From gold nuggets to "invisible" gold: how the coordination chemistry of gold demonstrates its diversity in geological systems

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Gold has always been regarded as a valuable commodity. Over history, the quest for gold has progressively moved from seeking nuggets during some famous gold rushes towards present-day industrial-scale mining of low-grade deposits by multinational companies. The continuing demand provides a huge challenge for discovering new gold deposits. This has fostered an intense research activity for a better fundamental understanding of how gold deposits form. When looking the outcomes of the myriad of studies undertaken to understand the behavior of gold in natural systems, gold appears to provide a unique window on Earth's history and on its past and present functioning. This is partly due the advances in specific methods for determining gold speciation (HRTEM, XANES/EXAFS, 197Au Mössbauer effect, biogeochemical markers…). Together with multi-scale data provided by geochemical/geophysical exploration or analogic and numerical modeling, the outcome of this research demonstrates the diversity of the forms under which gold occurs in natural systems.

Three examples will be illustrated:

(i) The Witwatersrand basin (South Africa) hosts the world's largest gold deposits. These deposits formed about 3 billion years ago and their formation conditions are unique worldwide. They formed before the rise of oxygen in the Earth's atmosphere and after the development of early continental life forms. This unusual context provided original (geo)chemical reactions responsible for a spectacular gold mobilization and concentration on a regional scale.

(ii) Gold nuggets have always been sought intensively worldwide and their origin has been elusive for a long time. The evidence of gold transport as natural nanoparticles and of bacterially mediated gold concentration provides new research directions to understand the growth processes of gold nuggets at the Earth's surface.

(iii) A detailed investigation of gold incorporation in the lattice of ore minerals ("invisible" Au) together with the in-situ determination of gold speciation in hydrothermal fluids, have provided unique constraints on the formation of world-class, low grade gold deposits that contain considerable gold reserves.

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