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Nano- to micro-scale platform in mineralogy and geochemistry: methods of research, typification and conditions of formation of gold mineralization in Uzbekistan

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Rapid development of nanosciences and nanotechnologies led to the formation of new fields of geosciences – nanomineralogy and nanogeochemistry. Nature programs main features of matters, phenomena and processes in a nanosize interval, and obviously, we can tell about natural nanotechnologies – processes occurring at the size of nanoscale in geological and other systems without human intervention.

Nanomineralogy is a section of mineralogy that studies the conditions of formation, physicochemical characteristics of natural compounds, which size refers to nanoscale (10-6–10-9m) at least by one dimension. Nanominerals and nanoparticles can be formed during the time of crystallization in magmatogene, hydrothermal, colloidal systems; decomposition of solid solutions; diffusion and localization of admixtures in structural defects; desintegration of unstable compounds and decay of unstable isotopes; in tectogene, explosive processes, by weathering etc. Unusual characteristics of nanoparticles are defined by significant specific surface – surface energy that is growing evidently starting from 100 μm and as minerals' size approaches zero it tends to infinity, i.e. the object turns into two-dimensional structure – a film forming fullerenes, nanotubes, or layer-by-layer forming crystal individuals.

Nanogeochemistry is a section of geochemistry that studies processes of migration, concentration-dispersion and mineral forms of elements in the Earth's crust. Clarks and industrial contents of these elements are ranged in ppm–ppb (10-6–10-9 t) diapason. It is obvious that geochemistry of Au, Pt, Pd, Te, Se, Bi differs from geochemistry of Si, Al, Ca, Mg, Na, Fe and other elements with 10n–n%clarks . Gold, known as "noble", chemically inert metal, becomes extremely active at nanosize scale and form nanomineral compounds with many elements: Au3Ni, Au2Bi, AuCu, AuPb2, AuTe2, AuSb2, Au2Hg, AgAuS, Ag3AuSe2.

There are well-known gold-ore giant Muruntau, the largest gold deposits Charmitan, Amantaytau, Daugyztau, Kochbulak etc. in Uzbekistan. Researchon these deposits, using mass-spectrometric (ICP MS) and electron-microprobe analysis (Superprobe 8800R) methods, showed that ores of all deposits were formed by a single range of geochemical types according to standard geochemical zoning of elements, minerals and associations deposition in cata-hypo-meso-epithermal conditions: /Au-W/Au-As/Au-Te/Au-Ag/Ag-Sb/Au-Hg/. Gold is a typical micro-nanomineral in primary endogenous ores. It segregates as native nanoparticles or forms nanoassemblages of certain compounds. Following recrystallization and redeposition lead to the formation of large aggregations.

In early Au-W and Au-As associations gold is diffused and invisible. Au-Te type separates as maldonite, pilsenite, hedleyite, joseite etc. in hypo-mesothermal conditions, and as kalaverite, petzite, hessite, altaite, tellurantimony, laitakarite and others in meso-epithermal conditions. Au-Ag type forms nanoassemblages of electrum, petrovskaite, fishesserite, naumannite, polybasite etc. in epithermal conditions. Besides, Au-Sb type with aurostibite, jamesonite, boulangerite, andorite, owyheeite and Au-Hg type with gold amalgams, kongsbergite, schwatzite, cinnabar, Se and Tl minerals form in epithermal conditions. Analysis of gold micro- nanoassemblages allows estimating the level of erosional profile, vertical and lateral zoning, and also ore scales. The more micro-nanominerals are detected, the more gold mineralization types are combined in one deposit, and it leads to understand how big the deposit is.