Correlating and subdividing the Ediacaran in Australia

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For many years, the lack of geochronology severely limited Australian Neoproterozoic correlations and stratigraphic interpretations had to be based mainly on lithostratigraphy. Although lithostratigraphic units showed a surprising uniformity across Australia, they were generally viewed with scepticism. In the 1990s, mineral and hydrocarbon exploration in the Centralian Superbasin and Adelaide Rift Complex, coupled with attempts to define a terminal Neoproterozoic system and period, prompted an integrated approach that tackled the problem from several perspectives. Current Ediacaran correlations use lithostratigraphy, event stratigraphy (recognition of key markers like glaciations and the Acraman impact ejecta layer), sequence stratigraphy, seismic interpretation, isotope chemostratigraphy, and biostratigraphy. Through these techniques, the Flinders Ranges succession can be correlated with successions across much of Australia. Lithostratigraphic correlations have been largely confirmed and further subdivisions appear feasible. The efforts of the working group on the terminal Proterozoic culminated in the ratification of a Global Stratotype Section and Point (GSSP) defining the base of the new Ediacaran System and Period. The GSSP is a lithostratigraphic marker backed by isotope chemostratigraphy at the base of the cap carbonate, (Nuccaleena Formation) overlying the diamictitic Elatina Formation in Enorama Creek.

The successful defining of the Ediacaran System highlights important lessons for Proterozoic correlation and subdivision. For example, it is best not depend on a single approach, a principal advocated by Ken Plumb when the Precambrian Timescale was proposed in 1991. The consistencies demonstrated by the various lines of evidence strengthen the case for an integrated approach. Current correlations comprise a mosaic constructed from independent, but mutually supportive, data. Even if one method later shows flaws, the framework remains stable. Consequently, Australia-wide correlations can be viewed with considerable confidence.

Biostratigraphy has been largely disregarded as a Proterozoic correlation method, despite its extensive use throughout the Phanerozoic. Reasons cited for ignoring biostratigraphy include low species diversity, taxonomic uncertainty, morphological simplicity, sporadic distribution, and conservative evolution rates. However, it seems likely that Precambrian correlation schemes are lacking because palaeontologists have failed to adopt a systematic approach and have rarely tried to compile that standard biostratigraphic tool: the range chart.

The Neoproterozoic palynological record is currently based on more than 2000 samples from at least 30 drillholes in the Adelaide Rift Complex, and Officer, Amadeus, and Georgina Basins. About half the samples are Ediacaran in age. To test the validity of a biostratigraphic approach, palynology and stable isotope analyses were conducted on the same samples. It is early days. Proterozoic palynology is at a similar stage to Phanerozoic palynology about forty years ago. However, the basic framework is there, and there is scope for refinement. Acritarchs (organic-walled, acid-insoluble, phytoplanktonic, polyphyletic microfossils) appear to be the most important fossils for correlation. They are ideal for biostratigraphy because they are abundant, have complex morphology, short stratigraphic ranges, and wide geographic and lithofacies distributions.

Five zones have been identified to date. Samples from the diamictite, cap dolomite and immediately overlying mudstone succession are barren. Above this, simple spheroidal acritarchs (leiospheres) increase rapidly in actual numbers but not in species diversity (contrary to Snowball Earth expectations). A marked change takes place during the second post-glacial sea-level rise, with the first appearance of >50 species of large, acanthomorph (spiny) acritarchs. Diversification was rapid, but ended around the first appearance of bilaterians in the Ediacara fauna, c.565 Ma. The carbon isotope curve supports Ediacaran palynological interpretations across Australia (also the case for the Cryogenian).

Global extension of the zonation scheme is not yet possible because ranges of key species have not been determined outside Australia. Nevertheless, there are species in common with Svalbard, Norway, Siberia, and China, indicating a potential for global correlation. However, attempts to match successions from the Australian Ediacaran and the Chinese Doushantuo Formation produces major inconsistencies. The anomalies apply to correlations based on both the biostratigraphy and carbon isotope curves and raise doubts about correlations of Neoproterozoic glaciations. More detailed studies are required to resolve these contradictions.