Gold-in-calcrete: A continental to profile scale study of regolith carbonates and their association with gold mineralisation

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Abstract

Regolith carbonate, especially when indurated (calcrete), has been widely adopted as a sampling medium by many Australian Au exploration companies. Rapid uptake of the medium in geochemical exploration programs, following its reported success in the South Australia Challenger Au deposit discovery, has resulted in poorly constrained sampling methodology with many inconsistencies. Results have therefore been equivocal. This study of regolith carbonates and their association with Au will improve this situation. Three aspects of regolith carbonate development and association with Au are investigated. These are based on variable spatial scales, ranging from the southern Australian continent, to local area, to individual profile.

On a continental scale, regolith carbonates cover extensive areas of southern Australia. The primary component, Ca, is sourced from mineral weathering or atmospheric sources. Through the use of Sr isotopes to provide a surrogate expression for Ca sources, the source was identified as > 90% atmospheric or marine derived. A uniform inland signature is identified, which is due to the continual recycling and mixing of marine derived Ca with minimal bedrock input. An external Ca source means that Ca does not have a direct relationship with Au, which is locally sourced from mineralised areas.

On a local scale, a Au-in-calcrete anomaly extending over 20 km^2 and lying over both mineralised (Tunkillia Au prospect) and barren bedrock was investigated. Regolith-landform mapping and geochemistry was used to further identify the zone of elevated Au-in-calcrete. The zone was found to correspond spatially with palaeo- and contemporary drainage systems that currently flow into ephemeral lakes. Geochemistry of the area shows that the majority of elements have been transported and enriched along these systems. This dispersion pattern and its contemporary landscape expression is complicated by dune fields over mineralisation that partially cover the palaeo-drainage. Millions of dollars have been spent drilling this anomaly with no significant mineralisation found beyond the discrete Tunkillia mineralized zones, yet with the aid of regolith-landform mapping an explanation of the anomaly spatial pattern and dispersion pattern has been provided at very low cost.

On the profile scale, two regolith carbonate profiles from the White Dam Au-Cu prospect were analysed in detail. Mass balance calculations revealed chemical gains and losses for the soil horizon and total profile. The investigation quantified the extensive external Ca input and revealed the position and size of the Au particles. Gold in the profile prior to regolith carbonate development is concentrated at the top of what is presently the regolith carbonate horizon as calcite precipitation in void spaces reduces permeability. Ongoing calcite precipitation up the profile locks in the Au, resulting in a Au-in-calcrete anomaly.

Exposure of Au-enriched calcrete horizons to chemical and physical weathering results in decomposition of the material. This material can then be transported in the form of surface lag, which may settle on top of existing and still developing regolith carbonates to form new Au-in-calcrete anomalies that are unrelated to underlying bedrock.

The formation of Au-in-calcrete anomalies in relation to landscape processes is demonstrated. Additional information on landscape setting, gathered while sampling, can therefore improve interpretation of regolith carbonate geochemistry. Exploration companies that take time to understand the landscape setting in this way and react accordingly, can therefore expect improved results.

Originality statement

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Robert Dart

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Robert

Definition of abbreviations and acronyms

AAS	Atomic Absorption Spectroscopy
AMIRA	Australian Mineral Industries Research Association Ltd
CEC	Cation exchange capacity
CRC LEME	Cooperative Research Centre for Landscape Environments and Mineral Exploration
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EDX (or EDS)	Energy Dispersive X-ray Spectroscopy
FA	Fulvic acid
FEGSEM	Field Emission Gun Scanning Electron Microscope
HA	Humic acid
ICP-MS	Inductively Coupled Plasma – Mass Spectrometer
ICP-OES	Inductively Coupled Plasma – Optical Emission Spectrometer
INAA	Instrumental neutron activation analysis
LGM	Last glacial maximum
PIRSA	Primary Industries and Resources, South Australia
PPL	Plane polarised light
REE	Rare Earth Elements
LREE	Light rare earth elements (La, Ce, Pr, & Nd)
MREE	Medium rare earth elements (Sm, Eu, Gd, Tb, Dy, & Ho)
HREE	Heavy rare earth elements (Er, Tm, Yb, & Lu)
RLU	Regolith Landform Unit
RO	Reverse osmosis purified water
TIMS	Thermal Ionisation Mass Spectrometer
XPL	Crossed polarisers
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence

Publications and conference abstracts derived from this thesis research

Peer reviewed journal articles

Dart R. C., Barovich K. M., Chittleborough D. J. & Hill S. M. 2007. Calcium in regolith carbonates of central and southern Australia: Its source and implications for the global carbon cycle. *Palaeogeography, Palaeoclimatology, Palaeoecology,* **249**, 322-334.

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