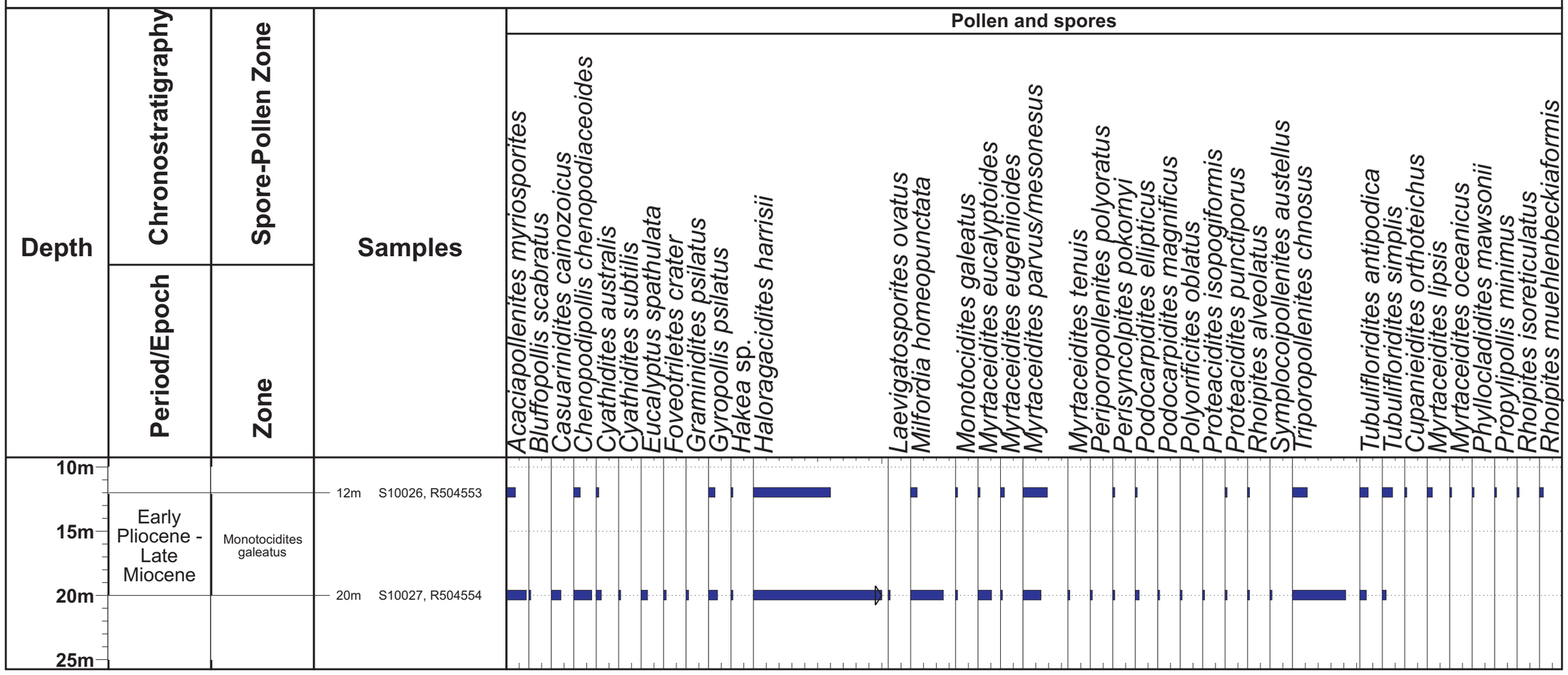
Chart date: 26 September 2003

Author: Liliana Stoian

Chart compiled by: Liliana Stoian

Mineral Resources, PIRSA
Adelaide, SA

Histogram chart of all identified taxa



202068-006

Figure A4 Histogram chart of all identified taxa.
Chart includes chronostratigraphy and spore-pollen zone, showing the participation of all identified taxa in reconstruction of the Late Miocene-Early Pliocene vegetation in the Eucla Basin, South Australia.

Drillhole Name : NALARA NR 4

Interval : 10m - 25m

Scale : 1:500

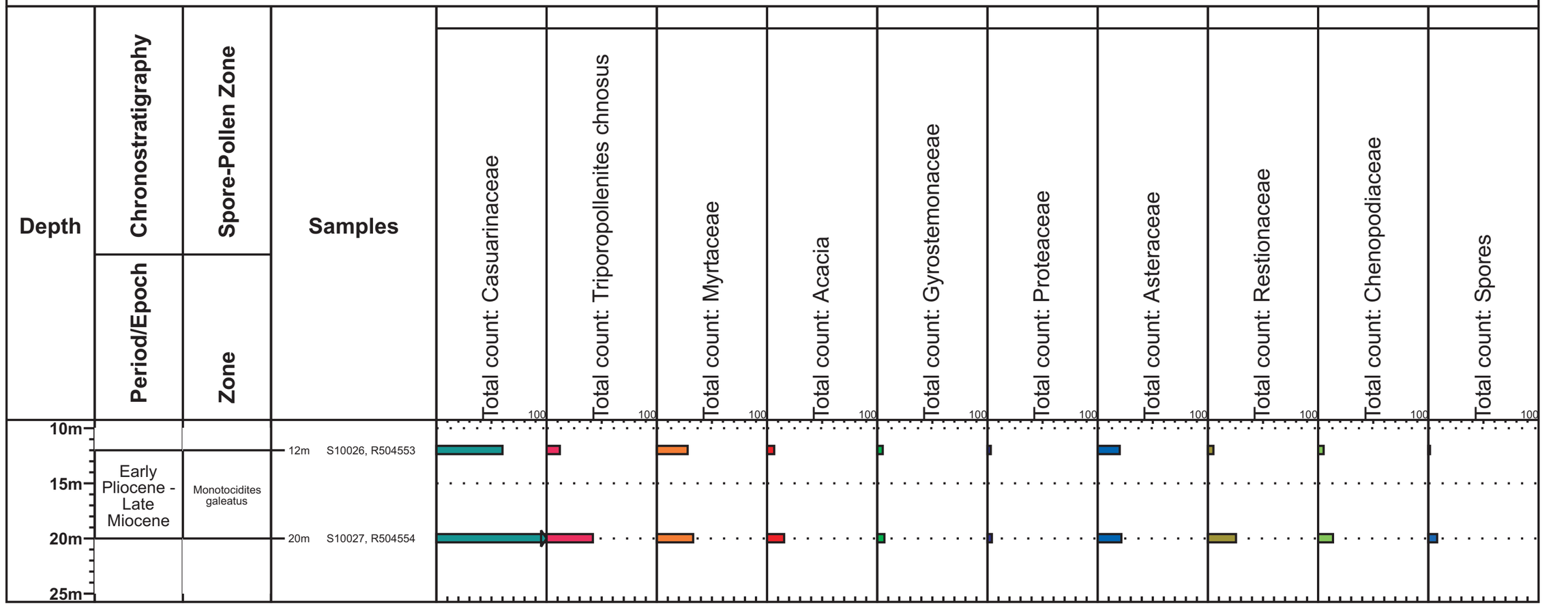
Chart date: 26 September 2003

Author: Liliana Stoian

Chart compiled by: Liliana Stoian

Mineral Resources, PIRSA
Adelaide, SA

Histogram chart of the main taxa



202068-005

Figure A5 Histogram chart of the main taxa grouped by family level. Chart includes chronostratigraphy and spore-pollen zone, showing the participation of the main taxa in reconstruction of the Late Miocene-Early Pliocene vegetation in the Eucla Basin, South Australia. Only selected taxa have been included.

BIBLIOGRAPHY

Alley, N.F., 1996. Palynological dating and correlation of Mesozoic and Tertiary sediments from Eyre Peninsula. *South Australia. Department of Mines and Energy Resources. Report Book,* 96/2.

Beadle, N.C., 1981. *The vegetation of Australia.* Cambridge University Press, Cambridge.

Bint, A.N., 1981. An early Pliocene pollen assemblage from Lake Tay, south-western Australia, and its phytogeographic significance. *Australian Journal of Botany,* 29: 277-291.

Clarke, D.A and B. Hou, 2000. Eocene coastal barrier evolution in the Eucla Basin. *MESA Journal,* 18: 36-41.

Clarke, D.A., P.R. Gammon, B. Hou, and S.J. Gallagher, 2003. Middle to Upper Eocene stratigraphic nomenclature and deposition in the Eucla basin. *Australian Journal of Earth Sciences,* 50: 231-248.

Hou B., Frakes, L. A., Alley, N. F., Stamoulis, V. and Rowett, A., 2000 . Geoscientific signatures of Tertiary palaeochannels and their significance for mineral exploration in the Gawler Craton region. *MESA Journal,* 19: 36-39.

Hou, B., Frakes, L. and Alley, N.F., 2001. Development of geoscientific models for exploration in Tertiary palaeochannels draining the northwest Gawler Craton, SA. *South Australia. Department of Primary Industries and Resources. Report Book* 2001/021.

Hou B., L. A. Frakes, N. Alley and Gray, D., 2001. Development integrated exploration methods: an inspiration derived from the study of palaeodrainage on the Gawler Craton, South Australia. *In:* Computer applications in the minerals industries: proceedings of the 29th International Symposium on Computer Application in the Minerals Industries (APCOM2001, eds. by H. Xie, Y. Wang & Y. Jiang,), Beijing, China, 25-27 April, 2001, Lisse: A.A. Balkema Publishers, pp.107-110.

Hou B., L. A. Frakes and Dodds, A.R., 2001. Recent drilling in the Garford Palaeochannel, the Gawler Craton – testing of a model derived from interpreted geological, geophysical and spectral methods. *MESA Journal,* 20: 24-27.

Hou, B., Frakes, L.A., Alley, N.F., 2002. Palaeochannel study models and their significance: example from the Gawler Craton, South Australia. *In:* Preiss, V.P (editor), 2002. Geoscience 2002: Expanding Horizons. Abstracts 67 of the 16th Australian Geological Convention 2002. *Geological Society of Australia*

Hou, B., Frakes, L.A., Alley, N.F. and D.A. Clarke, 2003. Characteristics and evolution of the Tertiary palaeochannels in the NW Gawler Craton, South Australia. *Australian Journal of Earth Sciences,* 50: 215-230.

Hou, B., and Alley, N.F., 2003. A model for gold and uranium dispersion and concentration in residual and transported regolith along palaeodrainage systems. - A case study from the central Gawler Craton, SA. *MESA Journal,* 30: 49-53.

Machail, M.K. and Kellett, J.R., 1993. Palynostratigraphy of the Bookpurnong Beds and related Late Miocene-Early Pliocene facies in the central west Murray Basin, part 1: dinoflagellates. *AGSO Journal of Australian Geology & Geophysics,* 14/4: 371-382

Macphail, M.K., Alley, N.F., Truswell, E.M. and Sluiter, I.R.K., 1994. Early Tertiary vegetation: evidence from spores and pollen. *In:* Hill, R.S. (Ed.), *History of the Australian vegetation: Cretaceous to Recent*. Cambridge University Press, Cambridge, pp. 189-261.

Macphail, M.K., Colhoun, E.A. and Fitzsimons, S.J., 1995. Key Periods in the Evolution of the Cenozoic Vegetation and Flora in Western Tasmania: the Late Pliocene. *Australian Journal of Botany,* 43: 505-526

Macphail, M.K., 1999. Palynostratigraphy of the Murray Basin, inland southeastern Australia. *Palynology,* 23: 197-240.

Martin, H.A., 1973. Upper Tertiary palynology in southern New South Wales. *Geol. Soc. Aust. Spec. Publ.,* 4: 35-54.

Martin, H.A., 1978. Evolution of the Australian flora and vegetation through the Tertiary: evidence from pollen. *Alcheringa*, 2: 181-201.

Martin, H.A. and Gadek, P.A., 1988. Identification of *Eucalyptus spathulata* pollen and its presence in the fossil record. *Mem. Ass. Australas. Palaeontols.* 5: 311-327.

Martin, H.A., 1994. Australian Tertiary phytogeography: evidence from palynology. *In:* Hill, R.S. (Ed.), *History of the Australian vegetation: Cretaceous to recent.* Cambridge University Press, Cambridge, pp. 104-142

Stoian, L.M., 2002. Palynological analysis and dating of Early Oligocene- Early Pliocene deposits in the western Murray Basin, South Australia. *South Australia. Department of Primary Industries and Resources. Report Book,* 2002/008.

Stover, L.E. and Partridge, A.D., 1973. Tertiary and Late Cretaceous spores and pollen from the Gippsland Basin, southeastern Australia. *Royal Society of Victoria, Proceedings,* 85:237-286.

Truswell, E.M. and Harris, W.K., 1982. The Cainozoic palaeobotanical record in arid Australia: fossil evidence for the origins of an arid-adapted flora. *In*: Barker, W.S. and Greenslade, P.J.M. (Eds), *Evolution of the flora and fauna of arid Australia.* Peacock Publications, Adelaide, pp. 67-76.

Truswell, E.M., Sluiter, I.R. and Harris, W.K., 1985. Palynology of the Oligocene-Miocene sequence in the Oakvale-1 corehole, western Murray Basin, South Australia. *BMR Journal of Australian geology and geophysics,* 9:267-295.