Ore Systems as Nanoparticle Factories

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Ore deposit formation is a complex natural phenomenon that creates favourable conditions for precipitation of mineral nanoparticles (NPs) and nanominerals. Generally, NPs in ore systems precipitate during (i) phase transformation upon cooling of magmatic systems; or (ii) extensive alteration of rocks imposed by migrating fluids which undergo physico-chemical changes affecting mineral stability and leading to dissolution, replacement of preexisting mineral assemblages.

Here we will review and present new results of nanoscale investigations in ore minerals from various environments including chromitites, iron oxide-apatite (IOA), Au-Ag epithermal, porphyry Cu, U roll-front, and supergene deposits. We discuss: (i) the effect of chemical composition of the mineral host on the formation of Au, Ag and PGEs; (ii) processes of mobilization and sequestration of U, Th, Nb, Ta, REE, and Pb during alteration under hydrothermal and supergene conditions; (iii) the textural and chemical effects of NPs on mineral composition and zoning, (iv) how metal-rich NPs impact the isotopic signature of ore minerals; (v) the influence of amorphous phase on the formation of NPs; (vi) accumulation of NPs along the mineral-fluid reaction front, and its utilization as a tool to decipher the reaction progress of ore-forming processes; and (vii) heterogeneous composition and structure of NPs.

Recent advances in sample preparation and nanoscale analyses of NPs have enabled to uncloak the “invisible” complexity of geochemical processes responsible for the formation of ore deposits, otherwise inaccessible by whole-rock analyses.