

# Supergene gold transformations under varying redox conditions, New Zealand

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Previous work in southern New Zealand has demonstrated that primary gold can undergo transformations in the surficial environment. Deposition of this so-called secondary gold is driven by dissolution of hypogene gold from sulphide minerals in exposed orogenic deposits, with subsequent transport and re-precipitation occurring in the supergene zone. Mechanical erosion and transport concentrates this gold into alluvial deposits where further chemical mobility may occur. This chemical mobility occurs at and near the water table under varying redox conditions. In particular, progressive uplift and sedimentary recycling in an active tectonic environment causes frequent variations in the redox conditions in which the gold is temporarily deposited.

Scanning Electron Microscope (SEM) imaging and analysis has been used to characterise Au grains collected from Quaternary and Eocene-age sediments. Many detrital particles are angular, with coarse (up to 0.5 mm) gold crystal shapes and complex three-dimensional forms. Crystalline overgrowths (10 to 100  $\mu\text{m}$ ), hexagonal and triangular nanoplates (<100 nm) and spheroidal nanoparticles (<1  $\mu\text{m}$ ) are observable on the surface of grains. Worm-like bacterioform gold (<1-5  $\mu\text{m}$ ) is associated with clay minerals in voids.

Gold particles have up to 6 wt% Ag in their cores, <2 wt% Ag in overgrowths, and <0.1 wt% Ag in bacterioform nanoparticles. Euhedral arsenopyrite and pyrite (up to 10  $\mu\text{m}$ ) are present as inclusions in some cores.

Three stages of mobilisation have occurred; 1) supergene liberation of primary Au from disseminated and microparticulate Au associated with primary sulphides, 2) supergene enrichment of primary Au to coarser crystalline forms, and 3) post-transport development of delicate nanoplates, nanoparticles and bacterioform gold within the sedimentary pile, including sediments as young as Late Quaternary.

Surface and groundwater pH is near-neutral, and the waters contain dissolved sulphate from oxidation of primary and authigenic pyrite. Metastable thiosulphate ( $\text{Au}[\text{S}_2\text{O}_3]_2^{3-}$ ) probably drove gold mobility and redeposition in the varying redox setting.