Preliminary information about the first finding Ti-bearing kirschsteinite (Fe-monticellite) in kimberlites

S.I. Kostrovitsky, L.A. Pavlova, L.V. Suvorova

Institute of Geochemistry, Siberian branch of Russian Academy, Irkutsk, Russia

First discovery of Mg-kirschsteinite was made in the melilite nephelinite from Congo. This mineral associates with pyroxene, melilite, kalsilite, sodalite, perovskite, apatite and other minerals (Sahama, Hytonen, 1957). Kirschsteinite from Congo contains 69.4 mole % $CaFeSiO_4$, 22.6 mole % $CaMgSiO_4$ and 4.3 mole % $CaMnSiO_4$. Kirschsteinite was later found (Konev et al, 1970) in carbonate skarn of the Tajeran area (Irkutsk region). It contained 47.8 mole % $CaMgSiO_4$, 48.5 mole % $CaFeSiO_4$, 3.7 mole % $CaMnSiO_4$. Ferromonticellite is also found (Sokolov, Sidorenko, 1997) in carbonatites; it contains up to 39.8 mole % $CaFeSiO_4$. It has been known (Nikishov, 1984; Egorov, Bogdanov, 1991; Mitchell, 1986), that monticellite in kimberlite rocks is the one of the most prevalent minerals of mesostasis showing variable composition when the content of kirschsteinite minal ($CaFeSiO_4$) ranges from 5 to 20 %.

Kirschsteinite was detected by micro-probe analysis of mineral composition of the kimberlite heavy fraction in the Beta pipe(North of Yakutian kimberlite province, Ari-Mastahsk field). In this pipe the fine-porphyry kimberlite with massive texture shows the following chemical composition (in wt%): SiO2 32.64-33.87; MgO 20.95-23.69; CaO 6.7-7.2; very high contents of total iron ($FeO+Fe_2O_3$ 15.5-17.6), TiO_2 (4.7-5.4); heightened contents of alkalis (K_2O 1.32-1.8, Na_2O 0.42-0.44), P_2O_5 1.05-1.18; very low CO2 0.55-0.8. Specific features of mineralogical composition are reflected in wide variations of olivine composition (8.5-15.5% FeO), and the presence of Ti-magnetite, perovskite, apatite and clinopyroxene in the groundmass. Ilmenite occurs infrequently and displays low (1-1.2%) abundance of MgO. Magnesian ilmenite occurs very infrequently.

Kirschsteinite is in a close association with perovskite and apatite and jointly with these minerals it commonly produced reaction zones around spinellide grains or forms polymineral inclusions in these grains. Much more seldom (only one grain has been found) kirschsteinite forms an independent phase.

The mineral composition was analyzed by the electron-microprobe device JCXA-733 at the Institute of Geochemistry, Irkutsk. Table 1 yields the results of the most representative analyses.

Representative Compositions of kirschsteinites from the pipe Beta

	Bt-33-2	Bt-68-1	Bt-68-2	Bt-77-1	Bt-91	Bt-98-1	Bt-98-2	Bt-110
SiO2	36.43	35.34	31.97	35.42	32.16	36.16	35.51	23.22
TiO2	0.29	1.22	9.14	1.74	6.35	0.65	1.73	21.86
Al2O3	4.86	1.29	0.60	3.16	1.38	2.37	1.86	0.75
Cr2O3	0.09	0.04	0.04	0	0.08	0.03	0.05	0.01
FeO	22.04	26.30	19.41	23.86	24.68	25.56	25.35	18.87
MgO	0.43	0.87	1.38	1.29	1.02	0.76	1.32	1.69
CaO	35.00	35.61	36.12	35.58	35.02	35.80	35.44	33.67
Total	99.14	100.67	98.66	101.05	100.69	101.33	101.26	100.07

Structural formulas based on 3 cations

Si	1.05	1.07	0.99	1.06	0.98	1.08	1.06	0.73
Ti	0.01	0.03	0.21	0.04	0.15	0.01	0.04	0.52
Al	0.17	0.05	0.02	0.11	0.05	0.08	0.07	0.03

Fe+2	0.53	0.66	0.50	0.60	0.63	0.64	0.63	0.50
Mg	0.02	0.04	0.06	0.06	0.05	0.03	0.06	0.08
Ca	1.08	1.15	1.20	1.14	1.15	1.15	1.14	1.14

The descriptions of the most interesting paragenetic interrelations of this mineral with other minerals are briefly provided below.

Sample Bt-33. Subidiomorphic grain of zonal heterogeneous spinel (dimensions 500 x 450 mkm) in the center consist of chrome spinellide (Cr_2O_3 43.6-58%), on the periphery (the zone is 10-50 mkm wide) it is Ti-magnetite, is surrounded by a discontinuous reaction rim, made up of kirschsteinite 50 x 50 and 100 x 30 mkm and perovskite plates (50 x 50 mkm).

Sample Bt-68. Subidiomorphic grain with rectangular section (450 x 300 mkm), totally built of kirschsteinite saturated with inclusions of idiomorphic and subidiomorphic apatite crystals (30õ15, 120õ20 mkm). Kirschsteinite shows varying contents of TiO_2, Al_2O_3. The peripheral rim is significantly enriched in titanium but is improverished in alumina.

Sample Bt-77. Subidiomorphic rounded grain of Ti-magnetite (430 x 400 mkm) containing elongated idiomorphic crystalline inclusions of apatite, kirschsteinite, partly serpentized, as well as intergrowths of these minerals. The marginal zone of Ti-magnetite is richer in inclusions. One of kirschsteinite inclusions exibits a clear crystallographic cut. In different inclusions TiO_2 of kirschsteinite varies from 1.7 up to 7.4 %.

Sample Bt-91. A fragment with rounded outlines of chrome spinellide (300x300 mkm) (Cr2O3 37.23%) with two-zoned rim retained only on one grain side. An internal narrow zone 5-10 mkm wide consist of Ti-magnetite, the external zone 10-20 mkm is two-phased from kirschsteinite and perovskite. Kirschsteinite has heightened contents of TiO_2 (6.35-10.97%) and relatively low Al_2O_3.

Sample Bt-98. A fragment of grain with irregular angular shape (350 x 200 mkm) basically looks as an intergrowth of kirschsteinite and apatite. The central part of grain retained the relic of spinel which is chromous Ti-magnetite. It is assumed that spinel can be of paragenic genesis. The TiO2 abundance in kirschsteinite varies from 0.65 up to 8.38%.

Sample Bt-110. Crystal of Ti-magnetite (TiO_2 - 7.1%, MgO - 5.4%) of right-angled cut (500 x 350 mkm) contains the net of numerous sites composed of kirschsteinite, F-apatite, perovskite and phlogopite and having right-angled outlines. The grains of kirschsteinite and apatite are intergrown by the thin plates of phlogopite (20 x 1-5 mkm). The kirschsteinite has uncommonly high TiO_2 content (up to 21.86%) and its identification is often the point of doubt. The paragenic perovskite contains noticeable amounts of SiO_2 (4.5-5.53%), Na_2O (1.07-1.15%). Phlogopite contains about 2% of F-apatite and perovskite, about 1% Sr.

The common feature in the occurrence of kirschsteinite is their inhomogeneity and constant association with apatite or perovskite or with both minerals at once. Considering paragenesis and relationships with other minerals, the mineral under study refers to the late stage of mineral formation and is the late magmatic or even reactional post-magmatic mineral. Assuming that the mineral refers to the monticellite group, the calculation was made for atomic quantities (for 3 cations). As evident from table, such calculations always result in a marked deficit in the position of Fe, Mg which is impossible to make up for transfer to this position of such elements as, Ti, Al and part of Ca. Note that fairly high contents of Ti and Al observed in majority of analyses were not known before neither in monticellite nor kirschsteinites. This arises doubt about the correctness of mineral identification. The authors hope to remove this generalization after X-ray-structural analysis is made. The study may lead to a possible discovery of a new mineral. However this is the point of question.

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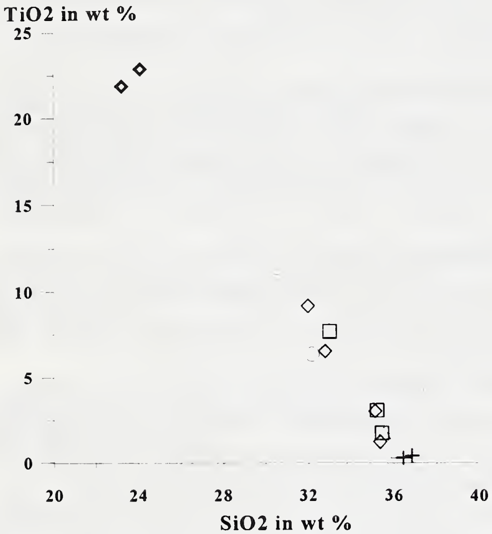

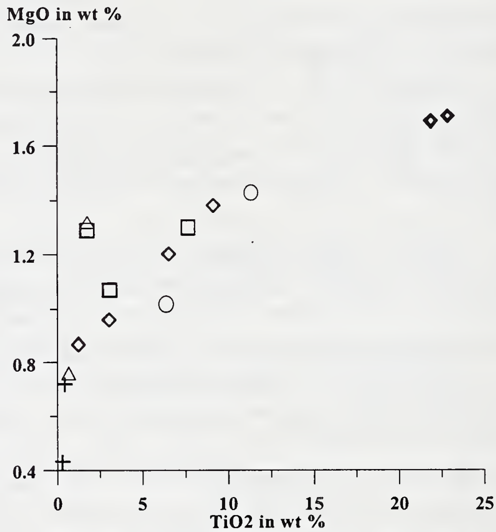

Fig. 1 Correlation between SiO2 and TiO2 in the kirschsteinites. Different symbols correspond to different grains of host minerals; the same symbols correspond to different grains of kirschsteinite from the same grain of host mineral.

Fig. 2 Correlation between TiO2 and MgO in the kirschsteinites.