

## Potential deposits of the rare earth elements and associated critical metals in the circum-Mediterranean regions

K.M. Goodenough

British Geological Survey, Lyell Centre, Research Avenue South, Edinburgh EH14 4AP, UK

[kmgo@bgs.ac.uk](mailto:kmgo@bgs.ac.uk)

The 'critical metals' are those metals for which demand is increasing, typically due to their use in green and high-tech applications, and for which there are concerns about supply risk. Several different methods have been used to estimate criticality (e.g. EC, 2014; Graedel et al., 2015). Virtually all studies place the rare earth elements (REE) among the most critical of all raw materials, due to the concentration of their production in China. Other critical metals that may be found in association with the REE include niobium (Nb) and tantalum (Ta).

Currently, the markets for these critical metals are relatively small, and global supply comes from only a handful of mines. However, their importance in technological applications means that demand is likely to continue to grow into the future. At present there are no REE, Nb or Ta mines in Europe or North Africa. However, this does not reflect a lack of deposits of these metals. In fact, the EC-funded EURARE project's recent review of REE metallogenetic belts in Europe highlights the significant potential for critical metal deposits (Goodenough et al., 2016).

Potential deposits of the REE, Nb and Ta can be divided into primary and secondary deposits. Primary deposits are those formed by magmatic, hydrothermal and/or metamorphic processes. These deposits are most commonly associated with alkaline igneous rocks and carbonatites, emplaced into extensional settings. Some deposits, particularly of Ta, are associated with syn- to post-collisional granites and pegmatites. In the Mediterranean area, the majority of alkaline-carbonatite provinces are relatively young (Mesozoic-Cenozoic) and are not deeply eroded, with volcanic superstructures still preserved. It is likely that critical metal deposits may exist at depth in these volcanic systems, and the newly-established EC-funded H2020 HiTech AlkCarb project aims to improve the models for such deposits.

Secondary deposits are those formed by erosion and weathering and may include placers, laterites and bauxites. Deposits of this kind are relatively common around the Mediterranean, but have been little studied and deserve further investigation. Such deposits are attractive as the ores can be relatively easily extracted and processed, and may represent significant concentrations of the critical metals. This talk will review some of the main REE, Nb and Ta deposits in Europe and North Africa, and will show that there is significant potential for this area to contribute to future supply of these metals.

EC, 2014. Report on critical metals for the EU. [http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical/index\\_en.htm](http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical/index_en.htm)

Goodenough, K. M., et al. 2016. Europe's rare earth element resource potential: An overview of REE metallogenetic provinces and their geodynamic setting. *Ore Geology Reviews* 72, Part 1, 838-856.

Graedel, T. E., Harper, E. M., Nassar, N. T., Nuss, P., Reck, B. K., 2015. Criticality of metals and metalloids. *Proceedings of the National Academy of Sciences* 112, 4257-4262.