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Differential trace element incorporation in sector-zoned zircon; selecting truly indicative petrogenetic indices

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Zircon is a chemically and physically resistant accessory mineral that is commonly used to date and characterise felsic rocks and associated metal ore deposits. The development of robust mineralisation vectors, however, relies on understanding the distribution of trace elements in zircon, which often show complexity such as sector zoning. Sector-zoned grains comprise cathodoluminescence (CL) -dark and -light prism sectors growing perpendicular to the c-axis, and CL-intermediate pyramid sectors growing along the c-axis. Sector-zoned zircon has bimodal distributions for the REE+Y, except Ce, which together with Zr, Hf, Ti and U appear to be sector independent. Here we investigate sector-constrained Andean detrital zircon data, demonstrating that: 1. the REE+Y and Th are enriched in dark prisms relative to light prisms and pyramids; 2. the extent of dark prism enrichment increases from heavy to light REE as ionic potential decreases; this observation reflects the preferential substitution of low charge density cations in protosites accompanied by in-plane oxygen atoms; 3. Aluminium is enriched in light prisms, where increased bond spacing within the zircon atomic lattice is interpreted to more easily accommodate the large Al cation in the Si site.

Assessing the role of sector zoning in zircon mineralisation vectors indicates that indices dependent on Ti, Zr, Hf, U and Ce remain robust as they are sector independent. Similarly, indices that ratio neighbouring REE with similar ionic potential show minor sector zoning effects (e.g. Eu/Eu*). In contrast, we caution the use of fertility signatures and petrogenetic indicators with elements that show variable sensitivity to sector zoning (e.g. Dy/Yb, (10^3xCe/Nd)/Y, (10^4xEu/Eu*)/Y) which may generate misleading trends. For instance, Ce/Pr (a proxy for Ce anomaly) shows three-fold enrichment in pyramid sectors relative to dark prism sectors, recording the marked enrichment in Pr in the latter. Intriguingly, the occurrence of sector zoning itself shows promise as a recorder of dynamic crystallisation conditions, including those conducive to the development of porphyry mineralisation.