MINERALOGICAL AND GEOCHEMICAL STUDY ON CARBONATITES AND FENITES FROM THE KAULUS DRILL CORES, SOKLI COMPLEX, NE FINLAND

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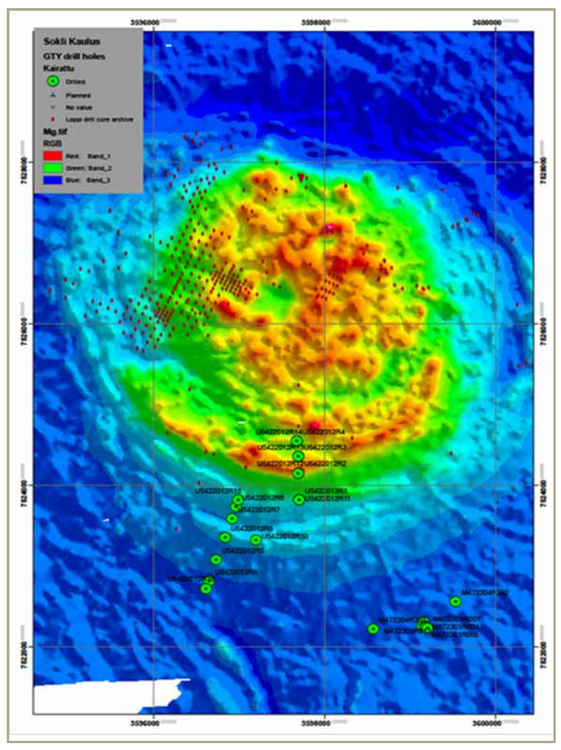
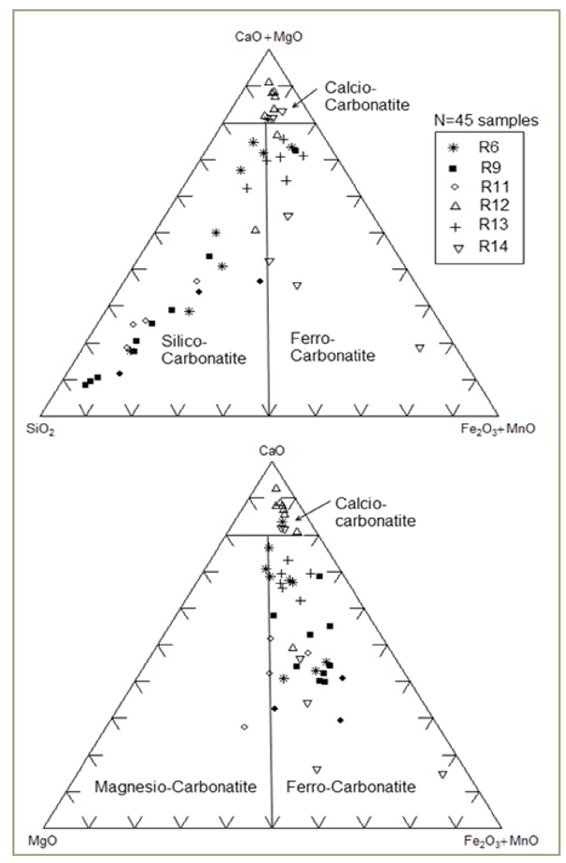
INTRODUCTION

The Kaulus prospect is located in the metasomatite and fenite zones in the southern part of the Sokli carbonatite Complex. Bedrock consists of Archaean mafic volcanic rocks and tonalitic gneiss, which were intruded by the Devonian Sokli carbonatite causing a large scale, intense fenitization of the country rocks (Vartiainen, 2001). The late-stage carbonatite veins dykes in the central fracture zone and in the fenite zone of the Sokli complex have a high potential for REE mineralisation (Al-Ani and Sarapää 2013). The studied samples which are are composed of carbonatite- breccias, fenites and partly highly altered and weathered, clay-rich rocks were obtained from six drill cores R6,R9,R11,R12,R13, R14.



Location of the studied drill cores in the high density low-altitude aeromagnetic map of the Sokli complex.

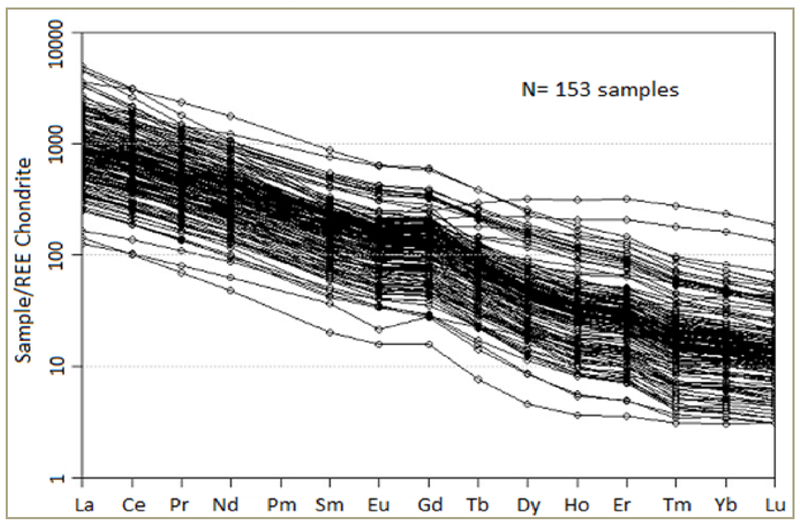


Ternary diagrams of major-element concentration data, Sokli carbonatite complex, Finland.

GEOCHEMISTRY AND MINERALOGY

New geochemical analyses indicate that the carbonatite dykes in Sokli Complex are enriched in incompatible elements, such as P2O5 (19.9 wt-% max), Sr (1.9 wt-%), Ba (6.8 wt-%), Zn (0.3 wt-%) and REE (1.8 wt-% max). The samples show a high total REE content of 0.11-1.83 wt-%, including 0.11-1.81 wt-% LREE and 0.002-0.041 wt-% HREE (Sarapää et al. 2013). Bulk chemical evidence suggests that most rock types are varieties of carbonatite that range in composition from silico-carbonatite to ferro- and calico-carbonatite. Calcio carbonatite dykes are characterized by enrichment in calcite (15–84 vol. %), subordinate dolomite, and locally plenty of apatite (up to 50 %) and remarkable suite of REE-minerals such as ancylite-(Ce), calcioancylite-(Ce), monazite, allanite, pyrochlore, strontianite and barite.

Chondrite-normalised REE patterns of the studied borehole of Sokli Complex

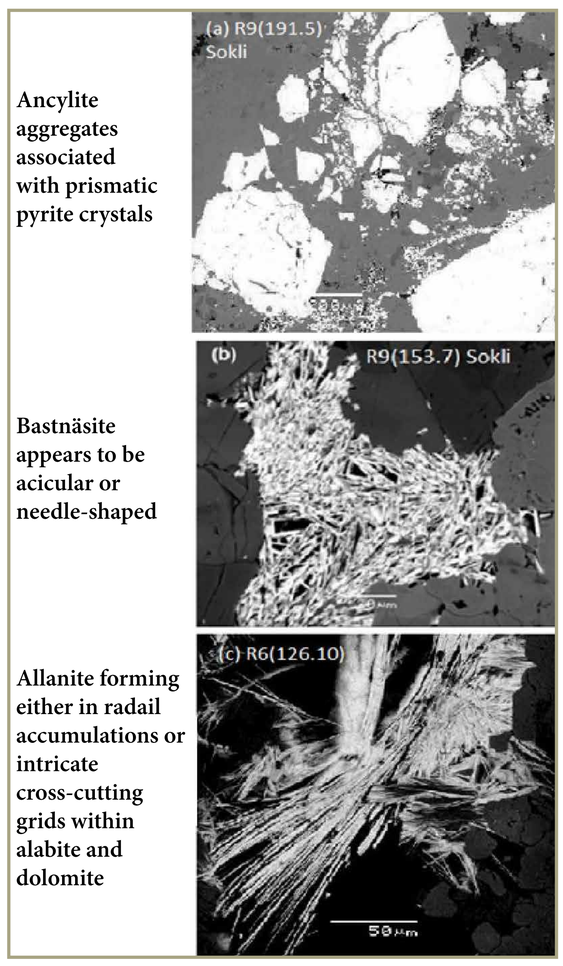


REE Ratios	Min	Max	Avg
Sum_REE	293.1	3627.8	935.9
Eu/Eu*	0.8	1.1	0.9
(La/Yb)N	9.3	304.7	45.8
(La/Sm)N	0.9	9.8	4.0
(Eu/Yb)N	3.7	20.8	8.2

Carbonatites from 6 drill holes have remarkably similar REE distribution. They are characterized by LREE enriched patterns and HREE-depleted. The REE distribution is controlled by carbonate and apatite content. The lack of a strong negative Eu anomaly suggests that silicate minerals may have not play in a more important role for REE enrichment in Sokli carbonatites rocks.

MINERALOGY

The REE minerals that occur in the Kaulus drill cores are almost entirely LREE ancylite-(Ce), calcioancylite-(Ce), monazite, allanite and bastnäsite (Ce). Ancylite-(Ce) is the most common in carbonatite veins and occurs as coarse grained phenocrysts with an average diameter of 300 µm and commonly associated with barite, strontianite and pyrite. Bastnäsite and allanite in the studied carbonatite veins and fenites appears to be acicular or needle-shaped forming either in radial accumulations or intricate cross-cutting grids within albite and dolomite.



Ancylite aggregates associated with prismatic pyrite crystals

Bastnäsite appears to be acicular or needle-shaped

Allanite forming either in radail accumulations or intricate cross-cutting grids within alabite and dolomite

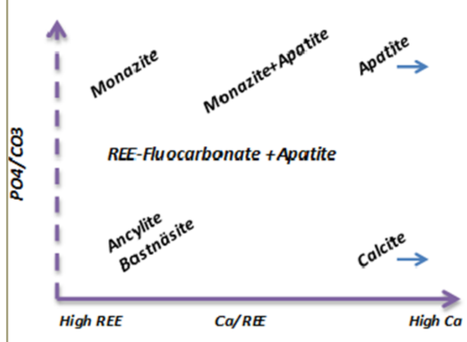
MINERAL CHEMISTRY

Ancylite-Ce is a hydrous carbonate containing REE and Sr as major cations, 28 wt% Ce2O3, 13.6 wt% La2O3, 7.4 wt% Nd2O3, Pr2O3 2.4% and 12.4 wt% SrO. Bastnäsite is strongly enriched in LREE (63.3 wt%) and fluorine. All P2O5 is assumed to be concentrated in monazite with LREE (50 wt%) and CaO (8.3 wt%).

SUMMARY

Detailed mineralogical investigations revealed three distinct types of REE-mineralization as phosphates, carbonates and silicates in the Kaulusarea. Mineralogical and mineral chemical evidence demonstrates that hydrothermal processes were responsible for the REE mineralization in studied rocks and confirms that such processes are predominant in the formation of REE minerals in carbonatites, silico-carbonatite and fenite rocks. During late-stage processes apatite and carbonate minerals have been replaced by various assemblages of REE–Sr–Ba minerals in carbonatite.

Oxides	Ancylite(Ce)	Bastnäsite(Ce)	Monazite(Ce)
CaO	1.9	2.3	8.3
SrO	12.4	15.1	0.9
BaO	0.8	0.9	0.5
P2O5	1.7	0.45	20.6
Ce2O3	27.8	33.2	25.2
Nd2O3	7.4	9.8	7.5
La2O3	13.6	16.2	13.3
Pr2O3	2.4	4.1	3.3
F	0.6	5.2	0.5
Total	70.9	87.25	89.6



Compositional relationships between rare earth minerals In Sokli Complex.

REFERNCES

Al Ani, T., and Sarapää, O., 2013. Geochemistry and mineral phases of REE in Jammi carbonatite veins and fenites, southern end of the Sokli complex, NE Finland. Geochemistry: Exploration, Environment, Analysis13, 217-224.

Sarapää, O., Al Ani, T., Lahti, S., Lauri, L., Sarala, P., Torppa, A., Kontinen, A., 2013. Rare earth exploration potential in Finland. Journal of Geochemical Exploration 133, 25-41.

Vartiainen, H., 2001. Sokli carbonatite complex, northern Finland. Res Terrae. Ser. A 20, University of Oulu, 8-24.

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