Tracing the Aqueous Fluid Exsolution in Mineralizing Granite Using Patchy Zoned Amphibole: An Example from the Tieshan Fe (Cu) Skarn Deposit, SE Hubei Province

Deng-Fei Duan,* Shao-Yong Jiang, and Yao-Ming Xu

China University of Geoscience, Wuhan, China, *e-mail, cugddf@foxmail.com

The Tieshan Fe(Cu) skarn deposit is the largest deposit in the Edong region, southeastern Hubei Province, which is located in the westernmost part of the Middle and Lower Yangtze River metallogenic belt. To trace the fluid exsolution process, patchy zoned amphiboles in the ore-related Tieshan quartz diorite were studied using EMPA analysis. The Tieshan quartz diorite is mainly composed of plagioclase (~70%), amphibole (~8%), quartz (~10%), K-feldspar (~7%), minor biotite, and accessory minerals (~5%). The plagioclase grains are euhedral and have a variable length of 400 μm to 3 mm with length to width ratio of 1.5–4.0. Except for a few large crystals, most amphibole grains are small (~200 μm in length) and are distributed within the edges of coarse plagioclase together with K-feldspar and quartz. Most amphiboles were replaced by plagioclase, K-feldspar, and biotite, leading to the unrecognizable original crystalline morphology.

The amphiboles show a patchy zoned character with variable grayscale in the BSM images. With increasing grayscale, the contents of SiO_2, MgO, and CaO increase, whereas the TiO_2, Al_2O_3, FeO^T, MnO, Na_2O, and K_2O decrease. Three kinds of amphiboles were classified based on the grayscale and relative position within the amphibole. *Type A* is the brightest discrete relict portion distributed in the amphiboles, *Type B* is the main body of the amphibole with different but variable grayscale, and *Type C* is the darkest part that is mainly located at the edge of the amphibole or beside the cleavage. Petrographic observation indicates that *Type A* amphiboles formed earlier than *Type B*, and *Type C* formed latest. Using amphibole thermobarometry, oxygen fugacity and hydrometric formulations, the temperature, pressure, water content and oxygen fugacity of the melt, corresponding to *Type A* (*Melt 1*), *Type B* (*Melt 2*) and *Type C* (*Melt 3*), were evaluated. The results show that the temperature and pressure decreased from 875° to 879°C and 199 to 206 MPa (*Melt 1*), through 719° to 793°C and 48 to 69 MPa (*Melt 2*), and to 656° to 669°C and 27 to 31 MPa (*Melt 3*). The water content also decreased from 4.0 to 4.2%, through 3.2 to 3.7% and to ~3.0%. The oxygen fugacity shows an increase from average ΔNNO + 0.31, through average ΔNNO + 1.6, and to average ΔNNO + 2.78. The Cl content in amphiboles also decreases with decreasing estimated pressure.

The consistent decline of temperature is likely attributed to natural crystallization. The gap in pressure between *Melt 1* and *Melt 2* is probably the result of the magma emplacement from a depth of 7.7 km to a shallower depth. However, the difference between *Melt 2* and *Melt 3* and within *Melt 2* is presumably the result of periodic fracture expansion of the surrounding rocks. Every expansion of the fracture will cause a sharp decline of pressure in the magma, which will induce the exsolution of hydrosaline chloride liquid. As a result, the episodic exsolution of aqueous fluid is probably the essential factor for the formation of the Tieshan Fe (Cu) deposit.