Significance of Early Triassic conodont zones from Western Australia

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SUMMARY

The Cunaloo Limestone Member of the Locker Shale (Kockatea Shale facies) from the Carnarvon Basin contains a distinctive conodont zone also seen in the informally named ‘Limestone Marker’ in the lower Kockatea Shale of the northern Perth Basin. The boundary between the Induan (Dienerian) and the Oleneikan (Smithian) is selected at the base of the incoming conodont Novispathodus waageni eowalageni in this core and provides an important biostratigraphic correlation point between the two basins.

The Cunaloo Limestone Member contains Novispathodus dieneri-Neospathodus waageni-Scythogondolella milleri conodont zone species and this correlates with upper Bed 32 at the type section of the Permian-Triassic transition at the Meishan Permian-Triassic stratotype section D in China, dated by zircon U/Pb as about 251.5 Ma. This suggests an absolute age correlation of the lower part of the Kraeuselisporites saeptatus palynological zone in the southern Carnarvon Basin. This conodont zone is Smithian in age.

A thin, apparently discontinuous, previously un-named limestone appears above the Cunaloo Limestone Member and is within the K. saeptatus zone. This carbonate unit becomes more prominent towards the north and contains conodonts, mostly fragmentary, of Smithian age. It is here named the Lawley Limestone Member.

The Chiosella timorensis conodont zone occurs within Core 1 in the Candace Member of Cunaloo-1 and lies within the basal Tigrisporites playfordii palynzone. The First Appearance Datum (FAD) of the conodont C. timorensis has been proposed as an index for the worldwide recognition of the Oleneikan-Anisian Boundary (OAB), although the species occurs first with upper Spithian Haugi Zone ammonoids. Nevertheless, it is a good approximation of the OAB, and therefore places the earliest occurrence of the T. playfordii palynzone in Western Australia at around the middle of the Spithian-earliest Anisian (Ageean), about 247.2 Ma.

A younger limestone, the Sholl Limestone Member of the Locker Shale facies, is recognised only from the Carnarvon Basin. This carbonate lies within the T. playfordii zone, but conodonts recovered from the unit are not age diagnostic. The Sholl Limestone is missing in several wells below sandstones of younger Triassic age, and in one case may be faulted out (e.g. Hampton-1).

Recognition of these Early Triassic limestones allows a better stratigraphic understanding of those regions from the marine realm in the northern Perth and Carnarvon basins.

Key words: Early Triassic, conodonts, Western Australia.

INTRODUCTION

For about 50 years, analyses of Early Triassic conodont zones for Western Australia have been discussed in the literature and in company documents. Here, we bring together several of these reports, updated for new and revised taxonomy. Conodonts have been known to occur in what was designated the Cunaloo Limestone Member of the Locker Shale (Kockatea Shale facies) from the Carnarvon Basin (Gorter et al., 2008) as far back as McTavish in 1970. The younger Sholl Limestone Member of the Locker Shale also contained a distinctive conodont fauna. Conodonts were also found in the informally named ‘Limestone Marker’ within the Early Triassic Kockatea Shale of the northern Perth Basin (McTavish, 1975; McTavish & Dickins, 1974; Nicoll & Jones, 2000; Metcalfe et al., 2008, 2013).

METHOD AND RESULTS

Early work by McTavish (1973; 1975) for West Australian Petroleum (WAPET) during the 1970s showed promise for dating the age of the calcareous strata at the base of the Triassic in several wells, located offshore and onshore, in the Carnarvon Basin. Further investigations of the Early Triassic strata of the Carnarvon Basin were carried out from 1977 through to 2009 (mostly unpublished), using drill cuttings samples collected from the Geological Survey of Western Australia Core and Cuttings collection in Perth, and some samples from cuttings held in a similar facility by the Australian Government in Canberra. The samples were prepared by standard procedures to separate the conodont microfossils from the carbonates and the resulting residues containing the apatite conodont elements assessed for age dating and conodont colour alteration analyses (CAL, Epstein et al., 1977) - the latter also used to estimate thermal maturation of organic matter in the enclosing strata.
Locations of the wells covered in this study are shown in Figure 1.

Few cores have been cut through the ‘Limestone Marker’ of the Kockatea Shale in the northern Perth Basin. Conodonts were first recognised from 448 m in the Geraldton Racecourse Bore (McTavish & Dickins, 1974), and from core in Dongara-4 (McTavish & Dickins, 1974). Later, drill cuttings from several wells were sampled, selected from the interval with maximum carbonate contents as determined by cuttings and wireline logs (Nicoll, 1983). It was not until Senecio-1 was drilled that a core was obtained that partially passed through the ‘Limestone Marker’ and into the older Sapropelic Interval of the Kockatea Shale (Metcalfe et al., 2013). This core provided the most definitive placement of the Induan to Olenekian boundary in Australia, based on the conodonts recovered from that core.

Conodonts have been recovered from cuttings of the Blina Shale in the onshore northern Canning Basin in Blackstone-1 and Langoora-1, but the limited fauna are not age-diagnostic (Nicoll, 1984). In the northern Perth Basin a log-defined Early Triassic lithofacies within the Kockatea Shale called the ‘Limestone Marker’ is traceable between petroleum exploration wells by means of the gamma ray and sonic log curves. Metcalfe et al. (2008, their fig. 2) have the ‘Limestone Marker’ as Dienerian to early Smithian in age (Neospathodus dieneri-Neospathodus paksitanensis zones) based on cuttings from Corybas-1, but in their 2013 paper on Senecio-1 they had the benefit of a cored section through the ‘Limestone Marker’ into the underlying ‘Sapropelic Interval’ of the Kockatea Shale. The base of the ‘Limestone Marker’ was shown in their Fig. 10 at about 2721.8 m and the boundary between the Induan (Dienerian) and the Olenekian (Smithian) selected at the base of the incoming of the conodont Neospathodus waageni cowaageni. The ‘Limestone Marker’ lies within the K. saeptatus palynozone in the Northern Perth Basin.

The Cunaloo Limestone Member of the Locker Shale from the Carnarvon Basin (also known as the Kockatea Facies, Gorter et al., 2008; 2009) contains distinctive conodonts (Figure 2). This is here designated Sequence 1. The Cunaloo Limestone contains the Neospathodus dieneri-Neospathodus waageni-Scythogondolella milleri zone species and this correlates (Metcalfe et al., 2008) with upper Bed 32 at the type section of the Permian-Triassic transition at Meishan section D in China, dated by zircon U/Pb as about 251.5 Ma (Fielding et al., 2019). This conodont zone is Smithian (=upper Nammalian, = lower Olenekian) to Spathian in age (Nicoll, 1992A, B), broadly Smithian. This correlation allows an absolute age correlation of the lower part of the K. saeptatus palynological zone in the southern Carnarvon Basin. In China, Sun et al. (2012, their fig. 2) interpreted the most intense peak of global warming in the Early Triassic to occur in the late Smithian and earliest Spathian, probably synchronous with the fossiliferous limestones described from Mermaid-1 and Cunaloo-1 (in well completion reports).

Sequence 2 does not contain any recognisable carbonate beds and is dated solely on the occurrence of the K. saeptatus zone contained within it, and its position between conodont-bearing high stand carbonates of Sequence 1 and 3.

A thin, apparently discontinuous, previously un-named limestone occurs in several wells near the top of Sequence 3. Fragmentary conodonts indicate a Smithian age and also lie within the K. saeptatus palynozone. This carbonate unit appears to become more prominent towards the north and contains conodonts, mostly fragmentary, of Smithian age. Here it is designated the Lawley Limestone Member.

The Chiosella timorenensis conodont zone occurs within the Candace Member (Gorter et al., 2008) and lies within the basal Tigrisporites playfordii palynozone (Sequence 4). The First Appearance Datum (FAD) of the conodont C. timorenensis has been proposed as an index for the worldwide recognition of the Olenekian-Anisian Boundary (OAB), although the species occurs first with upper Spathian Haugi Zone ammonoids. Nevertheless, it is a good approximation of the OAB, and therefore places the earliest occurrence of the T. playfordii palynozone in Western Australia at around the end of the Spathian-earliest Anisian (Aegean), about 247.2 Ma. This was a time when the hot temperatures that existed in the Smithian commenced a cooling phase (Cooling Event III of Sun et al. 2012), with an increase in diversity of shelled genera and a decrease in solubility of carbonate in seawater with lowered temperature. Cooling probably accompanied a fall in sea level and the Candace Member contains ample evidence of reworked cratonic material including monazite that probably accounts for the highly radioactive beds characteristic of this unit (Gorter et al., 2008).
(=Norigondolella) navicula ranges in age from the late Pelsonian to Norian (Nicoll, 1994), but may be misidentified.

Figure 2. Conodonts from the Cunaloo Limestone Member at the top of Sequence 1 are Smithian in age. There is no conodont age from Sequence 2, and the limestones near the top of Sequence 3 contain fragmentary conodonts, which suggest a Smithian age. Sequences 1 to 3 contain palynomorphs of the K. saeptatus zone. Sequence 4, also known as the Candace Member of the Locker Shale, is dated using the K. saeptatus zone and lies within the basal Tigrisporites playfordii palynozone (Sequence 4). The First Appearance Datum (FAD) of C. timorensis has been proposed as an index for the worldwide recognition of the Olenekian-Anisian Boundary (Goudemand et al., 2012).

CONCLUSIONS

Recognition of these Early Triassic conodont-bearing limestones allows a better stratigraphic understanding of those regions from the marine realm in the Northern Perth and Carnarvon basins. Four sequences have been interpreted in the Carnarvon Basin based on the distribution of these limestones, interpreted as high Smithian (Early Triassic) highstand systems tract carbonates at the top or near top of Sequences 1 and 3. Sequence 2 does not appear to contain any significant thicknesses of carbonates. Sequence 4 contains carbonates with conodonts indicative of deposition around the Olenekian-Anisian boundary. This sequence contains highly radioactive strata redeposited from the cratonic hinterland.

The conodonts from Sequences 1 and 3 in the Carnarvon Basin are similar in age to those ‘Limestone Marker’ in the northern Perth Basin and either limestone could be correlatives with the ‘Limestone Marker’.

Sequences 1 to 3 contain palynomorphs of the K. saeptatus zone as does the ‘Limestone Marker’. Sequence 4, also known as the Candace Member, contains the T. playfordii palynozone.

A younger limestone, the Sholl Limestone Member of the Locker Shale facies, recognised only from the Carnarvon Basin, lies within the T. playfordii zone, but conodonts recovered from the unit are not age diagnostic. The Sholl Limestone Member is missing in several wells unconformably below sandstones of younger Triassic age, and in one case may be faulted out.

REFERENCES


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