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Unconventional sediment-hosted critical element mineralisation – Insights from the Far East

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The demand for critical elements (Nb-Ta-Zr-Hf-REY-Ga) is increasing significantly due to their use in green technologies, with green energy applications contributing more to the global energy market each year. It is well-known that most occurrences of these elements are in primary magmatic environments involving highly fractionated syenitic and carbonatitic magmas (and their weathered correlatives), in hydrothermal vein systems, and in sedimentary environments involving ion-absorption onto clays. In this presentation, we will discuss a number of sediment-hosted environments from the Far East which contain large resources of critical elements that may, with cost-effective extraction processes, become viable economic deposits in the near future. The two main types are 1) coal and associated sedimentary rocks and interbedded volcanic ash beds within coal deposits 2) a remarkable extensive conformable mineralised volcanic ash bed associated with the waning stages of the Emeishan Large Igneous Province. Both types occur as conformable beds, and where shallow, are amenable to open-cut extraction methods.

In recent years, there has been much research on the occurrence of REE and Y (REY) within coals and coal ash products as their concentrations are sometimes equal to or higher than those within conventional types of REY deposits. The factors which have governed the occurrence and concentration of REY within coal beds includes the geochemistry of their terrigenous source rocks, influence of mantle plumes, ingress of hydrothermal fluids, influence of seawater, volcanic ash input, and the sedimentary environment of peat formation. Coals from SW China are especially enriched in REY, having twice the concentration of other coals from around the world (ave. REO of 485 ug/g). The critical elements within these sequences are either associated with clays or organic matter or occur as secondary minerals resulting from the alteration of primary phases under the influence of organic acids and hydrothermal fluids. Critical element concentrations can be in the order of 1-1.5% within the ash products from combustion of these coal deposits. The volcanic ash beds that sometimes occur as laterally extensive strata within these coal-bearing sequences can also contain significant concentrations of critical elements. The secondary REE minerals are generally carbonates or phosphates, although REE oxyhydroxides may also occur.

The Late Permian Xuanwei Formation of SW China unconformably overlies the Emeishan basalts and conformably underlies early Triassic strata. Within this formation are two laterally extensive conformable mineralised beds where the critical element concentration exceeds economic grades. The hostrocks are very fine-grained and non-descript, and there is a complete lack of any mineralisation. Mineralisation shows remarkably uniform concentrations, compositions and even elemental ratios over at least hundreds of square kilometres. A volcanic origin is indicated by the occurrence of volcanic shards, bipyramidal beta quartz and fragmented plagioclase crystals. The primary critical element host minerals include zircon (including remarkable spherulites (?gel zircon) less than 10 microns), apatite and a range of complex Ti-Nb

oxides. Critical element enrichment here is due the interaction of airborne alkaline volcanic ashes from the waning stages of the Emeishan LIP with later post-depositional low-T hydrothermal fluids.