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Geology and alteration mineral characteristics of the Tonglushan Cu-Fe-Au skarn deposit, SE Hubei Province, China

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The Tonglvshan Cu-Fe-Au skarn deposit located in the western part of the Middle-Lower Yangtze River metallogenic belt, China, consists of 13 orebodies hosted in the contact zone between the Tonglvshan quartz diorite pluton (~140 Ma) and the Lower Triassic marine carbonate rocks of the Daye Formation. It is one of the largest skarn Cu-polymetallic deposits in China with reserves of 1.34 Mt Cu (1.49%), 28.6 Mt Fe (39.7%), 81 t Au (0.45 g/t), and associated Co, Ag, and Mo. However, due to the continuous mining for many years, the Tonglvshan deposit has been facing the problem of resource depletion and the difficulties associated with deep exploring. In recent years, fortunately, the mineral-geochemical exploration technique is an emerging exploration method applied in global ore fields, particularly being applied to concealed porphyry systems and VMS deposits. This exploration method mainly uses of short wavelength infrared (SWIR), electron microprobe analysis (EMPA), and laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) techniques based on the physical and geochemical characteristics of alteration minerals. Therefore, it can provide some clues for exploring for new orebodies in the Tonglushan mining area.

Based on the mineral assemblages and their mega/microscopic texture relationships, the Tonglvshan Cu-Fe-Au mineralization/alteration can be divided into a pre-ore period (stage I: skarn stage), syn-ore period (stages II to IV: retrograde alteration, oxide and sulfide stages), and post-ore period (stages V to VI: carbonate stage and supergene processes). Meanwhile, through the interpretation of ~7500 SWIR data from 17 drill holes, 19 distinct alteration minerals have been recognized in the Tonglvshan Cu-Fe-Au deposit, namely kaolinite, dickite, halloysite, illite, montmorillonite, muscovite, phengite, saponite, chlorite, epidote, actinolite, phlogopite, tremolite, serpentine, talc, gypsum, calcite, dolomite, and ankerite. Among these, chlorite (Fe-chlorite, Mg-chlorite and Int-chlorite), white mica (illite, montmorillonite, muscovite and phengite), and smectite (saponite and montmorillonite) are the most widespread mineral groups in the drill holes. In addition, combined with short wavelength infrared (SWIR) mineral mapping, a montmorillonite-illite-chlorite-potassic alteration zone, plagioclase-kaolinite -chlorite-weak skarn alteration zone, and chlorite-saponite-strong skarn alteration zone have been defined from and inner area to outer contact zone. Moreover, SWIR spectral characteristics also reveal that the value of the chlorite 2250 nm absorption peak (Pos2250) shows a strongly decreasing trend from the mineralization center to the distal barren area, with the form of chlorite changing from Fe-chlorite, to Int-chlorite, and to Mg-chlorite. Further more, electron microprobe analysis (EMPA) results show that the value of the Fe/(Fe+Mg) ratios display the same trend, with values changing from 0.82 to 0.29 from the mineralization center to the distal barren area in this deposit. Therefore, we conclude that the SWIR anomalous (Pos2250; 2253 nm) and high Fe/(Fe+Mg) ratios of chlorite can be used to detect proximity to the mineralized skarn orebodies at the Tonglvshan ore deposit. Our research suggests that it has a great potential application for defining chlorite (and/or other minerals) geochemical characteristics for skarn deposit exploration.