

The geomicrobiology of gold: Fundamental processes to industrial applications

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The biosphere catalyzes a variety of biogeochemical reactions that transform gold (Au) [1, 2]. Microbial weathering contributes to the mobilization of Au by releasing Au trapped in minerals and by solubilizing it via complexation. Subsequent microbial destabilization of Au (I/III)-complexes coupled to bio-precipitation and biomineralization leads to secondary Au formation, completing the cycle. Secondary Au occurs as nano-particles as well as micro-crystalline and 'bacteriomorphic' Au, the latter being a controversial form of 'biogenic' Au. Recent research provides an understanding of genetic and biochemical mechanisms that microorganisms utilize to drive this biogeochemical cycle. These studies show that: (1) microorganisms mediate Au solubilization via excretion of metabolites, e.g. cyanide, amino acids and thiosulfate; (2) precipitate Au intra- and extracellularly, and in products of their metabolism leading to the formation of Au biominerals; and to achieve this (3) have developed biochemical responses to deal with toxic Au (I/III)-complexes.

Using genomic, proteomic and synchrotron spectroscopic techniques genes and proteins involved in Au detoxification have been characterized. For example, a transcriptional regulator (GolS) in the bacterium *Salmonella enterica* is activated specifically by Au-complexes. Activated GolS then activates the expression of a metallochaperone gene (*golB*) and of a transmembrane efflux ATPase (*golT*), which promote Au resistance [3]. Using these results a biosensor for Au is in development allowing the quantification of Au from environmental samples. This will provide a cost-efficient and environmentally sustainable technique for the improvement of Au exploration and ore processing.

[1] Reith *et al.* (2007) *ISME Journal* **1**, 567–584. [2] Southam *et al.* (2009) *Elements* **5**, 303–307. [3] Checa *et al.* (2007) *Mol. Microbiol.* **63**, 1307–1318.

Mobility of platinum and gold in the Australian regolith – Spectroscopic and electron microscopic analyses

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Biogeochemical cycling of gold (Au) and platinum (Pt) appears to play a fundamental role in the formation of secondary Pt and Au in placer deposits, and secondary 'biogenic' Pt and Au has been reported from Brazil and Australia [1, 2]. To compare Pt and Au mobility, Pt/Au nuggets, soils and groundwaters were collected from a platiniferous and auriferous site near Fifield, New South Wales, Australia. Collected materials were analyzed using (FIB)-SEM-(EDXA/EBSD), ICP-MS, EPMA, ICP-MS/OES, X-ray tomography, synchrotron- μ XRF, and thermodynamic modeling.

Secondary morphologies, presence of nano-particle and formation of micro-crystalline enrichment zones of Pt/Au on surfaces of Pt/Au grains suggest (bio)geochemical dissolution and re-precipitation that promote the mobility of Pt and Au in surface environment. This is supported by X-ray tomography of a rare specimen of deep lead material (Fe-oxides, silicates and clays) with embedded Pt- and Au grains. Grain surfaces display filigree and perforated structures, strong rounding of grains and the formation of nano- and micro-particles. Synchrotron μ XRF-mapping and FIB-SEM of polished sections uncovers differences in Au and Pt mobility. This is supported by groundwater data and geochemical modeling, suggesting lower Pt compared Au reactivity, and hence mobility, in surface environments.

[1] Cabral *et al.* (2011) *Chem. Geol.* **281**, 125–132. [2] Reith *et al.* (2010) *Geology* **38**, 843–846.