

REE and sulfide mineralization in the nelsonite from the Suwałki Anorthosite Massif, NE Poland: Implications of magmatic and hydrothermal processes

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Nelsonites are Fe-Ti-P-rich igneous rocks occurring in anorthosite massifs, typically composed of apatite, ilmenite, and magnetite. They are of economic interest due to their phosphorus, titanium, and rare earth element (REE) content. This study presents new data on the nelsonite from the Łopuchowo drill core [1,2], located in the Mesoproterozoic Suwałki Anorthosite Massif, part of the Mazury anorthosite–monzonite–charnockite–granite (AMCG) complex in northeastern Poland.

The fine-grained Łopuchowo nelsonite occurs as several veins within anorthosites and norites at depths >2100 m. It contains exceptionally high sulfide content (10–14 vol.%), with (Ni-bearing) pyrite, chalcopyrite, pyrrhotite, and minor millerite and sphalerite. Fe-Ti oxides constitute 12–15 vol.%, while fluoroapatite ~70 vol.% [1,2]. Accessory minerals include biotite, quartz, allanite, and chlorite. Sulfides are rimmed by monazite-group minerals containing -OH groups, suggesting rhabdophane.

Geochemical analyses reveal extremely high REE contents of 7530–7700 ppm (LREE = 5600–5700 ppm, HREE+Y = 1930–2000 ppm). Fluoroapatite exhibits zoning; cores contain 0.61–1.58 wt.% REE₂O₃ and 0.32–0.98 wt.% SiO₂, whereas rims are depleted in REE and Si (0.54–0.77 wt.% REE₂O₃, 0.22–0.40 wt.% SiO₂). The presence of rhabdophane correlates with elevated Pb (8.23–8.82 ppm) and U (9.0–9.6 ppm) content. The high sulfides content provide the enrichment in Ni (2270–2470 ppm), Co (221–225 ppm), Zn (166–212 ppm), and Cu (2710–3332 ppm). Additionally, nelsonite exhibits high Au (52–70 ppb), Ag (402–507 ppb), Re (26–28 ppb), and Pd (29–35 ppb). Elevated Cr (1825–2000 ppm) and V (485–620 ppm) are linked to magnetite and ilmenite.

The Łopuchowo occurrence represents a rare example of sulfide-rich nelsonite with extreme REE enrichment, suggesting a complex crystallization history influenced by magmatic and hydrothermal processes, offering new insights into nelsonite petrogenesis and its potential as a resource for critical raw materials.

References:

- [1] Krzemiński, Tyda & Wiszniewska (1988), *Mineralogia Polonica* 19, 2, 35–50.
- [2] Wiszniewska (1997), *Przegląd Geologiczny* 45, 8, 883–893.