Kathleen Grey

Paleontology Report No. 2013/08

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

by

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Abstract

Four drill cuttings samples from drillhole Shenandoah 1A (drilled by Sweetpea in 2007 to a depth of 1555 m and deepened by Falcon Australia in 2009 to a total depth of 2714 m, and held in the NTGS core library in Darwin, Northern Territory) were 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. Palynological samples were prepared using a modified technique. Initial examination of the prepared slides indicated abundant organic material in all four samples, but no identifiable palynomorphs in the upper two samples from the Kyalla Formation, and only sparse, poorly preserved palynomorphs in the lower two samples from the ?Lower Velkerri Formation. Despite the poor preservation, some of these taxa appear complex and similar to ones recorded previously from the upper Velkerri Formation in McManus 1. They appear to belong to new taxa that cannot 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: 4266
Drill Hole / Well Name: Shenandoah 1 and 1A
Tenement: EP 98
Operator: Sweetpea Petroleum Pty. Ltd; Falcon Oil and Gas Australia Pty. Ltd., ("Falcon Australia")
Core Type: Petroleum Cuttings
Location: Darwin
Hylogged: ?No
100K Name: Warramban
250K Name: TANUMBIRINI
MGA94 Easting: 348395.980, MGA94 Northing: 8161959.930, UTM Zone: 53
Latitude: 16° 37' 11.4741916°36'39.13"S, Longitude: 133° 34' 43.27037"E
Geological Region: McArthur Basin
Total depth: 2714 m

Locality details and sampling

Drillhole Shenandoah 1A, a petroleum drillhole located on TANUMBIRINI 1:250 000 sheet, is located near drillhole Balmain 1 near the central trough of the Beetaloo Basin (Silverman et al., 2007). It was drilled initially by Sweetpea Petroleum Pty Ltd and reached TD at a depth of 1555 m in the lower Kyala Formation. The well was deepened to 2714 m, terminating in the ?lower Velkerri Formation. by Falcon Oil and Gas Australia Pty Ltd ("Falcon Australia"). It penetrated the Early and Middle Cambrian, including the Antrim Plateau Volcanics, and various formations in the Mesoproterozoic upper Roper Group, including the Chambers River Formation, Hayfield Mudstone, and Jamison and Bukalorkmi Sandstones, the upper, middle and lower Kyalla Formation, the Moroak Sandstone and the Velkerri Formation, terminating in possible lower Velkerri Formation. Four cuttings samples were collected for palynological analysis, two from the lower Kyalla Formation (1601-1610 m and 1655-1664 m) and two from the ?lower Velkerri Formation (2519-2528 m and 2705-2714 m). The samples were 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 two samples from the Kyalla Formation contain abundant organic debris but no identifiable palynomorphs. The two samples from the Velkerri Formation are poorly preserved, but contain some identifiable palynomorphs. Some are new taxa, but resemble forms observed previously at

about the same stratigraphic level in McManus 1. Species distributions in the nearby wells Balmain 1 and Jamison 1 may be more reliable than in Shenandoah 1A because they are derived from core, rather than from cuttings that have potential for down-the-hole contamination. Preliminary results and illustrations of some of the better preserved specimens are given below.

Table 1. Drillhole location

Drillhole	Latitude	Longitude
Shenandoah 1A	16°37' 11.47419"S	133° 34' 43.27037"E

Report

The degraded nature of the palynomorphs and dark colour of the organic material reflects the sample depths. Although palynomorphs are present in the Kyalla Formation elsewhere in the basin, the two samples from the lower Kyalla Formation in Shenandoah 1 are barren of identifiable species. Abundant organic material and some degraded spheres are present, but material is generally degraded. In part this may be because of the depth of burial and proximity to levels of oil generation, but it also reflects poor sample preparation. They have been inadequately filtered and too densely mounted. The two samples from the ?lower Velkerri Formation are also dark and degraded, but some identifiable palynomorphs are present. Details of species present are given in Appendix 1, taxonomic details in Appendix 2, and selected specimens are illustrated in Fig. 1.

Degraded filaments and filament sheaths are present in the Velkerri Formation at 2705 m, and consist mostly of *Siphonophycus robustum* (Figs 1A,B). Various species of *Leiosphaeridia* are common in both samples from the Velkerri Formation (Figs 1C-F). Cell clusters (coenobial aggregates), tentatively assigned to *Symplassosphaeridium* (Fig. 1G), are present, but not common. Both samples contain tubular structures (Figs 1H-J). The fragments could be filament sheaths, but the one illustrated in Fig 1H is tapering, and the one in Fig 1J is conical, so it seems more probable that these are similar to the complex structures observed in the upper Velkerri Formation in McManus 1.

The assemblage is consistent with microfossils first described from the Roper Group by Peat et al. (1978), probably from what is now known as the Kyalla Formation from a series of mineral drillholes further north in the Sherwin River area. 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 taxa have also been 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). 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 thermal alteration index of organic material (TAI), based on well-established Phanerozoic measurements of organic maturity (Batten, 1996; Traverse, 2007), indicates that organic matter has reached a level of at least 3+ in the Kyalla Formation (so it probably lies close to the boundary between oil and gas generation), whereas that in Velkerri Formation is higher, and is 4+. This is over mature for the oil window. TAI is determined from pre-oxidation macerate slides. Determinations are currently based on spore colouration, which is a rough guide only, 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.

This preliminary study shows that the Kyalla formation in Shenandoah 1 lacks well preserved palynomorphs, possibly as a result of hydrocarbon generation, whereas the Velkerri Formation contains a sparse but diverse palynological assemblage that includes new taxa and complex forms. Because these forms appear widespread in the Beetaloo Basin, further palynological studies are indicated and have considerable potential for biostratigraphic correlation. More detailed analysis, including systematic studies and the description of potential new species, is required. 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.

Problems with sample preparation have hindered identification, and results could be improved considerably. The application of standard palynological methods often does not provide good results for Proterozoic material (Grey, 1999). It is important that samples be properly filtered to remove all fine debris and care must be taken in mounting samples. The present specimen density is so high it hinders identification and the presence of a large amount of fine debris is obscuring specimens. It is recommended that each sample be assessed from a kerogen slide, mounted once processing with hydrochloric and hydrofluoric acid is complete. This allows an assessment of the TAI and determination of how long the remaining organic material should be submitted to oxidation. Samples are often very variable and each sample may require independent treatment. It is often difficult to remove fluorides, and experience has shown that heavy liquid separation often removes 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: Shenandoah 1A

ENI sample no.	Depth (m)	No of slides	Type	Formation	Lithology hand specimen
13062	1601-1610	5	cuttings	lower Kyalla Formation	No data
13063	1655-1664	5	cuttings		No data
13066	2519-2528	5	cuttings	?lower Velkerri Formation	fine-grained bedded argillite and claystone
13067	2705-2714	5	cuttings		fine-grained argillite

Table 2. Summary of palynology

Depth (m)	Palynomorphs	Preservation	TAI*	Probable stratigraphic age
1601-1610	large filaments degraded spheres no identifiable palynomorphs	poor	3+	not determinable
1614-1655	large filaments degraded spheres no identifiable palynomorphs	poor	3+	not determinable
2519-2528	*Leiosphaeridia crassa* *Leiosphaeridia minutissima* ?*Symplassospaheridium* cone-shaped structures	poor	3+	not determinable
2705-2714	*Leiosphaeridia* spp. *Leiosphaeridia jacutica* *Siphonophycus robustum* *Siphonophycus septatum*			

Conclusions

Palynomorphs, comprising acritarchs, coenobial aggregates, filaments and problematic forms were not observed in the Kyalla Formation, but are present in the ?lower Velkerri Formation in Shenandoah 1A. The assemblage recognized appears to 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 diversity and high potential for biostratigraphic correlation within the Beetaloo Basin, it is strongly recommended that further palynological analysis be undertaken on Shenandoah 1A, as well as the preceding Shenandoah 1, and other selected Beetaloo Basin drillholes. Although preservation was poor in some of the samples, palynomorphs are present and 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.

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Appendix 1: Log details for individual samples

1601-1610 m lower Kyalla 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. Organic material consists mainly of abundant finely disseminated kerogen, degraded spheres and fragments of possible degraded bacterial mat. There are no identifiable palynomorphs. TAI is 3+.

Zone	Indeterminate
Probable age	Indeterminate

1614-1655 m lower Kyalla 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. Organic material consists mainly of abundant finely disseminated kerogen, degraded spheres and fragments of possible degraded bacterial mat. There are no identifiable palynomorphs. TAI is 3+.

Zone	Indeterminate
Probable age	Indeterminate

2519-2528 m ?lower Velkerri 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. Organic material consists of finely disseminated organic material and larger fragments and degraded spheres. Some poorly preserved palynomorphs are present, and include leiospheres, coenobial aggregates, and probable conical structures of unknown affinity. TAI is 4+.

Species identified include:

Leiosphaeridia crassa
Symplassosphaeridium sp.

Zone	Indeterminate
Probable age	Mesoproterozoic

2705-2714 m ?lower Velkerri 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. Organic material consists of finely disseminated organic material and larger fragments and degraded spheres. Some poorly preserved palynomorphs are present, and include leiospheres and a probable conical structure of unknown affinity. TAI is 4+.

Species identified include:

Leiosphaeridia jacutica
Symplassosphaeridium 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 jacutica (Timofeev 1966) Mikhailova and Jankauskas 1989 in Jankauskas et al., 1989
Leiosphaeridia minutissima (Naumova, 1949) emend. Jankauskas 1989 in Jankauskas et al., 1989
Siphonophycus robustum (Schopf 1968) emend. Knoll, Swett and Mark 1991
Siphonophycus septatum (Schopf 1968) Knoll emend. Knoll, Swett and Mark 1991
Symplassosphaeridium Timofeev 1959 ex Timofeev 1969
Tappania plana Yin L 1997
Siphonophycus robustum (Schopf 1968) emend. Knoll, Swett and Mark 1991

Figure 2

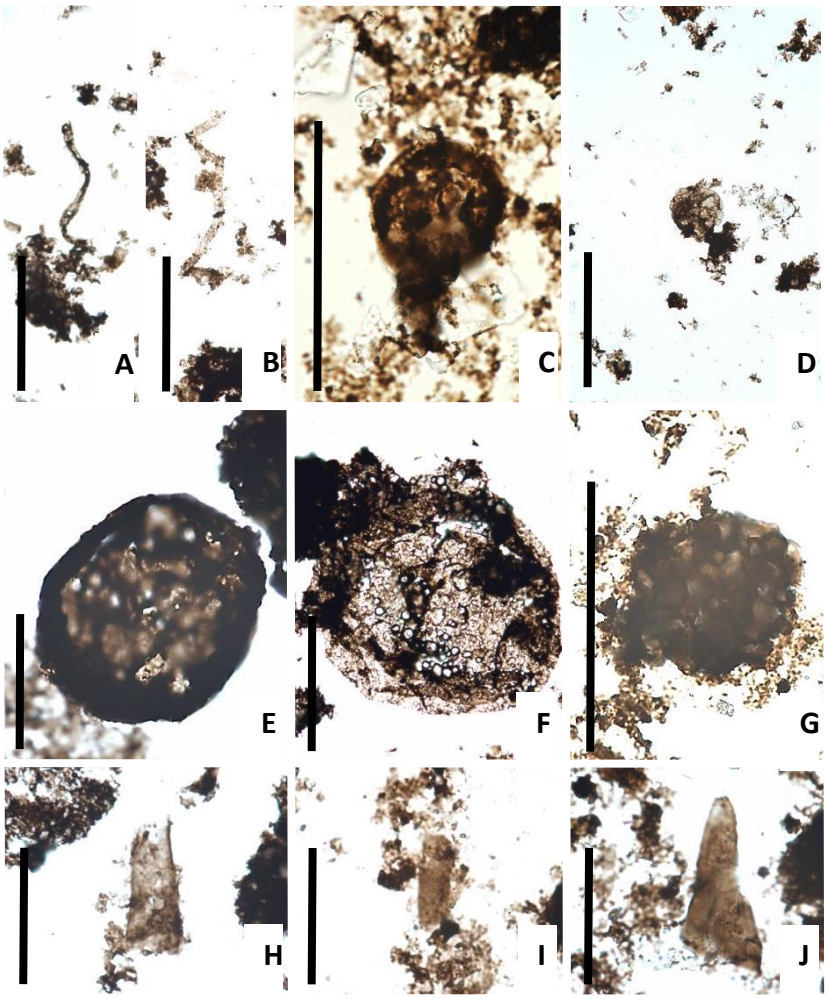

Figure 2. Selected palynomorphs from the ?lower Velkerri Formation in Shenandoah 1A. A, *Siphonophycus septatum*, 2705-2714 m/3, 59W2; B, *Siphonophycus robustum*, 2705-2714 m/2, 57K4; C, *Leiosphaeridia crassa*, 2519-2528 m/2, off grid; D, *Leiosphaeridia minutissima*, 2519-2528 m/1, 71N3; E, *Leiosphaeridia jacutica,* 2705-2714 m/3, 52X1; *Leiosphaeridia* spp., 2705-2714 m/3, 44M3; G, *Symplassosphaeridium* sp., 2519-2528 m/2, 72O1; H, fragment of cone, 2705-2714 m/3, 59P2; I, degraded cone fragment or sheath, 2519-2528 m/2, 69W1; J, cone, 2519-2528 m/2, 69L0. England Finder co-ordinates are given for each specimen. Scale bar is 20 µm.