Cryptic Sediment-Hosted Critical Metal Mineralization from SW China: A Likely Hidden Giant Resource

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Nb-Zr-REY dominant polymetallic mineralization occurs within Late Permian strata in eastern Yunnan Province, SW China. Mineralization occurs as relatively thick layers (mostly 2–5m) within the lowest Xuanwei Formation (major coal-bearing unit in eastern Yunnan) and has been studied in a number of widely spaced (up to 200 km apart; closest are 50 km apart) regional coal exploration drill holes. The mineralization was initially detected from gamma ray logging associated with coal exploration. Based on the available 12 drill holes, the depth to mineralization from the surface varies from ~350 to ~750 m. However, the host Xuanwei Formation crops out elsewhere in the region.

The mineralization is of a truly cryptic nature, with no visible signs of any associated alteration, veins, or visible distinction between ore layers and wall rocks. The host rocks comprise a relatively uniform conformable layered sequence of clay-altered volcanic ash (argillites, tuffaceous claystones), siltstones, fine sandstones, carb-argillites and basal hematite breccias. Some of the finer-grained siltstones contain well-preserved fossil leaves. The sequence unconformably overlies the eroded/weathered top of the Late Permian Emeishan volcanic sequence. The mineralized rocks contain clay minerals (60-92%; dominantly mixed-layer illite/smectite, kaolinite, berthierine), quartz, anatase, calcite and hematite, along with trace pyrite, barite, zircon, galena, chalcopyrite, rhabdophane and florencite. Evidence of a primary pyroclastic origin is in the form of beta-quartz with high-temperature embayments and high-temperature cracks, shard-like mineral fragments and high-T fractures.

Compared to average UCC, all samples are higher in Al_2O_3 and Fe_2O_3 and lower in total alkalis. Although the drill holes are widely spaced, the geochemistry and even elemental ratios (Nb/Ta, Zr/Hf, Th/U) are remarkably consistent with the following average values (in ppm): Zr (2814-3300), Nb (393-494), Ta (23-33), Th (66-88), U (16-24), Ga (70-78), Hf (69-83) and REY (1402-3000). These concentrations reach marginal to industrial grades according to China industrial standards. Critically, even within the non-ore layers, concentrations of Zr (200-1600) and Ga (28-51) are very high when compared to average upper continental crust. All samples have strongly negative UCC-normalized Eu anomalies and are of the medium-heavy REY enrichment types.

The remarkable geochemical consistency over such a large area, combined with petrographic/SEM evidence, strongly suggests that the mineralization is largely of a primary nature and was derived from mineralized tuffaceous fragments. Subsequent diagenesis and basin-wide ingress of low-T hydrothermal (i.e., syngenetic and epigenetic) fluids then led to remobilization of some of the components, mostly the major elements but with minor effects on the critical elements.

As far as we are aware, this is a completely new type of critical element deposit. However, the mineralization in some ways is similar to critical metal-rich alkaline tonsteins associated with coal-bearing sequences throughout SW China and in southern Primorye, Russia. This critical element mineralization type may also exist elsewhere in the world, associated with the waning stages of LIP magmatism. The fact that strata-bound mineralization with a remarkably high and consistent critical

element geochemistry occurs over an area of at least 12 000 km^2 suggests that this is truly a hidden world-class giant critical element deposit.