WHOLE ROCK K/AR VS. ZIRCON U/PB AGES FOR THE UPPER CRETACEOUS MAGMATIC ROCKS (BANATITE) ASSOCIATED TO GOSAU-TYPE BASINS LĂPUGIU AND RUSCA MONTANĂ (W ROMANIA)

IOAN SEGHEDI[1,*], ZOLTAN PÉCSKAY[2]

[1] Institute of Geodynamics "Sabba S. Ştefănescu", Romanian Academy, 19–21, J.-L. Calderon 020032 Bucharest, Romania; ORCID ID: 0000-0001-7381-7802; [*] Corresponding author
[2] Institute for Nuclear Research of the Hungarian Academy of Sciences, P.O. Box 51, Bem ter 18/c, H-4001, Debrecen, Hungary; ORCID ID: 0000-0002-3571-9352

Abstract: This study comprises 12 new K/Ar data on Upper Cretaceous intrusive and volcaniclastic deposits associated to Gosau-type basins Lăpugiu and Rusca Montană (South Carpathians, W Romania). Here we validate K/Ar as a useful method for age determination of Upper Cretaceous rocks, those that in the absence of zircon cannot be dated by U-Pb methodologies. The K-Ar age determinations fall within the age range of the known zircon U-Pb method, i.e. 83-70 Ma. We found that the age of volcaniclastic sequences or subvolcanic rocks is always younger (~70-76 Ma) than the associated hypabyssic intrusive rocks (~80-83 Ma). We suggest that 70-80 Ma may corresponds to a period with extensional tectonics and Gosau basins generation.

Keywords: K/Ar dating, Banatites, Gosau-type basins.

Résumé: Cette étude comprend 12 nouvelles données K/Ar sur les dépôts intrusifs et volcanoclastiques du Crétacé supérieur associés aux bassins de type Gosau de Lăpugiu et Rusca Montană (Carpates du Sud, W Roumanie). Nous validons ici K/Ar comme une méthode utile pour la détermination de l'âge des roches du Crétacé supérieur, celles qui en l'absence de zircon ne peuvent être datées par des méthodologies U-Pb. Les déterminations d'âge K-Ar se situent dans la plage d'âge de la méthode U-Pb connue sur le zircon, c'est-à-dire 83–70 Ma. Nous avons constaté que l'âge des séquences volcanoclastiques ou des roches subvolcaniques est toujours plus jeune (~70–76 Ma) que les roches intrusives hypabyssiques associées (~80–83 Ma). Nous suggérons que 70–80 Ma peut correspondre à une période avec tectonique extensionnelle et génération de bassins de Gosau.

Mots-clés: Datations K/Ar, Banatites, bassins de type Gosau.

1. INTRODUCTION

Upper Cretaceous tectonics is characterized by the collision of continental plates that resulted in crustal thickening and successive crustal extension that led to the formation of syn-orogenic sedimentary basins (Willingshofer *et al.*, 1999, 2001; Schuller, 2004; Schuller and Frisch, 2006), sometime associated with volcanic and subvolcanic rocks (e.g., Constantina *et al.*, 2009; Savu, 2012).

Here we will discuss the age of magmatic rocks associated with such type of basins located either in the top of the Supragetic units (Lăpugiu basin) along the Mureş valley, south of the Apuseni Mountains, or in the top of the Getic units in the Southern Carpathians (Rusca Montană basin) (Fig. 1).

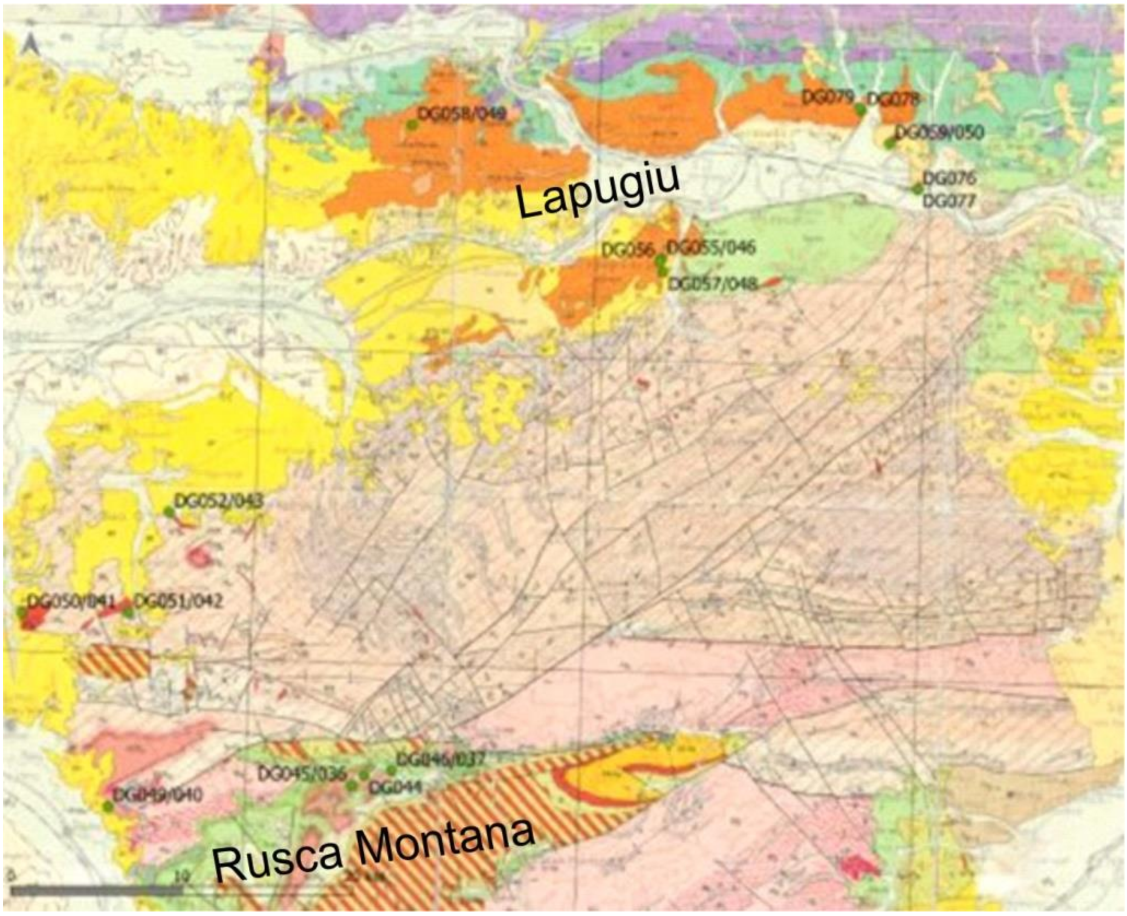

Fig. 1. The distribution on the geological map of Romania, 1:200,000 (IGR) of the samples analyzed with the K-Ar method, presented in parallel with the samples analyzed chemically and by the U-Pb method on zircon of Gallhofer (2015). See also below the Table I.

Upper Cretaceous basin formation is associated with generation of fluvio-lacustrine to marine deposits known as Gosau type (e.g. Săndulescu, 1988; Willingshofer *et al.*, 1999; Schuller, 2004; Schuller and Frisch, 2006; Schmid *et al.*, 2008; Merten *et al.*, 2011). The genesis of the Gosau-type sedimentary formations in the two mentioned basins is contemporary with the calc-alkaline banatitic magmatic activity (Strutinski and Hann, 1986; Ștefan *et al.*, 1992; Downes *et al.*, 1995; Berza *et al.*, 1998; Ciobanu *et al.*, 2002; Constantina *et al.*, 2009; Savu, 2012).

In the following we will comment a series of 12 new K-Ar analyzes performed on banatitic rocks associated or at the periphery of two basins, which are to be compared with radiogenic U-Pb age data ($^{206}Pb/^{238}U$) on zircon performed by Gallhofer (2015). We emphasize that the K-Ar analyzes were performed on the same samples analyzed by Gallhofer (2015).

2. METODOLOGY

The petrographic studies were carried out with the supplied Olympus microscope. Analytical data were obtained in the K-Ar ATOMKI laboratory, Debrecen, Hungary, by Dr. Zoltán Pécskay. The analytical procedures used in the laboratory have been described in detail in various publications (e.g. Pécskay *et al.*, 2006).

3. PETROGRAPHY

We present in Table I the petrographic data of the analyzed rocks (the first number of the sample represents the K-Ar analysis, and the second corresponding number from Gallhofer, 2015).

Table I

Nr.	*Sample Name/coordinates: ZP/DG*	*Location*	*Obs.*	*Mineralogy, rock*
1	036 /45 N45.604/E22.329	Rusca Montana Valley	Subvolcanic Intrusion: Porphyritic Holocrystaline; Slightly hydrothermaly altered	Plag (albite, sericite), Amphibole (chlorite); Biotite (chlorite), acc, op; **Micro-diorite**
2	037/46 N45.612/E22.358	Rusca Montana Valley	Dyke: porphyritic holocrystaline	Plag, K-feldspar, Quartz, Amphibole (chlorite), acc; **Dacite**
3	039 A/48 N45.529/E22.324	N-Glâmboca quarry	Dyke: porphyritic, Propilitic alteration	Plag, Cpx (chlorite), Amphibole (chlorite), Biotite (chlorite), Biotite (chlorite), acc, op. **Andesite**
4	039 B/48 N45.529/E22.324	N-Glâmboca quarry	Dyke: slightly porphyritic, Propilitic alteration	Plag, Cpx cumulophyric (chlorite), Amphibole (chlorite), acc, op; **Basaltic Andesite**
5	040/49 N45.589/E22.147	Tincova	Large intrusion; porphyritic, Holocrystaline; Slightly tectonized	Plag, Kfelds, Qtz, Amphibole; Opx, Biotite, acc. op, titanite **Granodiorite**
6	041/50 N45.689/E22.077	Drinova	Intrusive dome, sometimes brecciated; porphyritic, slightly propilitic	Plag (albite), Opx (chlorite), Amphibole (chlorite), qtz., sec. ser+carb **Andesite**
7	042/51 N45.691/E22.157	South Hauzeşti	Intrusion; Holocrystaline; fresh	Plag, Cpx, Opx, Amphibole, rare Biotite, acc. ap, op **Diorite**
8	043/52 N45.745/E22.185	Gladna	sill: porphyritic, slightly propilitic	Plag, Quartz, Amphibole (chlorite), Biotite (ser), acc, microlitic groundmass **Dacite**
9	046/55 N45.887/E22.549	South Mihăieşti	volcaniclast; aphyric, relatively fresh	Cpx, Opx, Plag microlitic, microlitic groundmass **Andesite**
10	048/57 N45.879/E22.551	South Mihaieşti	volcaniclast; porphyritic, slightly altered	Plag, Cpx, Opx- altered, Amphibole, microlitic groundmass **Andesite-Dacite**
11	049/58 N45.953/E22.358	Căprioara-Bulza	Intrusion; porphyritic, slightly altered	Plag, Cpx as cumulophyric , Opx, acc. **Diorite**
12	050/59 N45.951/E22.719	Bretea Mureşana Quarry	Lava dome; Fine equigranular, fresh	Plag (laths), Cpx, Opx-altered, rare Biotite, (Amph), **Andesite**

4. K-AR AGE OF THE ANALYZED ROCKS; CORRESPONDENCE WITH THE U-PB AGE ON ZIRCON

In Table II below, the K-Ar data on the studied rocks are presented for the first time:

Table II

No. of K/Ar data	*Sample*	*Rock type*	*Locality*	*K (%)*	$^{40}Ar_{rad}$ *(ccSTP/g)x10*$^{-6}$	$^{40}Ar_{rad}$ *(%)*	*K/Ar age (Ma)*	*Zircon age (Ma)*
8195.	036/45	Micro-diorite	Rusca Montană	1.913	5.5217	89.2	72.77±2.21	75.06±2.21
8196.	037/46	Dacite	Rusca Montană	3.04	9.0929	85.9	75.35±2.31	–
8197.	039A/48	Andesite	N Glânboca	2.05	5.8431	69.5	71.87±2.30	–
8198.	039B/48	Basaltic andesite	N Glânboca	2.24	6.7048	70.1	75.53±2.41	–
8199.	040/49	Granodiorite	Tincova	2.28	6.5287	84.5	72.20±2.22	77.15±0.1
8200.	041/50	Andesite	Drinova	1.585	4.4816	40.0	71.31±2.89	–
8201.	042/51	Diorite	S Hăuzești	2.105	6.8467	86.0	81.79±2.50	–
8202.	043/52	Dacite	Gladna	1.754	5.6045	80.5	80.38±2.49	78.0 ± 3.1
8203.	046/55	Andesite	Roșcani	1.811	5.3526	86.8	74.47±2.27	–
8204.	048/57	Andesite-Dacite	Roșcani	1.648	5.0387	67.7	76.98±2.48	–
8205.	049/58	Diorite	W Lăpugiu	2.09	6.8482	79.2	82.38±2.56	–
8206.	050/59	Andesite	Mureș valley	1.14	3.1870	55.4	70.52±2.43	–

5. COMPARATIVE OBSERVATIONS AND DISCUSSION

Gallhofer (2015) performed chemical analyzes for all the samples included in Table II, however for some of them she failed to separate a sufficient number of zircon crystals for age determinations. As can be recognized, only three samples were analyzed with both methods. Two of them have a K/Ar age younger by 2–5 Ma, only one of them (043/52) has a K-Ar age younger by ca. 2 Ma, but within the error limits of both methods.

It obviously outcomes that the K-Ar method can be taken into account when the U-Pb method cannot be applied. It is likely that the younger ages of K-Ar compared to those of U-Pb are related to the loss of Ar, as in most cases the rocks were affected by slight hydrothermal alteration processes.

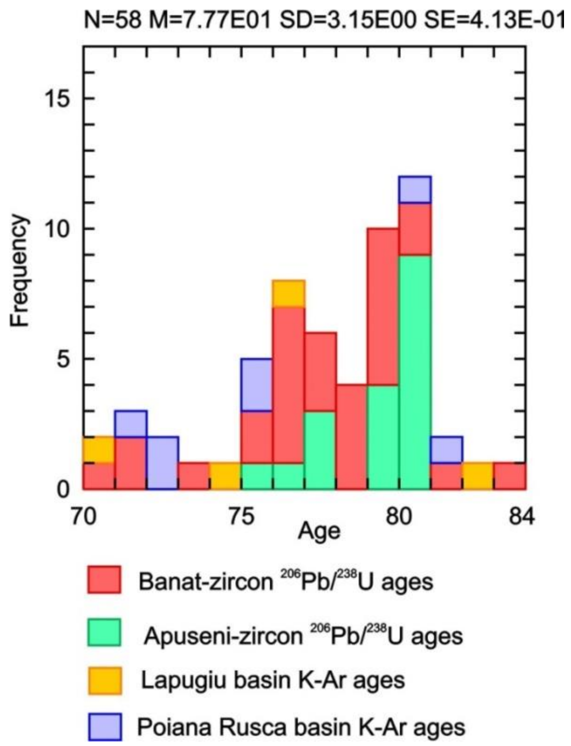

Fig. 2. Histogram with age samples determined by the U-Pb method (Gallhofer, 2015) from the Apuseni and Banat Mountains to which the samples analyzed by the K-Ar method from this study were added.

The diagram in figure 2 shows all the age samples determined by the U-Pb method (Gallhofer, 2015) from the Apuseni and Banat Mountains to which we added the samples analyzed by the K-Ar method from this study. It can be noted the existence of two age intervals with a higher frequency, one at 75–78 Ma and another at 79–81 Ma. The K-Ar age determinations fall within the age range of the samples determined by the U-Pb method, i.e. 83–70 Ma. This interval seems to characterize the temporal evolution of the two basins, but it is also characteristic for the entire period of generation of Banatitic magmatism in the two large regions, Banat and Apuseni.

Comparatively looking at the volcanic/subvolcanic relationship, it is found that the age of volcaniclastic sequences or subvolcanic rocks, such as sills or dykes (~70–76 Ma) from the two basins are mostly younger than the associated hypabyssic intrusive rocks (~80–83 Ma). This situation is also suggested by the K-Ar age data previously carried out also by Dr. Pécskay in the Lăpugiu basin (Constantina *et al.*, 2009), that reveal ages between 68.8–80.0 Ma for the volcanic rocks. Constantina *et al.* (2009) interprets the relatively wide age range (>10 Ma) obtained by the K-Ar method as a possible result of a polyphase volcanic activity. We consider that the interval of 70–80 Ma may corresponds to a period with extensional tectonics and Gosau basins generation, explicitly responsible for the easy access of magmas to the surface with the generation of effusive rocks within the two basins.

6. CONCLUSIONS

The present study attests the importance of the K-Ar method for age determinations of Upper Cretaceous igneous rocks (Banatites), as the only one at hand when ages cannot be obtained by modern U-Pb methods on zircon crystals. For the best possible accuracy, dating by the K-Ar method should avoid analyzing rocks deeply affected by secondary hydrothermal alteration processes, which can alter the real age of the rocks.

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