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Nanogeochemistry: metal migration mechanism and greenfield exploration in regolith-covered terrains

Wang, X.Q.[1,2], Zhang, B.M.[1,2] and Ye, R. [3]

[1]Institute of Geophysical and Geochemical Exploration, Langfang, China, wangxueqiu@igge.cn
[2]International Centre on Global-scale Geochemistry, Langfang, China
[3]China University of Geosciences (Beijing), Beijing, China

The diverse regolith-covered terrains in China remain unexplored and challenges of greenfield exploration. The cover overburden units act as filters or even impermeable barriers to vertical dispersion of elements. For exotic cover, or a thick sequence of various overlying post-mineralization rocks and transported regolith, the mechanism of metals migrating upward from buried deposits penetrating through the cover to the surface is still not fully understood. Recently, nanoparticles of hexagonal crystals mainly native copper, gold and alloys of Cu, Au, Cu-Au, Cu-Fe, Cu-Fe-Mn, Cu-Ti, were observed in gases, soils and ores at copper and gold deposits using a transmission electron microscope (TEM). These nano-crystal minerals were formed in the endogenic processes [1]. This finding has provided new insight into metal migration mechanism and greenfield geochemical exploration in regolith-covered terrains.

The vertical migration model process can be interpreted that 1) nano-crystal particles of Au and Cu were formed in the mineralized process; 2) nano-crystal particles released from the ore deposits during weathering; 3) nano-particles has gas-like characteristic with high diffusivity able enough to overcome gravity force to float in a liquid in underground water saturated zone or in gases in arid terrains; 4) nano-particles have properties with high surface area to volume ratio characterized by a tremendous force able to adsorb onto surface of gas bubbles by surface tension for diffusion with an ascending flow of gas or water bubbles upward to the surface; 5) sedimentary or volcanic rocks and overlying regolith with fractures or pores allow gases and gas-like nanoparticles to migrate upward through covers to surface; 6) arriving at the surface, some nano-particles may be retained in soil pore gases, and some trapped by soil minerals such as Fe and Mn oxides, clay minerals, colloids, soluble salts and secondary carbonates, and organic matters. Lateral dispersion after the upward vertical migration from mineralization has been taking place under the surface process.

Case studies shows that extensive geochemical anomalies distributed at the surface merely occurred in the fine-grained fraction of soils. Nano-particles of Au and Cu are more readily absorbed onto fine fractions of soils containing clays, colloids, oxides and organic matters. Thus, fine-grained soils enriched with clays, oxides and colloids are useful media for greenfield geochemical exploration in regolith-covered terrains. Case studies show that, in arid and semi-arid sand-covered terrains, sampling of fine-fraction (-120 mesh, <0.125 mm) clay-rich soil is cost-effective for greenfield geochemical surveys. In alluvium-covered fine-grained soil sampling (-200 mesh, <0.074 mm) combined with selective leaching

analysis show clear anomalies over concealed Cu-Ni and Cu-Au deposit. The characteristic of hexagonal crystals formed in the endogenic processes may also identify footprints of mineral systems in this undercover regions.

References:

[1] Wang X et al. (2016) Ore Geol Rev 73: 417-431