Microfossils and molecular fossils from the Neoproterozoic Alinya Formation – a possible new source rock in the eastern Officer Basin

Wenlong Zang[1] and D.M. McKirdy[2]
1. Mines and Energy South Australia, PO Box 151, Eastwood, SA, Australia, 5063
2. Department of Geology and Geophysics, University of Adelaide, Adelaide, SA, Australia, 5005

The Alinya Formation, a subtidal shelf to coastal sabkha deposit comprising anhydritic shale and siltstone with minor sandstone, dolomite, limestone and chert, conformably overlies the aeolian Pindyin Sandstone in the northeastern Officer Basin. Prior to the drilling of Giles-1, this Neoproterozoic sequence was recognised only in sporadic, deeply weathered outcrop along the southern margin of the Musgrave Block. Seismic interpretation indicates that the Alinya Formation extends across the Munyarai Trough and onto the Murnaroo Platform where its evaporites have been remobilised into diapirs and other salt-related stuctures. The unit is 230 m thick at its North Pindyin Hills type section and 57.3 m thick in Giles-1. A north-trending basement high, the Nurrai Ridge, appears to have acted as a sill that isolated a saline embayment in the east from the open ocean to the west (Zang 1994).

Grey-green shales and red-brown siltstones of the upper Alinya Formation in Giles-1 contain a diverse array of microfossils, including benthic cyanobacteria (notably *Eoentophysalis* mats) and abundant phytoplankton (spheroidal and spinose acritarchs). The acritarch assemblage is dominated by spheroids such as *Leiosphaeridia, Lophosphaeridium, Paracrassosphaera, Synsphaeridium, Strictosphaeridium, Satka, Tasmanites, Simia, Sinianella, Sphaerocongregus, Valeria* and *Caudosphaera.* Distinctive spinose elements include *Trachyhystricosphaera vidalii, T. aimica, Trachyhystricosphaera* sp., *Cymatiosphaeroides kullingii, Vandalosphaeridium* sp. and *Micrhystridium* sp. which together indicate an early Neoproterozoic age. The vase-shaped *Melanocyrillium* and the octahedral species *Octoedryxium intrarium* are also present. Many, but not all, of these microfossils have previously been described from the Gillen Member (Bitter Springs Formation) in the Amadeus Basin (Zang & Walter 1992). Biostratigraphic correlation of the lower Bitter Springs and Alinya Formations accords with the fact that both overlie the basal sandstone blanket (Heavitree Quartzite equivalent to Pindyin Sandstone) of the Centralian Superbasin and each is part of a transgressive systems tract.

The Alinya Formation intersected by Giles-1 can be divided into two units. The lower unit, anhydritic red-brown siltstone thinly interbedded with sandstone, was probably deposited on an intertidal flat. The upper unit consists of several upward-shallowing evaporite cycles deposited in a marine sabkha setting. A typical cycle comprises in turn grey siltstone; black shale; grey-green shale or siltstone; red-brown anhydrite, siltstone and dolomite rich in *Eoentophysalis* mats; and aeolian sandstone with minor anhydrite and halite. The enhanced preservation of microbial organic matter in the 35 m-thick upper unit makes it of interest as a possible source rock for petroleum. Preliminary analysis of six core samples from 1237–1266 m depth in Giles-1 revealed poor to fair organic richness (TOC = 0.10–0.62%), low concentrations of extractable organic matter (EOM = 57–149 ppm) and low hydrocarbon yields (4–15 mg/g TOC). Rock-Eval pyrolysis confirmed the presence of mature gas-prone kerogen (T_{max} = 439-445°C; hydrogen index = 58–106). Similar organic geochemical characteristics have been reported for the Gillen Member (McKirdy 1977; Jackson et al. 1984; Summons & Powell 1991). For the upper Alinya Formation at Giles-1, maturation levels corresponding to the oil-generation window are indicated by sterane epimer ratios (C_{29} $\alpha\alpha\alpha$ 20S/20S+20R = 0.48–0.54) and the isomer distributions of diaromatic and triaromatic hydrocarbons (e.g. dimethylnaphthalene ratio, DNR-1 = 1.5; methylphenanthrene ratio, MPR = 1.0–1.3).

GC and GC-MS analysis of saturated hydrocarbons in the evaporitic sediments of the upper Alinya Formation identified a diverse suite of steranes, triterpanes and acyclic isoprenoid alkanes. Features of these molecular fossil distributions are: pristane/*n*-heptadecane = 0.32–0.40; phytane/*n*-octadecane = 0.16–0.19; pristane/phytane = 1.6–2.0; 17α(H)-30-norhopane > 17α(H)-hopane; 29,30-bisnorhopane > 28,30-bisnorhopane; 2α-methyl hopanes; C_{27}–C_{30} desmethyl steranes in which cholestane (C_{27}) and 24-ethylcholestane (C_{29}) are co-dominant; and C_{30} 4-methyl steranes including dinosterane. The concentration of diasteranes is low relative to the regular steranes (diasterane/sterane = 0.2–0.6) and steranes are more abundant than hopanes (C_{30} hopane/C_{29} sterane = 0.4–0.5). An almost identical biomarker assemblage has been described from gypsiferous dolomite of the Gillen Member in Alice Springs-3 (Summons & Walter 1990; Summons & Powell 1991). Many of these biomarkers are commonly found in Phanerozoic marine carbonates and evaporites where they are consistent with inputs from eukaryotic algae and eubacteria. The occurrence of dinosterane, a marine dinoflagellate marker, in Proterozoic sediments remains problematical.

Reservoir facies of the underlying Pindyin Sandstone (5–20% porosity) and overlying Tarlina Sandstone

(5–15% porosity) are well placed to receive any hydrocarbons expelled from source beds within the Alinya Formation. The upper reservoir unit is sealed by the Meramangye Formation, making this early Neoproterozoic sequence a target for petroleum exploration, particularly along the northern margin of the Murnaroo Platform where halokinesis has produced a great variety of potential traps. Organic-rich Neoproterozoic siliciclastics and carbonates are source rocks for commercial oil and gas accumulations in eastern Siberia, Oman and southern China (McKirdy & Imbus 1992).

References

Jackson, K.S., McKirdy, D.M. & Deckelman, J.A. (1984), Hydrocarbon generation in the Amadeus Basin, central Australia. *The APEA Journal,* vol. 24, part 1, pp.42–65.

McKirdy, D.M. (1977), The diagenesis of microbial organic matter: a geochemical classification and its use in evaluating the hydrocarbon-generating potential of Proterozoic and Lower Palaeozoic sediments, Amadeus Basin, central Australia. PhD thesis, Australian National University.

McKirdy, D.M. & Imbus, S.W. (1992), Precambrian petroleum: a decade of changing perceptions. *In:* Schidlowski, M., Kimberley, M.M., Golubic, S., McKirdy, D.M. & Trudinger, P.A. (eds), *Early Organic Evolution: Implications for Mineral and Energy Resources.* Springer-Verlag, Berlin, pp.176–92.

Summons, R.E. & Powell, T.G. (1991), Petroleum source rocks of the Amadeus Basin. *In:* Korsch, R.J. & Kennard, J.M. (eds), Geological and geophysical studies in the Amadeus Basin, central Australia. *Bureau of Mineral Resources Bulletin,* vol. 236, pp.511–24.

Summons, R.E. & Walter, M.R. (1990), Molecular fossils and microfossils of prokaryotes and protists from Proterozoic sediments. *American Journal of Science,* vol. 290-A, pp.212–44.

Zang, Wenlong (1994), Torrensian Pindyin Sandstone and Alinya Formation in the eastern Officer Basin, South Australia. *Geological Survey of South Australia Quarterly Geological Notes.* In preparation.

Zang, Wenlong & Walter, M.R. (1992), *Late Proterozoic and Cambrian microfossils and biostratigraphy, Amadeus Basin, central Australia.* Association of Australasian Palaeontologists Memoir 12.