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K-Ar datings of Neogene-Quaternary calc-alkaline volcanic rocks in Romania

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Abstract

Neogene-Quaternary plate convergence-related calc-alkaline magmatic rocks from Romania have been dated using the K-Ar radiometric technique. The magmatic rocks occur in the East Carpathians and the Apuseni Mts. In the East Carpathians, the discontinuous magmatic arc is segmented into two main volcanic areas, Oaș-Gutâi (OG) and Călimani-Gurghiu-Harghita (CGH) at the extremities and an intrusive (subvolcanic) segment (Țibleș-Toroiaga-Rodna-Bârgau: TTRB) in the middle. According to biostratigraphical data, volcanic activity started in the Badenian, but the oldest rocks are dated at 13.4 Ma. The volcanic activity ceased at about 0.2 Ma.

The range of apparent ages during Pannonian (9-11 Ma) in TTRB is partly coeval with that of OG, reflecting the paroxysm of the magmatic activity. The longest interval of activity was detected in the Gutâi Mts. (13.5-6.9 Ma). An obvious age progression along the arc was pointed out for CGH volcanic chain, enhanced along the terminal 40 km of South Harghita Mts. (4.3-0.2 Ma). Preliminary data from the Apuseni Mts. suggest the Sarmatian as the main interval for magmatic activity in that region (13.4-12.4 Ma).

1. Introduction

This study deals with the geochronological interpretation of K-Ar ages from the Romanian volcanic areas performed at the Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen. Before the early 1990's only a few radiometric ages were available (Rădulescu et al., 1972; Edelstein et al., 1977; Michailova et al., 1983; Peltz et al., 1987; Lemne et al., 1983). In order to improve the knowledge of space-time evolution of the volcanic activity, especially in the East Carpathians, systematic K-Ar age determinations have been undertaken, starting in 1990 within the framework of a bilateral scientific collaboration between the Romanian Academy and the Hungarian Academy of Science. At present there are more than 300 age determinations on about 250 samples, covering all the studied volcanic areas. Some of these data and their interpretation have already been published (Edelstein et al., 1992; 1993; Pécskay et al., 1994; Szakács et al., 1993).

2. Methods

Most of the K-Ar age determinations were carried out on whole rock samples because of the mineralogy and texture of the investigated magmatic rocks. Secondarily altered specimens were eliminated after microscopic inspection of thin-sections. The samples were degassed in a conventional extraction system using induction heating and were measured by mass spectrometric isotope dilution with an ^{38}Ar spike using a mass spectrometer (magnetic sector type of 150mm radius and 90° deflection) in the static mode. Recording and evolution of the Ar spectrum were controlled by microcomputer. K analyses were made using standard flame photometric techniques. K and Ar determinations were checked regularly by interlaboratory standards LP-6, Gl-O, HD-B1 and Asia 1/65. Atomic constants suggested by Steiger & Jager (1977) were used for calculating the age. All analytical errors represent one standard deviation (68% analytical confidence level). Since we base our analytical errors on the long-term stability of the instruments and on the deviation of our results obtained on standard samples from the interlaboratory mean, the analytical errors are likely to be overestimated. Details of the instruments, the applied methods and results of calibration have been described elsewhere (Balogh, 1985).

K-Ar ages of suites of volcanic rocks generally are in good agreement with geological observations. However, both Ar and K concentrations may undergo changes during the history of the rock, due to diffusion, solution or ion-exchange. Since misinterpretation of the measurements because of excess Ar or diffusion deficiency cannot be excluded, particularly in some of the sub-volcanic and intrusive rocks, the isochron method was also used. On the other hand, the long-lived and continuous volcanism may have caused Ar loss from some samples. The full significance of this phenomenon has yet to be evaluated. In this paper, K-Ar ages are considered if their reality can be supported by geological, stratigraphical and petrographical arguments as well. For stratigraphic classification, we use the internationally accepted time-scale (Vass & Balogh, 1989).

3. Geologic framework

The Neogene-Quaternary volcanic activity is considered to be a response to compressive tectonic phases postdating continent-continent collision and developed along the inner part of the Carpathians (Săndulescu, 1988; Royden & Burchfiel, 1989). The Neogene volcanics of the Carpathians are dominantly calc-alkaline and are discontinuously distributed along the inner side of the orogenic arc forming an elongated chain running through Slovakia, Hungary, Ukraina and Romania. In

Romania, Neogene-Quaternary calc-alkaline volcanics occur in the East Carpathians and Apuseni Mts. The East Carpathian magmatic arc consists of (1) a northern volcanic sector: Oaş and Gutâi Mts. (OG), (2) a central intrusive (subvolcanic) sector: Ţibles-Toroiaga-Rodna-Bărgău Mts. (TTRB) and (3) a southern volcanic sector: Călimani-Gurghiu-Harghita Mts. (CGH) (Fig. 1).

The OG segment typically consists of calc-alkaline rock assemblages ranging from basalts to rhyolites. A series of isolated (in Oaş Mts.) or complex (in Gutâi and Oaş Mts.) volcanic edifices and associated or isolated (in the Poiana Botizei area) intrusive bodies have been built-up. Medium-K pyroxene andesites are the dominant rock type in the Gutâi Mts. (Kovacs et al., 1992).

The TTRB segment is characterized by swarms of simple or complex intrusive bodies. They pierce pre-Mesozoic metamorphic rocks in the Rodna and Toroiaga Mts. and Upper Cretaceous to Lower Miocene sedimentary deposits in the Tibleş and Bărgău Mts. The calc-alkaline bodies mainly consist of intermediate (andesite, diorites, monzodiorites) and acid (dacites, microgranodiorites) rocks.

The CGH segment is a ca. 160 km long continuous volcanic chain with its width, height and volume decreasing from north to south. Most of the chain is formed of calc-alkaline andesites, although basalts, basaltic andesite (especially in the Călimani Mts.) and dacites are also present. A slight tholeiitic trend has been identified for the early volcanic products in the Călimani area. The southernmost South-Harghita segment is notable for its along-arc variations from calc-alkaline to shoshonitic compositions (Seghedi et al., 1986; 1987; Szakács et al., 1993).

The Neogene volcanics in the Apuseni Mts. are mostly located along a ca. 100 km long NW-SE alignment in the central and north-western part of the Metaliferi Mts. They extend to the north-west in the Zărand Mts. and the adjacent Zărand Depression, and consist of andesite and dacite lava flows, volcaniclastics and shallow intrusions and minor rhyolitic-rhyodacitic volcaniclastics and lavas. At the south-eastern extremity of the area, in the Mureş Valley, an isolated rock body of shoshonitic composition occurs in the morphologically prominent Uroiu Hill. A second occurrence in the northern Metaliferi Mts. (Baia de Arieş-Roşia Montana-Bucium zone) consists mostly of andesitic-dacitic intrusive bodies and two necks of basaltic-andesites (Detunata).

4. Results and discussion

The results of the K-Ar age determinations are given in Tab. 1. For the OG and CGH segments where a large number of K-Ar data are available, histograms showing the range of the ages have been constructed (Fig.2). For the other areas (TTRB and Apuseni), an insufficient number of samples have been analysed and the results should be taken as preliminary. Fig. 3 shows the synthesis of the age data, according to geographical area, and compared with Mediterranean and Central Paratethys time-scales.

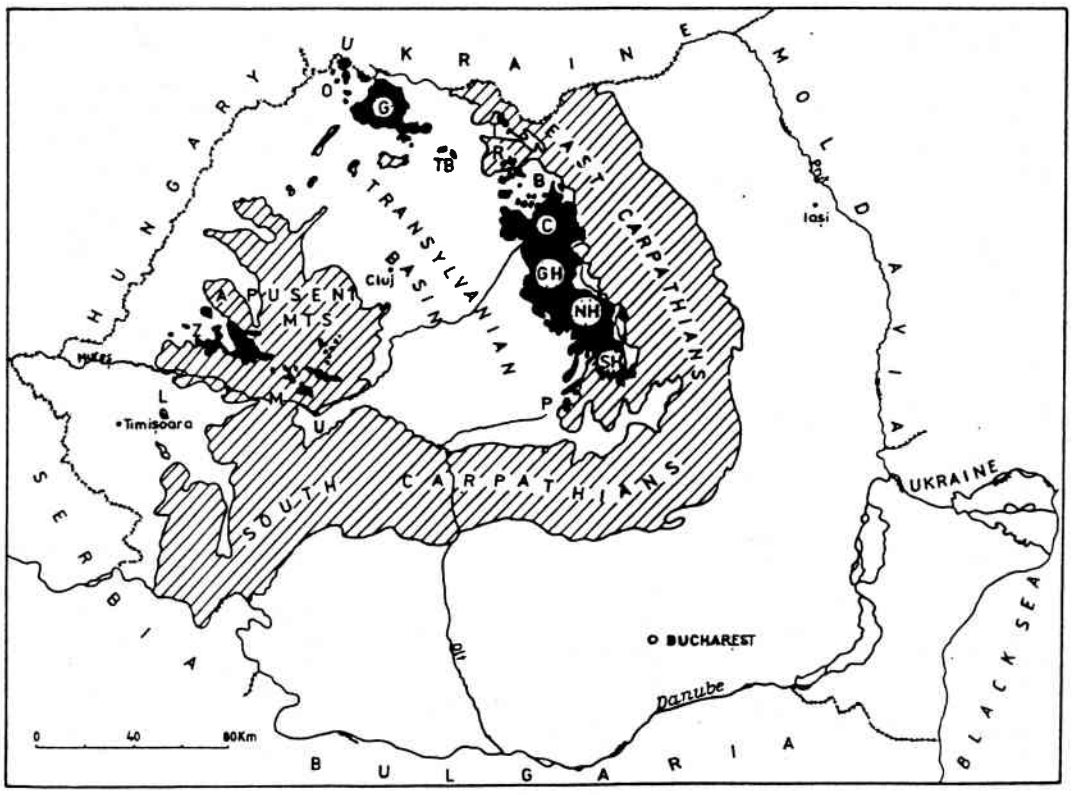

Fig. 1 – Sketch-map showing the occurrences of Neogene-Quaternary volcanics in Romania (O: Oaş Mts., G: Gutâi Mts., T: Toroiaga Mts., TB: Ţibles Mts., R: Rodna Mts., B: Bărgău Mts., C: Călimani Mts., GH: Gurghiu Mts., NH: North Harghita Mts., SH: South Harghita Mts., P: Perşani Mts., M: Metaliferi Mts., Z: Zărand Mts. and Zărand Depression, U: Uroiu Hill, L: Lucareţ basalts).

Table 1 – K-Ar datings of Neogene-Quaternary calc-alkaline volcanics in Romania performed in ATOMKI, Debrecen, during 1990-1994.

OAŞ MTS.

Sample no.	Locality	Rock type	Dated fraction	K %	40 Ar rad %	40 Ar rad cc STP/g	K-Ar age (Ma)	References
1	2	3	4	5	6	7	8	9
17.797 E	Sunătoarea V.	Tbi	bi	3.62	25.3	$1.684 \cdot 10^{-6}$	11.9 ± 0.7	
6058-91 K	Medieş Vii-Oraşu Nou	R	w.r.	3.23	39.8	$1.391 \cdot 10^{-6}$	11.0 ± 0.5	
5805 2 C	Jeleznic Peak	Apx	w.r.	1.63	82.9	$6.913 \cdot 10^{-7}$	10.9 ± 0.4	
6062-93 K	Turţ (F236/416)	MDipx	w.r.	1.70	28.8	$7.187 \cdot 10^{-7}$	10.8 ± 0.6	
27.565-L	Piatra Văscului Summit	ABpx	w.r.	1.04	25.1	$4.351 \cdot 10^{-7}$	10.7 ± 0.6	
19.757-91 E	Sarcoz Hill	Apx	w.r.	1.41	11.7	$5.822 \cdot 10^{-7}$	10.6 ± 1.2	
1132 A-6	Faţa Mare Hill	Apx	w.r.	1.83	31.4	$7.593 \cdot 10^{-7}$	10.6 ± 0.6	
22.577-89 L	Pietrele de casă V	Apx	w.r	1.03	37.6	$4.264 \cdot 10^{-7}$	10.6 ± 0.5	
1777-89 O	Geamăna Hill	Dpx	w.r.	2.25	32.2	$9.192 \cdot 10^{-7}$	10.5 ± 0.5	
14.701-89 E	Poiana Şesu	Apx	w.r.	1.78	41.3	$7.268 \cdot 10^{-7}$	10.5 ± 0.5	
1778-90	Gruiului Peak	Dpx	w.r.	1.92	66.3	$7.744 \cdot 10^{-7}$	10.4 ± 0.4	
22.582-89 L	Pleşcuţa Hill	Diqz	w.r.	1.56	12.7	$6.281 \cdot 10^{-7}$	10.3 ± 1.1	
27.566-92 L	Negru Hill	Aqz	w.r.	2.09	52.7	$8.285 \cdot 10^{-7}$	10.2 ± 0.4	
4684-89 H	Tărşolţ V.	Aqz	w.r.	1.16	17.4	$4.563 \cdot 10^{-7}$	10.1 ± 0.9	
27.567-92 L	Custurii V.	Aqz	w.r.	2.32	13.8	$9.019 \cdot 10^{-7}$	10.0 ± 1.0	
4568-1 C	Oilor V.	Apx	w.r.	2.19	15.4	$8.481 \cdot 10^{-7}$	9.9 ± 0.9	
7076-91 M	Gherţa Quarry (Turţ)	Dpxbi	w.r.	2.01	20.1	$7.733 \cdot 10^{-7}$	9.9 ± 0.7	
22.581-89 L	Viilor Hill	Apx	w.r.	2.48	50.5	$9.399 \cdot 10^{-7}$	9.7 ± 0.4	
20 S	Socea Mine	Apx	w.r.	2.63	28.8	$9.852 \cdot 10^{-7}$	9.6 ± 0.6	
6061-93 K	Frasin V. (Gherţa)	Apx	w.r.	2.81	42.9	$1.047 \cdot 10^{-6}$	9.6 ± 0.4	
19.564-91 E	Batarci V.	Dpx	w.r.	2.21	19.3	$8.148 \cdot 10^{-7}$	9.5 ± 0.7	

GUTÂI MTS.

27.684-83	Dărăbani Peak	Apx	w.r.	1.15	36.6	$6.010 \cdot 10^{-7}$	13.4 ± 0.7	1
24.006 L	Răchiţele V.	ABpx	w.r.	1.63	25.1	$8.485 \cdot 10^{-7}$	13.3 ± 0.8	1
2634-89	Şatra Hill	Dpx	w.r.	2.70	45.6	$1.385 \cdot 10^{-6}$	13.2 ± 0.6	3
9222-90 E	Mare V. (Cicârlău)	ABpx	w.r.	1.29	20.1	$6.624 \cdot 10^{-7}$	13.1 ± 0.9	1
25.256-90	Nistru Quarry	ABpx	w.r.	1.29	25.0	$6.352 \cdot 10^{-7}$	12.6 ± 0.8	1
25.256-85	Nistru Quarry	ABpx	w.r.	1.33	38.3	$6.275 \cdot 10^{-7}$	12.1 ± 0.6	1
27.235-0	Porcului V. (Ilba)	Apx	w.r.	1.76	72.0	$8.212 \cdot 10^{-7}$	12.0 ± 0.5	1
282/F260	Firizan gallery	Aqz	w.r.	1.78	25.2	$8.103 \cdot 10^{-7}$	11.7 ± 0.7	1
15.792-89 E	Bulzului V. (Dăneşti)	Dbi	Bi	6.69	43.5	$3.023 \cdot 10^{-6}$	11.6 ± 0.5	3

1	2	3	4	5	6	7	8	9
18.330-91 E	Ulmu Peak	Aqz	w.r.	1.26	24.0	$5.665 \cdot 10^{-7}$	11.5 ± 0.7	
8772 F 84	Poiana Cremenea Peak	Aqz	w.r.	1.77	73.1	$7.787 \cdot 10^{-7}$	11.3 ± 0.4	1
25.843-90	Vălini V.	Apx	w.r.	2.01	47.2	$8.752 \cdot 10^{-7}$	11.2 ± 0.5	
975-88	Usturoi V.	Aqz	w.r.	1.51	37.5	$6.471 \cdot 10^{-7}$	11.0 ± 0.5	3
25.050	Măgura Mare Peak	Apx	w.r.	1.63	56.8	$6.946 \cdot 10^{-7}$	10.9 ± 0.5	3
22 B-85	Piatra Tisei Peak	Aqz	w.r.	1.66	74.9	$7.011 \cdot 10^{-7}$	10.8 ± 0.4	1
12.522-89 E	Hircea Peak	Dqzampxbi	w.r.	1.64	40.7	$6.909 \cdot 10^{-7}$	10.8 ± 0.5	3
1951-0	Gutinului V.	ABpx	w.r.	1.40	24.7	$5.897 \cdot 10^{-7}$	10.8 ± 0.7	3
5590 M	Şuior Quarry	ABpx	w.r.	1.39	32.7	$5.786 \cdot 10^{-7}$	10.7 ± 0.5	3
27.823-83	Gotlieb V.	Apx	w.r.	1.41	17.3	$5.832 \cdot 10^{-7}$	10.6 ± 0.9	1
24.005 L	Piatra Tisei Peak	Aqz	w.r.	1.51	49.7	$6.701 \cdot 10^{-7}$	11.4 ± 0.5	1
27.607-93 L	Chicera Peak	ABpx	w.r.	1.28	36.5	$5.259 \cdot 10^{-7}$	10.5 ± 0.5	
5296-91	Budeşti Quarry	ABpx	w.r.	1.00	18.8	$4.390 \cdot 10^{-7}$	11.2 ± 0.9	
1747-81 E	Rotundu Summit	Apx	w.r.	1.51	43.3	$6.092 \cdot 10^{-7}$	10.3 ± 0.5	1
20.820 L	Ştur V.	ABpx	w.r.	1.43	36.0	$5.772 \cdot 10^{-7}$	10.3 ± 0.5	3
7999-84 E	Turnu Ars V.	ABpx	w.r.	1.26	59.9	$5.032 \cdot 10^{-7}$	10.2 ± 0.4	
5680 A-83 E	Higea Peak	Apx	w.r.	1.53	31.7	$6.050 \cdot 10^{-7}$	10.1 ± 0.5	1
5779-92 C	Jidovin V.	Apxam	w.r.	1.19	36.3	$4.565 \cdot 10^{-7}$	9.9 ± 0.5	
25.124-90	Breze Summit	Dampx	w.r.	2.73	47.7	$1.058 \cdot 10^{-6}$	10.0 ± 0.4	3
27.562-92 L	Holmuţ Peak	Apx	w.r.	1.45	47.5	$5.583 \cdot 10^{-7}$	9.9 ± 0.4	3
27.561-92 L	Stânilor Summit	Apx	w.r.	1.82	55.4	$6.970 \cdot 10^{-7}$	9.8 ± 0.4	3
14.595 L	Mogoşa Summit	ABpxam	w.r.	0.78	43.0	$2.903 \cdot 10^{-7}$	9.5 ± 0.4	1
1600-81 E	Braga Peak	Apxambi	w.r.	1.79	65.7	$6.488 \cdot 10^{-7}$	9.3 ± 0.4	
6714-F82	Igniş Summit	Apx	w.r.	1.94	24.6	$7.063 \cdot 10^{-7}$	9.3 ± 0.6	1
25.899-89	Gutâi Summit	Apxambi	w.r.	2.22	43.4	$7.998 \cdot 10^{-7}$	9.3 ± 0.4	3
25.879-89	Gutâi Summit	Apxambi	w.r.	2.40	38.4	$8.667 \cdot 10^{-7}$	9.3 ± 0.4	3
6713 A-90 F	Igniş Summit	Apx	w.r.	1.62	49.0	$5.773 \cdot 10^{-7}$	9.1 ± 0.4	1
6713-90 F	Igniş Summit	Apx	w.r.	1.94	70.6	$6.827 \cdot 10^{-7}$	9.0 ± 0.4	1
15.103-89 E	Gutâi Summit	Apxambi	w.r.	2.52	35.2	$8.815 \cdot 10^{-7}$	9.0 ± 0.4	3
26.106-90	Vidra V.	Bpx	w.r.	0.80	15.6	$2.767 \cdot 10^{-7}$	8.8 ± 0.8	2
5647-0N	Băii V.	Bpx	w.r.	1.16	20.6	$3.595 \cdot 10^{-7}$	7.9 ± 0.6	2
20.944-92 E	Peştilor V	Bpx	w.r.	1.32	50.9	$3.947 \cdot 10^{-7}$	7.7 ± 0.3	2
25.256-90	Berdu V.	Bpx	w.r.	1.31	15.7	$3.877 \cdot 10^{-7}$	7.6 ± 0.7	2
20.943-90 E	Runcului V.	Bpx	w.r.	1.37	24.8	$3.731 \cdot 10^{-7}$	7.0 ± 0.4	2

Table 1 (continued).

POIANA BOTIZEI SUBVOLCANIC ZONE

1	2	3	4	5	6	7	8	9
11.100-87 E	Runcaşi Peak	mDipx	w.r.	1.43	18.0	$6.282 \cdot 10^{-7}$	11.2 ± 0.9	
2437-87 B	Roţii V.	Apx	w.r.	1.50	25.2	$6.521 \cdot 10^{-7}$	11.1 ± 0.7	
4293-87 M	Ulmului V	mDipx	w.r.	1.12	25.8	$4.572 \cdot 10^{-7}$	10.4 ± 0.6	
2557-87 H	Poienii V.	Apx	w.r.	1.46	41.9	$5.905 \cdot 10^{-7}$	10.3 ± 0.5	
26.029-87	Rugului V.	MDipx	w.r.	1.79	37.7	$7.181 \cdot 10^{-7}$	10.3 ± 0.5	
25.898-87	Prisăcele Peak	Dbiampx	w.r.	2.63	42.6	$9.931 \cdot 10^{-7}$	9.7 ± 0.4	
18.817-87 L	Runcaşi Peak	Dbiampx	w.r.	2.27	61.0	$8.211 \cdot 10^{-7}$	9.3 ± 0.4	
25.406 A-87	Pietroasa Peak	QDipx	w.r.	1.96	33.4	$7.061 \cdot 10^{-7}$	9.3 ± 0.5	
3091-87 H	Izvorul Rugului V.	Dpxambi	w.r.	2.34	49.7	$8.213 \cdot 10^{-7}$	9.0 ± 0.4	

ŢIBLEŞ MTS.

26.073-89	Stegioara Peak	QDipx	w.r.	1.49	37.9	$6.677 \cdot 10^{-7}$	11.5 ± 0.5	
26.072-89	Stegioara Summit	QDipx	w.r.	1.25	47.6	$5.358 \cdot 10^{-7}$	10.9 ± 0.5	
19.767-92 E	Hudieş Peak	Dipx	w.r.	1.13	22.5	$4.706 \cdot 10^{-7}$	10.6 ± 0.7	
19.767 A-92 E	Hudieş Summit	Dipx	w.r.	1.41	50.7	$5.609 \cdot 10^{-7}$	10.2 ± 0.4	
15.880-89 E	Arcer Summit	Apx	w.r.	1.50	17.7	$5.956 \cdot 10^{-7}$	10.2 ± 0.8	
23.978-89 L	Hudin Summit	mGDibiampx	w.r.	2.26	53.8	$8.831 \cdot 10^{-7}$	10.0 ± 0.4	
986	Arieşului V.	mGDibiampx	w.r.	2.21	44.0	$8.601 \cdot 10^{-7}$	10.0 ± 0.4	
20.907-92 E	Arcer gallery	MDipx	w.r.	2.79	29.1	$1.068 \cdot 10^{-6}$	9.8 ± 0.5	
985	Cascadelor V.	MDipx	w.r.	1.51	40.0	$5.666 \cdot 10^{-7}$	9.6 ± 0.4	
202-89 G	Grohot	Dampx	w.r.	1.58	14.6	$5.814 \cdot 10^{-7}$	9.4 ± 0.9	
20.905-92 E	Arcer Peak	Apx	w.r.	1.69	23.1	$6.217 \cdot 10^{-7}$	9.4 ± 0.6	
20.906-92 E	Arcer Summit	Apx	w.r.	2.42	33.0	$8.262 \cdot 10^{-7}$	8.7 ± 0.4	
20.908-92 E	Arcer gallery	MDipx	w.r.	2.20	34.1	$7.078 \cdot 10^{-7}$	8.3 ± 0.4	

TOROIOAGA MTS.

19.316-91 E	Secului V.	GDibi	bi	6.69	54.7	$2.497 \cdot 10^{-5}$	9.6 ± 0.4	
19.316-91 E	Secului V.	GDibi	fp	1.19	30.8	$4.508 \cdot 10^{-7}$	9.7 ± 0.5	
26.469-91 E	Toroioaga Summit	Abi	fp	0.72	22.5	$2.544 \cdot 10^{-7}$	9.0 ± 0.6	

RODNA MTS.

1	2	3	4	5	6	7	8	9
RD-5	Măg. Sturzii Quarry	Dbiam	w.r.	0.91	21.9	$3.750 \cdot 10^{-7}$	10.6 ± 0.7	
RD-3	Rumcu Quarry	Dipx	w.r.	1.03	19.3	$4.198 \cdot 10^{-7}$	10.4 ± 0.8	
RD-9	Cornii Drill 3/470	Diam	w.r.	1.69	19.4	$6.503 \cdot 10^{-7}$	9.9 ± 0.7	
RD-8	Cornii Drill 11/670	Diam	w.r.	1.56	17.3	$5.953 \cdot 10^{-7}$	9.8 ± 0.8	
RD-1	Turnuri Quarry	Diam	w.r.	1.51	39.6	$5.434 \cdot 10^{-7}$	9.3 ± 0.4	
RD-6	Zagra Quarry	Aam	w.r	1.01	22.7	$3.565 \cdot 10^{-7}$	9.1 ± 0.6	
RD-7	Cormaia V.	Abiam	w.r.	2.23	27.9	$7.814 \cdot 10^{-7}$	9.0 ± 0.5	
RD-2	Chicera-Arşiţa	Dipx	w.r.	1.32	23.8	$4.494 \cdot 10^{-7}$	8.8 ± 0.5	
R-535	Măgura Rodnei Quarry	Diampx	w.r.	1.83	33.9	$6.116 \cdot 10^{-7}$	8.6 ± 0.4	

CĂLIMANI MTS.

CL - 67	Dornişoara Quarry	ABpx	w.r.	0.58	10.4	$3.190 \cdot 10^{-7}$	11.9 ± 1.6	
CL - 68	Dorna V.	Apx	w.r.	0.79	32.4	$3.272 \cdot 10^{-7}$	10.6 ± 0.5	
3426	Stânceni Quarry	ABpx	w.r.	1.31	23.2	$4.906 \cdot 10^{-7}$	9.6 ± 0.6	
CL - 57	Prislop Quarry	Aam	w.r.	1.47	38.3	$5.386 \cdot 10^{-7}$	9.4 ± 0.4	
CL - 47	Bolovăniş Quarry	Dam	w.r.	2.76	65.7	$9.686 \cdot 10^{-7}$	9.0 ± 0.4	
CL - 42	Cica Mica Summit	Aam	w.r.	0.73	20.2	$2.465 \cdot 10^{-7}$	8.7 ± 0.6	
CL - 14	Neagra V.	Apxam	w.r.	1.59	46.3	$5.297 \cdot 10^{-7}$	8.5 ± 0.4	
CL - 72	Budacu V.	Aam	w.r.	0.95	23.7	$3.165 \cdot 10^{-7}$	8.5 ± 0.5	
CL - 16	Calului V.	Aampx	w.r.	1.88	28.9	$6.014 \cdot 10^{-7}$	8.2 ± 0.4	
CL - 76	Scaunul Summit	Apx	w.r.	1.72	62.8	$5.458 \cdot 10^{-7}$	8.2 ± 0.3	
CL - 9	Toplicioara V.	Aam	w.r.	1.60	55.9	$5.050 \cdot 10^{-7}$	8.1 ± 0.3	
3377	Patului V.	ABpx	w.r.	1.43	54.8	$4.527 \cdot 10^{-7}$	8.1 ± 0.3	
CL - 10	Ilişoara V	ABpx	w.r.	0.80	9.0	$2.488 \cdot 10^{-7}$	8.0 ± 1.2	
CL - 15	Gura Haitei	Apxam	w.r.	1.19	39.4	$3.684 \cdot 10^{-7}$	7.9 ± 0.4	
CL - 6 B	Negoiu Românesc Peak	MDipxam	w.r. 0.31	3.16	30.1	$9.685 \cdot 10^{-7}$	7.9 ± 0.4	
CL - 7	Voevodeasa V.	Dam	w.r.	1.18	16.2	$3.623 \cdot 10^{-7}$	7.9 ± 0.7	
CL - 3 B	Pietricelul Peak	Dbiampx	medm 0.16	1.78	21.8	$5.197 \cdot 10^{-7}$	7.5 ± 0.5	
CL - 6 A	Negoiu Românesc Peak	MDipxam	w.r. 0.31	3.16	30.5	$9.127 \cdot 10^{-7}$	7.4 ± 0.4	
3365	Ilvei Ridge	Apx	w.r.	2.48	79.8	$7.138 \cdot 10^{-7}$	7.4 ± 0.3	
CL - 5	Negoiu Românesc Peak	Dbiampx	w.r.	1.92	17.7	$5.428 \cdot 10^{-7}$	7.3 ± 0.6	

Table 1 (continued).

1	2	3	4	5	6	7	8	9
CL - 3	Pietricelul Peak	Dbiampx	w.r. 0.16	1.56	61.5	$4.400 \cdot 10^{-7}$	7.2 ± 0.3	
CL - 3 A	Pietricelul Peak	Dbiampx	mostra 0.16	2.24	32.7	$6.282 \cdot 10^{-7}$	7.2 ± 0.4	
CL- 2 B	Reţiţis Peak	Apx	w.r	2.17	44.7	$6.039 \cdot 10^{-7}$	7.1 ± 0.3	
CL - 44	Băieşul Quarry	Apx	w.r.	1.77	35.8	$4.880 \cdot 10^{-7}$	7.1 ± 0.3	
3413	Tarnita Ridge	Dampx	w.r.	1.47	25.3	$3.995 \cdot 10^{-7}$	7.0 ± 0.4	
3366	Ilvei Ridge	Aampxbi	w.r.	2.23	71.6	$6.033 \cdot 10^{-7}$	6.9 ± 0.3	
CL - 1	Puturosul V.	Apx	w.r.	2.32	31.0	$6.203 \cdot 10^{-7}$	6.9 ± 0.4	
CL - 2 A	Reţiţis Peak	Apx	w.r.	2.17	53.2	$5.784 \cdot 10^{-7}$	6.8 ± 0.3	
CL - 4	Negoiu Românesc Peak	Apx	w.r.	2.05	21.8	$5.377 \cdot 10^{-7}$	6.7 ± 0.5	

GURGHIU MTS.

3989	Măgura de Sus V.	Aam	w.r.	0.71	21.8	$2.546 \cdot 10^{-7}$	9.2 ± 0.6	
G - 83	Zespezele Peak	Bpxol	w.r.	1.08	17.1	$3.714 \cdot 10^{-7}$	8.8 ± 0.7	
GH - 53	Salard V.	Aampx	w.r.	1.24	41.2	$4.183 \cdot 10^{-7}$	8.7 ± 0.4	
G - 161	Măgura Mare Peak	Apx	w.r.	1.01	34.1	$3.385 \cdot 10^{-7}$	8.6 ± 0.4	
GH - 57	Făncel V.	Aam	w.r.	0.82	20.2	$2.736 \cdot 10^{-7}$	8.5 ± 0.6	
3936	Piciorul Popii-Jina	Apx	w.r.	0.92	22.2	$2.988 \cdot 10^{-7}$	8.4 ± 0.5	
GH - 70	Sobasa V.	Apx	w.r.	1.39	19.2	$4.435 \cdot 10^{-7}$	8.2 ± 0.6	
3974	Făncel Peak	Apxam	w.r.	0.94	41.1	$2.986 \cdot 10^{-7}$	8.2 ± 0.4	
GH - 51	Sebeş V.	Apx	w.r.	0.91	58.4	$2.868 \cdot 10^{-7}$	8.1 ± 0.3	
GH - 56	Făncel V.	Apxam	w.r.	1.16	36.2	$3.598 \cdot 10^{-7}$	8.0 ± 0.4	
GH - 59	Făncel V.	ABpxol	w.r.	0.76	24.0	$2.363 \cdot 10^{-7}$	8.0 ± 0.5	
GH - 63 A	Hosu-Săcădat V	Apxam	w.r.	1.00	37.4	$3.021 \cdot 10^{-7}$	7.8 ± 0.4	
GH - 74	Bătrâna Ridge	Apxam	w.r.	1.46	59.4	$4.297 \cdot 10^{-7}$	7.5 ± 0.3	
GH - 48	Bacta V.	Aam	w.r.	1.34	70.9	$3.895 \cdot 10^{-7}$	7.5 ± 0.3	
GH - 61	Gurghiului V.	Aam	w.r.	1.00	11.6	$2.994 \cdot 10^{-7}$	7.5 ± 0.9	
GH - 69	Fuge Quarry-Corund	Apxam	w.r.	1.13	42.3	$3.264 \cdot 10^{-7}$	7.4 ± 0.3	
GH - 35	Bucin Pass	Apx	w.r.	1.11	58.0	$3.095 \cdot 10^{-7}$	7.2 ± 0.3	
GH - 30	Drumul lui Gavrilă V.	Aam	w.r.	1.18	62.9	$3.243 \cdot 10^{-7}$	7.1 ± 0.3	
GH - 62	North Seaca Summit	Apxam	w.r.	1.24	30.2	$3.399 \cdot 10^{-7}$	7.0 ± 0.4	
GH - 66	Iuhod Quarry	ABpxam	w.r.	0.89	53.1	$2.433 \cdot 10^{-7}$	7.0 ± 0.3	
GH - 47	Bacta V.	Aampx	w.r.	1.32	11.0	$3.608 \cdot 10^{-7}$	7.0 ± 0.9	
G - 20	Măguricea Summit	Aam	w.r.	1.30	31.0	$3.520 \cdot 10^{-7}$	7.0 ± 0.4	
GH - 64	Iuhodul Dracului V.	Apxam	w.r.	1.21	26.6	$3.255 \cdot 10^{-7}$	6.9 ± 0.4	
GH - 68	Borzont Summit	Apx	w.r.	0.81	20.8	$2.142 \cdot 10^{-7}$	6.8 ± 0.5	

1	2	3	4	5	6	7	8	9
GH 31	Şumuleul Mic V	Apx	w.r.	1.12	48.8	$2.928 \cdot 10^{-7}$	6.7 ± 0.2	
GH - 32	Şumuleul Mare V.	Apxam	w.r	1.11	45.7	$2.852 \cdot 10^{-7}$	6.6 ± 0.3	
GH 50	Şineu Quarry	Aam	w.r.	1.46	33.9	$3.938 \cdot 10^{-7}$	6.6 ± 0.3	
GH 71	Sobasa V.	Apxam	w.r	1.50	46.8	$3.778 \cdot 10^{-7}$	6.5 ± 0.3	
GH 72	Kemenes Koves Ridge	Apxam	w.r	1.19	16.6	$2.976 \cdot 10^{-7}$	6.4 ± 0.6	
GH 65	Iuhodul Dracului V.	ABpxdolam	w.r	1.29	43.8	$3.218 \cdot 10^{-7}$	6.4 ± 0.3	
GH 34	Tarvez Summit	Apx	w.r.	0.98	32.6	$2.429 \cdot 10^{-7}$	6.4 ± 0.3	
GH - 67	Seaca Ridge	Apx	w.r	0.95	36.3	$2.333 \cdot 10^{-7}$	6.3 ± 0.3	
GH - 75	Delhedy Peak	Apxam	w.r.	1.68	56.9	$4.119 \cdot 10^{-7}$	6.3 ± 0.2	
GH - 33	Şumuleul Mare V	ABpxam	w.r.	1.00	41.7	$2.407 \cdot 10^{-7}$	6.2 ± 0.3	
GH - 52	Salard V tributary	Aam	w.r	1.59	19.0	$3.691 \cdot 10^{-7}$	6.0 ± 0.4	
GH - 29	Chilieni Quarry	Apx	w.r	0.98	13.5	$2.231 \cdot 10^{-7}$	5.8 ± 0.6	
GH - 60	Secuşul V	Apxam	w.r.	1.38	27.9	$2.920 \cdot 10^{-7}$	5.4 ± 0.3	

NORTH HARGHITA MTS.

HR - 1	Observator Summit	Aampx	w.r.	1.48	32.9	$3.628 \cdot 10^{-7}$	6.3 ± 0.3	
HR - 2	Lok V	Ampx	w.r.	1.39	47.2	$3.407 \cdot 10^{-7}$	6.3 ± 0.3	
BC - 109	Ciuc Basin 10018/216	Apx	w.r.	1.03	25.3	$2.462 \cdot 10^{-7}$	6.2 ± 0.4	
VL 700	Ivo V.	Apxam	w.r.	1.80	30.8	$4.228 \cdot 10^{-7}$	6.0 ± 0.3	
BC 106 A	Ciuc Basin 10034/174	Apx	w.r	1.48	24.4	$3.482 \cdot 10^{-7}$	6.0 ± 0.4	
HR - 32	Gândac Quarry	Apx	w.r.	1.77	20.6	$4.095 \cdot 10^{-7}$	5.9 ± 0.4	
HR - 3	Raczkebel V.	Dam	w.r.	2.16	60.7	$4.917 \cdot 10^{-7}$	5.8 ± 0.2	
HR - 28	Răchiţiş Summit	Dam	w.r.	2.37	35.6	$5.374 \cdot 10^{-7}$	5.8 ± 0.3	
HR - 38	Tomesti	Apx	w.r	1.12	21.4	$2.540 \cdot 10^{-7}$	5.8 ± 0.4	
HR - 30	Sicaşău V.	Apxam	w.r.	2.11	55.3	$4.735 \cdot 10^{-7}$	5.8 ± 0.2	
VL - 1084	Filio V.	Apx	w.r.	2.02	20.7	$4.505 \cdot 10^{-7}$	5.7 ± 0.4	
HR - 33	St. Bufniţei Summit	Apx	w.r	1.97	16.4	$4.351 \cdot 10^{-7}$	5.7 ± 0.5	
HR - 4	Mădăraş V Quarry	Apx	w.r	1.32	27.0	$2.877 \cdot 10^{-7}$	5.6 ± 0.3	
VL - 307	Harghita Mad. Summit	Apx	w.r	0.98	58.1	$2.084 \cdot 10^{-7}$	5.6 ± 0.2	
V - 173	Mădăraş Sat Quarry	Apx	w.r.	1.56	32.0	$3.290 \cdot 10^{-7}$	5.4 ± 0.3	
HR - 40	W Dăneşti	Apx	w.r.	1.39	17.0	$2.926 \cdot 10^{-7}$	5.4 ± 0.4	
VL - 184	Borviz V.	Apx	w.r.	1.20	22.5	$2.477 \cdot 10^{-7}$	5.3 ± 0.3	
VL - 209	E Harghita Băi	Apxam	w.r.	1.19	11.9	$2.373 \cdot 10^{-7}$	5.1 ± 0.6	
LV - 8	S Var V.	Dam	w.r.	1.79	52.9	$3.448 \cdot 10^{-7}$	5.0 ± 0.2	
VL - 1122	Filio V	Aampx	w.r.	2.35	48.0	$4.504 \cdot 10^{-7}$	4.9 ± 0.2	

Table 1 (continued).

1	2	3	4	5	6	7	8	9
HR - 41	Racu	Apx	w.r.	1.23	42.9	$2.353 \cdot 10^{-7}$	4.9 ± 0.2	
HR - 5	H. Băi Drill 1055/105	Apx	w.r.	1.58	22.2	$3.004 \cdot 10^{-7}$	4.9 ± 0.3	
LV - 155 A	Tolvaios V.	Apx	w.r.	1.59	20.1	$2.985 \cdot 10^{-7}$	4.8 ± 0.3	
VL - 60	Var-Seghes Ridge	Apx	w.r.	1.15	23.1	$2.004 \cdot 10^{-7}$	4.5 ± 0.3	
VL - 88	E Harghita Ciceu	Dampxbi	w.r.	2.07	11.3	$3.353 \cdot 10^{-7}$	4.1 ± 0.5	

SOUTH HARGHITA MTS.

HR - LA	Biborţeni	Apx	w.r.	0.98	8.3	$2.243 \cdot 10^{-7}$	5.9 ± 1.0	
HR - 11	Biborţeni	Apx	w.r.	0.89	4.7	$1.934 \cdot 10^{-7}$	5.6 ± 1.7	
VL - 851	Tolvaios Pass	Apx	w.r.	1.73	21.2	$2.907 \cdot 10^{-7}$	4.3 ± 0.3	
BC - 38	Ciuc Basin 10004/274	Apxam	w.r.	1.35	31.1	$2.263 \cdot 10^{-7}$	4.3 ± 0.2	
BC - 14	Ciuc Basin 10001/234	Aampxbi	w.r	1.69	12.4	$2.616 \cdot 10^{-7}$	4.0 ± 0.4	
HR - 6	S Lazu Ridge	Apx	w.r.	1.42	14.7	$2.027 \cdot 10^{-7}$	3.7 ± 0.3	
HR - 7	Covacioc V.	Apxam	w.r.	1.72	14.0	$2.391 \cdot 10^{-7}$	3.6 ± 0.6	
C - 100	W. Cucu Ridge	Aampx	w.r.	1.31	39.8	$1.426 \cdot 10^{-7}$	2.8 ± 0.1	4
C - 3	Valea Mare V.	Aampx	w.r.	1.39	39.3	$1.504 \cdot 10^{-7}$	2.8 ± 0.1	4
T - 95	Mitaci V.	ABpx	w.r.	1.35	11.4	$1.336 \cdot 10^{-7}$	2.5 ± 0.3	4
C - 115	Dl. Porcului Summit	Aampxbi	w.r.	2.62	58.3	$2.556 \cdot 10^{-7}$	2.5 ± 0.1	4
HR - 8	Cucu Peak	Aampx	w.r.	1.44	15.9	$1.400 \cdot 10^{-7}$	2.5 ± 0.2	4
C - 119	Kapuş Summit	Aambipx	w.r.	1.79	38.2	$1.626 \cdot 10^{-7}$	2.3 ± 0.1	4
C - 64	N. Cucu Ridge	Aampx	w.r.	1.78	46.0	$1.609 \cdot 10^{-7}$	2.3 ± 0.1	4
C - 68	Valea Mare springs	Dambi	w.r.	1.97	46.7	$1.686 \cdot 10^{-7}$	2.2 ± 0.1	4
P - 2	Pilişca Summit	Dambi	Biotite	6.42	19.5	$5.233 \cdot 10^{-7}$	2.1 ± 0.1	
HR - 9	Pilişca Ridge	Aambi	w.r.	1.80	27.4	$1.302 \cdot 10^{-7}$	1.8 ± 0.1	
HR - 10	Pilişca Ridge	Aambi	Biotite	6.77	20.6	$3.943 \cdot 10^{-7}$	1.5 ± 0.1	
HR - 13 B	Balvanyos	Dambi	w.r.	2.36	9.1	$9.362 \cdot 10^{-8}$	1.0 ± 0.2	
HR - 13 A	Balvanyos	Dambi	w.r.	2.36	6.9	$8.464 \cdot 10^{-8}$	0.9 ± 0.2	
AM - 43 A	Haramul Mare Summit	Dambi	w.r.	2.30	5.2	$5.290 \cdot 10^{-8}$	0.6 ± 0.2	
AM - 35	Koves Ponk Summit	Dambi	Biotite	7.33	7.0	$1.598 \cdot 10^{-7}$	0.5 ± 0.1	4
AM - 2	S Tuşnad Băi Quarry	Dambi	Biotite	6.26	4.1	$1.311 \cdot 10^{-7}$	0.5 ± 0.0	
AM - SZ	N Ciomadul	Dambi	w.r.	2.64	5.0	$2.270 \cdot 10^{-8}$	0.2 ± 0.0	4

ZARAND MTS.

1	2	3	4	5	6	7	8	9
Z - 117	South Talagiu	Apxam	w.r.	1.27	48.6	$6.623 \cdot 10^{-7}$	13.4 ± 0.6	
Z - 5186	Dieci	Apxam	w.r.	1.01	16.2	$5.293 \cdot 10^{-7}$	13.4 ± 1.2	
Z - 1048	Camna	Apx	w.r	1.22	33.7	$6.195 \cdot 10^{-7}$	13.0 ± 0.7	
Z - 5199	Chişindia	Apx	w.r	1.18	43.3	$5.897 \cdot 10^{-7}$	12.8 ± 0.6	
Z - 1097	Minişul de Sus	Apx	w.r.	1.27	28.3	$6.144 \cdot 10^{-7}$	12.4 ± 0.7	

METALIFERI MTS.

MM - 2352	Curechi	Aqz	w.r.	1.18	12.2	$6.757 \cdot 10^{-7}$	14.7 ± 1.7	
MM - 2228	Bucium Citera Hill	Apxam	w.r.	1.21	12.8	$6.916 \cdot 10^{-7}$	14.6 ± 1.6	
MM - 795	Brazi	D	w.r.	1.25	17.5	$6.583 \cdot 10^{-7}$	13.5 ± 1.1	
MM - 193	Caraciu	Aampx	w.r	0.97	34.7	$4.714 \cdot 10^{-7}$	12.5 ± 0.6	
MM - 4220	Barza - Brad	Apxam	w.r.	1.44	14.4	$6.977 \cdot 10^{-7}$	12.4 ± 1.2	
MM - 4266	Brad	D	w.r.	1.22	54.4	$5.096 \cdot 10^{-7}$	10.7 ± 0.4	
MM - 776	Zâmbriţa	Apxambi	w.r	2.46	61.7	$1.011 \cdot 10^{-6}$	10.5 ± 0.4	
MM - 84	Rotunda	Aampx	w.r.	1.41	33.7	$5.095 \cdot 10^{-7}$	9.3 ± 0.5	
MM - 788	Detunata	AB	w.r.	1.25	37.3	$3.602 \cdot 10^{-7}$	7.4 ± 0.4	
MM - 29 A	Uroiu Hill	SH	w.r.	3.38	21.0		1.6 ± 0.1	

Abreviations: B=Basalts; AB=basaltic andesites; A=andesites; D=dacites; R=rhyolites; SH=shoshonites; T=tuffs; Di=diorites; MDi=monzodiorites; mDi=microdiorites; QDi=quartz diorites; GDi=granodiorites; mGDi=microgranodiorites; px=pyroxene; am=amphibole; bi=biotite; qz=quartz; ol=olivine; w.r.=whole rock; fp=feldspar; medm=medium magnetic fraction; mostm=most magnetic fraction; 0.31, 0.16=below 0.31, 0.16 granulometric fractions.
References: 1 = Edelstein et al. (1992); 2 = Edelstein et al. (1993); 3 = Pécskay et al. (1994); 4 = Szakács et al. (1993).

OG segment

According to biostratigraphical data, acidic volcanic activity took place within the OG segment during the Badenian and the early Sarmatian. However, acidic volcanic rocks have not yet been dated by radiometric methods because no suitable sample has been found so far. Regarding the intermediate volcanic activity, most of the K-Ar dates show a good agreement with the biostratigraphy (mainly for the Sarmatian and the Pannonian). However, they do not prove the biostratigraphically defined Pontian-Pliocene volcanic activity.

Despite the fact that in the adjacent areas (Tokaj Mts., Vihorlat Mts. and Gutâi Mts) Sarmatian intermediate volcanism is present (Pécskay et al., 1986), in the Oaş Mts. only Pannonian intermediate volcanics have been recorded. Rapid and continuous evolution of the volcanic activity in Oaş Mts. between 11.9 and 9.5 Ma is obvious. In the Gutâi Mts. the intermediate volcanism was initiated during the Middle Miocene around

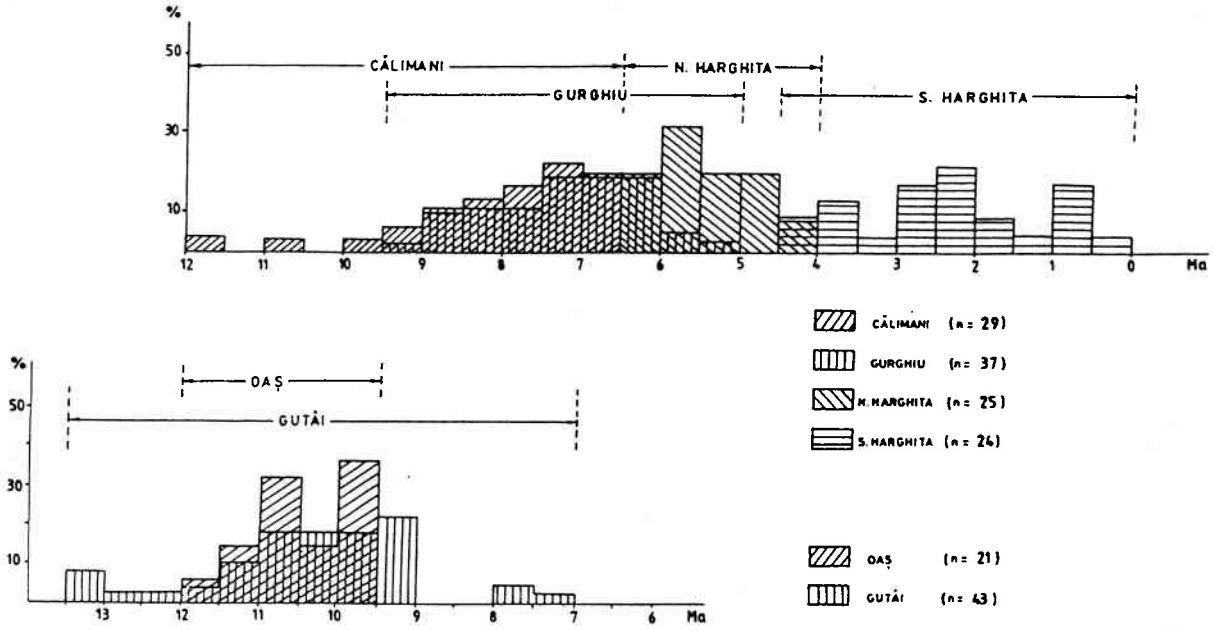

Fig. 2 – Statistical distribution of K-Ar ages for OG and CGH segments based on data listed in Tab. 1. Frequencies of age intervals of 0.5 Ma are given in percent for each of the volcanic areas separately (**n** is the number of analyses taken into account for each area; samples HR-11 and HR-LA, from Biborțeni, South Harghita have not been considered because they could belong either to a local vent or to a debris-avalanche deposit coming from a North-Harghita edifice).

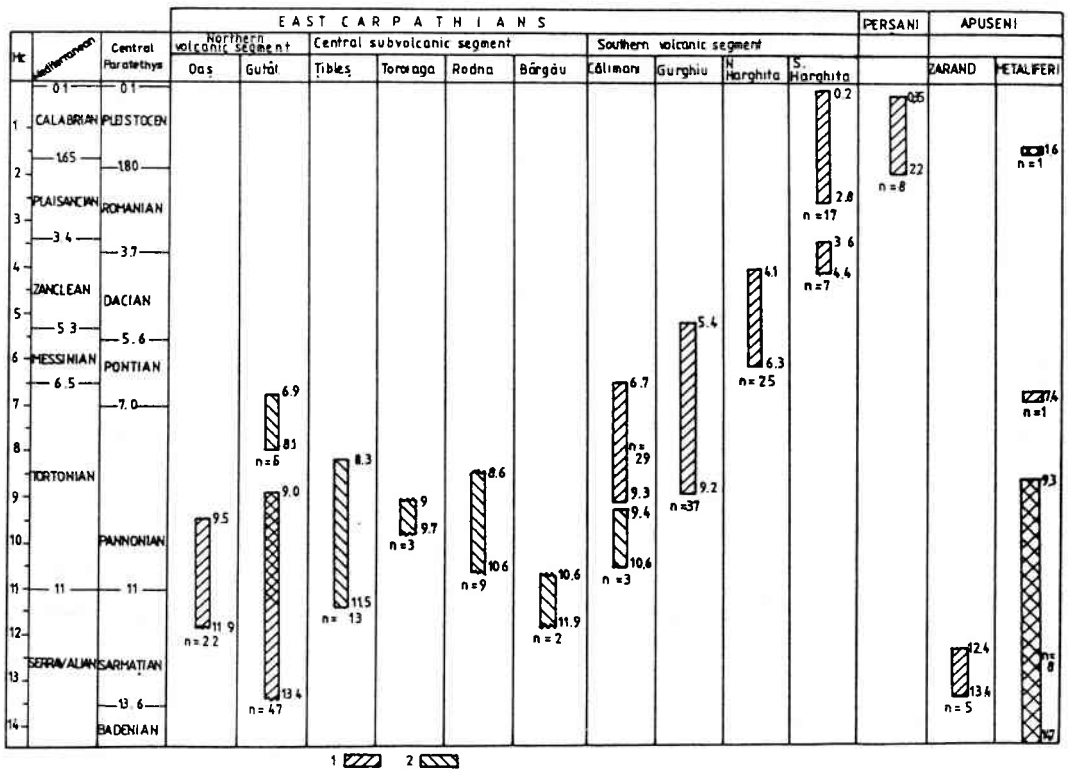

Fig. 3 – The space-time distribution of the Neogene/Quaternary volcanics in Romania, according to Mediterranean and Central Paratethys chronostratigraphic scales. 1 = volcanics and volcaniclastics; 2 = intrusive (subvolcanic) bodies.

the Badenian/ Sarmatian boundary, and continued until ca. 9 Ma. Basaltic intrusive activity followed after a period of about 1 Ma of quiescence (Edelstein et al., 1993). The K-Ar and Ar-Ar datings performed on adularia (Lang et al., 1994) and illite (Bonhomme, unpublished data) of the hydrothermal mineral assemblage are fully consistent with the ages obtained on fresh volcanics. The paroxysm of the volcanism in Gutâi Mts. belongs to the Pannonian. The ages of the isolated subvolcanic bodies in Poiana Botizei area are similar to the main Pannonian volcanic activity in Gutâi (11-9Ma).

TTRB segment

In the light of the available data, it can be suggested that the subvolcanic magmatism from this segment belongs mostly to the Pannonian (Tibleș Mts 8.3-11.5Ma, Toroiaga 9.0-9.7Ma, Rodna Mts 8.6-10.6Ma and Bărgău Mts 10.6-11.9Ma) and is partly coeval with volcanicism in the OG segment.

CGH segment

Magmatism consisting of intrusive activity in the range 12-9.5Ma began at the northwestern periphery of the Călimani Mts. as the southeastern extension of the subvolcanic zone of the Bărgău Mts. (TTRB segment). In this segment, the oldest volcanics are located in the eastern part of the Călimani Mts. (9.3 Ma) and are represented by dacitic rocks (Peltz et al., 1987). A long coeval period of volcanic activity was observed for the Călimani and Gurghiu Mts. (8.4-6.8 Ma). The K-Ar ages suggest that volcanic activity started at approximately the same time in the Călimani and Gurghiu areas but it lasted ca. 1.5Ma longer along the latter segment (Fig. 2).

There is a slight overlap between the final volcanism in the Gurghiu Mts. and the onset of North Harghita volcanicity (6.3-5.9 Ma; Fig. 2). It is notable that one North Harghita volcano and the northernmost South Harghita volcano were simultaneously active (Fig. 2). Following a period of waning activity of about 0.7 Ma, volcanism resumed vigorously along the rest of South Harghita and an enhanced southward migration is observed for the three main volcanoes (Cucu, Pilișca and Ciomadul) of the chain-terminus segment, ranging from 2.8 to 0.15 Ma. Ciomadul is the youngest volcano of the East Carpathians.

Apuseni Mountains

In the Apuseni Mountains, 7 samples from the Metaliferi Mts. range in age between 14.7-9.3 Ma. One sample from an intrusive body at Bucium (Northern Metaliferi) gave the oldest K-Ar age for the Apuseni Mountains Neogene volcanism (14.7 Ma). One of the two small-volume basaltic andesite outcrops at Detunata yielded 7.3 Ma. The shoshonitic rocks of Uroiu Hill (1.6 Ma, Fig. 1) are coeval with the Southern Harghita shoshonites (1.4-2.4 Ma, Michailova et al., 1983, Peltz et al., 1987).

5. Conclusions

Compared with West Carpathian calc-alkaline volcanism (Slavik et al., 1976; Durica et al., 1978; Hámor et al., 1987), the Romanian East Carpathian chain is younger. The southward migration of volcanicity along the East Carpathian volcanic arc as a whole (Rădulescu et al., 1972) has been confirmed by geochronological data. However, within the northern volcanic segments in Romania (OG and TTRB) no clear evidence of age progression was confirmed. The longest interval of activity occurred in the Gutâi Mts. (13.5-6.9 Ma). The paroxysm of the magmatism in the OG and TTRB segments belongs to the Pannonian (11-9 Ma) whereas the magmatism in the Apuseni Mountains is essentially Sarmatian. An obvious short-distance age-progression is seen along the southernmost South Harghita segment.

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