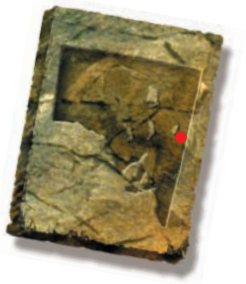

3D conceptual modelling to aid mineral exploration in the southern Callabonna Sub-basin

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Introduction

Mineral exploration in the northern Curnamona Province is made difficult by a cover of weathered Cainozoic sediments up to 200+ m thick overlying weathered Proterozoic bedrock of the Broken Hill and Olary Domains. Four projects have been initiated by CRC LEME to address issues of landscape evolution, geochemical anomaly recognition, and mechanical and hydromorphic dispersion in the southern Callabonna Sub-basin overlying the Curnamona Province. The research reported here provides the basis for a holistic investigation of mechanical and hydromorphic geochemical dispersion pathways within the regolith and sedimentary cover of the basin to aid the detection of mineralisation under deep cover.

Surface regolith and subsurface sediment

Two projects focusing on surface regolith and subsurface sediment aim to determine the geochemistry and mineralogy of the regolith and sediments, with a view to establishing their potential as vectors to bedrock mineralisation.

Over 300 surface regolith, subsurface sediment and saprolite samples were collected and their mineralogy (XRD, Portable Infrared Mineral Analyser) and geochemistry (XRF, total C analysis, pH, EC 1:5) determined. Sediment texture, colour, fabric and composition were described, as well as the morphology and composition of detrital and authigenic phases (SEM with energy dispersive X-ray analysis, electron microprobe).

Bulk mineralogy shows quartz, kaolin, smectite and illite to be the dominant minerals within the sediments, with (?)Tertiary sediments having high amounts of smectite and illite and slightly lower amounts of kaolin. The weathered bedrock (saprolite) contains high amounts of quartz, feldspar and kaolin, and lower amounts of muscovite and smectite. Some ?Quaternary mottled clays and ?Tertiary units show elevated levels of As, Rb, Pb, Ni and Co, which could be related to adsorption onto Fe and Mn-oxides or clays, particularly smectite. Changes in major and trace element concentrations occur at several of the contacts between the sedimentary units.

3D modelling of basin fill and sediment distribution

This project aims to define in 3D the architecture of the sedimentary cover sequence of the southern Callabonna Sub-basin to improve understanding of mechanical and hydromorphic geochemical dispersion processes. The digitised data set is based on 800+ open-file drill log reports from the CURNAMONA 1:250 000 map area and extending eastwards to the Mundi Mundi Fault in NSW. This area comprises two depressions separated by the north–south-trending Benagerie Ridge. The data set comprises those logs that contain interpretable downhole lithology, and location coordinates. Data from the logs have been digitised, and the lithology numerically coded. After gridding and filtering, the modelling results allow visualisation and manipulation of granulometrically distinct sedimentary bodies.

The results show that deposition during the Cainozoic was dominated by alluvial fill of a passive lacustrine basin, initially with significantly greater variation of topographic relief than at present. Movement of the Mundi Mundi Fault outpaced sedimentation relatively late in the period of sediment accumulation, leading to localised deposition of gravel. Gravel associated with the Benagerie Ridge is probably locally derived, possibly from ferruginised and silicified crusts (Fig. 1).

Groundwater geochemistry

This project aims to characterise groundwaters of the southeastern Callabonna Sub-basin in terms of geochemistry (major and trace elements, stable isotopes), with a view to establishing their potential as a regional tool for locating areas of mineralisation within or below the cover. Over 70 groundwater samples were collected from boreholes over the study area. The samples, collected after extensive pumping of the bores, were subjected to a comprehensive analytical protocol in the field and in the laboratory, covering physical parameters, major and trace elements, and stable isotopes (Caritat *et al*., 2000).

Groundwaters are dominantly brackish, of the Na–Cl–SO_4 and Na–Cl types, their pH is circum-neutral, and Eh mildly oxidising to strongly reducing (Fig. 2). They show general trends of increasing temperature, electroconductivity, $Fe^{2+}$and S^{2-}, and decreasing Eh, dissolved oxygen and alkalinity from the outcrop margins of the Broken Hill and Olary Domains towards the deeper basin. Maps of trace element distribution show evidence of regional dispersion in the groundwater. Examination of these changes in groundwater chemistry along hydrological flow paths and application of speciation and mineral saturation hydrochemical modelling allow interpretation of water–rock interaction processes. As a new tool for regional mineral exploration in the Curnamona Province, initial results indicate that hydrogeochemistry shows great potential for enhancing mineral

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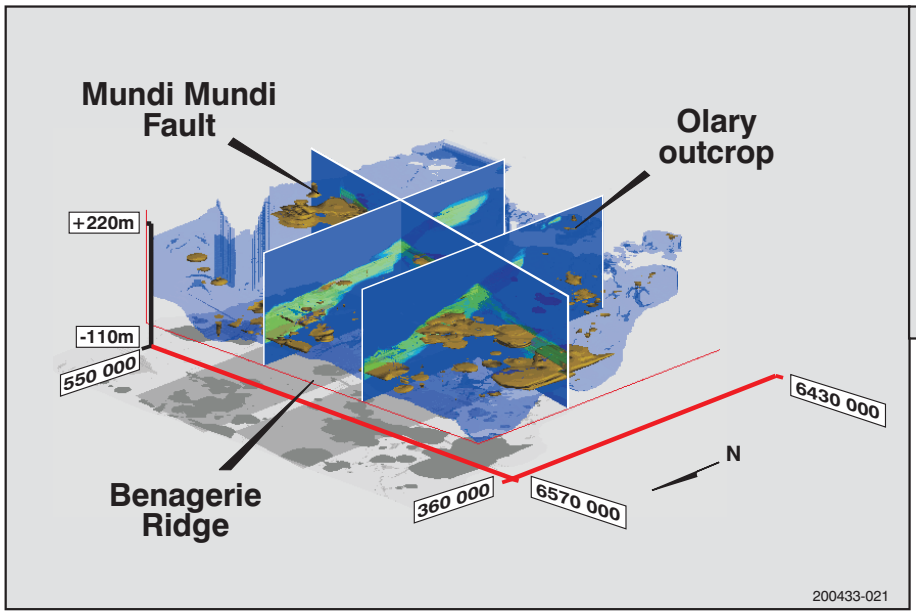

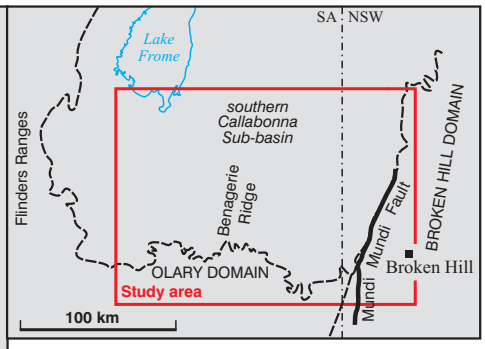

Fig. 1 3D isosurface model of sediment clast size distribution in the southern Callabonna Sub-basin. Gravel and gravelly sand (yellow-brown) are situated high in the basin fill close to the Mundi Mundi Fault scarp and Olary outcrop. Sand and silt (green) and silt–clay (blue) occupy the remainder of the volume above the basin outline (light blue).

exploration objectives along the covered margins of this prospective region.

Conclusions

The four ongoing projects briefly summarised here will help establish the regional framework within which geochemical dispersion can be interpreted when searching for buried mineral deposits. CRC LEME is establishing the geochemical patterns of the surface regolith to help interpret transport and mixing mechanisms at this most accessible interface. The geochemistry and mineralogy of the sediments is being determined in the third dimension, where core is available, to help determine processes by which geochemical anomalies move or remain fixed in the subsurface. These studies help define the regional thresholds for exploration in the area. The architecture of the sedimentary fill within the basin is being constrained to help identify significant units, facies or interfaces in terms of mechanical and hydromorphic dispersion. Finally, hydrogeochemistry is being tested as a regional exploration tool to help determine suitable protocols, constrain water–rock processes governing hydromorphic dispersion, and focus on areas requiring more detailed work. This work is being integrated into a conceptual 3D model of element dispersion for the southern Callabonna Sub-basin.

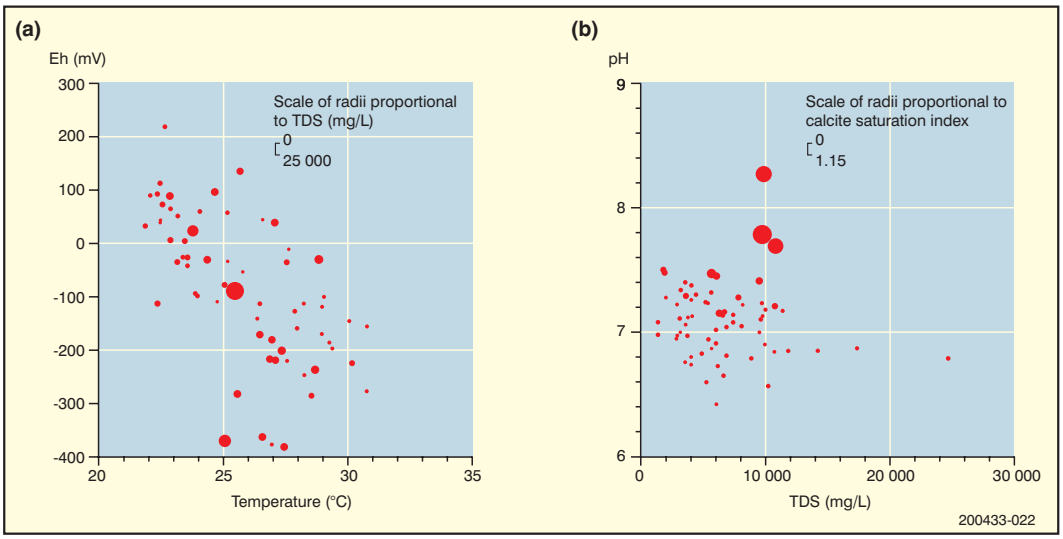

Fig. 2 (a) Eh (mV) versus temperature (°C) of southeastern Callabonna Sub-basin groundwaters. Symbol size proportional to Total Dissolved Solids (mg/L). (b) pH versus Total Dissolved Solids (mg/L) of southeastern Callabonna Sub-basin groundwaters. Symbol size proportional to calculated calcite saturation index (<1 is undersaturated; >1 is oversaturated).

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