Delamerian Porphyry Mineral Systems in South Australia: What Can Magmatic Mineral Chemistry Deliver on Fertility and Exploration?

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Paleozoic porphyry-style hydrothermal alteration was previously recognized in the Delamerian Orogen, South Australia in late 1960s-1970s, where porphyry prospects include Anabama Hill, Netley Hill, and Bendigo. However, limited exploration due in part to thick postmineralization cover hindered the understanding of the temporal context, metallogenic setting, and mineral potential of the porphyry systems along the Proterozoic continental margin of Australia. We have characterized the hydrothermal alteration and mineralization of these porphyry occurrences, and conducted microanalyses of zircon, apatite, molybdenite, and white mica. Zircon U-Pb analyses reveal that the intrusive rocks were emplaced mostly between 490 and 465 Ma. Molybdenite Re-Os dating identifies two Cu-Mo mineralization events at 480 and 470–460 Ma, respectively. In situ white mica Rb-Sr LA-ICP-MS/MS analyses return two age ranges: 470–460 and 455–435 Ma for phyllic alteration at these prospects. Zircon grains are characterized by heavy REEs enrichment relative to light REEs, high (Ce/Nd)N (1.3–45), and weak to moderate negative Eu/Eu* (0.2–0.78). Apatite crystals have Mn contents of 110–10,900 ppm, Y of 130–5,350 ppm, light REEs of 100–780 ppm, heavy REEs of 10–40 ppm, low Mg (< 670 ppm), and Sr/Y ratios (<5). The zircon and apatite chemistry results suggest that both Anabama and Bendigo complexes experienced prevalent (garnet-) amphibole crystallization from hydrous melts that have moderately high oxidation state (ΔFMQ +1 to +3) and elevated magmatic sulfur-chlorine components. The Delamerian porphyry systems are interpreted to have post-dated subduction-related magmatism in the region (514–490 Ma), forming within an inverted back arc regime. Porphyritic stocks, dikes, and aplites with ages of 470–460 Ma are the most likely hosts to porphyry-style mineralization. These results highlight the significance and potential of Early-Middle Ordovician intrusive systems to produce magmatic-hydrothermal mineralization in the Delamerian Orogen.