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Experimental studies on the gold-in-calcrete anomaly at Edoldeh Tank Gold Prospect, Gawler Craton, South Australia

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ABSTRACT

Calcrete sampling is the near-surface exploration method of choice for Au in many drier parts of the world, particularly southern Australia. Edoldeh Tank is a weakly mineralised Au prospect in calcrete terrain that lies at the eastern edge of the Great Victoria Desert dunefield (South Australia). At Edoldeh Tank a variety of calcretes occur but the dominant form is a laminated calcrete horizon (LCH). The mineralogy of the near-surface soil is relatively simple and consists of calcite, dolomite, quartz, kaolinite and minor smectite; quartz dominates the unconsolidated overlying sandy soil, and carbonate minerals dominate the LCH. We determine the distribution and nature of the Au at a small scale using a variety of techniques, including SEM, LA-ICP-MS and SXRF and dated sediments to understand calcrete genesis. In a series of thirty excavated soil pits, Ca and Au concentrations increased with depth, markedly so at the LCH. We provide multiple lines of evidence to show there is a general association of Au with calcrete but not a strong correlation as seen with soil profiles elsewhere that have younger, recently formed powdery calcrete. Experiments suggest Au and Ag are currently mobile in this environment despite the low rainfall and that Au occurs in two forms: Au (possibly ionic) occurs throughout the sample with some regions having higher concentrations than others; particulate Au occurs randomly but is more common where the general level of Au is higher. The laminated nature of the calcrete suggests it has formed episodically. An association of Ag with Au in calcrete suggests a means to distinguish anomalies that have developed in residual regolith from those that have dispersed into adjacent sediments. Laminated calcrete is just as effective an exploration sample medium as powdery calcrete. Mobilised Ca, Au and Ag in calcrete can extend the lateral extent and distance from the source of the geochemical anomaly thus providing an effective vector to target for sampling. A landscape dispersion model of Au in calcrete is presented, which requires further testing, to assist the mineral explorer in covered terrains.

1. Introduction

Calcrete (caliche) sampling is the near-surface exploration method of choice for Au in many drier parts of the world, particularly southern Australia. Calcrete here is defined as "regolith carbonate accumulations, forming more or less well cemented aggregates composed largely of calcium carbonate" (Eggleton, 2001). Calcrete sampling began in the early 1990s following the successful discovery of the Challenger Gold Deposit (Gawler Craton, South Australia; Edgecombe, 1997). Since then, particularly in Australia, calcrete has continued to be used in mineral exploration tenements and new anomalies are regularly reported for Au and a variety of other metals using this material e.g. Anon, 2009; Drown, 2003. The most noteworthy recent discoveries using calcrete include Golf Bore (Anon, 2010a;) Tunkillia (Anon, 2010b) and White Dam (Anderson, 2010; McGeough and Anderson, 1998). In Western Australia, where calcrete commonly occurs in the southern Yilgarn Craton, many deposits have been attributable to calcrete sampling including Tropicana, Corvette and several in the Kalgoorlie area (e.g. Doyle et al., 2007; Machukera and Paterson, 2009; Sage, 2010).

Calcrete occurs in many forms (Chen, 2002; Goudie, 1983; Netterberg, 1980) and its association with Au, although close, is variable. At Bounty, Panglo, Zuleika it occurs in powdery forms and is highly correlated with Au in the soil profile (Lintern et al., 1997). Nodular pisolitic carbonate that contains concentric layers of calcitic and/or dolomitic phases and massive carbonate consisting of cemented nodules, laminated horizons and large cemented masses of calcareous material represent a later stage of calcrete formation (Gile et al., 1966). While some work has been undertaken at studying and understanding the Au in powdery carbonate forms, few studies of the Au distribution in non-powdery calcretes have been published (e.g. Lintern, 2005a, b). These indurated calcretes (nodular, laminated and massive forms) are ubiquitous in South Australia and elsewhere and are commonly used by exploration companies as a sample medium for Au in preference to

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the powdery forms which may be diluted by aeolian sand. Samples are commonly sieved on site to remove the sand and fine calcretes and retain the coarser calcretes.

Edoldeh Tank (ET) is a weakly mineralised Au prospect that lies at the eastern edge of the Great Victoria Desert dunefield, 730 km northwest of Adelaide (South Australia) and within the Western Gawler Craton – Christie Domain (Fig. 1, −30.89°S 133.32°E). It represents a frontier area to mineral exploration in southern Australia which is hampered by encroaching sands. At ET, a variety of calcretes occur including the indurated calcretes mentioned above. At ET a survey has been previously completed using an auger which sampled soil and calcrete. As is usual in exploration surveys of this type, dilute hydrochloric acid was used to determine the presence of carbonate as the samples were taken. Carbonate was found at variable depths and anomalous concentrations of Au were found in the calcrete (Lintern et al., 2003; Fig. 2). Typically, where weathered bedrock was close to the surface, calcretes crop out. In areas of sandy colluvium calcretes were found at variable depths.

In this study, we sampled soils and calcrete in a detailed area of the prospect in order to investigate the processes by which Au anomalies may form in this environment (Fig. 2). We determine the distribution and nature of the Au in soils and calcrete using a variety of techniques, including scanning electron microscope (SEM), laser ablation inductively couple mass spectrometry (LA-ICP-MS) and synchrotron X-ray fluorescence (SXRF) and undertake dating of sediments which apprised us with the antiquity of calcrete in this area. We propose a combined organic and mechanistic model that explains the distribution of Au and how and when the anomaly may have formed. Understanding the nature and behaviour of Au at ET will assist the mineral explorer in searching for mineralisation in this area, the Great Victoria Desert as a whole and in prospective semi-arid sand dune environments elsewhere.

2. Site description

2.1. Introduction

The initial geochemical survey of the ET prospect covered an area approximately 9 km^2 (Lintern et al., 2003; Fig. 2). In this study, a detailed area over 0.04 km^2 (centred on line 339,000 mE, between 6,636,650 mN and 6,636,900 mN; UTM AGD66 Zone 53) was investigated to examine the distribution of Au and other elements in samples from soil pits. Grab samples of calcrete and sand were studied at the centimetre to micron scale in order to better understand the dispersion processes operating that lead to the formation of Au in calcrete anomalies.

2.2. Geology

The crystalline basement at ET is the compositionally-layered Archaean Christie Gneiss that has undergone multiple deformation

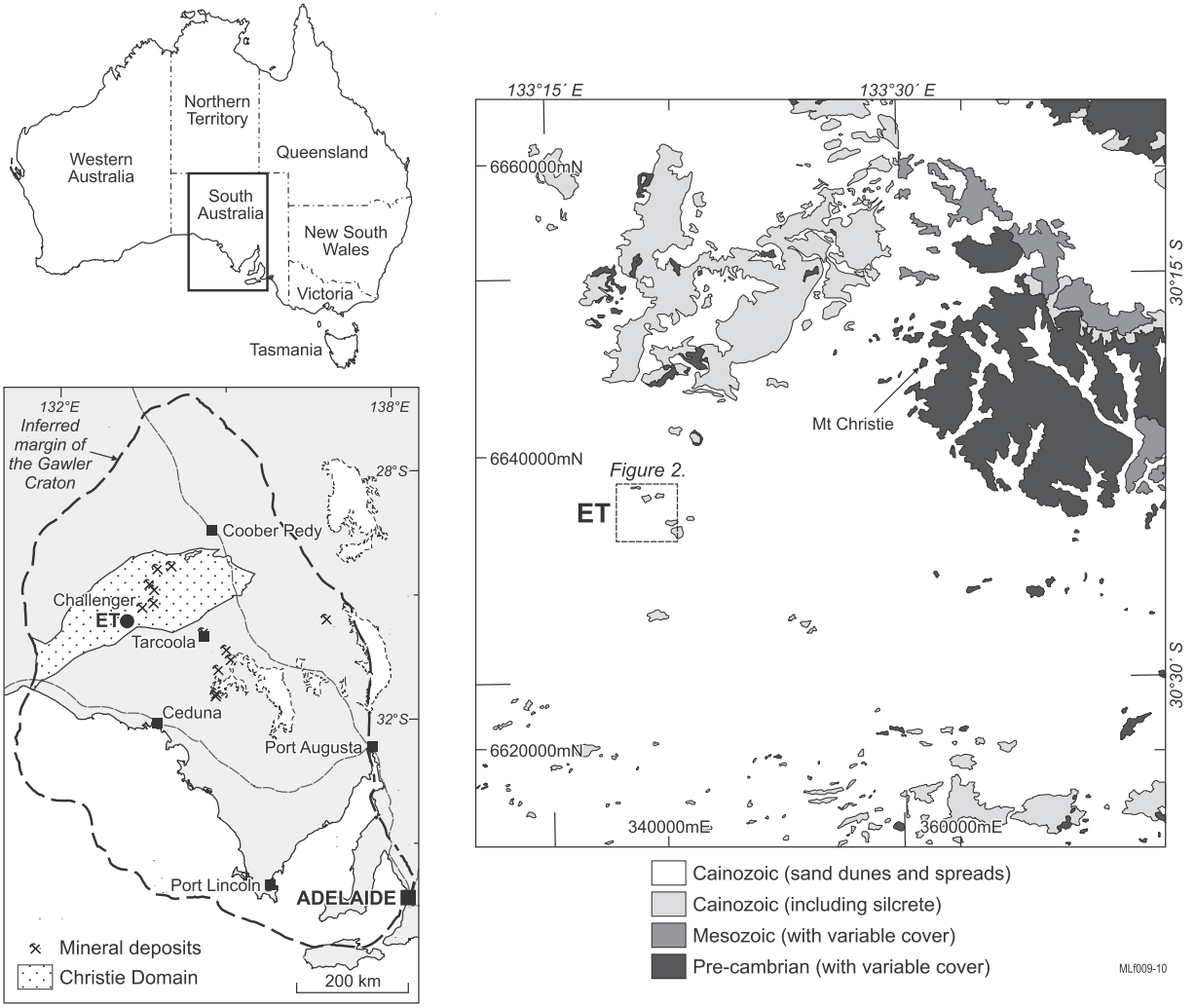

Fig. 1. Location of ET, Challenger Au mine and other selected prospects. Christie Domain outline of the western Gawler Craton derived from Cowley and Freeman (1993). Inset shows the ET study area location in Fig. 2.