Tapio Halkoaho (Geological Survey of Finland) 27 November 2022

Commodity	**Scandium (Sc)**	**Data source**
Significance for the EU (2023)	*Critical, not strategic*	
Uses of the commodity	Main uses: *Solid-oxide fuel cells (SOFCs) 90 %, aluminium-scandium alloys 9 %* Minor uses: *Ceramics, electronics, lasers, lighting, and radioactive isotopes.* Future uses: *Al-Sc alloys, fuel cells, electronics*	Latunussa et al. (2020), USGS (2022)
Resources and potential in Nordic countries	Finland: *Known resources: 2,184 t, possible additional potential in Ti, REE, and P deposits.* Norway*:* *Known resources: 6.5 t, possible potential in Ti, Nb, REE, and P deposits* Greenland and Sweden: *No indications of Sc occurrences, except small pegmatites; possible potential exists in REE, P, and Ti deposits.* *The resource figures above are very conservative minimum estimates; comprehensive Sc grades are not known for almost all of the Nordic Ti, Nb, REE, and P deposits.*	Åmli (1977), Hokka & Halkoaho (2016), Eilu et al. (2021, 2022)
Anthropogenic resources and potential in Nordic countries	*None known*	
Main deposit types in Nordic countries	*Ferromonzodiorites, albite rocks, granite pegmatites, peralkaline intrusions, carbonatites*	Åmli (1977), Raade et al. (2002), Hokka & Halkoaho (2016), Eilu et al. (2021, 2022)
Main global deposit types	*Ni-Co laterite, bauxite, and placer deposits, carbonatites and weathering caps of alkaline carbonatite complexes, granite-related pegmatites and hydrothermal veins, metasomatic rocks such as albitite, greisen, and ferro(monzo)diorites and syenites.*	Williams-Jones & Vasyukova (2018), Halkoaho et al. (2020), Wang et al. (2021), RTZ (2022)
Global production (2022)	*A few tens of tonnes scandium oxide, exclusively as a by-product from processing of various ores and recovered from previously processed tailings or residues. No recent mine production data available; refinery production data only partial and ambiguous.*	Williams-Jones & Vasyukova (2018), USGS (2023)
Nordic production (2022)	*No current mine nor refinery or smelter production.*	
Main producing countries (2021)	*China (about 85 %?), Philippines, Russia, Canada. Production and trade of Sc are not transparent, so production figures and trade within and between countries are uncertain.*	Latunussa et al. (2020), Wang et al. (2021), Rio Tinto (2022), USGS (2022)

Technological challenges in production	*Immature, apparently complicated and energy-hungry production technology. Scandium has always been a by-product. The enrichment processes for scandium deposits are mostly incomplete.*	Latunussa et al. (2020)
Recycling	*None known*	Latunussa et al. (2020)

References

Åmli R. 1977. Carbonatites, a possible source of scandium as indicated by Sc mineralization in the Fen Peralkaline complex, southern Norway. Econ. Geol. 72, 855–859.

FODD 2020. Fennoscandian Ore Deposit Database. Annual update (end-2019 data). https://www.gtk.fi/en/fennoscandian-mineral-deposits-application-ore-deposits-database-and-maps/

Eilu, P., Bjerkgård, T., Franzson, H., Gautneb, H., Häkkinen, T., Jonsson, E., Keiding, J.K., Pokki, J., Raaness, A., Reginiussen, H., Róbertsdóttir, B.G., Rosa, D., Sadeghi, M., Sandstad, J.S., Stendal, H., Þórhallsson, E.R. & Törmänen T. 2021. The Nordic supply potential of critical metals and minerals for a Green Energy Transition. Nordic Innovation Report. 93 p. https://norden.diva-portal.org/smash/get/diva2:1593571/FULLTEXT02

Eilu, P., Hallberg, A., Bergman, T., Bjerkgård, T., Reginiussen, H., Sandstad, J.S. 2022. Nordic Ore Deposit Database. Annual update (end-2021 data). https://gtkdata.gtk.fi/fmd/

Halkoaho T., Ahven, M., Rämö O.T. and Huhma, H. 2020. Petrology, geochemistry, and geochronology of the Sc-enriched Kiviniemi ferrodiorite intrusion, eastern Finland. Mineralium Deposita 55, 1561–1580. https://doi.org/10.1007/s00126-020-00952-2

Hokka, J. & Halkoaho, T. 2016. 3D modelling and mineral resource estimation of the Kiviniemi scandium deposit, Eastern Finland. Geol. Surv. Finland Rep. 65/2015. 16 p.

Latunussa, C.E.L., Georgitzikis, K., Torres de Matos, C., Grohol, M., Eynard, U., Wittmer, D., Mancini, L., Unguru, M., Pavel, C., Carrara, S., Mathieux, F., Pennington, D. & Blengini, G.A. 2020. European Commission, Study on the EU's list of Critical Raw Materials, Factsheets on Critical Raw Materials. 819 p. https://rmis.jrc.ec.europa.eu/uploads/CRM_2020_Factsheets_critical_Final.pdf

Raade, G., Ferraris, G., Gula, A., Ivaldi, G. & Bernhard, F. 2002. Kristiansenite, a new calcium–scandium–tin sorosilicate from granite pegmatite in Tørdal, Telemark, Norway. Mineral. Petrol. 75, 89–99.

Rio Tinto 2022. Media release 6 May 2022. https://www.riotinto.com/news/releases/2022/Rio-Tinto-becomes-the-first-producer-of-scandium-oxide-in-North-America

USGS 2022. Mineral commodity summaries 2022. U.S. Geological Survey. 202 p. https://doi.org/10.3133/mcs2022

USGS 2023. Mineral commodity summaries 2023. U.S. Geological Survey. 210 p. pubs.usgs.gov/periodicals/mcs2023

Wang, Z. Li, M.Y.H., Liu, Z.R.R. & Zhou, M.F. 2021. Scandium: Ore deposits, the pivotal role of magmatic enrichment and future exploration. Ore Geol. Rev. 128, 103906. https://doi.org/10.1016/j.oregeorev.2020.103906

Williams-Jones A.E. & Vasyukova, O.V. 2018. The economic geology of scandium, the hunt of the rare earth element litter. Econ. Geol. 113, 973–988. https://doi.org/10.5382/econgeo.2018.4579