

Accessory allanite and its petrogenetic significance for granitoids from Belassitsa Mountain, Serbo-Macedonian Massif

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Introduction

Recent studies on accessory allanite, $(\text{Ca}, \text{REE})_2(\text{Al}, \text{Fe}^{3+}, \text{Fe}^{2+})_3(\text{SiO}_4)_3(\text{OH})$, in granitoids have revealed an attractive potential of the mineral giving clues to the petrogenesis and postmagmatic history of the host rocks (Poitrasson, 2002; Broska et al., 2000). Allanite is also known as important repository for the actinide elements as Th and U in granitoid rocks, which makes it, together with monazite and zircon, a promising object for conventional and local age dating (Catlos et al., 2000). The present work considers the occurrence, chemical composition and petrogenetic implication of allanite from porphyroid granitoids outcropping near to Skrut village in Belassitsa Mountain (Bulgaria, Ograzhden block, Serbo-Macedonian massif - SMM). According to Zidarov et al. (2002), the Skrut granitoids are the first evidence for the Jurassic magmatism in the Ograzhden block of SMM. Granitoid plutons of Jurassic age have also been established in other parts of SMM (Arnea intrusion) as well as in the neighboring tectonic units as the Vardar-Axios zone (Fanos, Furka and Stip intrusions) (Baltatzis et al., 1992; Christofides et al., 1990; De Wet et al., 1989). In this respect, the data on allanite from the Skrut granitoids will be useful for a further detailed comparison of and correlation between the Jurassic magmatisms in the region.

Geological setting and petrography

The Skrut porphyroid granitoids are embedded in the high-metamorphic biotite and two-mica gneisses and amphibolites and have tectonic contacts with fine-grained I-type granitoids (Fig. 1). According to the Rb/Sr isochrone, the age of emplacement of granitoids is 167 ± 9.9 Ma (Middle Jurassic Age), and the initial ratio $(^{87}\text{Sr}/^{86}\text{Sr})_0$ equal to 0.7132 suggests crustal dominated origin of the magma (Zidarov et al., 2002). The chemical composition of granitoids defines them as peraluminous ($\text{ASI}=1.09$) granites and granodiorites of a high potassium calcium-alkaline series. The mineral compositions of rocks specify them as biotite two-feldspar (microcline phenocrysts and oligoclase) granitoids. Magmatic foliation is well manifested being marked via oriented short bands composed mainly of biotite and quartz.

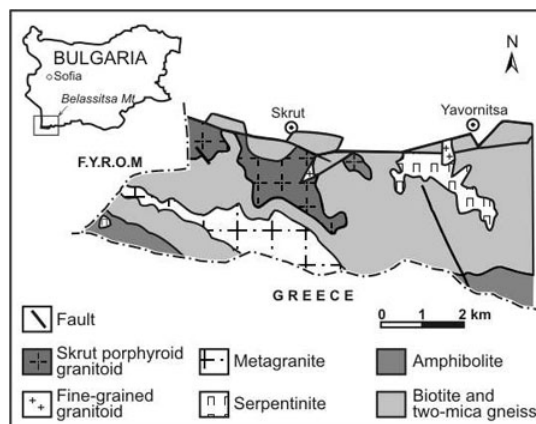


Figure 1. Schematic geological map of Belassitsa Mt. (Ograzhden block, SMM) according to Zagorchev & Dinkova (1991) with corrections by Tarassova et al. (2001).

The succession of crystallization of the main rock forming minerals is as follows: plagioclase, biotite, quartz, potassic feldspar. Accessory minerals are presented by allanite, epidote, apatite, zircon, and titanite. Postmagmatic processes cause the formation of garnet, sericite, chlorite, pyrite, chalcopyrite, sphalerite, molybdenite, and native silver.

For the present study, thin sections and polished specimens of rocks and allanite grains mounted in epoxy resin were prepared for optical microscope observation, SEM examination and electron probe analysis (Philips 515 SEM equipped with an EDAX-9100/70).

Occurrence of allanite and epidote

Optical microscopy (OM) and SEM observations reveal two types of allanite in the Skrut granitoids: type I occurs as well-shaped, elongated prismatic crystals sized up to 3 mm; type II is presented by randomly shaped grains sized below 1 mm (Fig. 2). Both types of allanite, observed as black grains macroscopically and as brown ones in plane-polarized light, are surrounded by colorless epidote, giving a zonal outlook of the allanite-epidote aggregates. Crystallization of epidote appears to occur both as a replacement of allanites (I, II) penetrating along fissures inside the allanite crystals and as an overgrowth around the allanite crystals. Opposite to allanite (I), allanite (II) is more intensively replaced by epidote, which seems to be the reason for the xenomorphic outlook of this type of allanite. Besides intergrowths with allanite, epidote forms also individual elongated crystals replaced partially by plagioclase. The relationships of allanite (I, II) and epidote with other minerals point to early magmatic origin of the epidote group minerals – they crystallize before plagioclase which is the earliest rock-forming mineral in the considered rocks. Although allanites (I and II) are found in the same rock samples, the relationships between the two types of allanite are not apparent in OM and SEM. Some suggestions can be done by considering electron microprobe and SEM data.

Chemical composition and petrogenetic implication of allanite

Both types of allanite represent the so-called “allanite-Ce”. The main difference between the two types of mineral is in the content of REE and Th: allanite (I) contains (in wt.%), 10.7-12.1 Ce₂O₃, 4.7-5.5 La₂O₃, 4.0-4.6 Nd₂O₃, and 0.8-1.8 ThO₂; allanite (II) demonstrates a bit lower content of REE (8.2-9.9 Ce₂O₃, 2.6-5.1 La₂O₃, and 2.2-3.9 Nd₂O₃) and a remarkably higher concentration of Th (2.1-3.9 ThO₂). In some cases, the crystals of allanite (I) include thin peripheral zone (10-50 μm) depleted in REE and enriched in Th, which corresponds well to the composition of allanite (II). These data suggest that allanite (II) is a later form of the mineral, crystallized in a chemically changed melt. Epidote, replacing allanite of both types, inherits partially the minor elements containing (in wt. %) up to 1.9 Ce₂O₃, 0.9 La₂O₃, 0.7 Nd₂O₃, and 0.5 ThO₂.

To illustrate better and to compare our data on allanite with those reported by others, the

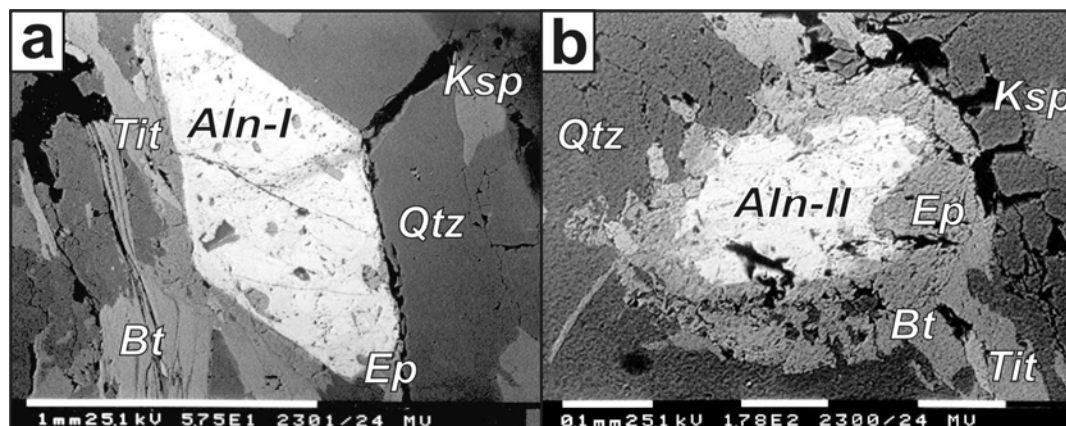


Figure 2. Allanites of types I and II: allanite I is presented by euhedral crystals with inclusions of apatite (a); allanite II is found only as randomly shaped grains intensively replaced by epidote (b).

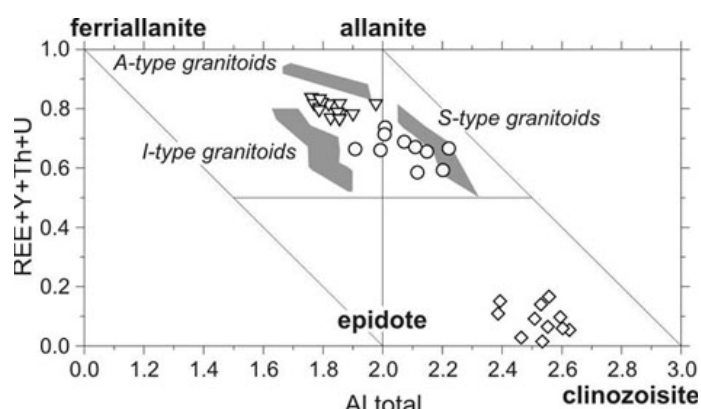


Figure 3. Allanite and epidote compositions plotted in terms of (REE+Y+Th+U) vs. total Al (in apfu, 8 cations per 23.5 oxygen atoms). Triangles – allanite (I), circles – allanite (II), diamonds – epidote. Shaded fields define the compositions of allanite from I-, A-, and S-type granitoids according to Broska et al. (2000).

chemical compositions of the studied mineral are plotted as (REE+Y+Th+U) versus (Al total) (in apfu) (Fig. 3). As seen, the points corresponding to allanite (I) fall in-between the regions of A- and I-type granitoids, whereas those of allanite (II) lie in the intermediate region between I- and S-type granitoids. The epidote studied is characterized by almost intermediate epidote-clinozoisite compositions. Several consequences follow from this presentation. The first one is that the chemical compositions of the studied allanites are in a good agreement with the geo-

chemically mixed character of the parent melt (S-type melted protholite with a significant contribution of I- and A-types). The second consequence consists in some details of the petrogenesis scenario that could be anticipated from the data on the studied allanite. Indeed, Fig. 3 allows suggesting that the two types of allanite crystallize in chemically differing melts. On the earlier stage, the crystallization of allanite (type I) seems to proceed in a melt with prevailing I- and A-type protholite components. The later variety of allanite (type II) results probably from a melt with prevailing S-type component. It is noticeable, that the points corresponding to allanite (I) in Fig. 3 are grouped in a more compact region, whereas those of allanite (II) are scattered in a much larger region. Besides, Fig. 3 shows that the points for the two types of allanite are spatially isolated without any gradual transitions. All these findings are in agreement with the petrogenetic scheme which suggests that: (i) the primary parent melt of I- and A-type characteristics had been quite homogeneous, giving rise to crystallization of allanite with comparatively uniform composition; (ii) with progressing the protholite melting, the primary melt had been enriched by S-type component thus producing allanite (II) with a more variable composition which, most probably, indicates an incomplete homogeneity of the mixed melt.

Conclusion

Both types of allanite, established in the Skrut granitoids, are indicators for early stages of magmatic history of the intrusive. The answer whether the proposed scenario of the earlier evolution of the magmatic system is true or not, may be attained performing a further detailed study of allanite and other accessory minerals accenting on their crystal chemistry, defect structure, and isotopic composition.

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