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Chapter 13

Zircon Compositions as a Pathfinder for Porphyry Cu ± Mo ± Au Deposits**

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Abstract

Zircon composition has great potential as a pathfinder for porphyry Cu ± Mo ± Au systems. The present study used a large integrated laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) U-Pb age and trace element dataset for both infertile and fertile magmatic suites in order to elucidate distinctive zircon signatures diagnostic of metallogenic fertility of the parent magma. The infertile suites are defined as magmatic rocks that are absent of alteration and mineralization at any grade, whereas fertile suites refer to the causative intrusions leading to porphyry-type ore formation. The infertile suites are relatively reduced S- and A-type and relatively dry A- and I-type magmas, including the Yellowstone rhyolite (Wyoming), Bandelier rhyolite (New Mexico), Bishop tuff rhyolite (California), Lucerne reduced granite (Maine), and Hawkins S-type dacite and Kadoona I-type dacite (Lachlan belt, Australia). The fertile suites are more oxidized and hydrous and are selected from representative causative I-type intrusions from porphyry and high-sulfidation epithermal Cu-Au deposits (Batu Hijau, Indonesia, and Tampakan, Philippines), porphyry Cu-Mo-Au deposits (Sar Cheshmeh, Iran; Dexing, eastern China; and Jiama, southern Tibet), porphyry Cu-Mo deposits (Sungun, Iran, and Qulong, southern Tibet), and porphyry Mo deposits (Nannihu and Yuchiling, central China). The best fertility indicators are zircon Eu/Eu* and (Eu/Eu*)/Y ratios, whereas zircon (Ce/Nd)/Y and Dy/Yb ratios are moderately useful. In particular, fertile magmatic suites have collectively higher zircon Eu/Eu* ratios (>0.3), 10,000*(Eu/Eu*)/Y (>1), (Ce/Nd)/Y (>0.01), and lower Dy/Yb (<0.3) ratios than infertile suites. In fertile suites, zircon (Eu/Eu*)/Y ratios are positively correlated with (Ce/Nd)/Y ratios, but this correlation is lacking in the infertile suites. The distinctive zircon ratios in the fertile suites are interpreted to indicate extremely high magmatic water content, which induces early and prolific hornblende fractionation and suppresses early plagioclase crystallization. In addition, we found that Mo is able to substitute for Zr in the zircon lattice. The Mo-rich porphyry systems that were analyzed as part of this study tend to produce some zircons with a higher Mo content (>1–9 ppm) than Mo-poor porphyry systems and infertile suites, indicating that Mo content in zircon is a potential pathfinder to porphyry Mo ore deposits. The zircon Mo/Ti ratio has a broad positive correlation with the oxygen fugacity of the magma, indicating that this ratio may be potentially used as a proxy for the oxidation state of the melt. Analyzing the compositions of detrital zircons from an area with little geologic information or poor outcrop could efficiently and cheaply discriminate whether the drainage source area is dominated by unprospective A-, S-, and I-type granitoids or by prospective I-type granitoids, which could help focus exploration on prospective areas.

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**Digital Appendix Tables and Figure for this paper are available online at www.segweb.org/SP19-Appendices.