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Review

The association of gold with calcrete

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ABSTRACT

The discovery that Au accumulates in calcrete (pedogenic carbonate or caliche) was made in 1987 by CSIRO. Calcrete is a general term describing accumulation of alkaline earth metals in soils of arid and semi-arid terrains around the world. The principal constituent of calcrete is calcite while Au is a noble metal. Calcrete has been a significant tool in a number of Au deposit discoveries, so understanding the mechanisms by which these diametrically different components come together is valuable for enhancing future discovery. Numerous laboratory experiments, case histories and exploration models have been published (most from Australia) yet we do not fully understand the mechanisms involved. It is timely, therefore, twenty-five years on since the first publication of this phenomenon, to review this highly unusual but economically important association.

Critical to any review on Au in calcrete is to first consider calcretes themselves. The nature of a particular calcrete, where it has formed and mode of formation is relevant to how, where and why Au accumulates within it. This review commences with a background, nomenclature, history, classification and some examples of calcrete types found near Au deposits. How calcretes form, their origins and the role of biota is considered. Their locations in the regolith and landscape, as well as exploration models for Au in calcrete are discussed. A section on the chemistry of Au in calcretes details what we know about possible mechanisms of formation and considers what laboratory experiments on microorganisms and abiotic experiments tell us. Following on is a summary of practical aspects of identifying, collecting and analysing samples for exploration purposes. Selected mineral exploration case histories are described and how they fit into models of exploration and different regolith settings. Concluding sections include a summary and implications of this accumulated knowledge to discovering Au deposits.

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1. Introduction

1.1. Background

Australia differs from much of Europe, North America and elsewhere, due to the presence of thick, and ancient (commonly Tertiary) regolith — a weathered mantle described as everything from "fresh rock to fresh air" (Eggleton, 2001). Up until the early 1970s, Au exploration in Australia relied heavily on traditional geophysical and geochemical surveys that included routine soil and stream sediment sampling. Deregulation of the Au price in 1971 saw the commodity soar in value and heralded resurgence in exploration. An impetus for more cost-effective and efficient exploration techniques followed, with particular emphasis on issues relevant to the deeply weathered terrains of the Yilgarn Craton, Western Australia (WA). A significant breakthrough in the late 1960s demonstrated that specific sampling of ferruginous materials and analysis for As was beneficial for Au exploration (Mazzucchelli and James, 1966). This demonstrated that targeted sampling of regolith material for geochemistry had enormous potential for finding mineral deposits. Further geochemical research particularly by the CSIRO and in-house research by industry (e.g. Carver et al., 1987) championed the use of a variety of ferruginous materials (e.g. lateritic residuum, saprolite and deflationary lag) that improved the effectiveness of targeting for base metals (Smith and Perdrix, 1983). Ferruginous materials have inherent qualities that are of benefit for mineral exploration in Australia: These materials commonly retain metallic signatures of the mineral deposit from which they were derived, including Au (Davy and El-Ansary, 1986). They are widespread in the regolith and provide a larger target for exploration than sampling outcrop. This enlargement of the geochemical anomaly allows sampling densities to be decreased (Smith et al., 1984). The success of sampling ferruginous materials was underpinned by a conceptual understanding of the mineralogy and geochemistry of their contained elements, coupled with: (i) an understanding of weathering processes e.g. Fe associated with the formation of redox boundaries; (ii) the realisation that Au and pathfinder elements accumulated in specific locations within the weathering profile e.g. lateritic duricrust; and (iii) a knowledge of the processes of regolith landform relationships (Butt and Smith, 1980). As the number of discoveries and exploration case histories accumulated, the conception, development and refinement of exploration models followed (Butt and