Vertebrate biostratigraphy from the Devonian and Carboniferous in the Canning Basin, Western Australia

Brett ROELOFS[1], Kate TRINAJSTIC[1], Ted E. PLAYTON[2], Eric TOHVER[3], Peter HAINES[4], Roger HOCKING[4], Milo BARHAM[1], Jeroen HANSMA[3], Kelly HILLBUN[5], Kliti GRICE[1], Maodu YAN[7], Ken RATCLIFFE[8], Sergei PISAREVSKY[3], Paul MONTGOMERY[9],

[1] Curtin University of Technology, Perth, Western Australia, brett.roelofs@postgrad.curtin.edu.au; [2] Chevron Energy Technology Company, Houston, Texas; [3] University of Western Australia, Perth, Western Australia; [4] Geological Survey of Western Australia, Perth, Western Australia; [5] University of Washington, Seattle, Washington,[7] Institute of Tibetan Plateau Research, CAS, Beijing, China; [8] Chemostrat Incorporated, London, United Kingdom; [9] Chevron Upstream Europe, Aberdeen, United Kingdom

Background

The Devonian Reef complexes of the Canning Basin record a change in vertebrate diversity and evolution from the Late Devonian to the Early Carboniferous and encompass two significant faunal overturns. The first being the Frasnian/Famennian mass extinction event that is estimated to have resulted in the loss of 60% of all taxa, and the second being the end Famennian event (McGhee 1982).

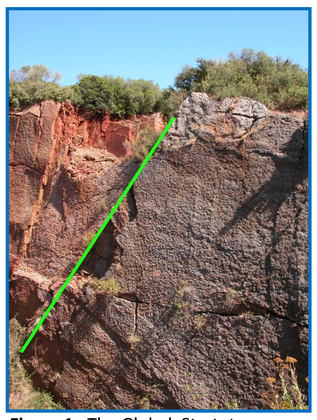


Figure 1. The Global Stratotype Section and Point (GSSP) in Montagne Noir, France depicting the dark brown – black shales associated with the Kellwasser event (boundary marked in green). Events like this are not readily recognisable in the Canning Basin.

Unlike areas in America and Europe (Fig. 1), the Canning Basin lacks the distinct lithological changes associated with these major extinction events (Fig. 2). Traditionally, these events in the Canning Basin have been identified solely on goniatite and conodont biostratigraphy. However, these groups are most useful in open marine conditions of the fore reef and basin but limited in the more restrictive back reef facies.

The usefulness of microvertebrates as a biostratigraphic tool, within restricted facies has been recognised with successive microvertebrate schemes established in Europe and North America (Turner 1997; Ginter & Ivanov 1992). Studies into the microvertebrate faunas of the Canning Basin are limited with one previous study by Trinajstic and George (2009) identifying globally correlative faunas.

Figure 2. Approximate position (in green) of the Kellwasser event in the Horse Spring section, Canning Basin. The rocks do not preserve the distinct lithological changes and require biostratigraphic analyses when identifying the events.

Study Area

This work focused on three measured sections at Casey Falls, Horse Spring and South Oscar Range (Fig. 3). Further spot samples were taken at the top of the Casey Falls section and within the Fairfield Group (Fig. 4).

Figure 3. Slope facies cropping out at the South Oscar Range.

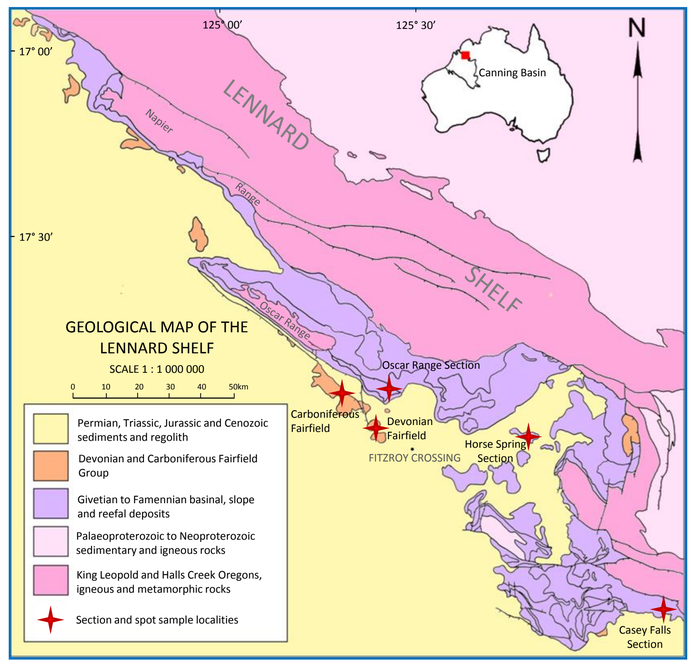


Figure 4. Map of the Lennard Shelf showing the location of sections and samples taken from the Devonian Reef complexes and the Late Devonian to Early Carboniferous Fairfield Group (After Playford and Hocking 2005).

Microvertebrate biostratigraphy

A diverse range of microvertebrate taxa was identified and correlated to standard conodont zonations from the fore reef and slope facies. These vertebrate taxa conform to the reported zonations for Europe and North America (Fig. 6).

The sections at Casey Falls and South Oscar Range contain both conodonts and microvertebrates. However samples from Oscar Hill and the Laurel Formation of the Fairfield Group, have not yielded diagnostic conodonts. A date from early *expansa* to late *praesulcata* was established for samples taken above the Casey Falls section, based on the presence the chondrichthyan *Thrinacodus tranquillus* and *Thrinacodus ferox.* Similarly, the samples from the Fairfield group lacked diagnostic conodonts however a range extending from *duplicata* to Late *crenulata* could be established based on the overlap of some microvertebrate species and long ranging conodonts.

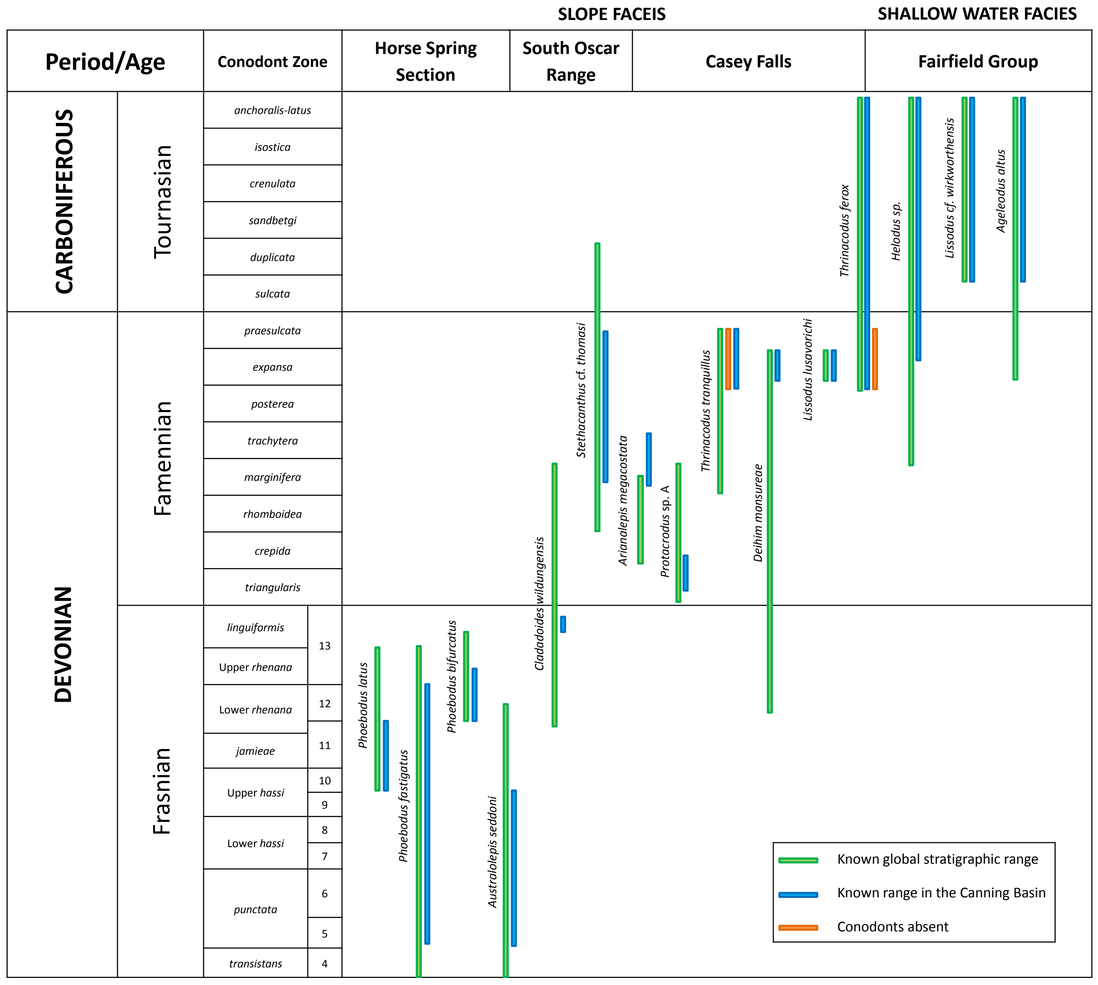


Figure 6. Stratigraphic ranges of global thelodont and chondrichthyan taxa identified in the Canning Basin and compared to current global stratigraphic ranges.

Precise conodont dates in other sections were able to give ranges for the newly discovered taxa, including thelodont (jawless fish) scales which extend the groups stratigraphic range to *trachytera* CZ – the youngest global record for this taxa. The work has also recorded the first presence of many potentially endemic microvertebrates as well as chondrichthyan taxa not previously identified in the Canning Basin (Fig. 8).

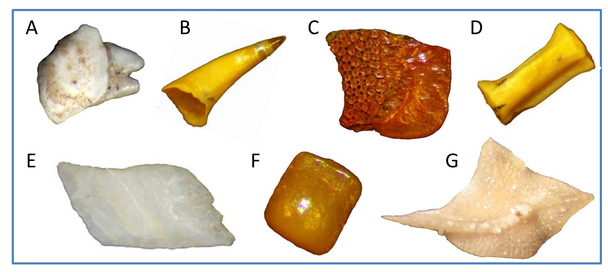
Figure 7. Late Devonian and Early Carboniferous Shark teeth and Late Devonian thelodont scales from the Canning Basin.

Oxygen isotope analyses

Microvertebrates used for biostratigraphic analyses were also tested for their usefulness as oxygen isotope markers (Fig. 5). Analyses of conodont and microvertebrate apatite followed the methodology outlined by Joachimski *et al*. (2009) at the GeoZentrum Nordbayern, University of Erlangen in Germany. All values are reported in ‰ relative to VSMOW.

Figure 5. Microvertebrate remains; A) shark scale; B) bony fish (palaeoniscoid) tooth; C) Lungfish scale; D) bony fish fin bone; E) bony fish scale; F) spiny shark (ancanthodian) scale and G) conodont element, used for oxygen isotope analyses.

The low colour alteration index (CAI) values of the conodont elements, associated with the microvertebrate remains, indicates a lack of diagenetic alteration.



- Conodont elements tested returned $\delta^{18}O$ values between 17.8 and 18.7‰ which is consistent with other studies on Late Devonian conodonts (Joachimski *et al*. 2009).
- Shark remains showed similar results in both the Late Devonian Famennian and Early Carboniferous Tournaisian samples (Fig. 5), however these results are consistently 1-2 ‰ lower than temporal and latitudinally equivalent conodonts previously analysed (Buggisch *et al*. 2008).

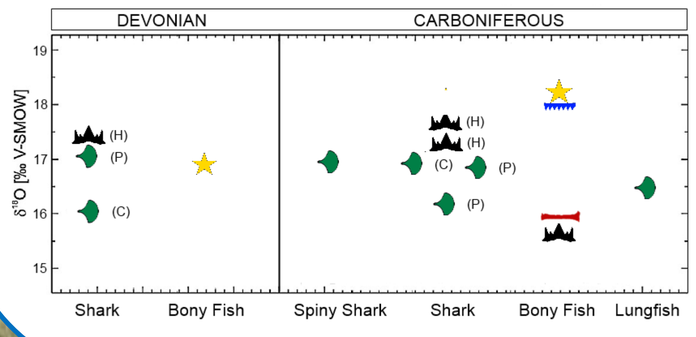


Figure 5. Preliminary results show the scale remains analysed give rather consistent results across multiple species and groups. The disparity between the bony fish remains may be a result of differences between species or the susceptibility of some fossil tissue to diagenesis.

Microvertebrate biogeography - Late Devonian 370 Ma

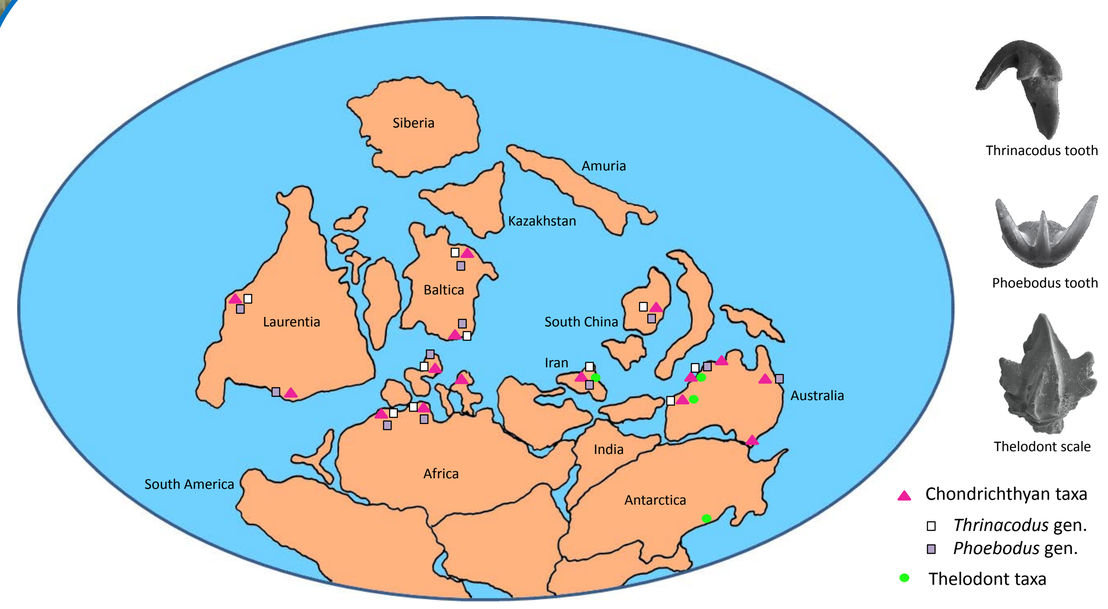


Figure 8. Distribution of common shark teeth and thelodont scales currently found in the Canning Basin from the Late Devonian to Early Carboniferous. The shark teeth show global distribution and are proving most useful for biocorrelation. This study represents the first time that Western Australian microvertebrates have been included into global biozonations from the Late Devonian to Early Carboniferous. The thelodonts for the Late Devonian are restricted to north eastern Gondwana and are proving useful for more localised biocorrelation. Base map modified after Golonka (2007),.

Conclusions

Recent studies into microvertebrates has revealed their usefulness in dating and correlating units where traditional biostratigraphic markers are rare or absent. In the Canning Basin this method can be utilised in the back reef and restricted facies as microvertebrate ranges can be constrained by conodont biostratigraphy in the deeper water facies. The microvertebrate remains discovered, show strong affinities to other globally identified taxa and aid in the construction of more robust biostratigraphic schemes, particularly for chondrichthyan and agnathan groups. Furthermore the use of microvertebrates is providing a potential tool for chemostratigraphy, where conodonts are absent, however a better understanding of vertebrate palaeobiology is necessary. Further work with ion probe analyses will allow for the determination of reliable microvertebrates tissues that preserves O-isotope ratios.

Acknowledgements/References

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