REGOLITH AND ASSOCIATED MINERAL SYSTEMS OF THE EUCLA BASIN, SOUTH AUSTRALIA

by

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ABSTRACT

This thesis documents previous research into the heavy mineral sands (HMS) of the Eucla Basin. It presents new research designed to incorporate previous work, and to then encourage a broadening of research into the future. Specifically, this thesis is dedicated to demonstrating the importance of encompassing all aspects of research within a mineral system rather than isolating system components.

In order to understand the complex regolith geology expressed within the Eucla Basin and its contained HMS deposits, a multi-faceted approach is applied, targeting two broad research areas.

The first research area addresses processes acting prior to deposition of the Eucla Basin sediments, including providing constraints on the source of the sediments using U-Pb zircon analysis. The conclusions of this area of the research are that the dominant U-Pb zircon population lies between 1100 and 1250 Ma. Further, that these zircon populations match with the ages of zircon growth events in two of the most proximal potential source regions, the Musgrave Province and the Albany-Fraser Province. This research has also shown that due to the similar magmatic and metamorphic history of the Musgrave Province and Albany-Fraser Province it is difficult to distinguish between the possible sources regions using the U-Pb zircon data alone, highlighting the need for other methods. This thesis also found that kyanite and staurolite, which are common minerals in the Eucla Basin HMS, do not have an identified source in the Musgrave Province but do have a potential source in the Mount Barren Group in the Albany-Fraser Province. Finally, this thesis clearly demonstrates that the recognition of a likely more western source of zircon, kyanite and staurolite requires a revision of existing models of Eucla Basin HMS provenance, which focuses on the Musgrave Province as the most likely source.

The second research area concentrates on the syn- and post-depositional history of the sedimentary rocks inclusive of depositional processes, weathering and groundwater interactions, the combination of which are expressed in multi-element whole rock major, trace element and isotope geochemical data. These data can be combined with other components of the HMS mineral assemblage, together with an understanding of the denudation history of the possible source regions, to establish a landscape evolution model from source, through transport to the site of deposition. The conclusion of this section of research is that stratigraphy of the sequences hosting HMS deposits at Jacinth requires revision because stratigraphic boundaries were assigned to horizons that are the result of post-depositional acid-sulphate weathering and groundwater processes.

Finally, differentiation of rock types into process related sub-groupings is vital for understanding exploration geochemical data but cannot be achieved using major element chemistry alone. A broad suite of trace elements and selected isotope data are required, including strontium/calcium and strontium isotope ratios for the purpose of discriminating between marine and pedogenic carbonates. This methodology has provided significant breakthroughs in the discrimination of carbonate materials, particularly for landscapes with a complex marine or marginal marine history.

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Dedicated to my amazing family and friends . . .

Especially to those that witnessed the beginning of this journey, and who are not here for the end:

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Jim

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Rationale

The basis for this thesis started in the 1980s to early 1990s, with the identification of palaeo sand ridges along the margins of the Eucla Basin. Whilst being explored for Heavy Mineral Sands (HMS) since this time, previous programs have yielded few discoveries. However, following a reinterpretation of the geology of the Eucla Basin in 2003, drilling commenced and three weeks later a deposit, large enough to supply ~25% of the global zircon demand, was discovered. Iluka Resources Ltd managed only five years from discovery to commissioning of the mine, with the project being delivered on time and within budget.

However, despite more successful drilling programs in the area, amongst the exploration companies there was still a limited understanding of the Eucla Basin and its innermost workings. Problems such as exhausted search space, spatially limited drilling information, incomplete geophysical targeting, restricted stratigraphic understanding, a focus on palaeogeographic reconstructions, and 'on the fly' interpretations plagued exploration companies. In an effort to find solutions for these problems, questions of scientific curiosity were also realised. Like the quotation below, this thesis details factors ranging from the scale of global weather patterns to the weathering effect on individual sand grains. It aims to address the limited understanding of the Eucla Basin regolith and associated mineral systems, whilst providing new understanding for future mineral exploration in the area.

'We live in an age of increasing specialisation, and for good reason. Humanity keeps learning more about each field of study; and as every speciality grows, it tends to split into subspecialties. That process happens over and over again, and it is necessary and desirable. However, there is also a growing need for specialisation to be supplemented by integration. The reason is that no complex, nonlinear system can be adequately described by dividing it up into subsystems or into various aspects, defined beforehand. If those subsystems or those aspects, all in strong interaction with one another, are studied separately, even with great care, the results, when put together, do not give a useful picture of the whole. In that sense, there is profound truth in the old adage, "The whole is more than the sum of its parts."

People must therefore get away from the idea that serious work is restricted to beating to death a well-defined problem in a narrow discipline, while broadly integrative thinking is relegated to cocktail parties. In academic life, in bureaucracies, and elsewhere, the task of integration in insufficiently respected.'

*Murray Gell-Mann, Nobel Prize winning Physicist (*in: *Christian, D., 2011)*