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Oxidation state of the Duobaoshan and Tongshan ore-bearing porphyritic intrusions, NE Central Asian orogenic belt, China: Evidence from Ce^{4+}/Ce^{3+} and Eu/Eu* ratios in zircon

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Porphyry Cu deposits are associated with oxidized felsic magmas that supply metals and S to ore deposits. The oxidized character of igneous rocks can be evaluated through determining Ce and Eu anomalies in zircons because Ce and Eu have different valence states reflecting the oxidation condition of the parent magma. Previous studies show that the Ce^{4+}/Ce^{3+} ratios in zircon can be used as a proxy for oxygen fugacity of magmas and to discriminate fertile igneous rocks from barren rocks.

The Duobaoshan deposit, with proven reserves of 2.44 Mt Cu and 0.11 Mt Mo, is the largest porphyry Cu-Mo deposit in the northeastern part of the Central Asian Orogenic Belt (CAOB) in NE China. The deposit and the nearby Tongshan deposit, with proven reserves of 0.91 Mt Cu and 0.04 Mt Mo, are hosted by Early Ordovician granodioritic intrusions. These gradnodioritic intrusions are variably altered and mineralized, and intruded by quartz monzonite. Uranium-Pb data of zircon grains in quartz monzonite show it was emplaced in Early Jurassic, suggesting that it is likely related to subduction of the Paleo-Pacific Ocean. The alteration is characterized by potassic alteration of plagioclase and magnetite in the inner core of the granodioritic intrusion, and phyllic, propylitic, and argillic assemblages in the outer part of the intrusion. Propylitic alteration is characterized by extensive formation of epidote and chlorite. Euhedral igneous magnetite grains are also present in the granodiorite, suggesting oxidized conditions of the parental magmas. Zircon grains from variably altered granodiorites show high Ce^{4+}/Ce^{3+} from 167 to 252 (median value of 200), and Eu/Eu* between 0.57 and 0.62. Mineralized samples, which are intensely altered, show very high Ce^{4+}/Ce^{3+} ratios from 220 to 328 (median value of 272), and Eu/Eu* ratios between 0.56 and 0.67, whereas Jurassic barren quartz monzonite in the deposit is not altered and shows low Ce^{4+}/Ce^{3+} ratios from 34 to 46 (median value of 40). The high ratios of Ce^{4+}/Ce^{3+} and Eu/Eu* in the Duobaoshan and Tongshan deposits are comparable to other porphyry Cu-Mo deposits in the central and western parts of the CAOB, suggesting that the oxidation state of their parental magmas were similar during the evolution of the CAOB. Together with the data for Ce^{4+}/Ce^{3+} and Eu/Eu* from other porphyry Cu deposits in CAOB, the data from the Duobaoshan deposit confirm that more oxidized magmas are associated with the formation of larger porphyry Cu deposits. The information is useful in regional exploration for porphyry Cu deposits in the region and in other areas.