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HIGH-TI PICRITES FROM PUTORANA REGION OF THE SIBERIAN FLOOD BASALT PROVINCE

by

I.D. Ryabchikov[1] & Th. Ntaflos[2]

MinPet 98

[1]Institute for Geology of Ore Deposits, Russian Academy of Sciences, Moscow
[2]Institut für Petrologie, Universität Wien

The Putorana plateau east of the Norilsk mining district is built of basalt flows and represents the location of the most intense activity of Siberian trap magmatism. Usually the complexes of continental flood basalts (CFB) include highly magnesian volcanics reflecting high temperatures of magma generating mantle plume. Such picritic basalts have been described for the Norilsk district (WOODEN et al., 1993), but not for Putorana plateau.

We collected specimens of picritic basalts from the lower part of Ayan unit of Siberian traps at the right shore of Ayan river approximately 60 km down from Ayan lake. These rocks are composed of large phenocrysts of olivine (ranging from Fo_{89} to Fo_{77} in their cores and having less magnesian rims) surrounded by matrix of clinopyroxene, ilmenite and titanomagnetite with the interstices filled by alkali feldspar, plagioclase and sometimes by residual glass. In contrast to the picrites of Norilsk district and overlying CFBs, these picritic rocks are characterised by high Ti contents (between 2.5 and 5.5 % TiO_2), high concentrations of potassium and other incompatible elements.

In order to access the composition of magma giving rise to these rocks we investigated microinclusions of melt trapped by olivine phenocrysts. In addition to melt inclusions olivines also contain small crystalline inclusions of chrom-rich spinel and fluid inclusions filled by dense carbon dioxide (liquid carbon dioxide plus gas at room temperature). This implies that the phenocrysts started to crystallize in a deep seated magma chamber, and that the volatiles played certain role in the genesis of these rocks (titanoan phlogopite was found as a daughter mineral in some of the melt inclusions).

Typically unheated melt inclusions contain clinopyroxene and ilmenite as daughter minerals and also residual siliceous glass. In many cases in addition to silicate melt these inclusions also trapped small grains of chromite and spheres of sulphide liquid.

All glasses produced by the quenching of homogenised melts in heated inclusions are characterised by high TiO_2 contents (between 5 and 7.5 wt %) and by variable concentrations of MgO and FeO. Some glasses contain between 12 and 14 % of FeO which are also typical for bulk rock analyses of picritic rocks. These compositions are likely to represent the prevailing melts giving rise to picritic magmas.

We attempted to model the compositions of mantle-derived magmas parental to the investigated picritic basalts using the approach described by RYABCHIKOV (1997) and considering homogenized melts in microinclusions as the derivative silicate liquids formed by fractional crystallization of olivine from certain primodial melts. All the investigated compositions cannot be produced by the dynamic partial melting of pyrolitic starting material, but for the majority of melt inclusions initial melts may be derived by partial melting of harzburgites. For the most Fe-rich homogenized glasses the estimated pressures of the generation of primary melts fall into the range of 40 - 50 kbars and temperatures are close to 1700°C. These calculations were conducted assuming volatile-free conditions, and, therefore real P and T may be somewhat lower. The MgO contents in the estimated initial melts are close to 23 wt.% and TiO_2 concentrations are in the range of 3 -4 wt.%. These estimated compositions are similar to the bulk compositions of the most magnesian investigated rocks. The source rock for such melts may be harzburgite with 0.2 - 0.3 % TiO_2 and 0.1 % K_2O. These could be common rocks of lithospheric mantle enriched in incompatible elements due to the addition of small amount of low fraction melts injected from the underlying asthenosphere.

Melts from microinclusions with 8 - 10 % FeO may result from partial melting with the subsequent fractional crystallization of olivine at approximately 25 kbar provided the mantle source for them is also represented by Ti-enriched harzburgite. Some of the analysed glasses are charcterised by low concentrations of both FeO (5 - 6 %) and MgO (6 - 8 %). In spite of their high Mg-numbers such melts cannot be produced by partial melting of neither harzburgites nor lherzolites. Such melts could be equilibrated with the monomineralic magnesian olivine, and they were possibly formed due to the percolation of melts through the olivine cumulates at the lower part of magma chamber where the initial crystallisation of the investigated magmas took place. Such melts obviously contribute only small part to the composite magmas which give rise to the investigated picritic basalts.

Conclusions

1. Like the other CFB provinces (Parana, Greenland) Siberian traps include low-Ti (flood basalts, picrites of Norilsk district) and high-Ti (subalkaline picritic basalts of Putorana region) volcanic rocks.
2. The investigation of melt inclusions reveal that the initial magmas of subalkaline picrites were formed by the mixing of the variety of high-Ti melts with the prevailing component represented by highly magnesian liquids produced due to the partial melting of mantle peridotites at pressures close to 40 kbar.
3. The source material for such melts was probably harzburgites abundant in subcontinental lithosphere enriched in Ti and other incompatible elements due to the injection of small fraction melts from the deeper levels of the mantle.

References

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