Origin and weathering of gold nuggets

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Gold nuggets have long captured the imagination (and avarice) of geologists, prospectors and the public alike. Unsurprisingly, descriptions of their geological occurrence are rare, but there have also been very few scientific studies describing their internal characteristics and composition. There has been continued speculation about whether they are supergene or hypogene in origin. Supporting a supergene origin, most gold nuggets in Australia have been found at or near the soil surface. Smaller nuggets, in particular, may be intimately associated with, and even appear to enclose, soil materials and weathered rock. Even large nuggets (e.g., >2 kg) have surface features and/or gross morphologies that suggest chemical reworking in the regolith. Conversely, others have been found deeper within the regolith, at the weathering front and large masses of gold have been found at considerable depth, in completely unweathered, primary environments.

The external and internal morphologies, Ag contents and other features of numerous grains and grain aggregates with masses of a few mg, and many nuggets from 0.5g to >8 kg, have been examined to determine characteristics that may indicate their genesis and stability in the regolith. Many of the grains and aggregates are Ag-poor, a well-documented characteristic of secondary gold. In most environments, those having 5->15% Ag are residual, primary grains, although some may also have Ag-poor rims. All of the nuggets, however, have these high Ag contents and, internally, all consist of randomly-oriented crystal domains. Most crystals display coherent twins and/or short incoherent twins that terminate within the crystal, all typical of thermal annealing at temperatures >300ºC. There is no visible internal zonation or concentric growth fabric. Although many nuggets have secondary minerals such as Fe oxides, clays and calcite within them, none of these is fully enclosed; rather, they are all within cracks and voids that may penetrate to the centre of the nugget. SEM and electron microprobe analyses show that some have external depletion rims and Ag-depletion zones along some crystal boundaries. EBSD shows there is no variation in crystallographic orientation across, or into, the depletion zones. The implications of these observations to the weathering of gold are discussed.

These characteristics confirm a century-old conclusion that large gold nuggets have a hypogene origin. They are dissolving in the surface environment, not forming, with weathering initiated by reactions along crystal boundaries.