ST.110
Compositional and Textural Features of Natural Gold and Implications for Gold Particle Studies

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Gold compositional studies have offered a refinement to the traditional prospector's methodology of "panning back to source." Recently, the scope of research on natural gold has expanded both in geographical terms and to include paragenetic, crystallographic, and isotopic studies. Researchers new to the field may be unaware of the complexity and diversity of heterogeneous alloy textures and inclusion mineralogy and their implications for gold particle studies.

This study is based on our own data derived from individual inspection and analysis of circa 35,000 gold particles from 505 placer and in-situ localities worldwide, coupled with published information describing a further 15,000 gold particles. Our aims are threefold. First, we have characterized textural heterogeneity according to generic compositional and/or crystallographic criteria. Second, we have identified the environment of formation of these features according to hypogene settings (both syn- and post-gold-deposition) and supergene environments. Third, we show how this new understanding should influence future approaches to both sample collection and data interpretation.

Compositional and textural characteristics of gold are easily observed in polished sections using the SEM, and EBSD-EDS systems permit correlation of crystallographic and chemical features. Gold-rich rims (Fig. 1A) are well documented, and various workers have noted both Ag-rich and Au-rich films or tracks, sometimes adjacent (Fig. 1B). Complex compositional variation within individual particles may be sympathetic to crystallographic domains (Fig. 1C), or not (Fig. 1D). Inclusions of other minerals are generally related to hypogene vein mineralogy (Fig. 1E). The application of Time of Flight mass spectrometry with laser ablation to polished sections of gold particles has revealed previously unreported heterogeneity at the sub-micron scale (Fig. 1F, G), which may either indicate tiny inclusions or sporadic concentrations of different elements ("clusters") within the gold alloy.

Characteristics such as mineral inclusions, clusters, and the composition of the primary gold alloy are functions of the initial environment of precipitation and are the only useful features for linking composition to primary ore genesis. Enrichment of pre-existing alloy with Ag may take place either in the late stages of the mineralization process or during subsequent residence in the hypogene setting. Gold rims form in the surficial environment largely by silver depletion, but Au-rich tracks are generated in a two-stage process involving Ag removal along grain boundaries during surface weathering by followed by addition of pure gold.

The present study has quantified the degree and nature of heterogeneity both within and between gold particles. Future studies should be based on populations of gold particles sufficiently large to minimise the potential for unrepresentative sampling. Understanding of the genesis of different characteristics of natural gold permits informed targeting of those relevant to studies of either the hypogene and supergene environments. Finally, new appreciation of the degree of sub-micron heterogeneity has implications for trace element characterization through analysis of a small proportion of the particle because the resulting signature may be unrepresentative.

Figure 1: Examples of compositional and crystallographic characteristics of gold particles. (A-E) SEM BSE images. (F, G) ToF lA-ICP-MS images