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Potential rare earth element metallogenetic belts in Africa

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The rare earth elements (REE) are considered among some of the most critical metals, particularly those that are used in new technology and green energy applications. These include Nd, Dy and Pr for high-strength magnets, and Eu, Y and Tb for phosphors. However, the majority of current REE production is from carbonatites, which are dominated by the light REE (LREE), chiefly La and Ce. Supply of all the REE is concentrated in China, with almost all of the world's heavy REE (HREE) derived from Chinese ion-adsorption clay deposits. Despite intense global exploration efforts, it has proved difficult for mining projects outside China to commence REE production, due to a complex set of financial, environmental and technical issues. Africa has enormous potential for REE resources, and is relatively under-explored; this talk reviews the principal REE metallogenetic belts.

The majority of known bedrock REE resources tend to be associated with alkaline igneous and carbonatite provinces (>60% globally [1]), although rare deposits are known associated with non-alkaline granites and pegmatites. Many of these deposits also have an additional hydrothermal component, with some forming predominantly from hydrothermal fluids. A significant proportion of the world's known REE resources is associated with secondary deposits such as placers and laterites, but in these cases the secondary enrichment was originally derived from a primary bedrock deposit. On a global scale, many notable REE deposits (such as Ilímaussaq in Greenland, Mountain Pass in the USA, and Thor Lake in Canada) are found in alkaline igneous provinces formed around the margins of Archaean cratons, during the Palaeo- and Mesoproterozoic. The basement geology of Africa, with Archaean cratons surrounded by Proterozoic mobile belts, suggests potential for similar REE deposits; but examples are currently only known from South Africa and Botswana (e.g. Phalaborwa, Pilanesberg, and Glenover). It is very likely that REE deposits of this age remain to be discovered around the margins of the Congo, Tanzania and West African cratons. Examples that are not well-dated, and may fall into this group, include the carbonatites at Ngualla in Tanzania and Glibat Lafhouda in the Western (Moroccan) Sahara.

The majority of Africa's known REE deposits are associated with two significant episodes of alkaline magmatism, reviewed by Woolley [2]. The first occurred from the late Neoproterozoic into the Cambrian, and represents extensional stages during the Pan-African orogeny. Alkaline igneous rocks and carbonatites of this age are found in Pan-African belts across Africa, and potential REE deposits of this age include Mabounie in Gabon, Gakara/Karonge in Burundi, and Lofdal in Namibia. The most recent and best-known period of extensional magmatism in Africa extends from the Cretaceous into the Cenozoic. The highest concentration of alkaline igneous rocks and carbonatites of this age is found along the East African Rift, but many other areas are also known, including the Hoggar Province in Algeria, the Cameroon Line, and the Damaraland Province in Namibia. Many of Africa's most well-explored REE deposits were formed at this time, including Mrima Hill in Kenya, Tantalus in Madagascar, and Songwe

Hill in Malawi. However, many igneous provinces of this age are only shallowly eroded, with volcanic rocks at the surface; the alkaline magma chambers that may have significant REE potential are rarely exposed. It is also notable that the most advanced REE projects in Africa are in carbonatites, which are dominated by the less critical LREE. We suggest that Africa's REE potential is not yet fully understood, and that there is significant scope for future targeted exploration around craton margins and at depth in younger rift zones.

References:

[1] Weng, Z, et al. (2015) Economic Geology 110: 1925-1952

[2] Woolley, A. (2001) *Alkaline Rocks and Carbonatites of the World Part 3: Africa*