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CA-TIMS and LA-ICP-MS (zircon) Characterization of Host Volcanic Rock Sequences and Porphyry Intrusions in the Eastern Timok Porphyry Cu-Au District

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The eastern Timok area of Serbia is underlain by Upper Cretaceous intrusive and volcanic rocks that compose the Timok Magmatic Complex. These rocks host large copper-gold porphyry and high-sulfidation epithermal deposits, including Cerovo, Veliki Krivelj, Borska Reka, Tilva Ros, and Cukaru Peki. We have characterized igneous rock suites from the eastern Timok and have assigned them to chronometrically constrained igneous rock sequences. We divide the rock units into 1) an intermediate composition volcanoclastic host-rock sequence, 2) a hornblende megacrystic porphyritic diorite phase, and 3) a biotite diorite porphyry phase. The Hb diorite and Bt diorite porphyry units form an axis of porphyry intrusions spatially associated with 18 km of mineralization centers of the eastern Timok (Cukaru Peki-Cerovo trend).

Chemical abrasion TIMS (zircon) data indicate that mineralized andesite volcanoclastic host rocks for the Borska Reka/Tilva Ros deposits are 85.0 ± 0.1 to 85.6 ± 0.1 Ma. The two porphyry phases are each 82 ± 1 Ma (LA-ICP-MS; zircon), consistent with crosscutting relationships. In the Bor Cu-Au camp, the Bt diorite porphyry predates hydrothermal alteration as it is cut by potassium-feldspar veins. The Hb diorite porphyry is the host rock for the Cerovo Cu-Au deposit and is therefore also premineralization.

The Ti-in-zircon thermometer indicates that most analytical points are between 600° and 800°C. The porphyry intrusions lie within a more restricted range (650°-750°C), whereas most of the outlier data (hotter and cooler than this range) are from the volcanoclastic host-rock zircons. Most of the Yb/Gd ratios in these rocks fall between 30 and 75, and the Th/U ratios mostly lie in the range of 0.15 to 0.70. The three rock units each display distinct zircon trace element characteristics and trends.

Zircon trace element data such as Ce/Ce_N* values >100 and Eu/Eu_N* values >0.4 (associated with high magmatic oxidation states) have been observed in porphyry copper deposits globally. Trace element in-zircon data from the eastern Timok indicate that Eu/Eu_N* values for the magmatic phases are typically 0.4 to 1 and that cerium anomalies lie mostly between 0 and 400.

The eastern Timok rocks are characterized by high-oxidation-state magma chemistry. Eruption and emplacement of supracrustal host rocks occurred at ~85 Ma at Bor, which was followed by intrusion of porphyry phases within 2 to 4 million years afterwards. In the Bor and Cerovo areas, alteration and Cu-Au mineralization are younger than 82 ± 1 Ma. Discrete magmatic lineages are identified in the eastern Timok (based on zircon trace element composition), despite short time frames for emplacement and overlapping spatial distribution within the Cukaru Peki-Cerovo trend. The trace element data distinguish between the host volcanoclastic rocks and the porphyry intrusive phases that postdate them. Low-viscosity, water- and volatile-rich dynamic magma chambers may yield igneous rock complexes such as the Timok, with mixed zircon populations from multiple chemical domains, emplaced in short time periods.