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Paleontology Report No. 2013/06

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

by

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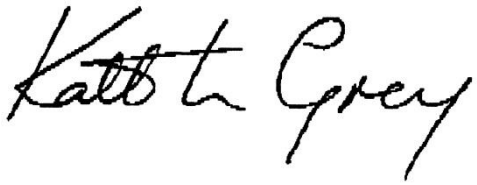
Date: 25 September 2013

Report Title Palynology of drillhole Mason 1 (Warramban 1:100 000 sheet; TANUMBIRINI 1:250 000 sheet), Beetaloo Basin, Northern Territory, Australia

Abstract

A cuttings sample from drillhole Mason 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. The sample is from the 'most marine' interval of the Chambers River Formation, and was prepared using a modified preparation technique. Initial examination indicated abundant, diverse, extremely well-preserved palynomorphs, many of 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: 1972
Drill Hole / Well Name: Mason 1
Tenement: EP18
Operator: Pacific Oil and Gas
Core Type: Petroleum Core and cuttings
Location: Darwin
Hylogged: No
100K Name: Warramban
250K Name: TANUMBIRINI
MGA94 Easting: 365575, MGA94 Northing: 8150654, UTM Zone: 53
Latitude: 16°43'23.06"S, Longitude: 133°44'20.56"E
Geological Region: McArthur Basin
Total depth: c. 1103 m

Locality details and sampling

Drillhole Mason 1, a petroleum drillhole located on TANUMBIRINI 1:250 000 sheet, was drilled by Pacific Oil and Gas on the eastern flank of the main depocentre for the Beetaloo Basin (Table 1), (Silverman et al., 2007). It reached TD at a depth of c. 1103 m, and bottomed in the upper Kyalla Formation after penetrating middle and early Cambrian, the Chambers River Formation, Hayfield Mudstone, Jamison Sandstone and Bukalorkmi Sandstone. A single palynological sample (of cuttings from 745 to 751 m) was collected by John Gorter on behalf of ENI from the ‘ most marine section’ of the Chambers River Formation (Fig. 1, Table 2). 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 examined contains abundant well-preserved palynomorphs. Most are long ranging, but the presence of *Satka colonialica*, *Myxococcoides* spp., abundant small coenobial aggregates and the general aspect of the assemblage suggests this could be Mesoproterozoic in age. Specimens are generally well preserved, and further systematic study is indicated. Some specimens are difficult to assign to species because of the scarcity of literature covering taxa of this age, and they may be new species. Preliminary results and illustrations of some of the better preserved specimens are given below.

Table 1. Drillhole location

Drillhole	Latitude	Longitude
Mason 1	16°43'23.06"S	133°44'20.56"E

Report

Palynomorphs are abundant and well preserved in a single cuttings sample from the 'most marine section' of the Chambers River Formation in Mason I. They are similar to those observed in the same unit in other Beetaloo Basin drillholes, such as Jamison 1 and McManus 1. Details of species present are given in Appendix 1 and taxonomic details in Appendix 2. Selected specimens are illustrated in Figs 2A-G, 3A-M.

Problems with sample preparation have hindered identification and results could be considerably improved if more attention was paid to laboratory work. Standard palynological methods often do not produce good results for Proterozoic material. Preparation methods that reduce the stages of processing and eliminate vigorous methods, which tend to fragment large specimens, generally give better results (Grey, 1999). Although Grey's methods were supposedly applied here, not enough care was taken with preparation. A high proportion of fluorides is present, indicating insufficient treatment with boiling hydrochloric acid. Samples were inadequately filtered, so even coarse fractions contain large amounts of fine debris. The kerogen slide has been overheated, causing cracking of the medium, and specimen colour may have been affected.

The sample contains numerous well preserved palynomorphs, as well as disseminated organic particles and large amorphous organic fragments, both probably derived from degraded bacterial mat. Pyrite grains are common. Well preserved filaments are present (Figs 2A-C), including *Siphonophycus* spp. (Figs 2A,B) which sometimes forms large tangles, and sheaths, which may contain traces of filaments (Fig. 2C). Various species of *Leiospheridia* are common (Figs 2D-F), together with specimens with a zone, tentatively attributed to *Simia* sp. (Fig. 2G). However, the most abundant microfossils are clusters of small spheres (Figs 3A-M), variously assigned to *Myxococcoides* spp. (Figs 3A-D), *Symplassospharidium* spp. (Figs 3E-I), *Synsphaeridium* sp. (Fig. 3J) and *Satka* spp. (Figs 3K-M), based on their size and degree of structural organization. However, these identifications require much more detailed systematic analysis before they can be confirmed.

The assemblage contains the same elements seen in the Chambers River Formation in other Beetaloo Basin drill cores, especially with regard to the small coenobial aggregates that seem to be particularly abundant in the middle Chambers River Formation, in the interval described as being the 'most marine section'.

The biota is consistent with microfossils first described from the Roper Group by Peat et al. (1978) from the McMinn Formation but so far, no specimens of the large, process-bearing *Tappania plana* or associated forms, previously recorded by Javaux et al. (2001) from the underlying Corcoran, Jalboi and Mainoru Formations, have been observed. It has a few elements of the 1270±4 to c. 850 Ma Bylot Supergroup of Arctic Canada (Hofmann and Jackson, 1994, Knoll et al., 2013) and a few taxa similar to ones reported from 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 kerogen slide indicated a thermal alteration index (TAI) of organic material of 4-. TAI is based on well-established Phanerozoic measurements of organic maturity (Batten, 1996; Traverse, 2007) and indicates that organic matter in the Chambers River Formation is overmature for oil and gas. However, as mentioned above, the colouration in this preparation is unreliable because the slide was overheated during preparation. Results for Proterozoic and Archean samples may be slightly inconsistent with Rock-Eval pyrolysis and vitrinite reflectance studies (Warren et al., 1998) because TAI determinations are largely based on Phanerozoic spore colouration. The index therefore provides only a rough guide partly because acritarchs biopolymers have a slightly different chemical composition to sporopollenin, and partly because Precambrian organic material has not so far 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 it does to age or redox values (Schiffbauer et al., 2012), and follows similar pathways to those observed in Phanerozoic successions (Batten, 1996; Traverse, 2007).

This preliminary study shows that an abundant and well preserved palynological assemblage is present in the Chambers River Formation in Mason 1, particularly in the 'marine interval'. The assemblage has been recognized in other drillholes in the Beetaloo Basin, and has potential for biostratigraphic correlation if more detailed analysis, including systematic studies and the description of potentially new species, is carried out. Palynology could also assist in determining both sedimentary facies and organic facies and shed further light on the thermal maturity of Mesoproterozoic strata within the basin.

Summary of samples

Figure 1. Samples and lithology

Drillhole: Mason 1

Sample no.	Depth (m)	No of slides	Type	Formation	Lithology hand specimen
12972	745 m	5	Core or cuttings	Chambers River Formation	No data

Table 2. Summary of palynology

Depth (m)	Palynomorphs	Preservation	TAI*	Probable stratigraphic age
745	*Leiosphaeridia crassa* *Leiosphaeridia minutissima* *Myxococcoides* spp. *Satka* spp. *Satka colonialica* ?*Simia sp.* *Siphonophycus* spp. *Synsphaeridium* sp. *Symplassosphaeridium* spp.	moderate	3+	Mesoproterozoic

The poor quality of the kerogen slide makes assement difficult, especially because the mounting medium is badly cracked through overheating. Fortunately, the oxidized slides are slightly better. All contain abundant fine organic particles and mineral grains, mostly pyrite. Fluorides are also common. Palynomorphs are difficult to identify because of the poor preparation, and any further samples should be treated for longer in boiling hydrochloric acid to remove fluorides and more edequately filtered (washing needs to occur until the liquid passing throught the filter runs clear).

Despite the poor preparation, it is clear that abundant well-preserved palynomorphs are present, and small coenobial aggregates are common. Most species are long ranging, and are know to occur from about the middle of the Mesoproterozoic to the Neoproterozoic. There are few time-constrained assemblages recorded from this interval, and there appear to be significant differences from assemblages recorded in the lower Roper Group. Mason 1 would certainly be worth more detailed study, although care should be taken in interpreting the biostratigraphy if only cuttings are available.

Conclusions

Palynomorphs, comprising acritarchs, filaments and abundant coenobial aggregates are common and well preserved, in the Chambers River Formation in Mason 1. Palynomorphs in Mason 1 are consistent with forms from the same level in other Beetaloo Basin drillholes and would appear to have good potential for correlation of 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

A single Chambers River Formation sample from Mason 1 indicates that the formation contains palynomorphs suitable for use in biostratigraphic correlation. It should be possible to erect a palynostratigraphy that will allow several Roper Group formations to be correlated. Underlying units in this drillhole, known to have high yields of palynomorphs elsewhere in the basin, were not sampled for this study and it is strongly recommended that further palynological analysis be undertaken on Mason 1 and other selected Beetaloo Basin drillholes. Additional sampling from this drillhole is indicated if there are adequate cuttings, and preferably core, available. Sample preparation requires attention, especially in filtering and mounting samples.

There is potential for the development of a correlation scheme that would have application both for the hydrocarbon-prone Beetaloo Basin and globally. Additional study is 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 potential as a valuable indicator of thermal gradient, especially for early 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.

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Appendix 1: Log details for individual sample

745 m middle Chambers River Formation

The sample contains abundant organic matter consisting of finely disseminated organic particles, large, amorphous organic particles (probably degraded bacterial mat), fragments of degraded spheres of uncertain affinity, and well preserved microfossils. *Leiosphaeridia crassa* and *Leiosphaeridia minutissima* are present, but only in small numbers and larger species of *Leiosphaeridia* were not observed. Filaments, particularly tangles of *Siphonophycus* are present. The assemblage is dominated by coenobial aggregates of varying sizes, which need further taxonomic analysis. Mineral grains, probably pyrite, are common in the kerogen mount and there is evidence of surface corrosion by pyrite framboids. More careful preparation to remove fluorides and more thorough sieving to eliminate fine particles is needed.

Taxa present include: *Leiosphaeridia crassa*; *Leiosphaeridia minutissima*; *Myxococcoides* spp., *Satka* spp., *Satka colonialica*, *Siphonophycus* spp.; *Symplassosphaeridium* spp. and *Synsphaeridium* sp.

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.

Leiosphaeridia crassa (Naumova, 1949) Jankauskas 1989 in Jankauskas et al., 1989
Leiosphaeridia minutissima (Naumova, 1949) emend. Jankauskas 1989 in Jankauskas et al., 1989
Myxococcoides Schopf 1968
Satka Jankauskas 1989 in Jankauskas et al., 1989
Satka colonialica Jankauskas 1989 in Jankauskas et al., 1989
Simia Mikhailova and Jankauskas 1989 in Jankauskas et al., 1989
Siphonophycus Schopf 1968 emend. Knoll, Swett and Mark 1991
Symplassosphaeridium Timofeev 1959 ex Timofeev 1969
Synsphaeridium Eisenack 1965

Figure 2

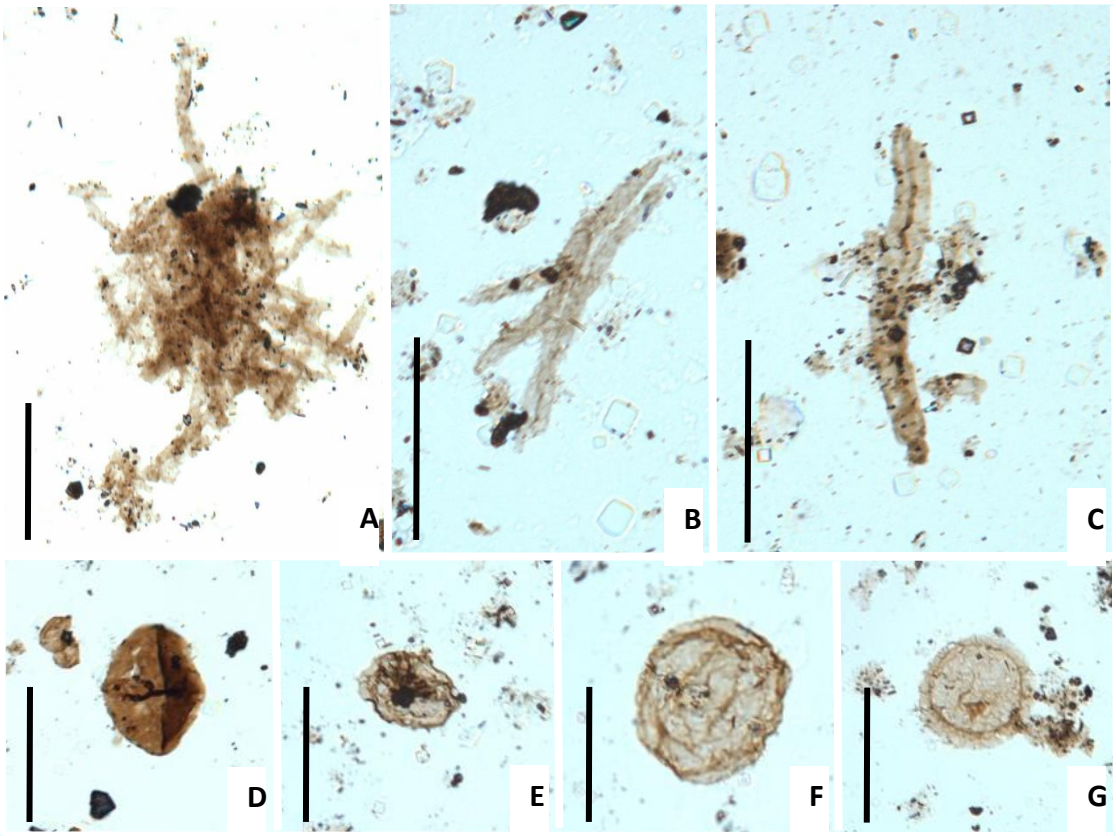

Figure 2. Selected palynomorphs from Slide 2, 745 m in the Chambers River Formation in Mason 1. A, *Siphonophycus* sp., filament tangle, off grid; B, *Siphonophycus* sp., 57U0; C, sheath with enclosed filament, 54K0; D, *Leiosphaeridia crassa*, with central body; E, *Leiosphaeridia crassa*, *folded specimen,* 68F1; F, *Leiosphaeridia minutissima*, 63N0; G, zoned sphere ?*Simia* sp., 35E1. England Finder co-ordinates are given for each specimen. Scale bar is 20 µm.

Figure 3

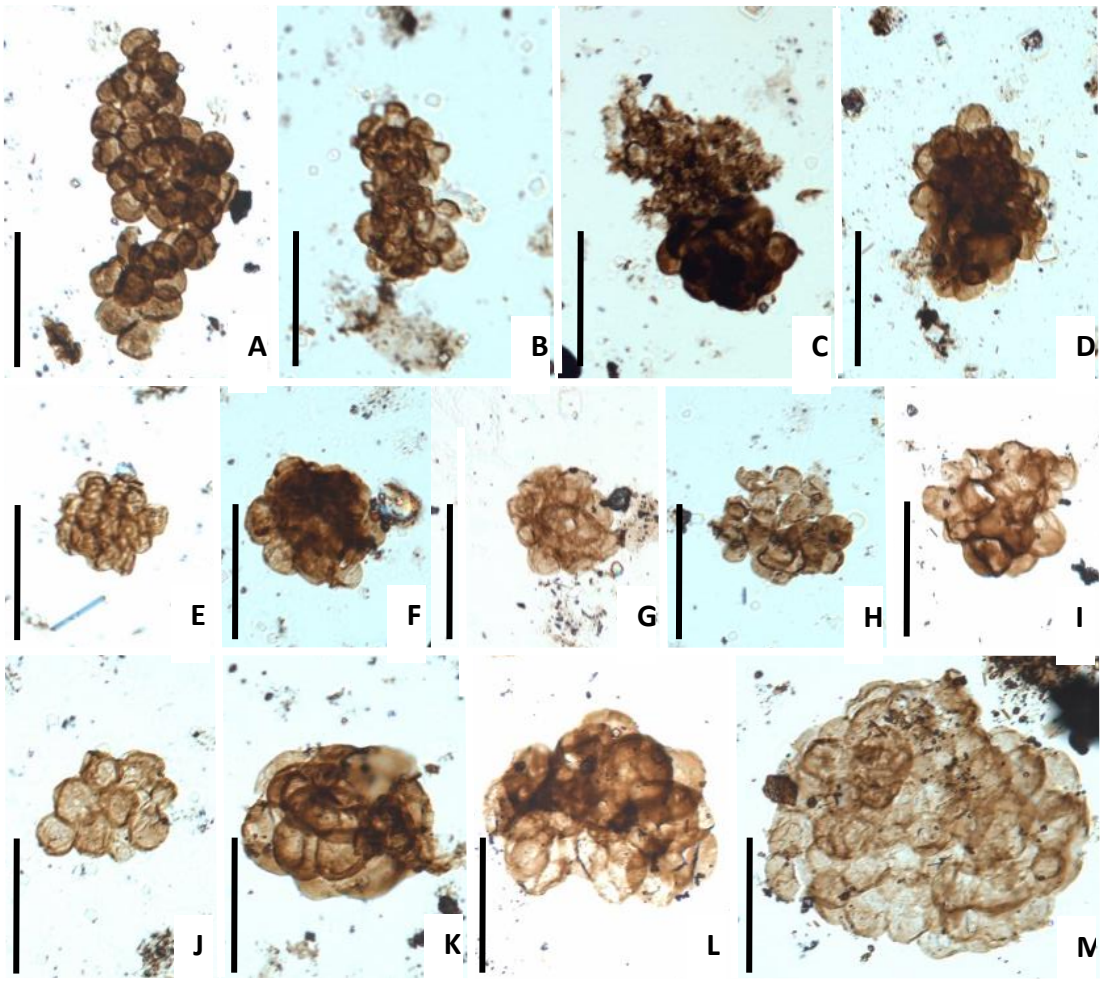

Figure 3. Selected palynomorphs from Slide 2, 745 m in the Chambers River Formation in Mason 1. A-D, *Myxococcoides* spp.; A, 38T3; B, 65E3; C, 67W2; D, 60V2. E-H, coenobial aggregates, ?*Symplassosphaeridium* spp., E, 46N3; F, 63K2; G, 70M4; H, 65E0; I, 68F2. J, *Synsphaeridium* sp., 62F4. K,L, *Satka* sp., K, 40O4; L, 66X4. M, *Satka* ?*colonialica*, 44F0.