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The search for rare earth elements: A phosphorite story

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Global supply of materials needed to address projected increases in development of high-tech and green technologies is currently falling short with many commodities, including rare earth elements (REE, lanthanide series plus Y), now deemed critical for the low-carbon future. A recent study [1] has identified phosphorite, a marine sedimentary rock with over 18-20 wt.% P_2O_5 currently mined as phosphate fertiliser, as a potential source of REEs. The primary mineral of phosphorite, carbonate fluorapatite (CFA), hosts the majority of the REEs that along with the ease of extraction of REEs from CFA, with possibility of REE extraction as a by-product of phosphate mining, makes phosphorites an attractive economic target. In addition, phosphorites also host a larger percentage of the more desirable middle and heavy REEs (Fig. 1a), thus increasing the economic potential of these rocks. The question then is, what causes the enrichment of REEs in phosphorites?

To answer this question, we examined the total concentrations and patterns of REEs in phosphorites of the Cambrian Georgina Basin in Australia. Phosphorites occur as a number of different exposures along the SE margin of the Georgina Basin, with some prospects currently being mined for phosphate fertiliser (e.g. Phosphate Hill). Basinal scale variation in total REE concentrations (up to two orders of magnitude) from the northern and central prospects towards the southern prospects is observed (Fig. 1b), with concentrations of up to 0.5 wt.% REE observed at Ardmore prospect in the south. Additionally, textural changes in the phosphorites also exist, with northern and central prospects largely of non-pelletal variety in contrast to largely pelletal phosphorites to the south. Differences in the textural nature of the phosphorites, along with the changes in the type of underlying basement rocks (mainly Paleoproterozoic carboniferous sediments in the north and granitic/metamorphic basement to the south) that may control the REE budgets of seawater, are here considered to be the main drivers of the REE enrichment in these phosphorites.

[1] Emsbo, et al. (2015), *Gondwana Research 27(2)*, 776-785.

[2] Seredin, V. V. (2010), *Geology of Ore Deposits 52(5)*, 428-433.

[3] Pourmand, et al. (2012), *Chemical Geology 291*, 38-54.

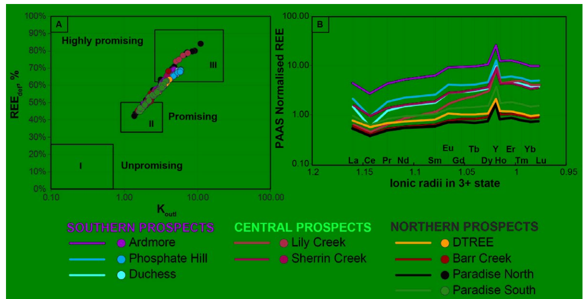

Figure 1: Rare earth element potential of phosphorites. **a**) REE prospectivity of the Georgina Basin phosphorites using the outlook coefficient [2], K_{outl} = (Nd+Eu+Tb+Dy+Er+Y)/(Ce+Ho+Tm+Yb+Lu) versus relative concentrations of critical metals REE_{def} % = (Nd+Eu+Tb+Dy+Er+Y)/ΣREE ×100; **b**) REE patterns normalised to Post Archean Australian Shale - PAAS [3].