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Dependence of the composition of the Zarnitsa pipe picroilmenites (*Yakutia*) on their formation conditions (*from data of thermomagnetic studies*)

Sh.Z. Ibragimov [a,*], S.G. Mishenin [b], Yu.N. Osin [c]

[a] *Kazan Federal University, Institute of Geology and Petroleum Technologies, ul. Kremlevskaya 4/5, Kazan, 420111, Russia*
[b] *V.S. Sobolev Institute of Geology and Mineralogy, Siberian Branch of the Russian Academy of Sciences, pr. Akademika Koptyuga 3, Novosibirsk, 630090, Russia*
[c] *Kazan Federal University, Interdisciplinary Center of Analytical Microscopy, ul. Kremlevskaya 18, Kazan, 420018, Russia*

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Abstract

A thermomagnetic analysis has been performed for 737 picroilmenite samples from the cores of eight boreholes in the N–S-striking drilling profile of the Zarnitsa kimberlite pipe in the Daldyn kimberlite field, Yakutia. Based on the shapes of thermomagnetic curves and the Curie points, 29 samples were chosen for detailed microprobe studies of chemical composition and elucidation of the dependence of their thermomagnetic parameters on the content of the hematite end-member in the picroilmenites. The thermomagnetic curves of most of the studied picroilmenite samples are approximated by a two-component model for the hematite end-member distribution: the main and supplementary distribution. The average hematite end-member content in the main distribution coincides with the probe microanalysis data and is always lower than the average content in the supplementary distribution. The relative hematite end-member contents in the main and supplementary distributions within the picroilmenite grains are indicators of the dynamics of mineral formation in different parts of the Zarnitsa pipe. The data obtained testify to the multistage formation of the pipe under unstable thermodynamic conditions, which explains the intricate distribution pattern of picroilmenite.

Keywords: picroilmenite; thermomagnetic analysis; Curie point; content of the hematite end-member in picroilmenite; magnetite; kimberlite pipe

Introduction

Picroilmenite is an intermediate member of the isomorphous series of solid solutions Fe_2O_3 (hematite)–$FeTiO_3$ (ilmenite)–$MgTiO_3$ (geikielite). Pyrope and picroilmenite are the main accessory minerals of kimberlite pipes and indicators of the thermodynamic conditions of their formation.

Mineralogical and geochemical studies of picroilmenite from the Zarnitsa pipe determined its chemical composition and crystallization conditions (Alymova and Kostrovitskii, 2002; Amshinskii and Pokhilenko, 1983; Bovkun et al., 2005).

One of the main factors influencing the composition of kimberlite picroilmenite is the depth at which magma chambers of kimberlite melts form in the heterogeneous upper mantle. Another crucial factor is the dynamics of evolution of the magma chamber of a particular body (Bovkun et al., 2005).

Picroilmenite macro- and megacrysts have reactionary rims (Garanin et al., 1986; Genshaft and Ilupin, 1982; Klopov et al., 1984; Silaev et al., 2008). Three varieties of rims were recognized: perovskite, secondary spinel in paragenesis with perovskite, and spinel–titanite (titanomagnetite). They formed mainly by the diffusion–metasomatic mechanism. The secondary ilmenite from the reactionary rims differs significantly from the primary ones in higher Mg/(Mg + Fe) value and Mn, Ca, and Si contents (Silaev et al., 2008). The Ti-spinel rim on the picroilmenite grain formed at the latest stage of epigenetic alteration of the primary picroilmenite (Klopov et al., 1984).

The compositional variability of picroilmenites was studied by modeling the *PT*-conditions and composition of the primary mineral (Genshaft et al., 2010). It was confirmed that the contents of the geikielite and hematite end-members in kimberlite picroilmenite depend on pressure and temperature. The wide variations in geikielite content apparently reflect the high compositional heterogeneity of the deep-seated substratum from which ilmenites got into the kimberlite magma.

* Corresponding author.
E-mail address: Shamil.Ibragimov@ksu.ru (Sh.Z. Ibragimov)

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