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BREAKDOWN ON MONAZITE AND REE, Th, U MOBILITY IN THE HIGH TATRA GRANITOIDS

INTRODUCTION

Monazite in granitoids is a minor accessory minerals but it can contain 40-80% of REE of the rock (e.g. Bea 1996) and significant amount of Th (e.g. Cathelineau 1987). Monazite is unstable during metamorphism of granites. Finger et al. (1998) described formation of apatite-allanite-epidote coronas around replaced monazite in an amphibolite facies granite. Broska and Siman (1998) noted complete breakdown of monazite in metagranites in the Veporic Unit in the Carpathians but only low degree of alteration of monazite in Tatric granitoids. Michalik and Skublicki (1999) noticed that monazite enclosed in Fe-Ti oxides is almost unaltered whereas monazite present in biotite, feldspars or quartz can be more or less altered but never surrounded by regular allanite and/or apatite corona. They interpreted this difference as a result of different availability of fluids carrying Ca²⁺ and other elements.

Studies of monazite breakdown give information on mobility of REE, Th and U during alteration of granites (Cathelineau 1987; Poitrasson et al. 1996). Data on stability of monazite are important because this mineral is often used for geochronology or can be considered as nuclear waste repository.

CHARACTERISTICS OF THE HIGH TATRA GRANITOIDS

The High Tatra granitoids are mostly granodiorites and tonalities. Granites are related spatially to so-called pegmatitic marginal zone (Michalik 1951). The High Tatra granitoids are mostly peraluminous; metaluminous are less common. Peraluminous characteristics can be induced by secondary alterations. Chloritization, sericitization, albitization, carbonatization, epidotitization are common secondary alterations in all types of granitoids (Duraman et al. 2001).

RESULTS

Monazites were studied in granodiorites and tonalities samples collected in the High Tatra. Thin sections were studied using optical microscopy and electron microscope fitted with energy dispersive spectrometer.

Analyses of monazite grains from the High Tatra granitoids indicate that chemical composition is dominated by monazite (s.s.) with small amount of other end-members of solid solution (brabantite and huttonite).

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Monazite without any alteration features occur inside Fe-Ti oxide grains or apatite. Monazite surrounded by plagioclases, biotite (or minerals resulting from biotite transformation – chlorite, epidote, titanite), K-feldspar or quartz is more or less decomposed. Degree of decomposition and assemblages of secondary minerals replacing monazite or formed in its vicinity can differ within broad range. Some examples are listed below:

1. Monazite partly replaced by apatite. Irregular and discontinuous rim of apatite and small grains of allanite (or REE rich epidote) and titanite close to monazite grain can be noticed.

2. Monazite completely replaced by apatite containing Th (up to 8.6 wt.%) and small amounts of REE. Inside newly formed apatite, there are “spots” of phases rich in Th (up to 50 wt.%) and Si (Fig. 1). Monazite with irregular rim of apatite with high Th (and REE in some examples) and Si content has been also found. The grain is enclosed in biotite partly converted to chlorite and epidote enriched in REE.

3. Monazite partly replaced by apatite without secondary concentration of REE and Th around it. Apatite enriched in REE (but without Th) can be found in the vicinity (Fig. 2).

4. Monazite partly replaced by apatite without rims or secondary rims. Th and U concentration areas mimic the original shape of monazite crystal but slight decrease of content towards rims can be noted. REE are present exclusively in monazite remains.

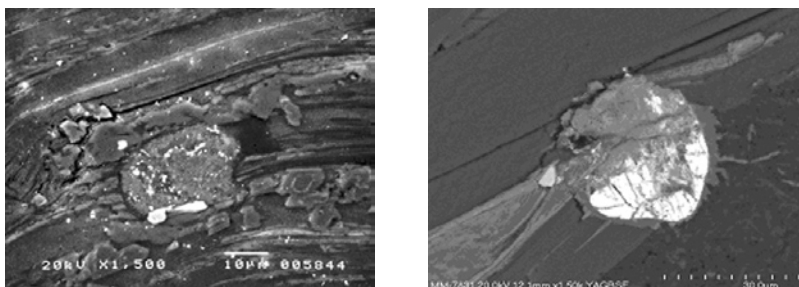


Fig. 1. (left) Monazite completely replaced by apatite; bright spots – Th and Si rich phase.

Fig. 2. (right) Monazite (bright field) partly replaced by apatite.

DICUSSION AND CONCLUSIONS

The breakdown of monazite in the High Tatra granitoids is common. Only crystals insulated against Ca bearing solutions (enclosed in Fe-Ti oxides or apatite) are non-altered. Regular coronas of secondary minerals, typical of amphibolite facies granite (Finger et al. 1998), are absent. It can be concluded that lack of coronas is typical of low-temperature (200-300°C; determination based on chlorite composition) alterations of the Tatra granitoids. Formation of apatite is the most widespread alteration process and is controlled by availability of Ca ions in solution. Ca is released mainly during sericitization and albitization of plagioclases.

Secondary apatite contains usually Th but the form of Th occurrence is unknown. It is possible that substitution $2\text{REE}^{3+} \rightarrow \text{Th}^{4+} + \text{Ca}^{2+}$ was important in this type of altera-

tion of monazite. In the second, less common type of alteration, Th silicate (huttonite or thorite) is formed inside secondary apatite probably by substitution $2\text{REE}^{3+} + \text{P}^{5+} \rightarrow \text{Th}^{4+} + \text{Si}^{4+}$. According to Poitrasson et al. (1996) these two types of substitutions are related to different hydrothermal alterations of granite (chloritization and greisenisation, respectively). Enrichment in Th and Si can be also explained by concentration of residual Th silicate during monazite decomposition (Mathieu et al. 2001).

Different types of monazite alteration processes can be attributed to different conditions (T, P) during different period of granitoid alteration processes or to local variations of chemical composition of fluids.

Absence on REE-bearing minerals around altered monazite (and low content of REE in apatite) indicate mobilization of REE during granitoid alteration. REE-containing epidote (spatially not related to altered monazite) can be noted (beside epidote devoid of REE) in the High Tatra granitoid. Th (and U) seems to be only partly mobilized during monazite alteration. The distance of transport of these elements is unknown.

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