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Zircon Chemistry as a Pathfinder for Porphyry Cu ± Mo ± Au Systems

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Zircon chemistry has great potential to be used as a pathfinder for porphyry Cu ± Mo ± Au systems. Here we report a large integrated LA-ICP-MS U-Pb age and trace element dataset for both infertile and ore-productive magmatic suites in order to elucidate distinctive zircon signatures diagnostic of metallogenic fertility of the parent magma. The infertile suites are relatively reduced S- and A-type and relatively dry A- and I-type magmas, including the Yellowstone rhyolite in Wyoming, USA; Bandelier rhyolite in New Mexico, USA; Bishop Tuff rhyolite in California, USA; Lucerne reduced granite in Maine, USA; and Hawkins S-type dacite and Kadoona I-type dacite in the Lachlan belt, Australia. The ore-productive suites are more oxidized and hydrous, chosen from representative causative intrusions from porphyry and high-sulfidation epithermal Cu-Au deposits (Batu Hijau in Indonesia and Tampakan in the Philippines), porphyry Cu-Mo-Au deposits (Sar Cheshmeh in Iran, Dexing in eastern China, and Jiama in southern Tibet), porphyry Cu-Mo deposits (Sungun in Iran and Qulong in southern Tibet), and porphyry Mo deposits (Nannihu and Yuchiling in central China). The most effective ore-fertility indicators are zircon Eu/Eu*, Ce/Nd, Dy/Yb, (Eu/Eu*)/Y, and (Ce/Nd)/Y ratios. In particular, fertile magmatic suites have collectively higher zircon Eu/Eu* (>0.4), (Ce/Nd)/Y (>0.01), 10,000 · (Eu/Eu*)/Y (>1), and lower Dy/Yb (<0.3) ratios than infertile suites. In fertile suites, the zircon (Eu/Eu*)/Y ratio is positively correlated with the (Ce/Nd)/Y ratio; the correlation is lacking in the infertile suites. These zircon trace element ratios are proposed to be proxies for the hydration state of the magmas. 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 have higher Mo content in zircon (>1 ppm, up to 75 ppm) than Mo-poor porphyry systems and infertile suites, indicating that Mo content in zircon is a potential pathfinder to giant porphyry Mo systems. The zircon Mo/Ti ratio has a broad positive correlation with the oxygen fugacity of the magma, indicating that the Mo/Ti ratio may be used as a proxy for the oxidation states of the melt. These new data provide a relevant boost in the exploration kit arsenal of porphyry explorers, both at the

detection and predictive scale. There is significant potential for translation of this knowledge into ongoing exploration campaigns that utilize the detrital record as the primary means of sample analysis.