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The mineral deposits of strategic metals are vulnerable to political and economic changes, and their availability is essential for high-technology, green energy, and other applications. The most of them are related to the deep-seated alkaline magmas. This book offers a collection of papers presented at the 36th International Conference on “Magmatism of the Earth and Related Strategic Metal Deposits” held from May 23th to 26th 2019 in Saint Petersburg State University, Saint Petersburg, Russia. The conference articles are focused on the understanding of the geological processes that produce high concentrations of critical metals in geological systems such as the metal transport in the mantle and crust and enrichment processes, hydrothermal and metasomatic processes leading to the formation of such significant deposits. Papers in this book give a representative overview including mineralogy, geochemistry and origin of strategic metals deposits.

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The cover pictures – View down the Neva to the river between the Winter house of its Imperial Majesty and Academy of Sciences. G.A. Kachalov's engraving according to M.I. Makhayev's drawing (approx. 1750-1752).

Zr-CONTAINING SILICATES IN KIMBERLITE PIPE SEITAPERÄ (KUHMO CLUSTER, FINLAND)

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The largest (6.9 ha) of diamond-containing body in Finland is pipe Seitaperä at present, which is located in the Kuhmo-Lentiira area (Eastern Finland). The body was made by orangeites (kimberlites of group II) (O'Brien, 2015). The age of rock formation was 1202±3 million years (⁴⁰Ar/³⁹Ar phlogopite analysis) (Phillips et al., 2017).

The studied rocks are composed of phenocrysts (up to 0.5-0.8 sm) of phlogopite (8,6-10,5 wt.% FeO*, 3,1-5,8 wt.% TiO₂), less often – clinopyroxene (Mg#=81-85,8; Ca#=53,3-54,8) and completely modified olivine, immersed in a fine-grained binder mass of phlogopite, carbonate, serpentine, diopside, numerous small (up to 70-100 microns) grains of oxide minerals and Sr-containing apatite (1,3-1,4 wt.% SrO), as well as rare selections Ba-Ca-carbonate phases.

Among oxide minerals prevail: zonal perovskite, usually enriched with rare-earth elements (up to 1,2-5,1 wt.% REE₂O₃ in grain centers), and titanomagnetite (up to 15 wt.% TiO₂, 5.2 wt.% MnO), rarely zoned grains of chrome spinel. The cores of the latter contain 39.7-46.0 wt.% Cr₂O₃, and 8.4-9.7 wt.% Al₂O₃, 4,9-6,1 wt.% TiO₂, 7,4-11,6 wt.% MgO (Cr# = 74,0-77,7), boundary (rim) zones are composed by titanomagnetite. There are rare grains of Mn-containing magnesium ilmenite (6,0-6,7 wt.% MgO, and 2.3-2.5 wt.% MnO, up to 0.6 wt.% Cr₂O₃ and 4,5 wt.% Fe₂O₃).

Rare grains of Zr-silicates up to 120 µm in size were found in the bonding mass of the rock. Grains are idiomorphic, pseudo-hexagonal, heterogeneous in composition and in all cases partially or almost completely changed.

For pic. 1 the BSE image of one of the least modified grains of Zr-silicates containing the inclusions of perovskite and apatite of 10-15 µm size is presented.

For the main unchanged part of the grain (an. 5-6 in figure. and table.) relatively constant SiO₂ content (41.6-42.6 wt. %) and ZrO₂ (30.8-31.5 wt. %) at variable CaO contents (7.7-12 wt. %), Na₂O (1-4 wt. %), TiO₂ (0-1, 4 wt. %) and FeO_Σ (0.4-1.8 wt. %). The chemical composition of such sites and results of calculation of crystal chemical formulas testify to belonging of the mineral composing them to Ca-catapleite (Ca,Na)_{1+x}ZrSi₃O₉·2H₂O.

Table 1. Composition of Zr-containing silicate (mineral diagnostics is a preliminary).

oxide %	Ca-catapleite		Wadeite	Mixture of primary Ca-catapleite, Mg-hydrosilicates and Fe-containing minerals		NaCa-Zr- and K-Zr silicate			
	5	6	7	4	8	38	39	40	46
SiO ₂	34,2	21,7	20,2	34,6	35,0	42,6	41,6	44,5	32,8
TiO ₂	0,7	0,9	0,7	0,5	n.d	n.d	1,4	1,0	1,8
ZrO ₂	32,5	44,2	51,0	30,2	31,9	30,8	31,5	32,7	45,0
Al ₂ O ₃	1,0	0,7	1,1	1,2	1,0	n.d	n.d	n.d	0,7
FeO*	3,6	3,8	3,6	3,8	5,6	1,8	0,4	n.d	2,4
MnO	n.d	0,7	0,6	0,2	n.d	n.d	n.d	n.d	n.d
MgO	13,3	9,3	9,8	13,8	12,0	n.d	n.d	n.d	3,6
CaO	1,7	7,4	4,3	1,6	1,5	7,7	12,0	3,2	3,0
Ce ₂ O ₃	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	1,2
Na ₂ O	n.d	n.d	n.d	n.d	n.d	4,0	1,0	n.d	0,2
K ₂ O	n.d	n.d	n.d	n.d	n.d	n.d	n.d	11,3	n.d

n.d - not detected; EN. 4-8 – grain in Fig. 1 (> 100 µm), other – grains 40-60 µm.



Figure 1. The formation of Zr-silicate in serpentine-carbonate binder weight orangeite pipe Seitaperä. The image in the back scattered electrons (figures indicate the points of analysis in table. 1).

More bright in BSE image areas (an. 7 in Fig. and table.) with blurred boundaries contain about 44.5 wt.% SiO_2 and 32.7 wt.% ZrO_2 , but high in K_2O (up to 11.3 wt.%), low in CaO (up to 3.2 wt.%) and the absence of sodium. Perhaps they are wadeite $\text{K}_2\text{ZrSi}_3\text{O}_9$, while lower concentrations of K_2O and the amount of analysis may be due to underdeterminate amount of K_2O .

The changed areas along the grain edge with clear boundaries are composed by a micro grain porous aggregate of spongy appearance. Its composition (an. 4 and 8 in Fig. and table.) also characterized by a high content of ZrO_2 (31, 9-45 wt. %), stands out by the presence of varying amounts of MgO (from 4.8 to 12 wt. %), low contents of SiO_2 (a 32.8-35.0, wt. %) and CaO (1.5-3.0 wt. %). In the altered areas is increasing the content of FeO_2 (2,4-5,6 wt.%), sometimes – Ce_2O_3 (1,2 wt.%) and TiO_2 (1.8 wt.%). It is possible that a mixture of primary Ca-catapleite, Mg-hydrosilicates and Fe-containing minerals in different proportions, represents the aggregate of the changed sites. Thus, within the described grain there are several zones with more or less similar contents of Zr and Si, but contrasting contents of Na, K, Mg and Ca.

In the sample, there are pseudo-hexagonal grains, composed of micrograin aggregates, similar in composition to the above-described modified areas of grain in Fig. 1, but more widely varying in contents of Zr, Si, Mg and Ca (Ah. 38-40, 46 in table.). They are probably formed because of complete replacement of earlier NaCa-Zr and K-Zr silicates.

It is known that zirconium silicates are relatively common as late-stage groundmass minerals in orangeites (Mitchell, 1995). However, compositional and paragenetic data are few for them, especially for calcium zirconium silicate. Presence of grains of a calcium zirconium silicate (Ca-catapleite?) orangeite (Group II kimberlites) Seitaperä pipe (Pipe no. 16) it was assumed earlier (O'Brien and Tuni, 1999), but the composition of the mineral in the mentioned work was not cited and the features of its association were not discussed.

The data obtained by us is the first description of the grains of zirconium silicates found in the rocks of the pipe Seitaperä, indicating their complex structure and diversity of compositions. These preliminary data require further more detailed study, including an accurate diagnosis of minerals and clarify the conditions of their formation.

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