SEDIMENTOLOGY AND DIAGENESIS OF LATE PALAEOPROTEROZOIC CARBONATES, SOUTHERN McARTHUR BASIN, NORTHERN AUSTRALIA

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THESIS STATEMENT

This thesis contains the results of four years research undertaken at the Centre for Ore Deposit Research, University of Tasmania, between March 1997 and April, 1999. The author states that this thesis contains no material that has been accepted for the award of any other higher degree or graduate diploma in any tertiary institution, and to the best of the author's knowledge and belief, it does not contain any material previously published or written by another person except where due reference is made in the text of the thesis. This thesis may be made available for loan and limited copying in accordance with the Copyright Act (1968).

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ABSTRACT

The late Palaeoproterozoic (Statherian) McArthur Group comprises a thick (~5 km) sequence of platformal stromatolitic dolostone and clastic sediment with local pyritic, carbonaceous siltstone units. Exposure of the McArthur Group is largely confined to the elongate, ~N-S trending Batten Fault Zone, southern McArthur Basin. The Barney Creek Formation and Reward Dolomite in particular, are characterised by rapid thickness changes that reflect the onset of a phase of tectonically controlled subsidence. Detailed study of the middle McArthur Group sequence that includes these units has recognised three distinct depositional sequences, each of which provides important insights into the prevailing basin architecture and palaeoenvironmental conditions during sedimentation.

The Emmerugga Depositional Sequence (EDS) represents a phase of increasing accommodation (from Myrtle Shale to Emmerugga Dolomite) during which carbonate platform lithofacies accumulated in a series of shallowing-upward cycles that thicken and deepen upsection. An abrupt basinward shift in lithofacies at the top of the EDS marks the onset of tectonically-induced basin subsidence recorded by the deposition of the Barney Creek Depositional Sequence (BCDS). The BCDS comprises the Teena Dolomite, Barney Creek Formation and Reward Dolomite, and is characterised by rapid lateral lithofacies variation and the development of numerous sub-basins adjacent to pre-existing major ~N-S trending structures (i.e. Emu, Tawallah and Hot Spring Faults).

Facies architecture within the BCDS demonstrates that the thickest sections of Basinal lithofacies (or depocentre maxima) occur adjacent to NNW-NW trending segments of the major fault systems, while condensed BCDS sections developed adjacent to NNE-NE segments. This facies architecture is consistent with differential strike-slip movement along sinuous ~N-S faults resulting in the formation of transtensional (or releasing bend) sub-basins adjacent to NNW-NW fault segments, while 'transpressive' sub-basins or BCDS platform margins developed along NNE-NE trending fault sections. Adjacent to sub-basin margins, gravitationally unstable slopes were formed that are characterised by coarse-grained clastic Slope lithofacies and abundant slope-related synsedimentary deformation. This caused the development of neptunian dykes; liquefaction breccias, megabreccias and soft-sediment intrafolial folds.

The initial stages of BCDS deposition were characterised by abundant submarine cementation, including the widespread precipitation of radiating fan-like seafloor cements (or Coxco needles). Coxco fan-like cements are recognised throughout a number of lithofacies and are interpreted to be associated with the upwelling of anoxic, HCO_3^- charged bottom water. This upwelling event is thought to have been triggered by changes

in the bathymetry of the basin during the onset of differential subsidence. Isotopic analysis of the basal BCDS sequence records a negative excursion in $\delta^{13}C$ values that is consistent with the interpretation of upwelling of anoxic bottom water and the widespread precipitation of carbonate.

The Lynott Depositional Sequence (LDS) overlies the BCDS and is interpreted to represent a phase of renewed basin subsidence. The spatial distribution of the LDS lithofacies is distinctly different to that of the BCDS, suggesting a subtle but important shift in the controlling structures on LDS deposition.

Diagenesis of the middle McArthur Group is dominated by abundant synsedimentary cements and precipitates which include: fibrous dolomite cements; micritic cements; fan-like seafloor cements; and spheroidal dolomite. Depositional components and early synsedimentary cements are exclusively preserved as dolomite, with average $\delta^{13}C$ and $\delta^{18}O$ values ranging from 0‰ to -2‰ PDB and -4‰ to -10‰ PDB respectively. Textural relationships and excellent fabric preservation support early dolomitisation of the sequence. Pervasive dolomitisation of dully luminescent depositional and early diagenetic components must have occurred relatively early during diagenesis, as overlying burial-related dolospar cements are zoned under cathodoluminescence, indicating that they precipitated as primary dolomite.

Widespread synsedimentary cementation of the middle McArthur Group effectively controlled the pattern of later diagenesis. Primary porosity is commonly rimmed by several generations of fibrous dolomite cement, with only a relatively minor component of post-depositional dolospar cement occluding porosity. The petrography and geochemistry of dolospar cements is consistent with a burial origin with $\delta^{18}O$, and to a lesser extent $\delta^{13}C$, showing a trend toward lighter values. Several distinct dolospar generations are recognised that form a regionally recognisable pattern (Do1→Do2→Do3) reflecting progressive burial of the middle McArthur Group sequence. The development of a burial cement stratigraphy allows some constraints to be placed on the timing of discordant MVT-style sulphide precipitation and hydrocarbon migration. Base-metal sulphides commonly directly overlie brightly luminescent dolospar (Do2b), while bitumen post-dates Do2b. Considerations of the burial history of the middle McArthur Group sequence indicate that the onset of hydrocarbon migration most likely occurred prior to maximum burial (~3 km) of the sequence (~1600 Ma). This suggests that precipitation of pre-bitumen dolospar cements (i.e. Do1, Do2a & Do2b) and sulphides probably occurred prior to ~1600 Ma.

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SUPPORTING PUBLICATIONS

*WINEFIELD, P.R. AND MCGOLDRICK, P., 1998. Evidence of Proterozoic primary $CaCO_3$ precipitation from the McArthur Group of northern Australia: Water-Rock Interaction Conference Proceedings, WRI-9, p. 373-376.

* included within enclosure