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Contrasting petrological processes between the Yuanbaoshan and Qingmingshan mafic-ultramafic intrusions in the Neoproterozoic Jiangnan orogenic belt, South China: Implication for Ni exploration in the region

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The Qingmingshan (QMS) and Yuanbaoshan (YBS) intrusions, which occur only ~50 km apart from each other, represent the mafic and ultramafic end-members of a prominent Neoproterozoic mafic-ultramafic intrusive cluster in the Baotan district, northern Guangxi, the western segment of the Jiangnan Orogenic Belt between the Yangtze craton to the north and the Cathaysia block to the south. Persistent regional exploration to date reveals that the only known economically valuable magmatic Ni-Cu sulfide deposit in the region is associated with the QMS mafic intrusion. No visible sulfide mineralization in hand-specimens has been found in the YBS ultramafic intrusion. The reason for the different degrees of sulfide mineralization between these intrusions, which is an important question for many researchers as well as exploration geologists, is the focus of this study. In addition to their close locations, these two intrusions have similar zircon U-Pb ages (YBS, 854.7 ± 5.3 Ma, from Yao et al., 2014; QMS, 847.8 ± 3.8 Ma). Gabbronorite is the predominant rock type in the QMS intrusion. In contrast, the YBS intrusion is predominantly composed of lherzolite, plus subordinate amounts of olivine gabbro and gabbronorite. Despite different rock assemblages, these two intrusions share some common arc lithochemical signatures, such as pronounced negative Nb-Ta anomalies. The most primitive olivine in the YBS intrusion contains 85 mol% Fo and 2530 ppm Ni. All of the olivine crystals in the YBS samples used in this study show Ca-depletion (<1000 ppm) and a positive Fo-Ni correlation that is consistent with olivine fractional crystallization without cotectic sulfide segregation. The YBS mafic-ultramafic rocks are characterized by elevated ε_{Nd} values close to +6 and low $(^{87}Sr/^{86}Sr)_i$ close to 0.704, indicating <5 wt% of crustal contamination. Os-S isotope data for the QMS magmatic sulfide deposit indicate addition of external sulfur to the parental magma. The QMS deposit shows depletions of IPGE relative to Pt and Pd, consistent with a highly fractionated parental magma composition. Numerical modeling indicates that the parental magma of the QMS deposit was severely depleted in all PGE, possibly due to previous sulfide segregation at depth. In contrast, the YBS ultramafic rocks are characterized by flat mantle-normalized PGE patterns, consistent with a more primitive parental magma. Mass balance calculation indicates that the concentrations of PGE in the parental magma of the YBS ultramafic rocks are similar to those of undepleted picritic basalts worldwide. This, together with olivine data for the YBS intrusion, indicates a fertile parental magma that is capable of producing high metal tenor sulfide liquids, much higher than the bulk sulfide ores of the QMS deposit. However, due to lack of crustal contamination, especially the addition of external sulfur, no sulfide saturation and segregation took place during olivine fractional crystallization in the YBS magmatic system. Nonetheless, sulfide saturation and segregation may have occurred in other coeval ultramafic intrusions that experienced higher degrees of crustal contamination, especially significant addition of external sulfur. It is recommended that future Ni exploration in the region focus on this type of ultramafic intrusions.