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Geology, geochemistry, and hydrothermal evolution of the giant Chalukou high-fluorine porphyry Mo deposit, NE China

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The Chalukou porphyry Mo deposit is located in the northern Great Xing'an Range, northeastern China, and is characterized by a fluorine-rich and highly oxidized magmatic and hydrothermal system. Thedeposit has a provenMo resource of 2.46 Mt, and economic resource of 1.78 Mt with an average grade of 0.087%, which makes Chalukou the largest Mo deposit discovered in China to the present.

Multiple magmatic intrusions injected into Early Ordovician intermediate to felsic metavolcanic-sedimentary complexes in this relative narrow ore field include pre-ore monzogranite (172-164 Ma);ore-related aplite porphyry, granite porphyry and quartz porphyry (148-147 Ma); and post-ore feldspar porphyry, quartz monzogranite porphyry, and diorite porphyry (141-128 Ma). The ore-forming rocks belong to high-silica, alkaline-rich and high-K calc-alkalic series. Geochemistry and Sr-Nd-Hf isotopes imply that the magma source region comprised70~80% mafic lower crust and 20~30% pre-existinglower crust (continental basement). Furthermore, the magmas have undergone extensive fractional crystallization (e.g., hornblende, biotite, plagioclase, feldspar, apatite), and enrichment by fractional crystallization played an important role in concentrating Mo during formation of the Chalukou deposit. Theore-forming porphyries formed in a transitional setting from compression to extension caused by closure of Mongol-Okhotsk Ocean and subsequent post-collision extension.

The Chalukou deposit is regarded as a typical high-fluorine type porphyry Mo deposit based on its ore-related porphyries, alteration, vein system, and breccias.Multiple ore-forming intrusions consist of aplite porphyry, granite porohyry. and quartz porphyry. There is aconsistent, broadalteration zoning pattern developed at thedeposit. The alteration zones comprise a strong silicic zone, potassic zone, illite-sericite zone, and weak propylitic zone outward from the ore-forming porphyry and upward. Hydrothermal fluorine, magnetite, and hematite are widespread in thedeposit, indicating the hydrothermal fluid was fluorine-rich and highly oxidized. Hydrothermal micas typically show high fluorine contents, but a very low chlorine content. The contents of fluorine in sericite and illite range from not detected to 2.33 wt%. Biotite commonly has higher concentration of fluorine, ranging from 0.59 wt% to 6.38 wt%. There is a well developedstockwork vein system. The veinlets formed during the pre-ore stage are dominated by quartz, K-feldspar, and magnetite with halos of K-feldspar and biotite. The veinlets from the syn-ore stage consist of molybdenite-rich veins with different textures and minerals. The post-ore stage veins generally contain pyrite, sericite, illite, and base metals. There are multiple Mo mineralization events. This can be confirmed by crosscutting relationships of hydrothermal veinlets and multiplestages of Mo-bearing hydrothermal breccias.

We set up a model of fluid evolution based on quartz CL images, fluid inclusion microthermometry, and H-O isotopic compositions. The B40 fluid inclusions have recorded the initial single-phase magmatic fluids, with salinitiesof 2.4-8.0 wt%NaCl equiv. This fluid might have originated at 600℃ and 135-200 MPa, and experienced aprocess of ascension, depressurization, andcooling. Temperature decrease accompanying the intense fluid-rock interaction and mixing with meteoric water led to the precipitation of molybdenite.