



The role of metasomatism in the balance of halogens in ore-forming process at porphyry Cu-Mo deposits

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Volatile components play an important role in the evolution of ore-magmatic systems and their ore potential. Of special interest are fluorine and chlorine compounds that principally control the transportation of ore elements by the fluid in a magmatic process and under high-temperature hydrothermal conditions. Study of the evolution of fluorine-chlorine activity in the ore-forming process and their source is usually based on analysis of their magmatic history, whereas the additional source of fluorine and chlorine released during metasomatic alteration of rocks hosting mineralization is poorly discussed in the existing literature.

Based on microprobe data on Cl and F abundances in halogen-containing minerals (biotite, amphibole, apatite, titanite) in intrusive rocks and their hydrothermally altered varieties, the role of metasomatic processes in the balance of volatiles in the ore-forming system is discussed by the example of porphyry Cu-Mo deposits of Siberia (Russia) and Mongolia. Two groups of the deposits are considered: copper-molybdenum (Erdenetiin Ovoo, Mongolia and Aksug, Russia) with prevailing propylitic and phyllitic alteration and molybdenum-copper (Sora, Russia), with predominant potassic alteration. All types of hydrothermal alterations have led to drastic decrease in Cl contents in metasomatic minerals as compared with halogen-containing magmatic minerals.

All studied deposits (particularly those where propylitic and phyllitic alteration were developed) show a nearly complete chlorine removal from altered halogen-containing rock-forming minerals (biotite and amphibole). The Cl content in amphibole decreases several times at the stage of replacement with actinolite in the process of propylitization. In the later chlorites (ripidolite and brunsvigite) that replace amphibole, actinolite, and biotite, chlorine is not detected by microprobe (detection limit 0.01-0.02% Cl). Chlorine was also not detected in white micas (muscovite-phengite series) in quartz-sericite alteration zones. No Cl-bearing minerals were revealed in ore-metasomatic assemblages with the exception of extremely low Cl contents in secondary biotite and very rare low-Cl apatite in the early potassic alteration zone.

In contrast, fluorine concentrates in chlorites and white micas; however, the F content in them is commonly lower than in dark minerals, especially in biotite from altered rocks. The highest F contents are typical of biotites related to potassic alteration (K-feldspar + biotite + quartz assemblage). For example, the F content at the Sora deposit ranges from 2.5-2.7 wt.% in the metasomatic biotite to 0.44-1.63 wt.% in the rock-forming biotite of host granitoids. At this deposit, fluorite is a major mineral of the ore-metasomatic assemblage. The Mo-rich Sora deposit drastically differs from the Cu-rich Erdenetiin Ovoo and Aksug deposits by extremely low (0.02-0.08 wt.%) Cl contents in dark minerals from all of the host rocks.

The considerable quantity of chlorine released as a result of large-scale propylitic and phyllitic alteration from halogen-bearing dark minerals at Cu-rich deposits considerably affected the general Cl budget in the ore-metasomatic system. This could significantly promote the generation of Cl-rich (up to 50-70 wt.% NaCl-equiv.) ore-forming solutions at such deposits. At the Sora deposit characterized by less concentrated ore-bearing solutions (12-20 wt.% NaCl-equiv.), the metasomatic alteration of host rocks was not accompanied by an appreciable removal of Cl.

At the studied deposits, huge volumes of enclosing rocks were involved in metasomatism. The large amounts of halogens released during the metasomatic alteration of host rocks might have significantly influenced the balance of volatiles in the ore forming system, including the increase in the salinity of hydrothermal solutions.