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SEG 2017 Conference

Local Deformation, Metasomatism, Permeability Experiments, and Numerical Modeling for Skarn Formation at the Middle-Late Jurassic Tongshanling Cu-Pb-Zn Deposit, Nanling Range, South China

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South China is world famous for its widespread late Mesozoic granites and related polymetallic mineral deposits, and these have been rigorously investigated by numerous geochronological and geochemical studies. However, very few studies have focused on structural controls of the late Mesozoic mineralization. The Tongshanling Cu-Pb-Zn deposit formed in the most important metallogenic epoch during Middle-Late Jurassic and is typical of the skarn deposits in the Nanling Range of south China. It occurs mainly in the northeastern concealed contact zone between an undeformed stock-like granodiorite and Middle-Late Devonian carbonate rocks, and is dominated by skarn and sulfide-quartz vein mineralization. The skarn in the contact zone can be divided into endoskarn and exoskarn, which occur as masses or irregular shapes along the boundary of granodiorite and as veins in wall rocks, respectively. They both have a well-developed prograde stage that mainly comprises grandite and salite, and also wollastonite in the exoskarn. The massive endoskarn is not well zoned, whereas the exoskarn displays early vein-like marble overprinted by a zonation front starting with wollastonite and followed by grandite and salite. Sulfides and quartz fill the center of the vein structure. The compositions of grandite from the endoskarn and the exoskarn show contrasting variations, which change from early Al-rich (Gr77Ad18) to late Fe-rich (Gr42Ad55) and from early Fe-rich (Gr01Ad95) to late Al-rich (Gr77Ad18), respectively. Both the endoskarn and the exoskarn present a retrograde stage with minor hydrosilicate minerals (amphibole, epidote, and chlorite) and abundant sulfide minerals (pyrrhotite, pyrite, chalcopyrite, sphalerite, and galena) and quartz. By the amphibole geobarometer, the chlorite geothermometer, and the Raman spectra of carbonaceous materials in wall rocks, a relatively high pressure of approx. 3 kbar and a temperature range of 400 ~ 600°C were obtained for skarn formation. A permeability experiment on an unfractured wall rock sample, which was performed by a Paterson apparatus under conditions of 3 kbar and 400 ~ 600°C, gave a very low permeability of 10-21 ~ 10-20 m2, indicating that the infiltration of hydrothermal fluids along the primary lithological pores is not predominantly responsible for skarn formation. The wall rocks of the exoskarn veins are generally deformed. In this area, the deformation is evidently localized at the granodiorite contact and is always parallel to the intrusion boundary with intensity decreasing outward, suggesting it is controlled by the magmatic emplacement. Most exoskarn veins cut the flatter bedding of deformed wall rocks, have an approximately consistent northwest- to west-strike and north- to northeast-dip, and are roughly parallel to the intrusion boundary. It is in all probability that the magmatic emplacement-induced deformation increased the permeability of wall rocks and led to the effective infiltration of hydrothermal fluids, and this resulted in the skarn formation. A numerical modeling using permeability conditions and an idealized intrusion geometry also showed that the magmatic emplacement and induced deformation are highly favorable for skarn formation and metallic mineralization.

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