Reassessment of the geology and exploration potential of the Western Australian Amadeus Basin

by
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The Amadeus Basin, a relic of the Centralian Superbasin (Walter et al., 1995), is exposed over about 170 000 km^2 in central Australia. The majority lies in the Northern Territory, but about 30 000 km^2 is exposed in eastern Western Australia, with more beneath the Canning Basin to the west. The basin contains a thick Neoproterozoic to Paleozoic succession, although confirmed Paleozoic strata are limited in WA, and underwent regional folding during the Petermann (Ediacaran–Cambrian) and Alice Springs (mid Paleozoic) Orogenies. The NT portion is well known and moderately explored, but remoteness, difficult access, and poor exposure have conspired to see very little activity in the western Amadeus Basin since first-pass reconnaissance mapping by the Bureau of Mineral Resources in the early 1960s (Wells et al., 1961, 1964).

Apart from the Heavitree Quartzite and its correlative the Dean Quartzite, and the overlying Bitter Springs Formation, separate stratigraphic schemes were devised for eastern and western portions of the basin (Wells et al., 1970). Recent fieldwork by the Geological Survey of Western Australia indicates that the western Amadeus Basin shows much closer similarity to the well-established stratigraphy within the NT than previously reported and reveals new insights into the geological history of the area, necessitating a revision of basin-wide correlations (Fig. 1). Ultimately, the western Amadeus Basin should provide an important link between the Officer and eastern Amadeus Basins.

The key has been understanding the stratigraphic complexity of the poorly exposed Boord Formation and its relationship to the Carnegie Formation. These units disconformably overlie the Bitter Springs Formation in the north and south of the area, respectively, and were regarded as lateral equivalents. The Boord Formation includes glacigene strata and was previously correlated with either the Areyonga Formation (Wells et al., 1970; Weste, 1989) or Olympic Formation/Pioneer Sandstone (Grey, 1990), the glacigene units of the eastern Amadeus succession, and correlatives of the Sturt or Elatina glaciations of the Adelaide Rift Complex, respectively. Our fieldwork indicates that the Boord Formation contains not one, but two glacial units, several disconformities, and significant pre- and post-glacial intervals. In total it contains likely correlatives of the 'Finke beds' (an informal unit recognized in several petroleum wells in the NT: Grey et al., in press) and Areyonga, Aralka, Olympic, Pertatataka, and Julie Formations of the northeastern Amadeus Basin. We propose eventual abandonment of the 'Boord Formation' as presently defined, but until a new stratigraphy is finalized we use this name informally for the composite package. The new correlations are based on lithostratigraphy with strong support from stromatolite biostratigraphy. Unique stromatolite assemblages can be used to subdivide the Bitter Springs Formation into Gillen and Loves Creek Members, as in the NT, and to link the inferred correlatives of the 'Finke beds', upper Aralka, and Julie Formations to their counterparts in the eastern Amadeus and other basins throughout Australia.

The Carnegie Formation is a thick, immature siliciclastic unit, strongly resembling the lower part of the Ediacaran–Cambrian Arumbera Sandstone in the NT. Both formations contain *Arumberia*, a problematic biogenic structure first described from the Arumbera Sandstone (Glaessner and Walter, 1975). Although there is minor interfingering at the Boord–Carnegie Formation contact, we consider the latter to be mostly younger than the 'Boord Formation'. In the south, the Carnegie Formation overlies the Bitter Springs Formation with an angular unconformity, the intervening succession having been presumably uplifted and eroded in that area. Together, the Carnegie Formation and overlying Sir Frederick Conglomerate, Ellis Sandstone, and Maurice Formation are interpreted as a synorogenic package related to the Petermann Orogeny. The Sir Frederick Conglomerate is thus a likely correlative of the Mount Currie Conglomerate at Kata Tjuta (Mount Olga) in the NT. The synorogenic package probably extends across the Proterozic–Phanerozoic boundary, into the Cambrian, although the position of the boundary is unknown.

Fault-bound outliers of Amadeus Basin lie within Arunta Province basement to the north of the main basin. In addition to recognized Neoproterozoic units, the outliers contain a thick, immature, conglomeratic siliciclastic package referred to as the 'Angas Hills Beds'. Previous workers have suggested that this unit may correlate with the Devonian synorogenic (Alice Springs Orogeny) Pertnjara Group of the eastern Amadeus Basin (Blake, 1977), or be of Permian age. Although its age remains unknown, we note the similarity of clast assemblages and paleocurrent directions to the older Petermann synorogenic package in the south. Future detrital zircon dating should provide better age constraints.

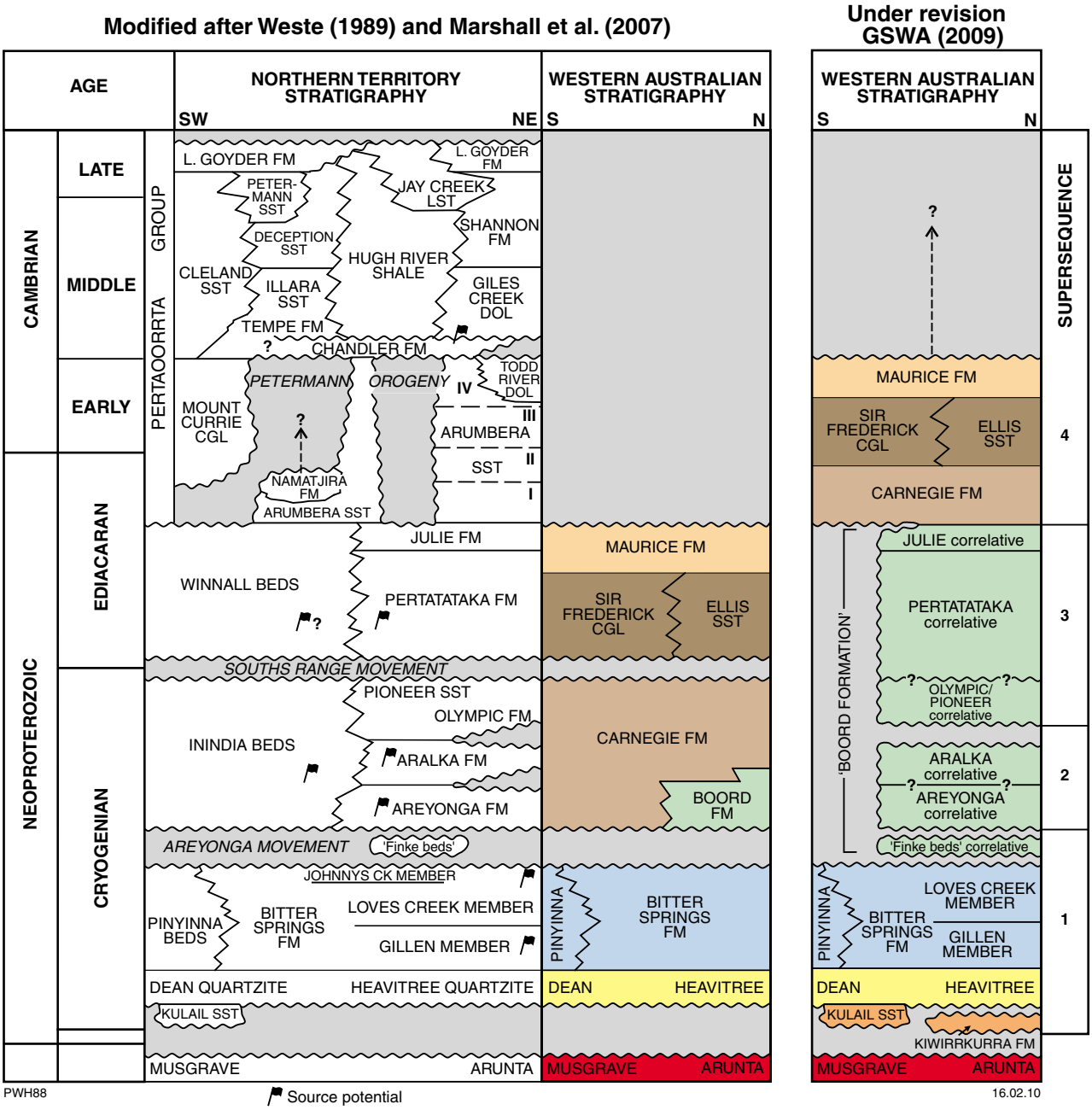

Figure 1 Neoproterozoic to Cambrian stratigraphy of the NT and WA Amadeus Basin, comparing the most commonly used current scheme on left with our revisions in progress at right. The supersequence scheme of Walter et al. (1995) is shown at far right. The Kiwirrkurra Formation and Kulail Sandstone are local units, of uncertain age, pre-dating the regional basal siliciclastic unit of the Amadeus Basin.

Thin outcrops of glacigene rocks lie unconformably on Amadeus Basin strata of various ages and basement rocks across the area. Most have previously been assigned to the Buck Formation, of assumed Permian age (Wells et al., 1964), and thus considered outliers of the Canning Basin. We located similar strata around, and north of, the Pollock Hills that had not previously been differentiated from Neoproterozoic units, or had been mapped as Mesozoic (Blake, 1977). In this area, stratigraphic relationships suggest, but do not prove, that these glacigene rocks are of Neoproterozoic age. This raises the issue of distinguishing Neoproterozoic from Permian glacial units in isolated areas lacking unambiguous stratigraphic constraints. A glacial pavement between Buck Formation and Heavitree Quartzite reported by Wells et al. (1961, 1964) was relocated during 2009 fieldwork (Zone 52, MGA 478760E 7443446N). The actual outcrop figured by Wells et al. (1961) is devoid of convincing glacial striae, but we found striae and chattermarks on polished surfaces of Heavitree Quartzite nearby, giving an unequivocal ice movement direction to the west (average vector 273°). This contrasts with the more northerly trend of ice movement reported from Permian pavements elsewhere in WA (Playford et al., 2009).

There are producing oil and gasfields in the NT in the Paleozoic section, and the Neoproterozoic succession is associated with demonstrated or possible source rocks at numerous levels (e.g. Bitter Springs, Areyonga, Aralka, and Pertatataka Formations and lateral correlatives; Marshall, 2003, 2005; Marshall et al., 2007; Fig. 1), numerous shows, and the sub-economic Dingo gasfield. Exploration for Neoproterozoic plays is ongoing. The western end of the basin may also be prospective for hydrocarbons and uranium. Actual source potential or maturity cannot be determined from weathered surface outcrops, but the recognition of correlatives with similar facies to units with source potential in the NT, raises the potential for petroleum in western parts of the basin, or in the overlying Canning Basin where they are juxtaposed with source and fluid pathways of the Amadeus succession. There is also strong evidence for halotectonics, both from geophysics (Dentith and Cowan, 2009) and surface outcrop expression. This is likely related to a salt unit within the upper Gillen Member, which is widespread in the east, and hence a salt seal is expected over the 'Gillen petroleum system' at depth within WA.

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