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A LA-ICP-MS STUDY OF CARBONATES FROM LATE-STAGE CARBONATITE VEINS IN THE TAJNO MASSIF (POLAND)

Abstract: The Tajno massif is an igneous complex composed of plutonic and volcanic rocks intruding the Proterozoic basement of NE Poland. It is made of ultrabasic, alkaline and carbonatite rocks. Three stages of carbonatite have been recognised. This study focuses on two thin late-stage carbonatite veins. The first vein is made of calcite, ankerite, Ba- and Ce-rich carbonate, sphalerite and natrolite while the second vein is made of ferroan dolomite to ankerite, calcite and quartz. REE distribution in the various carbonates have been measured by LA-ICP-MS and are discussed.

Keywords: Tajno massif, carbonatites, LA-ICP-MS, geochemistry.

INTRODUCTION

The Tajno massif is a pluto-volcanic body emplaced in Proterozoic rocks near the Mazury Complex. It belongs to the Fennoscandia block of the East European Craton. The Tajno massif is known from boreholes only; the whole massif is covered by a thick (~ 600m), Mesozoic to Caenozoic, sedimentary cover. The emplacement age of the massif is not well known but it is assumed to be contemporaneous with the nearby Elk nepheline syenite complex, dated at 355+-4 Ma (Blusztajn 1994). The Tajno massif consists of ultramafic rocks, alkaline silicate rocks and carbonatites. The carbonatite material occurs as veins (from cm to m thick) cross-cutting the whole massif and as cement in the central chimney, polygenetic breccia. Three stages of carbonatite emplacement have been recognised by Ryka (1992): 1) the early stage carbonatites, which have only been found as fragments in the central breccia; 2) the second stage carbonatites, forming the main stage and occurring as veins and as cement in the chimney breccia; 3) the late-stage carbonatites, that are related to late hydrothermal activity.

METHODS

The chemical compositions of the carbonates (calcite, ferroan dolomite and ankerite) of the veinlets have been obtained by electron microprobe for the major elements (Cameca SX-50, CRPG, Nancy, France; Fig. 2) and by LA-ICP-MS for the trace elements (VG elemental Plasma Quad instrument coupled to continuum Minilite Q-switched Nd:YAG laser, Musée de l'Afrique Centrale, Tervuren, Belgium.

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PETROGRAPHY AND STRUCTURE OF LATE-STAGE CARBONATITE VEINLETS

The investigated samples were collected from boreholes 6 and 7 at depth of 992.7m and1173.8m respectively. They consists of small veins of carbonate associated to silicates (zeolite or quartz; Fig. 1).

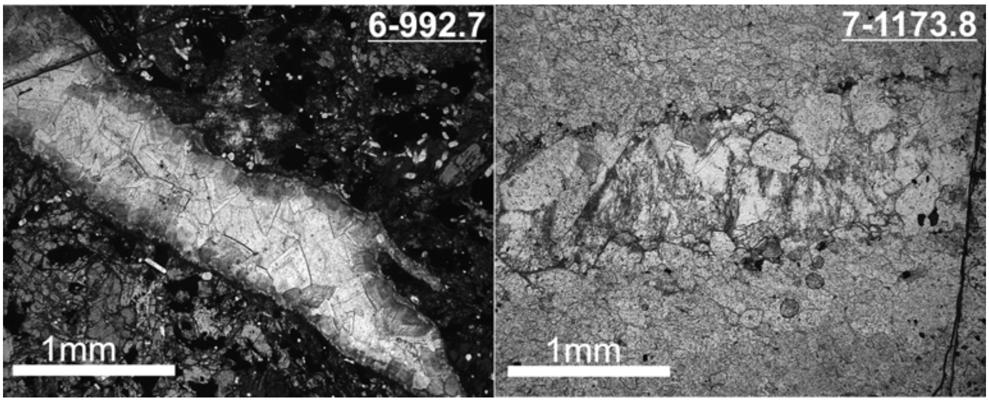

Fig. 1. Microphotographs of two late-stage carbonatite veinlets (samples 6-992.7 and 7-1173.8, natural light-greyscale).

The thin carbonate vein from sample 6-992.7 crosscuts an apatite- and titanite-rich clinopyroxenite; the contact is sharp and there is no trace of metasomatism between the mentioned above rock varieties. The vein consists of Fe-rich carbonate, ferroan dolomite to ankerite (several hundreds of µm) with interstitial xenomorphic calcite and quartz.

The vein from sample 7-1173.8 crosscuts a carbonatite with polygonal texture. The centre of the vein is composed of natrolite, while euhedral grains of calcite, ankerite and sphalerite (carbonate minerals – few hundred µm, sphalerite – few dozen µm) occur at the vein border .

The modal compositions of these veins are similar to the late - stage carbonatites from Kola Peninsula (*i.e.* Namo-Vara Hill in the vicinity of Vuoriyarvi massif; Kukharenko *et al.* 1965).

CHEMISTRY OF THE CARBONATES (MAJOR AND TRACE ELEMENTS)

The carbonates of the early stage carbonatites are mainly Sr-rich calcite (up to 5.2 wt% SrO), poor in Mg, Fe and Mn (<0.18 wt% MgO, < 1.4 wt% FeO and <0.65 wt% MnO).
The carbonates of the two late-stage veins have been extensively studied. The carbonates of sample 6-992.7 are represented by euhedral grains ranging from Fe-dolomite to ankerite composition and anhedral interstitial calcite (Fig. 3). The crystals occurring at the border of the vein have ferroan dolomite cores (Fe/Fe+Mg ~ 0.18) with ankerite rims (Fe/Fe+Mg up to 0.32) but they are poor in Mn (0.08-1.1 wt% MnO). The ankerite rims are enriched in REE (ΣREE from 650 up to 1540 ppm) with La/Yb_N: 5-11 and no Eu or Ce anomalies. Interstitial calcite is close in composition to a pure calcite (~1.5 wt% FeO, ~1.2 wt% MgO and ~0.6 wt% MnO). It is poorer in REE (ΣREE varying from 150 up to 385 ppm) than the dolomite-ankerite grains and shows a moderate LREE enrichment: La/Yb_N: 2-16. It also displays a strong positive Eu (Eu/Eu*: 2.3-4.4) anomaly and locally a negative Ce anomaly.

The carbonate of sample 7-1173.8 is essentially ankerite with minor calcite and a Ba- and Ce-rich mineral (up to 68 wt% BaO and 15 wt% Ce_2O_3). The calcite is rich in Mn (0.7-1.2 wt% MnO) and Fe (0.4-0.8 wt% FeO) but relatively poor in Mg (< 0.2 wt% MgO). It is enriched in heavy rare earth elements (La/Yb_N: 0.07-0.44) with a rather low ~ 55 ppm REE content. The vein core is composed of ankerite grains Mg-rich (12.3 wt% MgO, 11.1 wt% FeO and 1.8 wt% MnO) whereas the rim contains Fe-rich carbonate (2.8 wt% MgO, 24.6 wt% FeO and 1.1 wt% MnO). The REE content of the ankerite crystals is highly variable (ΣREE: 23 to 1357 ppm) with both LREE-rich (La/Yb_N: 25) and HREE-rich (La/Yb_N below 0.01) patterns.

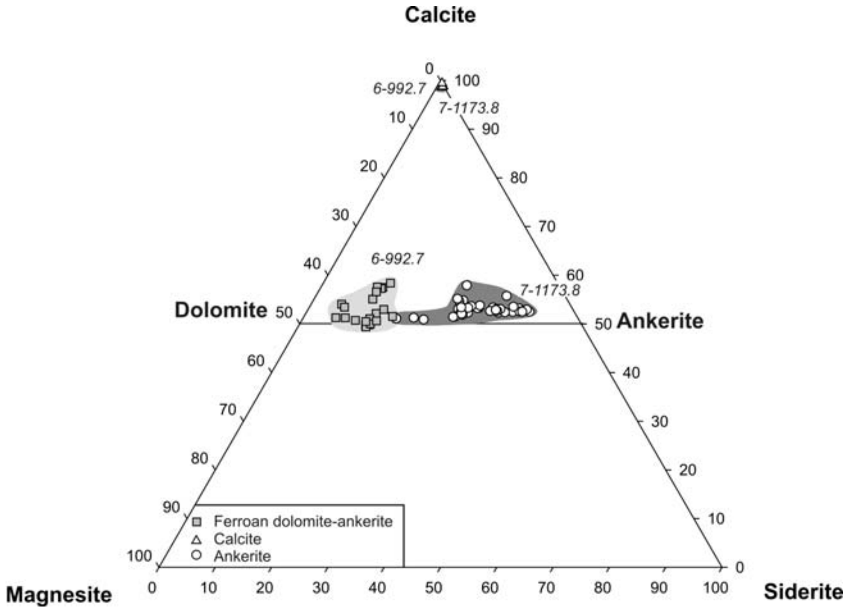

Fig. 2. Chemical composition of the carbonates from late carbonatite veinlets of the Tajno massif (samples 7-1173.8 and 6-992.7) in the system $MgCO_3$, $CaCO_3$ and $FeCO_3$.

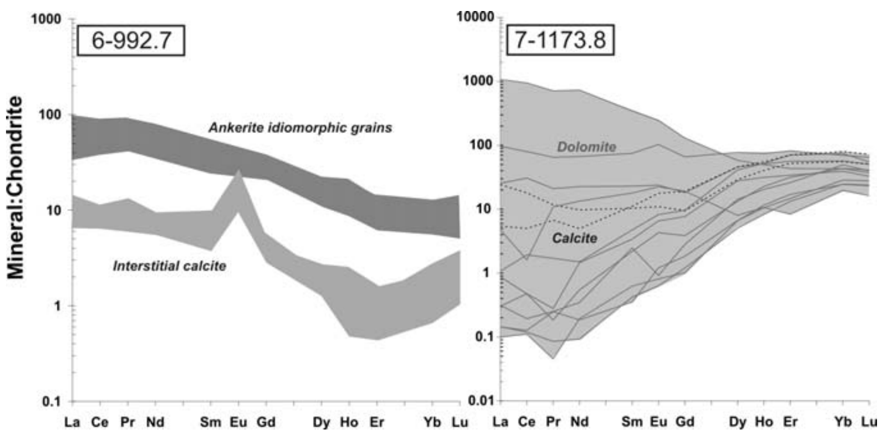

Fig. 3. Chondrite normalised REE patterns of the various carbonates of the Tajno late-stage veinlets (samples 6-992.7 and 7-1173.8). Normalizing values from McDonough, Sun (1995).

DISCUSSION AND CONCLUSIONS

In the Tajno late carbonatite veinlets, the chemical composition and the microstructure of the carbonates can be interpreted in terms of magmatic evolution. The major element composition evolves from Mg-rich, Fe-poor cores to Mg-poor, Fe-rich rims which implies a decrease of the Mg/Fe ratio of the carbonatite melt. Such carbonatite melt can still be calcitic in composition (Gittins *et al.,* in press) and could crystallise dolomite or ankerite grains. The sequence calcite-dolomite-ankerite-siderite is typical for the magmatic evolution of carbonatite as observed in the Iron Hill carbonatites (Nash 1972). The ferroan dolomite - ankerite grains of sample 6-992.7 are less evolved than the ankerite crystals of sample 7-1173.8. The euhedral carbonates from both veinlets are strongly enriched in REE as compared with their respective interstitial material (calcite, quartz and natrolite) which suggest that the REEs had a compatible behaviour. The ankerite grains from sample 7-1173.8 display strong variation of REE content, eg. La_N varies from 0.1 to 1000. This huge variation could be related to the fractionation of a REE-rich mineral. A REE- and Ba-bearing phase have been observed but its precise mineralogical determination has not been performed; it seems to be close in composition to the series kukharenkoite ($Ba_2Ce(CO_3)_3F$)-cebaite ($Ba_3Ce2(CO_3)_5F_2$)-huanghoite ($BaCe(CO_3)_2$). These minerals occur in ankerite carbonatites and in veins composed of carbonates, quartz and zeolite in the Khibiny massif of the Kola Peninsula (Wall, Zaitsev 2004).

So, the late-stage carbonatite activity in the Tajno massif is mainly Mg- and then Fe-rich, as compared to the Ca-rich carbonatites formed at early stage. These late carbonatites contain silicate minerals (quartz or zeolite) and REE-rich minerals. The latter strongly control the REE patterns of carbonates.

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