SEG 2017 Conference

Hydrothermal alteration and fluid evolution of the giant Aktogai porphyry Cu deposit, Kazakhstan

Changhao Li*, Ping Shen, and Hongdi Pan

Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China, *e-mail, lch81661079@sina.com

The Central Asian Orogenic Belt is one of the largest accretionary orogenic belts, extending for more than 5000 km from Europe to the Pacific Ocean. The Balkhash metallogenic belt, located in the western part of the orogenic belt, hosts large porphyry copper deposits, such as Aktogai, Kounrad, and Borly.

The giant Aktogai porphyry Cu deposit is located in the western part of the Balkhash-Junggar metallogenic belt. More than 12.5 Mt of Cu and 83 t of Au are hosted in the Carboniferous Koldar complex, which includes gabbro, dolerite, diorite, quartz diorite, granodiorite, and granite. The earliest intrusive phase at the Aktogai deposit is porphyritic granodiorite that crosscuts diorite, quartz diorite, and granodiorie of the Koldar pluton. This was followed by emplacement of a stock of ore-bearing granodiorite porphyry at 327±1.9 Ma based upon a zircon U-Pb age. Contents of SO_3 and values of logfO_2 in apatite vary from 0.09-0.95wt% (mean=0.46wt%) and -14.9--10.9, respectively. These indicate the mineralized granodiorite porphyry had a high oxygen fugacity.

The formation of the Aktogai Cu deposit can be divided into four stages, namely potassic alteration stage, sericite(-chlorite) alteration stage, propylitic alteration stage, and clay alteration stage, based on mineral assemblages. The potassic alteration is characterized by a K-feldspar, biotite, and magnetite assemblage with disseminated mineralization and abundant “A” and “B” veins. Homogenization temperatures and salinities of fluid inclusions in early quartz were 401-466℃, and 1.22-7.59 wt% and 45-46 wt%, respectively. Homogenization temperatures and salinities of “A” veins were 320-380℃, and 0.35-7.45 wt% and 38.01-51.08 wt%, respectively. Homogenization temperatures and salinities of “B” veins were 260-320℃ and 0.7-9.86 wt%. Sericite(-chlorite) alteration, which partly overprints the potassic alteration, hosts high grade Cu mineralization. Homogenization temperatures of quartz in this zone show two peaks: 260-300℃ and 340-420℃, and the salinities are 1.22-13.72 wt% and 48.66-49.45 wt%. The propylitic alteration stage, which occurs in the granodiorite porphyry and its wallrocks (e.g., granodiorite), is characterized by a chlorite, epidote, muscovite, and prehnite assemblage with some disseminated and/or vein chalcopyrite and pyrite. Homogenization temperatures and salinities of the propylitic alteration zone were 262-293℃ and 3.55-6.30 wt%. Clay alteration is characterized by a clay and quartz assemblage with abundant quartz veins. Homogenization temperatures and salinities of the clay alteration zone vary widely but mainly range from 150-223℃ and 0.35-9.08 wt%.

In the Aktogai deposit, magnetite is not only associated with mafic mineral alteration but is also disseminated in the rocks, whereas the magnetite and sulfate decreased sharply with increase of sulfide. Therefore, we suggest the magnetite alteration provides an abundance of reduced sulfur and H^+ to the fluid and promotes the mineralization (as equations (1) and (2) show below).

Meanwhile, accompanying ore fluid ascent, the decrease of pressure (from 200-400 bar at the potassic stage to about 50 bar at the propylitic stage) and temperature (from ＞400℃ to ＜200℃) also has enormous effects on mineralization.

$$8KFe_3AlSi_3O_{10}(OH)_{2(biotite)}+2H_2SO_4=8KAlSi_3O_{8(muscovite)}+8Fe_3O_{4(magnetite)}+8H_2O+2H_2S \quad (1)$$

$$12FeCl_2+12H_2O+H_2SO_4=4Fe_3O_{4(magnetite)}+24HCl+H_2S \quad (2)$$