Paleontology Report No. 2013/03

PALYNOLOGY OF DRILLHOLE BALMAIN 1 (WARRAMBAN 1:100 000 SHEET; TANUMBIRINI 1:250 000 SHEET) BEETALOO BASIN, NORTHERN TERRITORY, AUSTRALIA

by

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Abstract

A sample from drillhole Balmain 1 (held in the NTGS core library in Darwin, Northern Territory) was collected by John Gorter on behalf of ENI and examined by Kathleen Grey as part of a reassessment of the hydrocarbon prospectivity of the Beetaloo Basin. A single palynological sample was prepared using a modified preparation technique. Initial examination of the prepared slides indicated abundant, diverse, extremely well-preserved palynomorphs, many of numerous new taxa that could not be readily be assigned to existing species or precisely dated. Because of the difficulties presented by these previously undescribed taxa, slides were set aside until time was available for a more detailed examination. Further work has now been carried out, but it still has not been possible to do more than document some of the more common species. A more extensive study is needed to define the taxa present and document their stratigraphic distribution. The general aspect of the assemblage indicates a Mesoproterozoic age. More detailed analyses should provide a biostratigraphic scheme covering much of the Mesoproterozoic Beetaloo Basin succession. Such a scheme would have considerable potential for correlation of hydrocarbon exploration drillholes in the Beetaloo Basin.

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Drillhole Specifications

COREDAT ID: 1833
Drill Hole / Well Name: Balmain 1
Tenement: EP18
Operator: Pacific Oil and Gas
Core Type: Petroleum Core
Location: Darwin
Hylogged: Yes
100K Name: Warramban
250K Name: TANUMBIRINI
MGA94 Easting: 348384, MGA94 Northing: 8162954, UTM Zone: 53
Latitude: 16°36'39.13"S, Longitude: 133°34'43.10"E
Geological Region: McArthur Basin
Total depth: 1050 m

Locality details and sampling

Drillhole Balmain 1, a petroleum drillhole located on TANUMBIRINI 1:250 000 sheet (Table 1), was drilled by Pacific Oil and Gas near the central trough of the Beetaloo Basin (Silverman et al., 2007). It reached TD at a depth of 1050 m in the upper Kyala Formation and penetrated the Mesoproterozoic Chambers River Formation of the Roper Group, in the Beetaloo Basin, from which a single palynological sample was taken at a depth of 800.8 m (Fig. 1, Table 1). The sample was prepared using a modified preparation technique designed to extract large fragile specimens from Proterozoic samples (Grey, 1999) by Core Laboratories Australia Pty. Ltd, P.O Box 785, Cloverdale, WA, 6105, Australia, Email : corelab.australia@corelab.com.

The single sample contains a rich and diverse assemblage of well preserved palynomorphs. Many are difficult to identify because of the scarcity of literature covering taxa of this age. Preliminary results and illustrations of some of the better preserved specimens are given below.

Table 1. Drillhole location

Drillhole	Latitude	Longitude
Balmain 1	16°36'39.13"S	133°34'43.10"E

Report

Palynomorphs are abundant in the upper Roper Group, and are particularly well preserved in the Chambers River Formation. Details of species present are given in Appendix 1 and taxonomic details in Appendix 2. Selected specimens are illustrated in Figures 2 and 3.

Degraded filaments and filament sheaths, including some tapered forms, possibly of *Polytrichoides lineatus*, are common (Figs 2A-I), as are more complex filamentous structures composed of linked spheres, here placed in *Chlorogloeaopsis contexta* (Figs 2J,K). Some problematica are present and could be fungal bodies or possible contaminants (Fig. 2L). Various species of *Leiosphaeridia* are common (Figs 3A-C), as is *Chuaria* cf. *circularis* (Figs 3D-F). The assemblage contains an abundance of various cell clusters (coenobial aggregates), tentatively assigned to *Symplassosphaeridium* (Fig. 3G), ?*Arctacellularia* (Fig. 3H) and *Satka* sp. (Figs 31, J). The assemblage is consistent with microfossils first described from the Roper Group by Peat et al. (1978) from the then McMinn Formation. So far, no specimens of the large, process-bearing *Tappania plana*, previously recorded by Javaux et al. (2001) from the underlying Corcoran, Jalboi and Mainoru Formations, have been observed. The assemblage is similar, but not identical, to one in the 1200 to 1300 Ma Bylot Supergroup of Arctic Canada (Hofmann and Jackson, 1994). Similar species are present in younger Mesoproterozoic stratigraphic units, such as the c. 1000 Ma Lakhanda Formation and late Mesoproterozoic Miroyedikha Formations of Siberia (Jankauskas et al., 1989; Bartley et al., 2001).

The thermal alteration index of organic material (TAI), based on well-established Phanerozoic measurements of organic maturity (Batten, 1996; Traverse, 2007), indicates that organic matter in the Chambers River Formation has reached a level of 3+, so lies close to the boundary between oil and gas generation. These results may be slightly inconsistent with Rock-Eval pyrolysis and vitrinite reflectance studies (Warren et al., 1998). TAI is determined from pre-oxidation macerate slides. Determinations are based on spore colouration, which is a rough guide only, partly because acritarch biopolymers have a slightly different chemical composition to sporopollenin, and partly because Precambrian organic material has not been adequately calibrated with Phanerozoic material, or with burial history. Kerogen colour in Precambrian rocks has more to do with depth of burial, tectonic stress, or heating by thermal fluids than to age or redox values (Schiffbauer et al., 2012) and follows similar pathways to those in Phanerozoic successions (Batten, 1996; Traverse, 2007).

This preliminary study shows that a diverse, well preserved palynological assemblage is present in the Chambers River Formation and has considerable potential for biostratigraphic correlation in the Beetaloo Basin. More detailed analysis, including systematic studies and the description of potentially new species, is required. Palynology could assist in determining both sedimentary and organic facies and shed further light on thermal maturity of the basin.

Problems with sample preparation have hindered identification, and results could be considerably improved. The application of standard palynological methods often does not provide good results for Proterozoic material (Grey, 1999). Present specimen density is so high it hinders identification and fine debris obscures specimens. Samples must be properly filtered to remove all fine particles. Each sample should be assessed from a kerogen slide after processing with hydrochloric and hydrofluoric acid to allow assessment of TAI and to determine how long organic material requires oxidation. Samples are often variable and require independent treatment. Fluorides can be difficult to remove and heavy liquid separation can remove a large of amount of organic matter, which often has a higher specific gravity than usual because of the presence of pyrite framboids.

Summary of samples

Figure 1. Samples and lithology

Drillhole: Balmain 1

Sample no.	Depth (m)	No of slides	Type	Formation	Lithology hand specimen
12974	800.8 m	5	Core	Chambers River Formation	fine-grained argillite-claystone

Table 2. Summary of palynology

Depth (m)	Palynomorphs	Preservation	TAI*	Probable stratigraphic age
800.8 m	?*Arctacellularia* *Chlorogloeaopsis contexta* *Chuaria* cf. *circularis* *Leiosphaeridia crassa* *Leiosphaeridia jacutica* *Leiosphaeridia minutissima* *Leiosphaeridia tenuissima* ?*Polytrichoides lineatus* *Satka* sp. *Siphonophycus kestron* *Siphonophycus septatum* *Siphonophycus solidum* *Siphonophycus typicum* *Siphonophycus* spp. *Symplassosphaeridium* sp. ? Fungal body	excellent	3+	Mesoproterozoic

Conclusions

Palynomorphs, comprising acritarchs, cyanobacteria, filaments and problematic forms are abundant and well preserved in the Chambers River Formation in Balmain 1. They have good correlation potential for the upper Roper Group. It is difficult to determine the stratigraphic age at present, other than to suggest that the assemblage has a Mesoproterozoic aspect. Many of the taxa require description and categorization before a zonal scheme can be proposed.

Recommendations for further work

Given the excellent preservation, diversity and high potential for biostratigraphic correlation, it is strongly recommended that further palynological analysis be undertaken on Balmain 1 and other selected Beetaloo Basin drillholes. Only a single sample has been processed so far, so further sampling is indicated. Sample preparation requires attention, especially in filtering and mounting samples. The present specimen density is so high it hinders identification.

There is potential for the development of a correlation scheme that would have application both for the hydrocarbon-prone Beetaloo Basin, as well as globally. Additional study is also needed to calibrate the thermal alteration index as determined from the colour of organic matter in Proterozoic sediments with maturity determined from vitrinite reflectance and Rock-Eval pyrolysis. TAI has the potential to be a valuable indicator of thermal gradient, especially at early stages of analysis, but requires standardization before it can be used with confidence. Further palynological studies would be a suitable project for a PhD or post-doctoral student.

References

Bartley, JK, Semikhatov, MA, Kaufman, AJ, Alan J, Kaufman AJ, Knoll AH, Pope MC, and Jacobsen SB, 2001, Global events across the Mesoproterozoic-Neoproterozoic boundary: C and Sr isotopic evidence from Siberia: Precambrian Research v. 111, p. 165–202.

Batten, DJ 1996, Palynofacies and petroleum potential: *In* Palynology: Principles and Applications *edited by* J Jansonius and DC Mcgregor, American Association of Stratigraphic Palynologists Foundation, Dallas, Texas, p. 1065–1084.

Grey K, 1999, A modified palynological preparation technique for the extraction of large Neoproterozoic acanthomorph acritarchs and other acid insoluble microfossils. Geological Survey of Western Australia, Record 1999/10, 23 p.

Hofmann HJ and Jackson GD, 1994, Shale-Facies Microfossils from the Proterozoic Bylot Supergroup, Baffin Island, Canada: Memoir of the Paleontological Society, v. 37, Supplement to Vol. 68, Journal of Paleontology, pp. 1–39, Paleontological Society.

Jankauskas TV, Mikhailova, NS and German, TN, 1989. (editors), Mikrofossilii Dokembriya SSSR. [Precambrian microfossils of the USSR], Trudy Institut Geologii i Geokhronologii [Proceedings of the Institute of Geology and Geochronology] Akademiya Nauk SSSR, Lenningrad, 191p. (Russian).

Javaux E, Knoll AH and Walter MR., 2001, Morphological and ecological complexity in early eukaryotic ecosystems: Nature, v. 412, p. 66–69.

Peat CJ, Muir MD, Plumb KA, McKirdy, DM and Norvic MS, 1978, Proterozoic microfossils from the Roper Group, Northern Territory, Australia: Bureau of Mineral Resources Journal of Australian Geology and Geophysics, v. 3, p. 1–17.

Schiffbauer JD, Wallace F, Hunter JLjr, Kowalewski M, Bodnar RJ and Xiao, S 2012, Thermally-induced structural and chemical alteration of organic-walled microfossils: an experimental approach to understanding fossil preservation in metasediments: Geobiology, v. 10, p. 402–423.

Silverman MR, Landon SM, Leaver JS, Mather TJ and Berg E 2007, No fuel like and old fuel: Proterozoic oil and gas potential in the Beetaloo Basin, Northern Territory Australia: *In* Proceedings of the Central Australian Basins Symposium Alice Springs 16-18 August, 2005 *edited by* TJ Munson and GT Ambrose, Northern Territory Geological Survey Special Publication 2.

Traverse A, 2007, Palaeopalynology (Second edition), Topics in Geobiology, v. 28, Springer, Dordrecht, The Netherlands, 814 p.

Warren JK, George SC, Hamilton, PJ and Tingate P, 1998, Proterozoic source rocks: Sedimentology and organic characteristics of the Velkerri Formation, Northern Territory, Australia: American Association of Petroleum Geologists, Bulletin, 82, p. 442–463.

Appendix 1: Log details for the individual sample

800.8 m Chambers River Formation

The kerogen and finer filtered mounts contain abundant finely disseminated organic particles, which in some cases obscure specimens because the preparation has not been adequately filtered and the slides have been mounted too densely. Removal of fluorides has also been inadequate. Mineral grains, probably pyrite, are common in the kerogen mount. Large, amorphous organic particles, probably of degraded bacterial mat, are common. Numerous degraded spheres of uncertain affinities are common. Many specimens are broken or show the effects of surface corrosion as a result of pyrite framboid formation.

The sample contains abundant, well preserved palynomorphs; many are apparently new species or difficult to assign to known taxa. Species of *Leiosphaeridia* are common, as are very large specimens of *Chuaria* cf. *circularis*. Spheroidal clusters are abundant and are tentatively assigned to *Symplassosphaeridium* spp. or *Satka* spp. Linear chains of cells have been assigned to ?*Arctacellularia*. Several species of these coenobial aggregates may be present, but statistical analysis of size and numbers of individual spheres in each cluster will be required to determine speciation with any certainty. Filamentous microfossils, including numerous specimens of *Siphonophycus* spp. are present. Tapering curved sheaths of ?*Polytrichoides lineatus* are present. There are also complex linear chains of cells, here assigned to *Chlorogloeaopsis contexta*.

Zone Indeterminate
Probable age Mesoproterozoic

Appendix 2: Taxonomic citations

The names of authors of scientific names were omitted in the text and instead are listed here. They are the names of taxonomic authors, not references, so are not necessarily cited in the references.

Arctacellularia German *in* Timofeev et al., 1976
Chlorogloeaopsis contexta (German 1976) Hofmann and Jackson 1994
Chuaria cf. *circularis* Walcott 1899; emend. Vidal & Ford 1985
Leiosphaeridia crassa (Naumova, 1949) Jankauskas 1989 in Jankauskas et al., 1989
Leiosphaeridia jacutica (Timofeev 1966) Mikhailova and Jankauskas 1989 in Jankauskas et al., 1989
Leiosphaeridia tenuissima Eisenack 1958
?*Polytrichoides lineatus* (German 1974) Yankauskas, Mikhailova and German 1989
Satka Jankauskas 1979
Siphonophycus Schopf 1968 emend. Knoll, Swett and Mark 1991
Siphonophycus kestron Schopf 1968
Siphonophycus septatum (Schopf 1968) Knoll emend. Knoll, Swett and Mark 1991
Siphonophycus solidum (Golub 1979) emend. Butterfield 1994
Symplassosphaeridium Timofeev 1959 ex Timofeev 1969
Tappania plana Yin L 1997

Figure 2. (p. 9). Selected palynomorphs from the Chambers River Formation in Balmain 1. 800.8 m. Palynomorphs are abundant and well preserved. A-C, large tapering sheaths, ?*Polytrichoides lineatus*. A, tapering sheath,3/ 65E0. B, curved filament sheath, 3/59O1. C, curved tapering filament, 2/68K4. D, large sheath, 2/68V0. E, *Siphonophycus solidum*, 3/67U1. F, *Siphonophycus typicum*, 3/66X2. G, *Siphonophycus kestron*, 2/63V0. H, *Siphonophycus solidum*, 4/40V0. I, large filament sheath, 2/46M2. J. *Chlorogloeaopsis contexta*, 3/69M2. K, *Chlorogloeaopsis contexta*, 3/62F0. L, ?fungi, 4/38Q0. England Finder co-ordinates are given for each specimen. Scale bar is 20 µm.

Figure 2

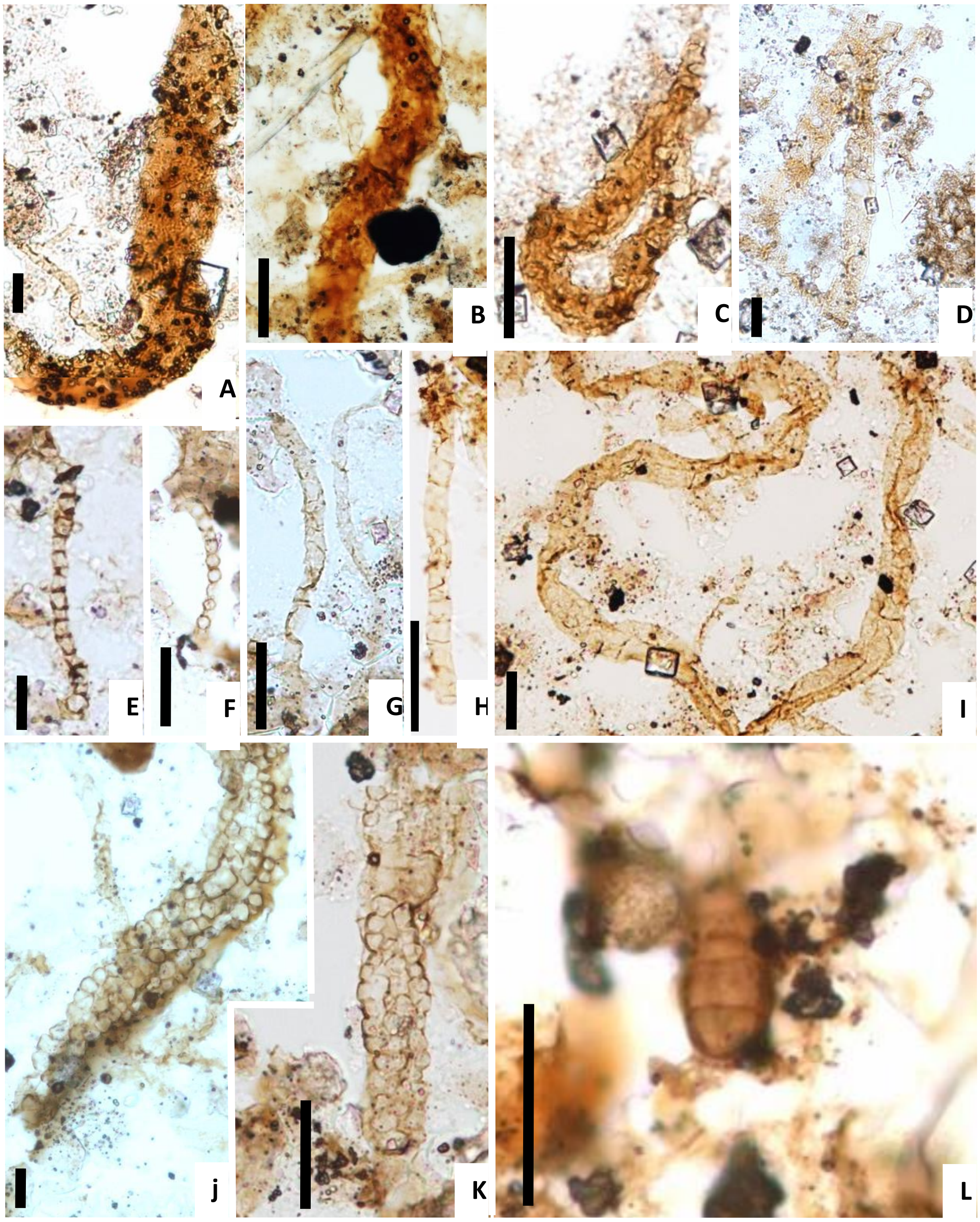

Figure 3

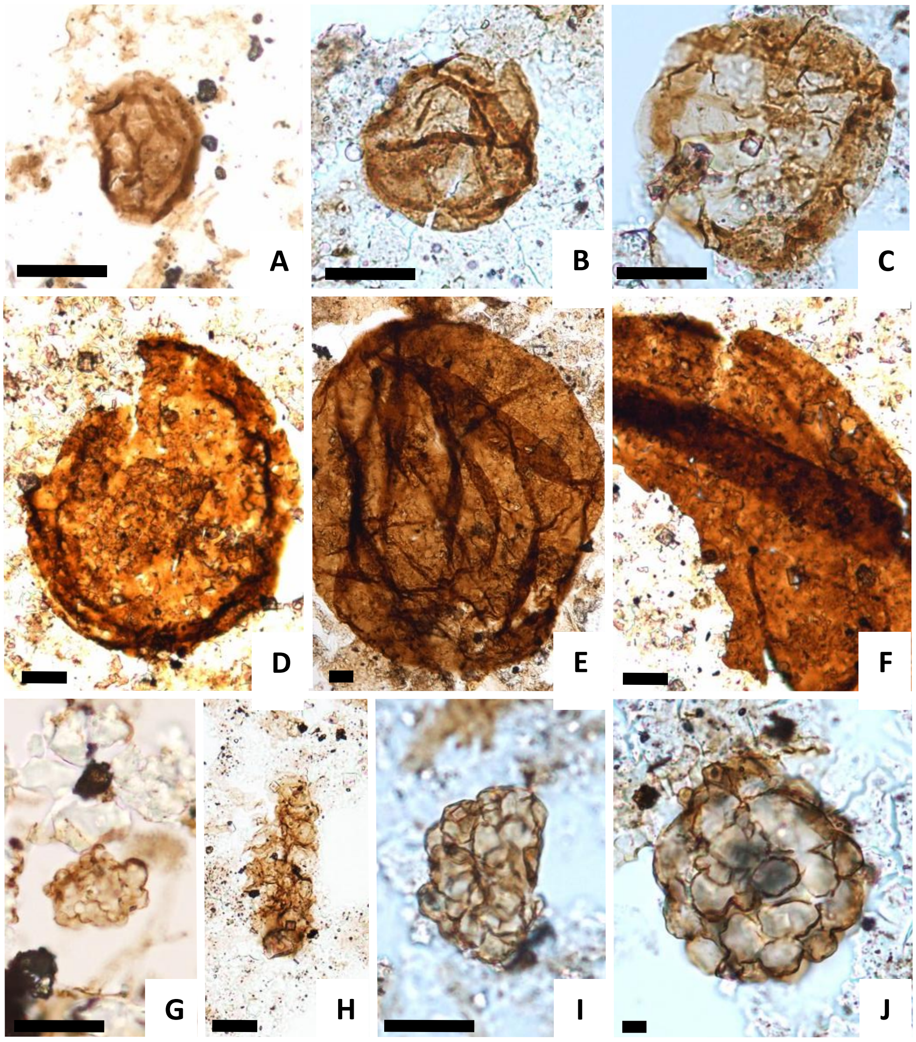

Figure 3. Selected palynomorphs from the Chambers River Formation in Balmain 1. 800.8 m. Palynomorphs are abundant and well preserved. A, *Leiosphaeridium crassa*, 4/66H4. B, *Leiosphaeridium jacutica*, 2/69W2. C, *Leiosphaeridia tenuissima*, 2/63H2. D, *Chuaria* cf. *circularis*, 3/62O0. E, *Chuaria* cf. *circularis*, 3/56U2. F, *Chuaria* cf. *circularis* fragment, 2/50D3. G, *Symplassosphaeridium* sp., 4/44C0. H, linked sphere in chain, cf. *Arctacellularia*, 2/65K2. I, *Satka* sp. 2/64J4. J, *Satka* sp., 2/46K2. England Finder co-ordinates given for each specimen. Scale bar is 20 µm.