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Mg-rich ilmenite from the Grib kimberlite (Arkhangelsk region, Russia): composition and origin

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Magnesian ilmenite (Mg-ilmenite) is a common indicator mineral of a kimberlite magmatism. Its composition is used not only as an important tool in prospecting of potentially diamondiferous kimberlite, but also as instrument to study of metasomatic processes in the subcontinental lithospheric mantle (SCLM) as well as evolution of a kimberlite melt during its ascend and interaction with SCLM. Here, we provide new compositional data for Mg-ilmenite from the Grib kimberlite (Arkhangelsk region, Russia) and propose some genetic models.
The Grib kimberlite (376±3 Ma) is located in the north part of East-Europe Craton within Arkhangelsk diamond province. Based on geochemical and isotope systematics, kimberlite is classified as a Group-I kimberlite. This kimberlite hosts a variety of mantle xenoliths as well minerals of a megacrysts suit including Mg-ilmenite.
Based on petrography study of kimberlite samples, garnet peridotite xenoliths and megacrysts, we proposed five main types of Mg-ilmenite: (i) megacrysts; (ii) within coarse peridotite xenoliths; (iii) within sheared peridotite xenoliths; (iv) inclusion in garnet megacrysts; (v) inclusion in clinopyroxene megacrysts. All studied ilmenite have high contents of MgO and be defined as Mg-ilmenites with range in Cr, Mg, Nb, Ti, V contents.
Megacrysts usually form round to oval shapes with diameters up to 4 cm. Less often, some megacrysts have angular or elongated grains. In contact with host kimberlite, megacryst grain boundaries are resorbed and layered by reaction rims with rutile, Cr-spinel, titanomagnetite, perovskite and titanite. Megacrysts are usually homogeneous in composition and are characterized by high content of (average wt% and standard deviation): TiO_2 =53±0.6 wt.%, Cr2O_3=2.9±0.1 wt.% and MgO=15±0.6 wt.%. The Nb2O5 content does not exceed 0.04 wt.%. Thin rim zones show highest contents of these elements.
Mg-ilmenite within coarse peridotite xenoliths may constitute up to 40 vol.% of rock and occurs as sinuous and elongated anhedral polycrystalline aggregates in the interstitial space between peridotite minerals and penetrates along their boundaries. Sometime, fragments of peridotite could be cemented by Mg-ilmenite. In sheared peridotite, Mg-ilmenite forms rounded to anhedral shapes. Mg-ilmenites from both peridotite types are similar in composition by TiO_2 = 52±0.4 wt.%, Cr2O_3 = 2.1±0.2 wt.%, MgO = 14±0.5 wt.% but differ by Nb2O5 content that is higher in Mg-ilmenite from sheared peridotite (average 0.05 wt.%) than coarse peridotite (average 0.01 wt.%).
Mg-ilmenite inclusions within garnet and clinopyroxene have rounded shapes and size up to 350 μm. Its composition could reflect processes of diffuse equilibration with the host mineral and shows widely range of composition. For instance, Cr2O_3 content varies from 2.0 to 7.5 wt.%.
The obtained data shows that primary high-Mg ilmenite from the Grib kimberlite occurs as megacrysts as well as grains within peridotite xenoliths with coarse and sheared textures. However, megacrysts are enriched in Mg and Cr contents whereas Mg-ilmenite from sheared peridotite have higher Nb concentration. This suggests evolution of Mg-ilmenite composition, which may result from continuous evolution of equilibrium melts (kimberlite melts) or existence of separate stages of Mg-ilmenite forming including a mantle metasomatism stage and liquation of Fe-Ti phases.