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GEOLOGY, GEOCHEMISTRY AND GENESIS OF GOLD MINERALIZATION OF THE OKOTE AREA, SOUTHERN ETHIOPIA

by

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This study deals with ductile shear zone-hosted mesothermal gold mineralizations of the Okote area, which is located in the southern part of the Adola Belt in southern Ethiopia. The Okote area comprises intensely deformed mid- to upper-amphibolite facies biotite-quartzofeldspathic gneiss and amphibole-quartzofeldspathic gneiss of sedimentary origin, ophiolitic mafic-ultramafic rocks of greenschist facies, syntectonic calc-alkaline metatonalite of sub-greenschist facies, syn- to late collision meta-granite, and ocean floor plagiogranite.

The mafic-ultramafic rocks consist of metamorphic peridotite, ultramafic cumulate, meta-gabbro, amphibolite, and meta-volcanic rocks, whose Sm-Nd whole rock dating yielded a 750 ± 24 Ma magma formation age. Detailed major and trace element analyses of whole rock samples from mafic-ultramafic rocks, using instrumental neutron activation analyses (INAA), inductively coupled plasma-mass spectrometry (ICP-MS), and X-ray fluorescence spectrometry (XRF), as well as interpretation of the data using various discriminant diagrams, revealed that they fractionally crystallized from a low potassium tholeiitic magma that was emplaced at an island arc environment by partial melting of depleted mantle.

Three N-S striking shear zones, with different intensity of shearing and hydrothermal alteration, cut the mafic-ultramafic rocks. The gold-mineralized parts of these shear zones reveal a zoning from altered protoliths at shear boundaries, a transitional zone to a mylonitic zone at the central part of the shear zones. High abundances of quartz-carbonate-tourmaline veins and gold mineralization occur mainly in the mylonite zone. Native gold occurs mainly in these veins and in their wallrocks. The ore minerals associated with gold are mainly pyrite, chalcopyrite and pyrrhotite, as well as accessory chalcocite, covellite, galena, and melonite ($NiTe_2$).

Three mineral parageneses associated with hydrothermal alteration ± gold mineralization have been determined. They are epidote - ferro-amphiboles - magnetite, chlorite - ankerite - K-feldspar - pyriteI - pyrrhotite - tourmaline - chalcopyriteI and chlorite - calcite - biotite - pyriteII - gold - chalcopyrit II - tourmaline - galena.

The textural relationships between alteration minerals indicate that epidote, ferro-amphiboles and magnetite formed first, followed by chlorite, ankerite, pyrrhotite, chalcopyrite I and K-feldspar, and, finally, calcite, chlorite, biotite, tourmaline, gold, and galena.

Chlorite geothermometry gives temperatures of chlorite formation at 230°C to 410°C with modes at 250°C, 340°C and 380°C. Chemical mass balance studies of the samples from meta-gabbro and alteration products reveal the additions of K_2O, P_2O_5, volatiles, Sr, Cu, and Ba, into wallrock and loss of MgO, CaO, and SiO_2 from the wallrock to the veins that accompany the mineralization. Au contents of hydrothermally altered wall-rock show strong positive correlations with the abundances of the large-ion lithophile elements (LILEs). Chondrite-normalized Rare-Earth Elements (REE) patterns of samples from alteration zones show light REE enrichments in hydrothermally altered meta-gabbro, a flat pattern with a positive Eu anomaly in the epidote-amphibole-magnetite-rich transitional zone, and heavy REE enrichments with a negative Ce anomaly in the mylonite zone. Fluid inclusions in auriferous quartz veins are aqueous-carbonic inclusions with low salinity (< 6.59 wt.% NaCl equivalent), 0.38 to 0.90 g/cm^3 density, and 218°C to 345°C homogenization temperature. Most of the inclusions decrepitate at 220°C to 388°C. Stable isotope ratios of sulfur, carbon, and oxygen indicate a predominance of deep-seated fluids of metamorphic and magmatic signature.

Considering the combined geological, structural, mineral chemistry, wallrock geochemistry, fluid inclusion and isotopic data presented in this work, I conclude that the Okote gold mineralization is formed by interaction of structurally focused deep-seated auriferous fluid with mafic-ultramafic rocks of the ophiolitic sequence.