Bacteria gold interactions

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An *Acidithiobacillus thiooxidans* culture and a sulphate reducing bacterial (SRB) consortium, isolated from the Witwatersrand Basin, RSA were able to precipitate gold from $Au(S_2O_3)_2^{3-}$. In chemical control experiments, gold was not precipitated under similar experimental conditions and duration.

Growth of *A. thiooxidans* on media containing thiosulfate and gold thiosulfate decreased the pH of the culture medium from pH 5.4 to 1.9 and increased the Eh from 0.3 to between 0.5-0.6 Volts. The gold was stable in the bacterial systems until sulfur oxidation was complete, then the bacteria precipitated fine-grained colloidal gold (5-10 nm) inside the bacterial cells and μm-scale crystalline gold in the bulk fluid phase.

After gold thiosulfate was added to stationary phase SRB cultures (pH 7.4-8.0), the Eh decreased from approx. 0 down to –0.2 Volts and the gold precipitated intracellularly as nm-scale colloids (Fig. 1A) and extracellularly as nm-scale colloids within the FeS(s), μm-scale spherical aggregates of gold and μm-scale, octahedral gold (Fig. 1B).

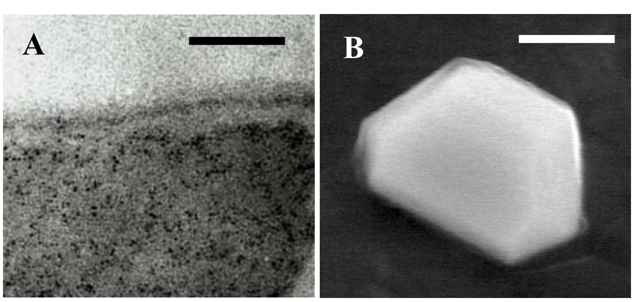

Fig. 1 – An ultrathin section TEM micrograph of colloidal gold within a SRB (A) and a SEM micrograph of octahedral gold within the fluid phase of the culture (B). Bars = 50 nm and 200 nm, respectively.

Carbon, and gold-only deposits

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The association of carbon with gold deposits extends to graphite, carbonaceous material in black slate, CO_2-bearing fluid, carbonate minerals, migrated hydrocarbons, methane and coal. Of the 'gold-only' deposits (i.e. accounting for over 80 percent of the World's gold, and being deposits with gold as the prime economic mineral, and with low base metals), those without an apparent link to carbon species are rare. The source of the carbon includes that within original gold host rocks, and carbon introduced to the mineralizing domain as an essential component of the gold-bearing fluid.

Fluid inclusions associated with gold-only deposits in greenschist facies domains are highly distinctive amongst all ore forming fluids. They are of low salinity, elevated temperature, and mixed H_2O-CO_2 composition. The limited range of H_2O-CO_2 ratios around 3:1 is explained by mineral buffering during metamorphic devolatilization to produce the auriferous fluids. The role of the CO_2 in auriferous fluids is not to complex with gold, but to buffer the fluid acidity to maintain pH within a range that favors gold transport as a reduced sulfur complex (Phillips and Evans, 2004).

Host rocks to gold deposits contain variable proportions of carbon in what are essentially coal seams (e.g. Owl Creek mine, Canada), black slates (e.g. Bendigo, Victoria), and migrated hydrocarbons (e.g. Carbon Leader reef in Witwatersrand goldfields; Carlin gold province). This carbon plays a role in fluid reduction and gold precipitation.

The result of fluid-wallrock interaction during gold formation includes carbonate minerals defining an alteration halo around many larger gold-only deposits that can be kilometers in scale. Several carbonate species can be present in single alteration haloes including calcite, ankerite, dolomite, magnesite and siderite, and there are multiple controls on the carbonate mineral species including host rock composition, degree of carbonation, and level of sulfidation. In mafic rocks, mild carbonation converts amphiboles to chlorite and calcite, and then progressive alteration breaks down the chlorite to stabilize ankerite. Higher levels of sulfur activity near mineralization may lead to pyrite growth, and the ankerite may give way to dolomite. Extreme variation of ankerite-dolomite composition over a few centimetres (Fe/(Fe+Mg) from 0.02 to 0.43) reflects sulfur activity gradients adjacent to mineralization. Where the host rocks are ultramafic, rather than mafic, the dominant carbonate is likely to be magnesite. Siderite is common in iron-formations.

In gold deposits close to carbonaceous rocks, such as black shales, the fluid inclusions typically contain methane and CO_2, and this is attributed to local rock interaction rather than a separate methane-bearing fluid.

Reference

Phillips G.N. and Evans K.A., (2004) Role of CO_2 in the formation of gold deposits. *Nature* **429, 860-863**.