From the deposit to the nano-scale: Advancing our understanding of gold ore-formation

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Although the presence of colloidal processes has been recognized two hundred years ago by the German mineralogist August Breithaupt, still only very little is known since about the role and impact of nano-scale processes on the formation of mineral deposits. Today, a repertoire of powerful, modern analytical techniques is available, including high-resolution SEM with large-area imaging and automated mineralogy capabilities, TEM combined with focused ion-beam in situ sampling, as well as additional EPMA, LA-ICP-MS, µ-EDXRF & (nano)-SIMS that can be applied to discover and study micro- and nanoparticle phases.

For this talk, we chose i) the gold-bearing meta-conglomerates of the Witwatersrand basin (South Africa) and ii) the gold-rich polymetallic seafloor massive sulphide occurrence at the PACMANUS hydrothermal field (Bismarck Sea) as examples to provide insights into the nature and formation of gold nanoparticles in an ancient continental and a modern seafloor deposit. Furthermore, we discuss the advantages and limitations of the methods used.

Even though the ultimate origin of gold in the Witwatersrand is uncertain, there are convincing evidences for the hydrothermal (re-)mobilization of gold. Nano-/micro-particles of gold are observed in spectacular hydrocarbon-mineral structures precipitated in response to the formation of oil-in-water micro-emulsions. The transport of colloidal gold may have also played a minor role.

Masses of gold nanoparticles have been discovered encapsulated in primary (partially nanocrystalline) sulphide mineral assemblages at the PACMANUS vent field that coexist with solitary monocrystalline gold grains (µm size). A model is proposed, in which gold nanoparticles rapidly flocculated from the hydrothermal fluid (i.e., by instant boiling / flashing), whereas monocrystalline gold progressively precipitated during (adiabatic) cooling to ambient temperatures.