Geochemistry of Au and As in pyrite from ore deposits

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The association of Au and As in pyrite suggests a coupled geochemical behaviour of these elements in ore deposits formed under different physico-chemical conditions, tectonic settings, and crustal levels. A survey of EMPA, LA-ICP-MS, SIMS, and PIXE analyses of pyrite from coal, Carlin-type, epithermal, porphyry, orogenic, VMS, Witwatersrand, and IOCG deposits cover temperature conditions of pyrite formation from 30-600ºC. The analyses show that the highest amounts of Au, often in excess of Au/As = 0.02, are in hydrothermally modified coal, Carlin-type, and epithermal deposits, and lower amounts of Au, Au/As <0.004, are in orogenic, IOCG, and porphyry deposits. Most of the data plot below the solubility limit for Au in arsenian pyrite suggesting that Au^+ is a dominant species in the pyrite structure, and that most of the pyrite-depositing fluids were undersaturated with respect to Au^0. The Au/As ratio of 0.02 is independent of the geochemical environment of pyrite formation, and instead depends on the crystal-chemical properties of pyrite and subsequent alteration processes. The concentration of Au and As in all pyrite considered as a group decreases with increasing temperature probably due to removal of defects and growth As-rich domains. This review defines two major trends of pyrite compositions in: (i) Carlin-type and orogenic deposits in which pyrite composition is controlled by fluid-rock interaction (although the Au-As relation in pyrite may be perturbed by later changes in temperature and/or recrystallization); (ii) porphyry and epithermal deposits in which pyrite composition records and possibly controls the Au/As ratio of parent magmatic-hydrothermal fluids.