MONAZITE AND ZIRCON U-PB AGES OF MIGMATITES FROM THE ARDA RIVER VALLEY, CENTRAL RHODOPIAN DOME, BULGARIA

Z. CHERNEVA[1], M. OVTCHAROVA[2], A. Von QUADT[3], K. KOLCHEVA[2],
E. STANCHEVA[1], S. SAROV[4] and I. PEYTCHEVA[5]

[1]*Geological Institute, BAS, 1113 Sofia, Bulgaria;*
[2]*Sofia University "St. Kliment Ohridski", 1000 Sofia, Bulgaria;*
[3]*ETH Zurich, IGMR, ETH-Zentrum, 8092 Zurich, Switzerland;*
[4]*SRI "Geology and Geophisics" Co, 1513 Sofia, Bulgaria;*
[5]*Earth and Man national Museum, 1421 Sofia, Bulgaria*

Abstract: The timing of cooling and exhumation of the metagranite from Madan core complex is based on cooling ages of monazite whereas the zircon is considered to characterize the crystallization age of the protoliths. U-Pb analyses of single monazite and zircon grains from orthogneiss mesosome, granite body and different leucosomes reveal the presence of two different ages. The one is Variscan age of the protolith (310,7+/-4,6 Ma) calculated on zircons from the mesosome and leucosome. Another revealed the age of monazite and zircon cristalization (37,8+/-1,5Ma) from newly formed anatectic melt during the Alpine metamorphism.

Key words: migmatization, zircon, monazite, U-Pb geochronology, exhumation

Introduction

The Rhodopian metamorphic complex is a part of the Alpine metamorphic belt (Ivanov et al., 1989). The migmatization in the Central Rhodopes was related to the Alpine regional metamorphism (Ivanov et al., 1984; 1985). The time span of anatexis corresponded to the thermal peak of metamorphism in the deeper crustal levels (Kostov et al., 1986; Arnaudov et al., 1992). Migmatite's age determinations show a wide variation from 60 to 30Ma (Arnaudov et al., 1990a; 1990b; 1992; Arkadakskiy et al., 2000; Peytcheva et al., 2000). These facts indicate that the thermal peak varied systematically depending on structural evolution that is the most important controlling factor for melting and melt crystallization. The objectives of this study are to (1) present the ages of U-Pb accessory minerals from anatectic melts that generated in the core of the Central Rhodopian extension dome; and (2) to discuss the U-Pb accessory minerals behaviour during anatexis and it's effect on age determinations of migmatitic orthogneisses in the Rhodopes. Nomenclature for migmatites used in this paper is after Ashworth (1985).

Geological setting

The post-collision late Alpine extension is marked by detachment systems and isostatic exhumation of migmatites and granites in several domes (Ivanov, in press). Several shear zones control the dome structure . The Middle Rhodopian detachment delimits two metamorphic terrains represented by high-metamorphic core and lower metamorphic hanging wall, or so called lower and upper plate, or Arda and Asenitsa unit respectively (Ivanov et al., 2000). Madan and Startsevo detachments outline several high metamorphic allochtonous fragments formed during the continuing extension and multiplication of detachment faults. According to the interpretation of Ivanov (2000) some of these fragments have been separated from the lower plate and joined to the upper plate by incising. The autohtonous core and the allochtonous fragments differ in style of migmatization: migmatites in the core are dominated by disrupted diatexite areas with anatectic granite bodies; the allochtonous fragments are dominated by stromatitic and/or vein type injection migmatites.

The high-temperature clockwise P-T evolution of the Central Rhodopian dome is interpreted in terms of an extensional collapse of thickened crust (Ivanov et al., 2000). The reconstruction of the P-T-t path suggests pressure of about 6.5 kbar and temperatures of 675-680°C for the thermal peak of metamorphism in the core (Kostov et al., 1986; Cherneva et al., 1995, 1997). These estimates are consistent with the melting of rocks of granitic composition under water saturated conditions (Johannes, 1985), the moderate migmatization, and the stability of biotite. The migmatization developed within the biotite stability field so that melanosomes are predominantly biotite-bearing; the leucosomes are either tonalitic or granitic in composition, depending on the absence or presence of K-feldspar in the parental gneisses (Arnaudov et al., 1990a; Cherneva et al., 1987, 1995, 1997).

Migmatites in the dome core range from regularly layered stromatitic types to disrupted diatexite areas where regular planar structure is scarce. We have distinguished three main leucosome types on the basis of their relations with gneiss foliation in transition zones between diatexites and layered migmatites: 1) millimetre- to centimetre-scale concordant leucosome; 2) centimetre- to meter-scale discordant leucosome; and 3) meter-scale lens-shaped or irregular autochtonous or subautochtonous leucogranite bodies. Leucosome margins are not associated with biotite rich mafic selvages. Seven samples, representative of common migmatites from the true core of the dome were collected in the Arda river valley, west of Stoianov bridge . These are two metagranitic mesosomes (2668 and 2668-1), two concordant leucosomes (2668-2L; 2668-3L), a discordant leucosome (2668-4L) and a granite body (2668A) as well as a mesosome (2668-2) filled with thin millimetre scale leucosomes. The mesosomes that comprise most of the outcrop have been considered (Sarov et al. 1998) as metamorphosed felsic magmatic rocks.

Petrography

Mesosomes consist of medium- even-grained orthogneiss comprised of quartz, plagioclase, K-feldspar, biotite, ± muscovite, ± garnet, zircon, monazite, apatite, magnetite and secondary chlorite. Leucosomes are coarser grained, white to white/pink coloured The difference between the leucosome and mesosome is in the modal amount of minerals, most notably of biotite and K-feldspar: the leucosomes are enriched in K-feldspar and depleted in biotite compared to the mesosome. Concordant leucosomes (samples 2668-2L and 2668-3L) consist of equal proportions of quartz, plagioclase (An10) and K-feldspar, scarce chloritized biotite flakes and accessory zircon, monazite, apatite and magnetite. Discordant leucosomes (sample 2668-4) have similar mineral composition dominated by K-feldspar. The later (latter) forms anhedral grains (up to 0.4 - 0.5 mm) enclosing quartz and plagioclase. The accessory mineral assemblage consists of zircon, monazite, xenotime, apatite, garnet and magnetite. Mesosomes and leucosomes do not exhibit subsolidus deformation fabrics.

Geochemistry

The leucosomes have near minimum melt major-element compositions. The elements occurring as trace constituents in felsic major phases (Rb, Ba and Sr) have concentrations similar to those of model equilibrium melts. The incompatible element (REE, Hf, Zr, Y and Th as well as Sc, Cr, Co, Zn, Nb and Ta) occurring as essential structural components in accessory phases and/or as trace constituents of major mafic phases show a positive correlation with Fe+Mg+Ti thus demonstrating residence in refractory phases and low mobility during melting. The concentrations of LREE and Zr in some of the leucosomes coincide with the concentrations calculated for felsic peraluminous equilibrium melts (Watson, 1988). Leucosome samples with higher REE contents have negative Eu anomalies, whereas those with low total REE abundances have positive Eu anomalies, which indicate that feldspar fractionation was important in their petrogenesis.

Age determinations

The timing of cooling and exhumation of high-grade metamorphic terrains in orogenic belts is largely derived from cooling ages of various minerals, e.g. monazite whereas the zircon is considered to characterize the crystallization age.

U-Pb analyses of single monazite and zircon grains from orthogneiss mesosome (2668), granite body (2668a), mesosome filled with thin millimeter scale leucosomes (2668-2) and discordant leucosome (2668-4) reveal the presence of two different ages. The zircons from mesosome (2668) are concordant or near concordant but show sighs (signs) of lead loss. Single zircons measurements of all other samples show phenomena of both inheritance and post-crystallization lead loss. A best-fit line calculated through points intersects at 310,7+/-4,6 Ma (MSWD=0,51), which is interpreted as protolith age of the gneiss sequence. One analysis, which consists of long prismatic zircon, comprises an inherited lead component. Only the zircon from discordant leucosome 2668-4 yields a concordant age of 37,08+/-0,38Ma. Similar ages are revealed by the monazite from other leucosome 2668-2, 2668-4 and granitic body 2668a – 37,8+/-1,5 Ma (MSWD=2,6). The group of monazite data lies slightly above the concordia yielded reversely discordant isotope ratios. Reverce discordance is a common feature of U-Pb data sets for young monazites and is thought to indicate ^{230}Th disequilibrium (Viskupic, Hodges, 2001; Schärer, 1984; Parrish, 1990). This result is interpreted as crystallization age of newly formed migmatic melt corresponding with peak of the Alpine metamorphic event.

Conclusions

The timing of cooling and exhumation of the metagranite from Madan core complex is based on cooling ages of monazite whereas the zircon is considered to characterize the crystallization age of the protoliths.

In the core of the complex the accessory zircons from the mesosome and leucosome usually shows inheritance and post cristalization lead loss that yield Variscan age of the protholith (310,7+/-4,6 Ma) with one exception – the newly formed zircon from discordant leucosome.

The monazites U-Pb analyses are near to concordant line at 37,8+/-1,5 Ma and revealed the age of their crystallization from newly formed anatectic melt during the Alpine metamorphism.

The feature of the melting process (at low temperature) determines the felsic character of the anatectic melt, low solubility of the protholith accessory minerals and formation of the monazite as a new mineral phase. This corresponds to exhumation geotectonic regime that affected the Rhodope massif during the late Alpine extension.

References

Arkadakskiy, S.V., Boehm C, Heman L, Cherneva Z & Stancheva E. 2000. *ABCD GEODE Workshop - Borovets, Abstracts,* 1, 5.

Arnaudov, V., Amov B, Cherneva Z, Arnaudova R, Pavlova M & Bartnitsky E. 1990a. *Geologica Balcanica*, 20.5, 29-44.

Arnaudov, V., B.Amov, Ts. Baldjieva, M. Pavlova. 1990b. *Geologica Balc., 20,* 6, 25-32.

Arnaudov, V., Amov, B., Cherneva, Z., Arnaudova, R. 1992. *Scientific meeting "Attainments and aims of the Bulgarian mineralogy and Petrology",* 32-33 *(in Bulgarian).*

Ashworth, J.R.1985. *Glasgow, Blackie & son Ltd.*1-35.

Cherneva, Z., Stancheva, E., Tadjer, L. 1987. *Geologica Balc.,* 17, 5, 41-63 (in Russian) .

Cherneva, Z., A. B. Kotov, D. P. Vinogradov, E. B. Salnikova. 1991. *Compt. rend. acad. bulg. sci.,* 44, 10, 85-88.

Cherneva Z., Dimov, D., Stancheva, E., Daieva, L. 1995. *Review of the Bulg. Geol. Soc.,* 56.3, 91-101.

Cherneva, Z., Arnaudova, R., Iliev, Tz., Rekalov, K. 1997. *Review of the Bulg. Geol. Soc.,* 58.3, 139-166.

Ivanov, Z., Moskovski, S., Kolceva, K., Dimov, D., Klain, L.1984; *Geol. Balc.,* 14, 1, 3-42. (in Bulgarian, abstract in English)

Ivanov Z., Moskovski, S., Dimov, D., Kolceva, K., Klain, L.1985; *Geol. Balc.,* 15, 3, 3-32. (in Russian, abstract in English)

Ivanov, Z. 1989. *CBGA-XIV Congress, Sofia, Bulg.,* 126.

Ivanov, Z., D. Dimov, S. Sarov. 2000.*ABCD-GEODE workshop, Borovets,Guide to excursion(B),*6-17.

Kostov, I., Grozdanov, L., Petrusenko, S., Krasteva, M., Rashkova, D. 1986. *Geochem., Mineral., Petrol.*, 20-21; 25-48.

Parrish, R.R. 1990. *Can J. Earth Sci*. 27: 1431-1450.

Peytcheva, I., E. Salnikova, Y. Kostitsin, M. Ovtcharova, S. Sarov. 2000. *ABCD-GEODE Workshop, Borovets, Bulgaria, Abstracts,* 66.

Sarov St., Ovtcharova, M., Voinova, Em., Georgieva, I. Jordanov, B., Marinova, R., Tsvetkov, A., Markov, N. 1998. Report MoEW. GGC Co. National Geo-fond

Schärer, U. 1984. *Earth Planet Sci Lett*. 67: 191-204.

Viskupic,K. & V. Hodges. 2001. *Contrib. Mineral. Petrol*. 141; 233-247