REGOLITH CARBONATES OF THE TIBOOBURRA/MILPARINKA INLIERS, NORTHWEST NSW: CHARACTERISTICS, REGIONAL GEOCHEMISTRY AND MINERALS EXPLORATION IMPLICATIONS

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INTRODUCTION

The Tibooburra-Milparinka landscape is a regolith-dominated terrain that is highly prospective for Au and possibly other minerals resources. The main challenges for this region to be able to realise its mineral exploration potential include:

1. The present paucity of geological knowledge of the area, in particular bedrock geology, associated mineral systems and the flanking basin sediments; and,
2. The dominance of transported regolith and the development of what is presently a preliminary understanding and framework for these materials.

Ongoing research by CRC LEME and the NSW Geological Survey is addressing these challenges in the Tibooburra-Milparinka area. Research is being conducted on using the widespread regolith carbonate accumulations (RCAs), which include calcrete and dolocrete, to provide a regional geochemical context across this region. Over 300 RCAs samples have been collected and geochemically assayed from the region. Preliminary results and interpretations from this are presented here. This study suggests that RCAs can be useful in providing a regional geochemical context, particularly for Au and other trace metals around the margins of bedrock inliers. Although RCAs are not abundant from the region they are widespread enough to provide a regional geochemical representation, with individual samples reflecting the geochemical or metalliferous ‘fertility’ of areas approaching the scale of 1 km^2.

SETTING

Location

The Tibooburra-Milparinka area is approximately 300 km north of Broken Hill in northwestern NSW. The focus of this manuscript is the area centred on the Milparinka 1:250,000 map sheet. The landscape history of the area includes weathering, induration, tectonism, eustacy, sedimentation and denudation across Mesozoic and Cainozoic sedimentary basins and their hinterland areas (Hill in prep.).

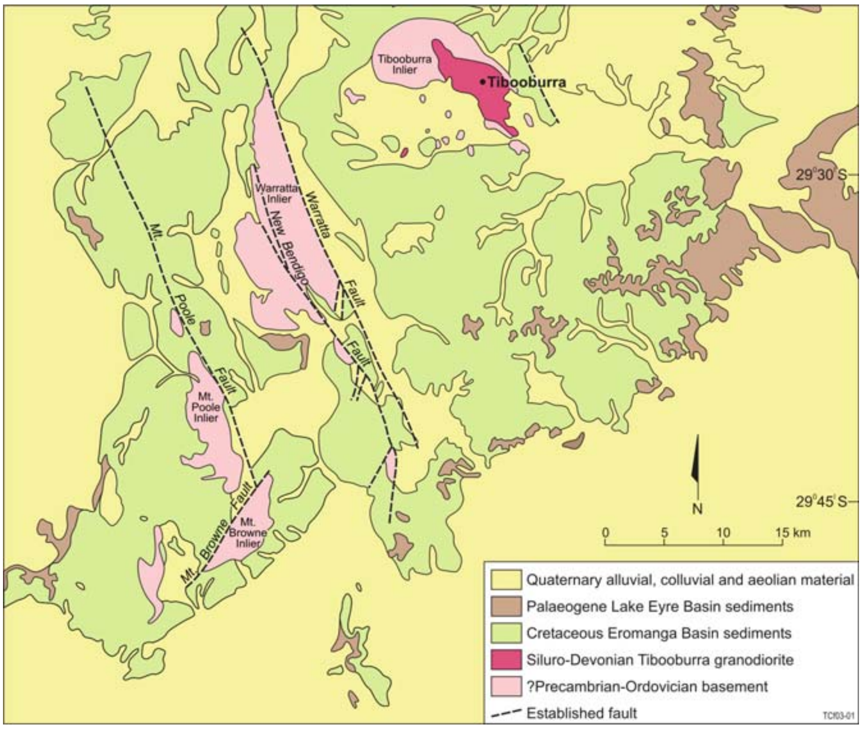

Figure 1: The bedrock Inliers of the Tibooburra-Milparinka Region from Hill (in prep) after Rose *et al.* (1967) and Chamberlain (2001).

Regional Geology

The study area is mostly located within the Thomson Orogen, which extends into southern Queensland, and the adjoining Delamerian Orogen. Outcrop in this area is mostly confined to a series of small inliers which occur in a general north-south trend and are named, from north to south, the Tibooburra, Warratta, Mt. Poole, Mt. Browne, Gorge and Mt. Shannon Inliers.

This manuscript focuses on the Tibooburra, Warratta, Mt. Poole and Mt. Browne Inliers and surrounding basin areas. The oldest rocks exposed in the inliers are metasediments believed to be of Cambrian to Ordovician age consisting of phyllites, schists, sandstone with minor conglomerates and volcanics which have been regionally metamorphosed to greenschist facies. During the Late Silurian to Early Devonian the Tibooburra Granodiorite and associated pegmatites, granites, dacite and diorites intruded the metasediments and caused localised metamorphism (Morton 1982, Stevens & Etheridge 1989, Thalhammer *et al.* 1998).

Mineralisation

Gold was first discovered in the region in 1881 and it is estimated that by 1890 the majority of Au extraction in the area was complete, although minor prospecting still occurs in the area today. The most Au-rich region was known as the Albert Goldfields within the Warratta Inlier (Brown 1881, Pittman 1894, 1985a, b, Hill in prep.) There was minor quartz vein mining within the Warratta Inlier, although the majority of the Au was retrieved from the Mesozoic and Cainozoic alluvial deposits (Hill in prep.) The Au nuggets found in the area are typically described as being flaky or 'foil-like' and typically up to 3 mm long and some contain angular quartz clasts (Marston 1984). Nuggets collected for analysis from the Tibooburra Inlier are of a sub-rounded flaky morphology, and are described similarly to those examined in Chamberlain (2001).

Figure 2: Photographs of nuggets found at The Granites diggings, Tibooburra Inlier (from Chamberlain 2001).

The vein Au from the Warratta Inlier is associated with minor sulphides that tend to give them a grey platy appearance. These sulphides have been observed within quartz veins with cubic pits and large (up to 5 mm in diameter) iron oxide cubic pseudomorphs after pyrite, such as found at the Good Friday diggings within the Warratta Inlier (Barnes 1975). There is a strong relationship between the basal conglomerate of the Mesozoic sediments and the location of mineralisation. The majority of recent alluvial diggings are associated with the sub-Mesozoic unconformity and basal Mesozoic conglomerate, such as at Tunnel Hill on the west of the Tibooburra Inlier. There is a close association between where drainage systems cross the unconformity at the base of the Mesozoic and alluvial diggings within the young alluvial deposits. This suggests that these drainage systems source Au from the unconformity and then deposit it downstream in depocenters where the alluvial diggings are now located. Examples of this are at the Good Friday diggings in the Warratta Inlier and the diggings at Billy Goat Hill on the edges of the Mt Browne Inlier.

Geomorphological setting

The Tibooburra-Milparinka area consists predominately of large plains and rises with the only areas of substantial relief being within the inliers. The inliers are formed in dome and half dome structures. The Mt Shannon, Warratta, Mt Browne and Whittabrenah Hills are part of the Grey Range, which includes the drainage divide between the Lake Eyre Basin in the west of the region and the Bulloo/Bancannia Basins in the central north of the area (Hill in prep.).

Climate

The study area is considered to be a semi-arid to arid environment, with temperatures highly variable between the seasons. It is typical for summer temperatures to exceed 30ºC, and in winter temperatures as low as 6ºC have been recorded (Hill in prep.). Rainfall in the region is slightly summer dominated with the annual rainfall being approximately 229 mm at Tibooburra; this is highly variable although generally evaporation exceeds the annual rainfall (Hill in prep.).

Land use and Vegetation

The Tibooburra-Milparinka Region is predominately pastoral grazing land stocked with sheep, goats and minor cattle. There is a large population of kangaroos in the area, and at present the rabbit population is small but has been much larger in the past. The region is dominated by chenopod shrubland with species such as pearl bluebush (PBB) (*Maireana sedifolia)*, black bluebush (BBB) (*Maireana pyramidata)* and bladder saltbush (BSB) (*Atriplex vesicaria*). A strong geobotanical association has been made regarding *Maireana sedifolia* and *Maireana pyramidata* which predominately colonise areas of friable calcareous regolith materials and sub-cropping moderately to highly weathered bedrock.

METHODS

Field Characterisation and Sampling

Fieldwork in the area was carried out in 3 main blocks. This enabled sampling to take place over a regional scale. To ensure that the samples were equivalent and therefore comparable, a protocol was established and enforced during all blocks of fieldwork. The main aim of the fieldwork was to establish a regional chemistry map using RCAs as the sampling medium. The RCAs were collected from surface exposures, which mostly occurred within small drainage depressions with exposed metasediments, as well as from rabbit warrens where RCAs have been exposed from depth. Areas with rabbit warrens coincide with the areas which are densely colonised by *Maireana sedifolia* and *Maireana pyramidata*, coinciding with areas of calcareous regolith material. Approximately 200 g of RCA was collected at each site along with a large, approximately 5 cm piece which was used for hand sample examination or for thin-sectioning, the RCA samples were labelled with GPS coordinates (MGA 94 datum). General regolith and landform field observations were also recorded at each site.

Analytical Methods

Once the samples were collected and returned to Adelaide they were re-bagged to ensure that loose soil, which may have been attached to the RCAs, was removed. Samples were analysed at Amdel Laboratories, Thebarton, SA, for Au using graphite furnace atomic absorption spectrometry (Amdel method AA9 using aqua regia digest) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma-Optical Emission Spectrophotometry (ICP-OES) (Amdel method IC3E/M/R using HF/multi-acid digest).

RESULTS

Distribution and RCA morphology

RCAs are widespread but relatively scarce in the region, particularly when compared with areas such as the southern Yilgarn, Central Gawler Craton and the Curnamona Province. This is consistent with the Tibooburra-Milparinka region being positioned north of an environmental transition equivalent to the Menzies Line in Western Australia (Hill *et al.* 1998). The RCAs are, however, sufficiently abundant for them to be used as a regional sampling medium.

RCAs are found in a number of different regolith landform settings, although they have been found to occur predominately on sheet flow plains and rises (CHep and CHer) and within minor drainage systems (Aed). There are four main regolith-landform settings for the RCAs in the region:

- Hardpans covering saprock exposed in drainage depressions;
- Powdery and hardpan morphologies overlying weathered Mesozoic sandstones with calcareous cements;
- Powdery and hardpan morphologies along faults and lineaments; and,
- Hardpans and powdery morphologies associated with weathered primary alteration zones hosting mineralisation.

The most common landscape setting of the RCAs was in small drainage depressions, where hardpan RCAs partially cover metasediments. The RCAs would have formed from evaporation of carbonate-rich, pedogenic waters ponding at the hydromorphic boundary along the saprock-sediment interface. The dissolution of the calcareous cement and matrix of Cretaceous sandstones in the region also facilitates the formation of RCA hardpans and powdery RCA on sandstone outcrops in the region. Structural lineaments and fault zones also tended to host a local abundance of powdery and hardpan RCAs. These closely correlate with small groundwater discharge sites, where fractured-rock aquifers have provided a conduit for groundwater flow. This is prevalent along the New Bendigo Fault and the Warratta Fault. Many primary alteration zones hosting mineralisation also tend to have well developed RCAs. The best examples of these occur within the New Bendigo Inliers and parts of the Warratta Inlier (such as near the Albert Town ruins). Calcium-enrichment and alteration has been described along many of the Au-mineralised zones in the district (Thalhammer 1991), suggesting that assays of the RCAs developed from the weathering of these zones could be used to assess the degree of mineralisation in these areas. RCAs sampled from some of these zones in the Warratta Inlier had over 200 ppb Au contents. Some alteration zones, however, had a notable absence of RCAs and a an abundance of pyrite pseudomorphs and ferruginous staining, such as near the Good Friday diggings. This suggests that acidic weathering conditions were not conducive to RCA development. Powdery RCAs were not sampled because of their tendency to also include a large amount of detrital contaminants.

Geochemistry

As part of the field sampling method, the rock type associated with each sample was noted. The rock type is used to determine if the chemical signature of the RCA samples is influenced by the associated rock type, as this could result in a lack of continuity between samples from areas of different rock types. In the results of assays carried out on over 200 samples, no geochemical variation is recognisable between samples and the type of rock from the sample site.

CONCLUSION

Regolith Carbonate Accumulations are not as abundant in the Tibooburra-Milparinka region as they area in the southern Yilgarn and Gawler Cratons, however, they can still provide a useful sampling medium for regional-scale mineral exploration. By understanding the regolith-landform context and local regolith geochemical dispersion pathways, it is suggested that RCAs sampled on a regional-scale can provide up approximately 1 km scale geochemical resolution and context.

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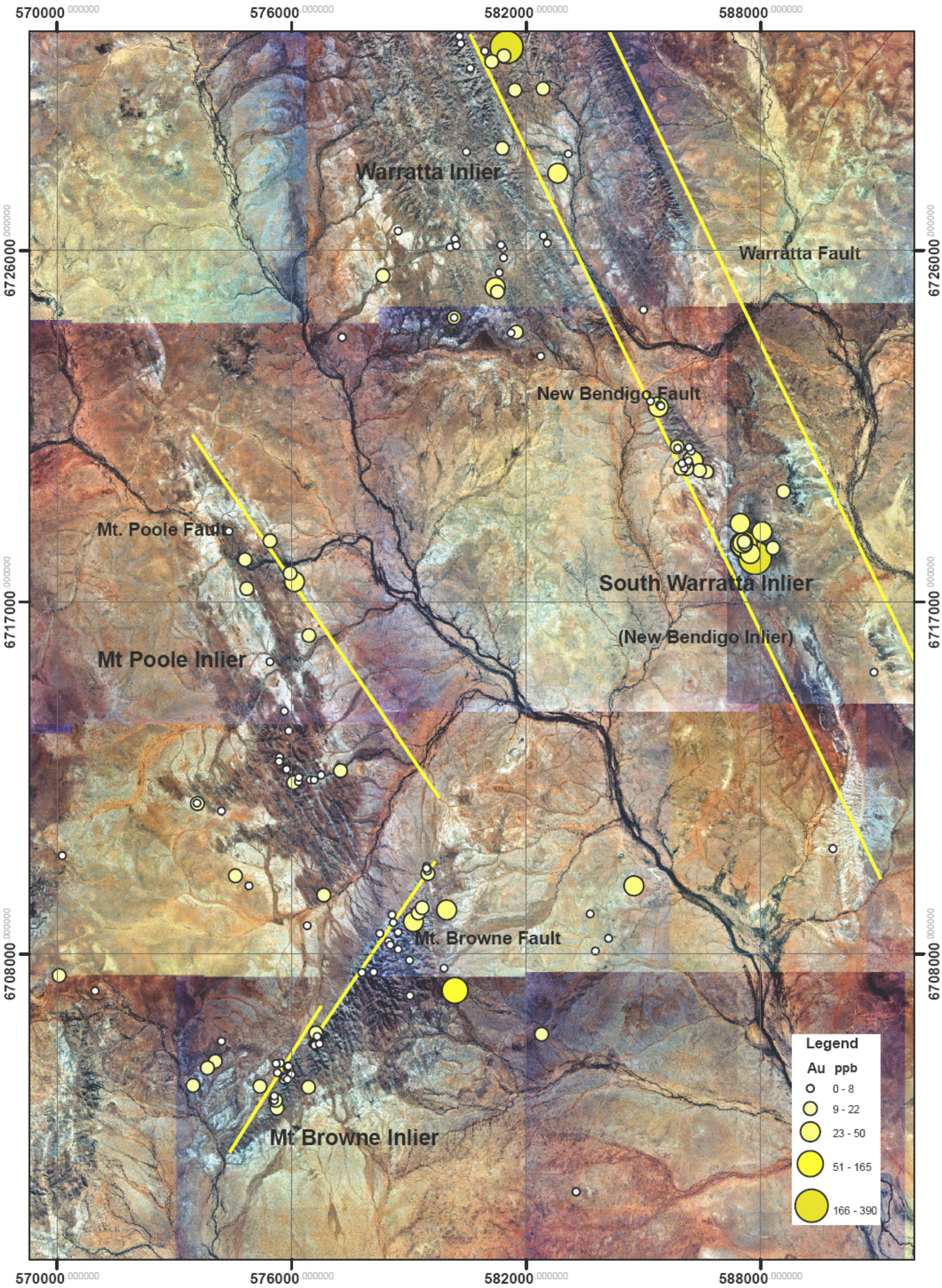

Figure 3: Gold-in-RCA geochemical distribution map from sample sites through the Mt Poole and Mt. Brown Inliers, northwest NSW.