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### MINERAL HOSTS FOR GOLD AND TRACE ELEMENTS IN THE REGOLITH, BODDINGTON AND MT PERCY GOLD DEPOSITS, WESTERN AUSTRALIA

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#### ABSTRACT

Mineral-trace element associations have been investigated in the regolith developed on mineralised rocks, at the Boddington Cu-Au deposit and Mt Percy gold deposit, Western Australia. A detailed characterisation of the mineralogy and geochemistry has been achieved using *in situ* microanalyses on regolith materials. The use of Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) for the *in situ* quantification of trace elements in clays and other regolith minerals has been assessed, and a method to process the data was developed.

#### Boddington

##### *Mineralogy*

The weathering profiles consist of a saprock, saprolite, clay zone, bauxitic horizon, duricrust and a layer of loose pisoliths. The saprock is composed of abundant muscovite and quartz, epidote, chlorite, titanite and ilmenite. Chlorite-vermiculite and a biotite-chlorite interstratified mineral have been identified in the clay fraction. The Cu and Fe-sulphides are often partially dissolved or oxidised. The saprolite consists largely of microcrystalline kaolinite and quartz, with minor goethite, high charge corrensite, biotite-vermiculite interstratified mineral and vermiculite. Iron sulphides are replaced by goethite and hematite. In the overlying clay zone, kaolinite is replaced by microcrystalline gibbsitic and goethitic plasmas. The duricrust typically comprises a fragmental duricrust overlain by a pisolitic duricrust, characterised by the *in situ* induration of plasmic domains. Angular concretions, nodules and pisoliths contain abundant hematite, goethite and gibbsite, and are set in a soft gibbsitic matrix. Anatase-rich domains resulting from the weathering of ilmenite and titanite are scattered in the duricrust and the loose pisolitic material. Maghemite is occasionally present in the fragmental duricrust, and becomes more abundant in the loose pisolith along with boehmite and corundum.

##### *Trace element-mineral associations*

New data about natural concentrations of trace elements in regolith minerals are reported. In the saprolite, trace elements are concentrated in minerals of marginal abundance such as corrensite, vermiculite and Fe oxides. The trace elements directly related to the Cu-Au mineralisation (Cu, Au, As, Pb, Bi, Mo and W) released by the dissolution of the sulphides are incorporated in goethite and hematite, with a preference for the former. Corrensite and vermiculite contain large amounts of Cu.

Tungsten, Bi and Mo are also hosted by anatase. Trace elements related to the nature of the host rock are either residual in primary minerals or in their alteration products. Manganese, originally contained in chlorite, is retained in vermiculite. In the duricrust, Co, Zn, As and Mo are concentrated in goethite in the cutans and matrix of the nodules. Tungsten occurs as residual scheelite, in the matrix goethite and in anatase. Gold is present as microparticles scattered in the Al-Fe microplasmas. Copper, Zn, Ni, Co and Mn are also concentrated in goethite in the loose pisolith cortex. Kaolinite and gibbsite do not scavenge any significant amounts of trace elements.

## **Mt Percy**

### *Mineralogy*

The regolith is over 60 m thick, and comprises a saprolite, a clay upper saprolite, a mottled and plasmic clay zone, a lateritic duricrust and gravel layer, and a top loamy soil containing pedogenic carbonates. The saprolite is composed of fuchsite, quartz, sulphide relicts replaced by Fe oxides, minor rutile and Cr-spinels. The clay saprolite is characterised by the replacement of fuchsite by kaolinite and the development of kaolinitic and goethitic rich microcrystalline plasmas. In the vicinity of the sulphide relicts, the plasmas and quartz grains are dissolved and replaced by alunite. The overlying mottled and plasmic clay zone is strongly ferruginised in places, and cutans consisting of kaolinite, gibbsite and goethite fill cracks and voids.

### *Trace element-mineral associations*

The trace elements used as pathfinders have multiple hosts. Antimony and W are hosted in rutile and in Fe oxides replacing the sulphides. Arsenic is strongly concentrated in goethite. Copper and Zn are contained in goethite in the saprolite and mottled and plasmic clay zone. Alunite hosts copper in the clay saprolite, and Zn is present in Cr-Zn spinels. The trace elements related to the parent-rock such as Ni, Co and Mn are concentrated in goethite replacing the sulphides, in vermiculite and fuchsite in the lower saprolite. Higher up in the profile, Ni, Co and Mn are held by goethite in the ferruginised rock and cutans. The elements associated with the fuchsitic-carbonate alteration such as Ba, K and Rb are located in fuchsite in the saprolite. In the clay saprolite, alunite hosts Ba and kaolinite contains Rb.

## **Implications for exploration**

The *in situ* mineralogical and chemical studies of the Boddington and Mt Percy regolith material have provided data of relevance for Au and mineral exploration. It has shown that targeting individual minerals and mineralogical phases provide a potential tool to enhance geochemical anomaly detection. Kaolinite and gibbsite do not scavenge any significant amounts of trace elements and should therefore be disregarded as a sampling medium. The importance of the clay fraction (<2 µm) in kaolinite-dominated samples has been demonstrated. Phyllosilicates such as interstratified minerals and vermiculite provide the potential to trap large quantities of trace elements. Goethite is the ideal target for analysis as it has a high capacity to scavenge pathfinder elements. Tungsten and Sb are mainly hosted by resistant minerals and are not reliable indicators of mineralisation.