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New U/Pb and Pb/Pb zircon ages from the Biharia terrane rocks, Apuseni Mountains, Romania

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Abstract. The Biharia sequence from the Apuseni Mountains is a component of the Biharia Paleozoic terrane. The Biharia terrane probably evolved as an island arc between the Cadomian Someş and Baia de Arieş terranes. A gneissic metagranodiorite associated with metabasites from the Valea Ierţii creek, was sampled for U/Pb and Pb/Pb zircon age determination. The zircons extracted out of the sampled rock were subjected both to dilution and evaporation methods. Dilution method offered Concordia intercepts at 227±23 Ma, 312±13 Ma, 465.7+8.4/-8.0 Ma, 703±21 Ma and 1604±45 Ma. Evaporated zircon grains gave 450±20 Ma and 543±17 Ma. The 227±23 Ma age and 312±13 Ma age have been interpreted as Pb loss due to the final effect of the Permian widespread magmatism and late Variscan anatexis respectively. The 465.7+8.4/-8.0 Ma and 450±50 Ma ages probably represent the protolith generation time. The 543±17 Ma is viewed as an inherited Cadomian age and the 703±21 and 1604±45 Ma might represent Cadomian and Saharan detrital zircon ages.

Key words: Apuseni Mountains, Biharia terrane, Cadomian orogeny, zircon ages.

INTRODUCTION

The Apuseni Mountains are comprised of three Paleozoic terranes and five metamorphic suites (Fig. 1). The three terranes are called: Someş, Baia de Arieş and Biharia (Balintoni, 1994; Pană and Balintoni, 2000). Out of the five metamorphic suites named: Someş, Baia de Arieş, Biharia, Păiuşeni and Vulturese-Belioara (Ianovici et al., 1976; Balintoni, 1997) the first three corresponds respectively to the same named terranes. The Păiuşeni and Vulturese-Belioara suites represent a Permian volcano-sedimentary pile and a Triassic carbonate series respectively, metamorphosed during the Alpine orogeny (Pană, 1998; Dallmeyer et al., 1999; Ianovici et al., 1976) overlaying the Biharia terrane (Ianovici et al., 1976). As an Alpine orogen, the Apuseni Mountains are built up out of Bihor autochthonous unit overlaid by the Codru and Biharia nappe systems and by the Transylvanides (Ianovici et al., 1976; Bleahu et al., 1981; Sandulescu, 1984).

The Biharia metamorphic suite as the main component of the Biharia nappe system is formed essentially of two rock types: metabasites and metaacidic rocks (Mârza, 1969). Geochemically these rocks can be interpreted as a bimodal magmatic association, or as an island arc assemblage (Pană and Balintoni, 2000). Balintoni (1994) considered the Biharia metamorphic suite as a part of the Variscan suture between the Someş and Baia de Arieş terranes. Pană and Balintoni (2000) reports U/Pb zircon ages of 489.6±6.9 Ma and 502±4.2 Ma performed on metaacidic rocks of this metamorphic suite. They accepted these ages as being protolith crystallization ones. Apparently the metaacidic rocks are younger than the metabasites. In this paper we report new U/Pb and Pb/Pb single zircon ages performed on metaacidic rocks of the Biharia metamorphic suite.

SAMPLE DESCRIPTION

The sample #268 was collected from the Valea Ierţii creek, near Băişoara locality. The rock is a gneissic metagranodiorite associated with metabasites. It consists of albite, quartz, chlorite, epidote and clinozoisite, muscovite, apatite, opaque minerals and zircon. The plagioclase and quartz are recrystallized and contain oriented inclusions. Mârza (1969) called these rocks plagio-metavolcanics.

ZIRCON U/PB AND PB/PB ANALYTICAL METHODS

Samples of approximately 10 kg have been collected and milled to fine powder. The initial crushing was performed with a typical jaw crusher followed by Bico disc mill before passing over a Wilfley table in order to concentrate the heavy minerals. Zircon was separated using magnetic mineral separation and heavy liquid procedures respectively. Finally, the zircon grains were hand selected under a binocular stereomicroscope.

Measurements of isotopic ratios were performed in the Laboratory of Radiogenic Isotope Geochemistry, Institute of Geology and Geophysics, Chinese Academy of Sciences,

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Beijing, using an IsoProbe-T thermal ionization mass spectrometer manufactured by the GV Company. The IsoProbe-T is equipped with 9 Faraday cups, 1 Daly receiver and 7 ion-counters. The technique used for zircon evaporation is similar to that developed by Kober (1986). Pb isotopes (^{204}Pb, ^{206}Pb, ^{207}Pb, and ^{208}Pb) were statically measured using four ion-counters with an 8-second-intergration. Calculation of $^{207}Pb/^{206}Pb$ ages is based on mean values of all measurements and uncertainties are given at 2σ standard deviation. Ages for several zircons from the same sample are given as a weighted average and its 2σ error propagated from the assigned errors (2σ internal error; Ludwig, 2001). For conventional U-Pb isotopic dilution analyses, a single zircon grain was washed in warm 7N HNO_3 and warm 6N HCl, respectively, prior to dissolution to remove surface contamination after air abrasion. A mixed ^{205}Pb-^{235}U-tracer solution was added to the grain. Dissolution was performed in PTFE vessels in a Parr acid digestion bomb (Parrish, 1987) using the vapour digestion method. The bomb was placed in an oven at 210°C for one week in 22N HF and for one day in 6N HCl to dissolve fluorides into chloride salts and avoid U-Pb fractionation. No separation of U and Pb was carried out by the ion exchange chromography method. Pb isotopic ratios were measured statically using a combination of Daly receiver and Faraday cups. U isotopic ratios were measured in UO^{2+} using the Daly receiver in dynamic model. Total procedural blanks were <10 pg for Pb and U. A factor of 1‰ per atomic mass unit for instrumental mass fractionation was applied to all Pb analyses, using NBS 981 as the reference material. Common Pb contribution remaining after correction for tracer and blank was corrected using the values of Stacey and Kramers (1975). U-Pb analytical data were evaluated with 2σ standard error using the PbDAT program of Ludwig (1988). Regression of the U-Pb data in concordia diagrams was done using the Isoplot program (Ludwig, 2001). More details on analytical techniques are given in Chen et al. (2000).

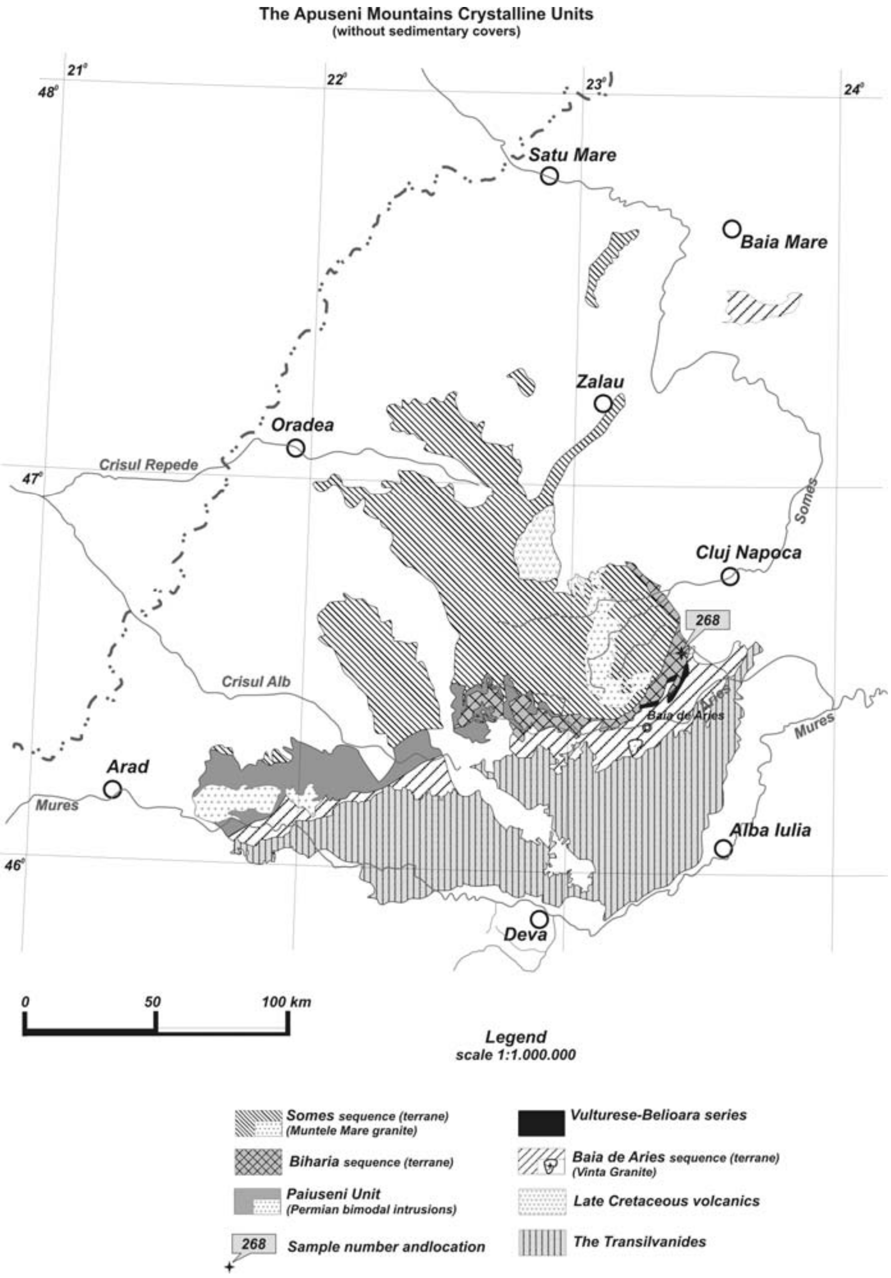

Fig. 1. *Structural sketch of the Apuseni Mountains showing the distribution of the main metamorphic sequences and sampling locality. The Transylvanides is a generic name referring to an Alpine nappes stack. Compiled based on Ianovici et al. (1976), Bleahu et al. (1981), and Balintoni (1994, 1997).*

ANALYTICAL RESULTS

Seven zircon grains separated from sample 268 were analyzed by dilution method and two crystals by evaporation method. The analytical data for U/Pb and Pb/Pb are presented in the Tables 1 and 2.

The dilution data projects discordant (Fig. 2). A discordia line through the grains 1, 3, 5 (Fig. 3) has a lower intercept at 227±23 Ma and an upper intercept at 703±21 Ma. A second discordia line through the grains 2, 4 (Fig. 4) has a lower intercept at 312±13 Ma and an upper intercept at 1604±45 Ma. A third discordia line through the grains 1, 2, 7 (Fig. 5) has an upper intercept at 465.7+8.4/- 8.0 Ma.

The 268–II evaporated crystal gave a data cluster at 450±20 Ma (Fig. 6) and the 268–I evaporated crystal offered an age around 543±17 Ma (Fig. 7).

Table 1. *Zircon evaporation data for samples #268-I and 268-II of the Biharia suite. Calculation of $^{207}Pb/^{206}Pb$ ages is based on mean values of all or selected measurements and uncertainties are given at 2σ standard deviation.*

Sample	No of grains	No. of ratios	Mean value of $^{207}Pb/^{206}Pb$ ratios	$^{207}Pb/^{206}Pb$ age (Ma)
268-I	1	34	0.055947596	450±20
268-II	1	31	0.05835442	543 ±17

Table 2. *Zircon U-Pb dilution data of the sample #268, metadiorite from the Biharia suite. The analytical data were evaluated with 2σ standard error using the PbDAT program of Ludwig (1988). See text for details.*

					Apparent ages		
206/238	**2σ % err**	**207/235**	**2σ %err**	**rho**	**206/238**	**207/235**	**207/206Pb**
0.067233	0.497	0.546508	0.583	0.85874	419.46	442.71	565.4
0.059839	2.21	0.513301	2.59	0.86827	374.65	420.67	681.46±28
0.078404	0.66	0.650822	0.71	0.933969	486.59	508.98	610.9±5.5
0.0875195	0.66	0.928545	0.77	0.87433	540.85	66.87	1119±7.5
0.0863518	0.61	0.727987	0.79	0.78053	533.92	555.37	1516.6±11
0.0601571	1.07	0.497366	1.27	0.88132	376.58	409.92	602.26±13
0.0634326	0.58	0.528829	0.62	0.933541	396.47	431.03	620.24±4.9

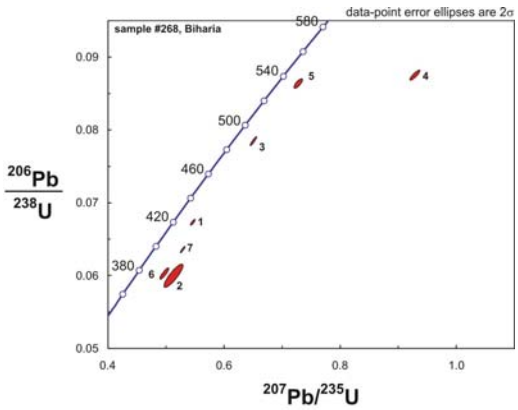

Fig. 2. *Concordia projection of dilution data for seven zircon fractions from sample #268. Except the point 4, all data projects close to the Concordia, showing a slight discordance. Regression of U-Pb data in diagram was done using the Isoplot program (Ludwig, 2001).*

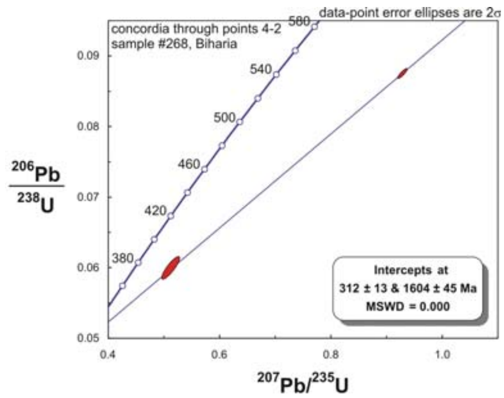

Fig. 4. *Concordia solution through data points 4 and 2. The lower and upper intercepts are at 312±13 and 1604±45 Ma respectively. See text for details.*

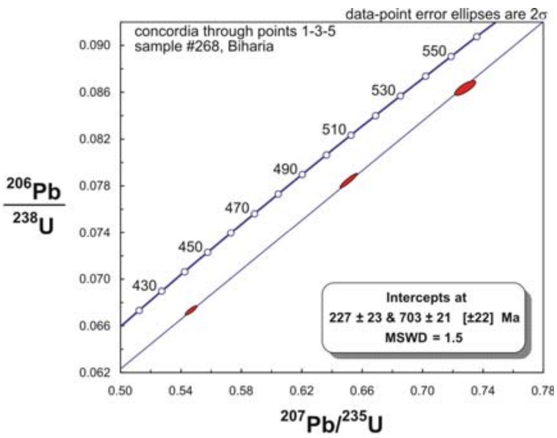

Fig. 3. *Concordia solution through data points 1, 3 and 5. The lower and upper intercepts are at 227±23 and 703±21 Ma respectively. For the significance of these ages see the text.*

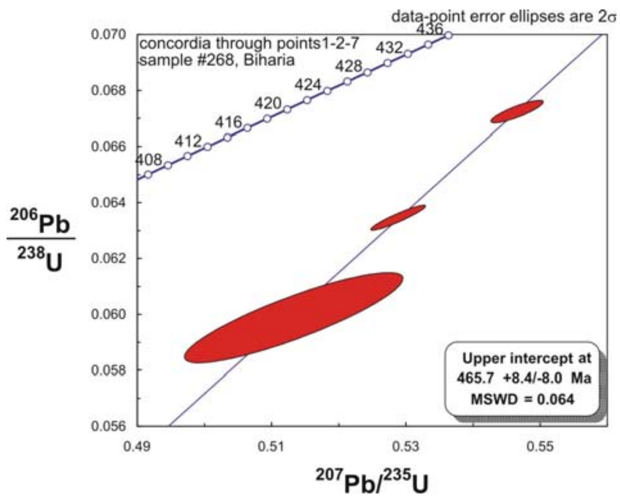

Fig. 5. *Concordia solution through data points 1, 2 and 7. The upper intercept at 435.7 +8.4/-8.0 Ma may be considered as the protolith age, although the grain 2 has quite large errors.*

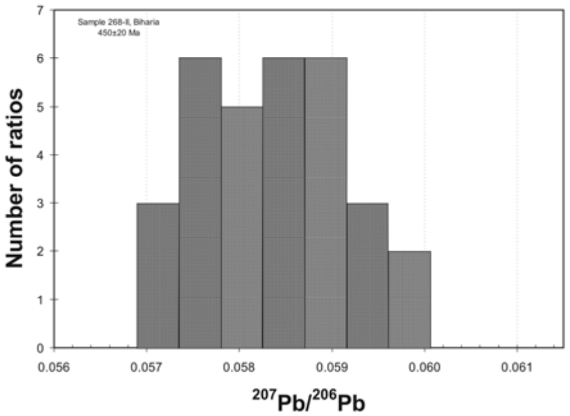

Fig. 6. *Probability-density plot of evaporation data from sample 268-II. The mean age is constrained to 450±20 Ma, after the rejection of highly discordant isotopic ratios.*

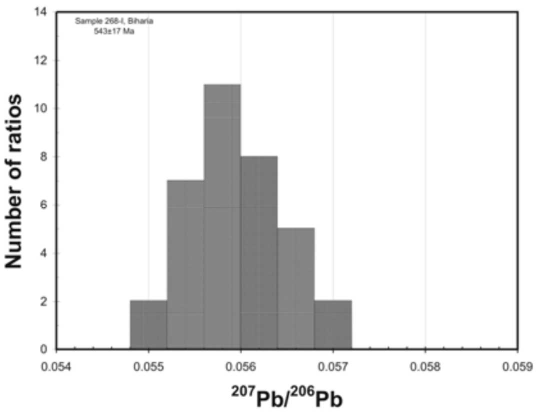

Fig. 7. *Probability-density plot of evaporation data from sample 268-I. The mean age is constrained to 543±17 Ma, after the rejection of highly discordant isotopic ratios.*

DISCUSSION

All of the constrained ages may have a geological significance. Ages of ≈220 Ma has been reported by Pană (1998) from the Vința granite, Dallmeyer et al. (1999) from Biharia granites and Balintoni et al. (2007 a, b) from Muntele Mare granite and Mihoeşti orthogneiss. These ages may reflect the final effect of the Permian extensional magmatism widespread in the Apuseni Mountains (*e.g*., Ianovici et al., 1976) on the older crust.

The 312 Ma age is a late Variscan age. These ages are common in the Apuseni Mountains (Pana, 1998; Dallmeyer et al., 1999; Balintoni et al., 2007 a, c). They indicate the strong influence of the Variscan thermotectonic event and anatexis upon the Paleozoic terranes.

The ages of 465.7+8.4/-8.0 Ma and 450±20 Ma can be accepted as protolith ages for the Biharia metagranites. They are younger than the ages reported by Pana and Balintoni (2000) of 489.6±6.9 Ma and 502±4.2 Ma, but those ages were obtained on zircon populations. We appreciate that SHRIMP data or LA-ICP-MS data may resolve the crystallization age of Biharia metagranites.

The 543 Ma probably represents an inherited age. This age is similar to protolith ages of the Baia de Aries and Somes metamorphic sequences (Balintoni et al., 2007 b, c). The ages of 703 Ma and 1604 Ma are known as Cadomian and Saharan detrital ages in the Somes sequence rocks and Vinta granites (Balintoni et al., 2007 b, c).

CONCLUSION

The Biharia metagranites show the same history like the other two Paleozoic terranes of the Apuseni Mountains, Somes and Baia de Aries. However, their protoliths appear younger than the orthogneiss protoliths of the two terranes. This supports the interpretation of Pană and Balintoni (2000) that the Biharia terrane represents an island arc between the Someş and Baia de Arieş terranes. The original location of the Biharia terrane was near the North African-Gondwanan margin, too.

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