Geochronology and Geochemistry of the Zhunsujihua Intrusions and Associated Porphyry Mo Deposit, Northern Inner Mongolia, China: Analysis of Petrogenesis, Tectonic Significance, and Mo Mineralization

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The Zhunsujihua molybdenum deposit, located in the western Daxing'anling metallogenic belt that belongs to the Central-Asian Orogenic Belt, is one of few deposits formed in the Late Carboniferous to Early Permian. Its mineralization is mainly restricted to the Zhunsujihua granodiorite stock, which is composed of the main granodiorite and crosscutting, virtually coeval, minor diorite porphyrite dikes and leucogranite dikes. These bodies were emplaced into sedimentary rocks of the Late Carboniferous to Early Permian Baoligaomiao Formation. Most molybdenum ores are hosted by the intrusive rocks close to the contact zone between the Zhunsujihua stock and its wall rocks; the orebodies are predominately veins or lens-shape and fill NW-trending minor faults. The metallic minerals, mainly including molybdenite, chalcopyrite, and pyrite, with minor pyrrhotite, sphalerite, and digenite, occur as veins and veinlets in quartz or as disseminated grains in altered granodiorite. The alteration includes sericitization, silicification, potassic alteration, beresitization, and chloritization.

LA-ICP-MS zircon U-Pb dating yields crystallization ages of 299.2 ± 3.2, 300.4 ± 2.2, and 300.3 ± 3.4 Ma for the granodiorite, diorite porphyry, and leucogranite, respectively. The major and trace element lithogeochemical data show that the granodiorite and leucogranite are metaluminous to weakly peraluminous, high-K calc-alkaline series with I-type granite characteristics, highly oxidized, with low concentrations of Ba, Nb, Sr, P, and Ti and elevated K and Rb contents, all indicating typical arc magma features. The Sr-Nd-Hf isotope data show the granodiorite and leucogranite have low I_{Sr}(0.70406~0.70462), moderate ε_{Nd}(300 Ma) (–0.9~1.5), and relatively high ε_{Hf}(300 Ma) values (–3.6 to +11.2) for zircons from the granodiorite, suggesting the magma mainly originated from the juvenile lower crust that was derived from depleted mantle, with a minor component of ancient continental crust. Lead isotope data have characteristics typical of a lower crust source with contamination of upper crustal material. Combined with previous research, the Zhunsujihua granodiorite stock developed in an active continental volcanic arc accompanied by northward subduction of the Paleo-Asian Ocean plate beneath the Uliastai active continental volcanic margin during Late Carboniferous to Early Permian. This suggests that the subduction of the Paleo-Asian Ocean may have continued to Late Carboniferous, and the Hengenshan basin probably closed in the Early Permian.

The granodiorite and leucogranite mainly show oxidized features and have a genetic relationship with the Mo mineralization. Fractional crystallization has played an important role in the Mo mineralization. The increasing Rb, Nb, Ta, and HREE and the decreasing Nb/Ta and Zr/Hf ratios from granodiorite to leucogranite indicate the leucogranite is more highly fractionated and may have a more intimate relationship with the Mo mineralization. In addition, the diorite porphyry may have provided some of the energy for the evolution of the magma chamber and some components.