

## Preliminary data on the K-Ar dating of the basic rocks from the region southerly of Momchilgrad, Eastern Rhodopes, Bulgaria

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П. Лилов, З. Печкай, А. Горанов, И. Боянов - Предварительные данные К-Аг датирования базических пород южнее г. Момчилграда в Восточных Родопях, Болгария. Исследованы вулканыты Восточнородопского палеогенового понижения возле Болгаро-Греческой границы. Исследовано 6 проб измененных пород основного состава 4 даек и 2 более крупных тел, расположенных соответственно в Капиновском грабене и в Кушленской вулcano-тектонической структуре. К-Аг возраст исследованных пород  $(31 - 32,5) \pm 1,3$  Ма относится к раннему олигоцену (рупель). Интервал возраста образования этих пород соответствует в целом диапазону возраста параксизмальных вулканических событиям в Восточнородопском вулканическом регионе.

**Abstract.** Volcanic rocks from the Eastern Rhodope depression near to the Bulgarian-Greek border are investigated. Six samples of basic altered rocks from 4 dykes and 2 larger bodies located into Kapinovo graben and Kushla volcano-tectonic structure are characterized. The K-Ar age of the basic dykes and small bodies is  $(31 - 32.5) \pm 1.3$  Ma and they are referred to the Early Oligocene (Rupelian). The time-span of the formation of the dykes corresponds as a whole to the time-span of the paroxysmal volcanic events in the East Rhodope Volcanic Area.

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**Key words:** Eastern Rhodopes, basic rocks, K-Ar isotopic dating, Early Oligocene.

### Introduction

The Eastern Rhodope Paleogene magmatism is characterized by intrusions and extrusions controlled by faults and linear (E-W to WNW-ESE) dyke swarms (Harkovska et al., 1989). Volcanic fields and shield volcanoes were fed by a large number of dyke swarms (Костов, 1954; Марчев, 1985). Recently Harkovska et al. (1998) published K-Ar dates for the Zvezdel acidic dykes, which indicate that at least a part of them have been intruded not after but coeval to the paroxysmal (Early Rupelian, 31-33 Ma) Tertiary magmatic activity (Lilov et al., 1987).

In this paper we present the characteristics and the K-Ar age determinations of basic rocks that have relation to paroxysmal magmatism in the Eastern Rhodopes both on Bulgarian (Harkovska et al., 1998; Lilov et al., 1987) and on Greek territory (Innocenti et al., 1984).

### Geological setting

In this region, which extends over ca. 100 km<sup>2</sup> two geostructural units are distinguished near to the Bulgarian-Greek border, and namely, Kushla volcano-tectonic structure and Kapinovo graben (Fig. 1). The Kushla volcanic structure includes one volcanogenic-sedimentary complex with Early Eocene - Oligocene age. The acid volcanics are predominant. The Kapinovo graben is situated between the Snezhinski block (Боянов, Горанов, 1997) and the Kesibir swell. The two geostructural units are situated in the southern periphery of the Eastern Rhodopes. The outcropping basement is represented by strongly tectonized and folded high-grade metamorphic rocks described by Кожухаров (1993) and Кожухаров и др. (1995).

The rocks studied (Fig. 1) occur as single short (up to 7-8 m) and thin (0.2-1 m) dykes or larger

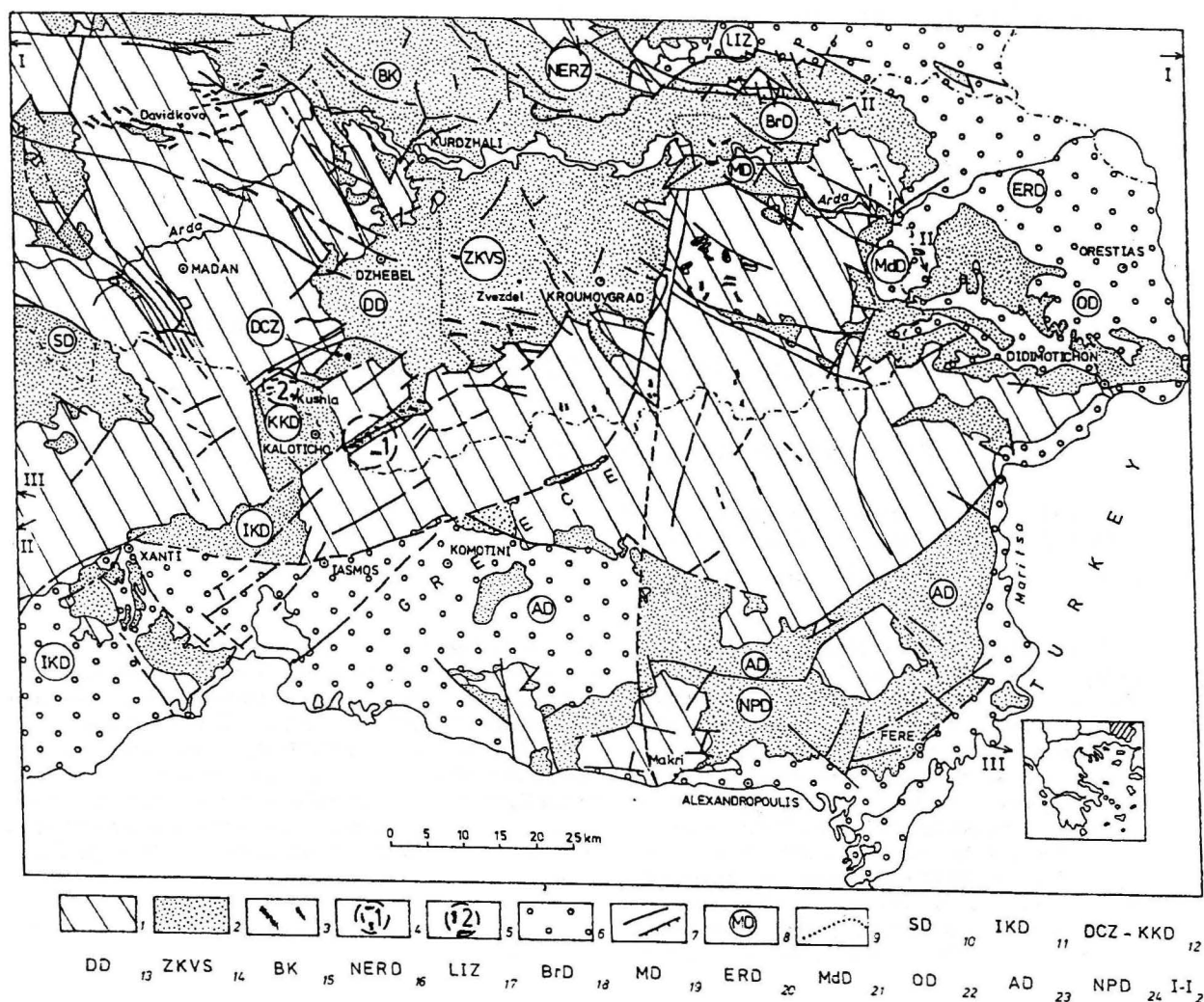


Fig. 1. Geological sketch of the Paleogene deposits from the southern part of the Eastern Rhodopes, Bulgaria, and Western Thrace, Greece: 1 - Pre-Paleogene basement, 2 - Paleogene (Paleocene-Oligocene) sediments, volcanogenic-sedimentary and volcanic rocks, 3 - Acidic, intermediate and basic Paleogene volcanic dykes, 4 - Basic basaltic dykes from the Kapinovski graben, 5 - Basaltic dykes from the Kaloticho-Kushla volcano-tectonic structure, 6 - Neogene-Quaternary cover, 7 - faults and thrusts, 8 - names of the volcano-tectonic units, 9 - boundaries between volcano-tectonic depressions, 10 - Smolyan depression, 11 - Iasmos-Kaloticho depression, 12 - Kaloticho-Kushla depression, 13 - Dzhebel depression, 14 - Zvezdel-Krumovgrad volcano-tectonic structure, 15 - Borovitsa caldera, 16 - Northeastern Rhodope depression, 17 - Lozen-Ibredzhik zone, 18 - Bryagovo depression, 19 - Madzharovo depression, 20 - Eastern Thracian depression, 21 - Mandritsa depression, 22 - Orestias depression, 23 - Alexandroupolis depression, 24 - Nipsa-Petrota depression

Фиг. 1. Геоложка скица на палеогенските отложения от южната част на Източните Родопи, България и от Западна Тракия, Гърция: 1 - допалеогенски фундамент, 2 - палеогенски /палеоцен-олигоценски/ седименти, вулканогенно-седиментни и вулкански скали, 3 - кисели, среднокисели и базични палеогенски вулкански дайки, 4 - базични базалтови дайки от Капиновски грабен, 5 - базалтови дайки от Калотихо-Кушленската вулcano-тектонска структура, 6 - неоген-кватернер на покривка, 7 - разломи и навлаци, 8 - наименование на вулcano-тектонските единици, 9 - граници между вулcano-тектонски депресии, 10 - Смолянска депресия, 11 - Язмос-Калотихо депресия, 12 - Калотихо-Кушла депресия, 13 - Джебелска депресия, 14 - Звездел-Крумовградска вулcano-тектонска структура, 15 - Боровишка калдера, 16 - Североизточнородопска депресия, 17 - Лозенско-Ибреджевска зона, 18 - Бреговска депресия, 19 - Маджаровска депресия, 20 - Източнотракийска депресия, 21 - Мандришка депресия, 22 - Депресия Орестиас, 23 - Александрополис депресия, 24 - Нипса-Петрота депресия

bodies (70-80 m long and 20-30 m wide). They cross a terrigenous and volcanogenic-sedimentary complex in the scope of the Kushla volcanic region around Kushla village. The dykes in the Kapinovo graben have a prevalent E-W direction.

## Petrography and chemistry

The rocks (Tables 1 and 2) from 4 dykes (samples 14, 15, 16 and 17) in the Kapinovo graben and two larger bodies (samples 12 and 13) in the Kushla

volcanic structure are melanocratic dark grey to black, with a fine-grained porphyritic structure and a volcanic habit. The examined rocks have undergone postmagmatic alteration of different intensity, expressed in chloritization, carbonatization, and partly, sericitization. The primary mineral composition is best represented in the dyke outcropping in the limits of Kapinovo graben (sample 15). It is built up of single fine amphibole phenocryst in a fine-grained groundmass composed of amphibole, salic mineral (K-feldspar?) and accessory apatite. The small body of Kushla region (sample 12) consists of small phenocrysts of unaltered clinopyroxene, plagioclase and a subordinate amphibole. The groundmass is built up of microclites of plagioclase and late fine-grained carbonate. The dyke in Kapinovski graben (sample 14) consists of clinopyroxene phenocrysts and a groundmass of plagioclase microlites and rare sanidine. The chloritization is established in the groundmass. In the other small body in the Kushla region (sample 13), the rock is built up of phenocrysts of plagioclase, serpentinized phenocrysts of mafic minerals and carbonatized groundmass. In addition the dykes in Kapinovo graben near to Dolno Kapinovo village are intensively carbonatized.

The major and trace elements in the analysed samples (Table 1) are determined by XRF in the Geological Institute of BAS. The LOI values ex-

ceed 3 %, thus excluding the application of the officially accepted classification for the volcanic rocks proposed by Le Bas et al. (1968) for unaltered volcanics. The classification of altered rocks is commented in the literature (Магматические горные породы 1983, page 16). Up to now this problem has not been solved satisfactorily. As far as a partial alteration of the chemical composition and considerable alteration of the primary mineral composition in the rocks examined is possible, for basis is taken the nomenclature given in Магм. горн. породы (1983).

Based on the contents of  $\text{SiO}_2$ ,  $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$  the rocks under study can be determined conditionally as trachybasalts. According to the classification (Магм. горн. породы, 1983), shoshonites are also referred to the subalkalic series of basic volcanic rocks. The values for the sum of  $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$  of examined rocks (from 5.62 to 7.27, Table 1) in combination with the contents of  $\text{SiO}_2$  according to respective diagram (Магм. горн. пород, 1983; page 288, picture 46) are concentrated in the field of the shoshonites.

The values for the Mg # considerably vary. It is difficult to comment these values in great detail because of essential postmagmatic alteration of the rocks examined.

Chemical analysis of basalts from the Kaloticho region and Zvezdel volcano according Yaney et

Table 1

Major (wt%) and trace element (ppm) for the basic rocks from Kushla-Kaloticho regions, Kapinovski graben and Zvezdel volcano, Eastern Rhodopes.  $\text{Mg\#} = 100\text{Mg}/(\text{Mg} + \text{Fe}^2)$ .  $\text{Fe}^3/\text{Fe}^2 = 0.15$

| Samples No.:            | Kushla region |       | Kapinovski graben |       |       |       | Zvezdel volcano |        |       | Kaloticho region |       |
|-------------------------|---------------|-------|-------------------|-------|-------|-------|-----------------|--------|-------|------------------|-------|
|                         | 12            | 13    | 14                | 15    | 16    | 17    | 3               | 7      | 9     | 10               | 11    |
| $\text{SiO}_2$          | 50.45         | 49.94 | 47.61             | 51.64 | 50.47 | 50.65 | 49.28           | 51.86  | 52.98 | 51.16            | 51.21 |
| $\text{TiO}_2$          | 1.14          | 0.97  | 1.17              | 0.80  | 1.15  | 1.27  | 1.00            | 0.82   | 0.97  | 0.51             | 1.10  |
| $\text{Al}_2\text{O}_3$ | 17.52         | 18.98 | 16.17             | 17.52 | 14.41 | 13.88 | 18.55           | 17.24  | 17.21 | 17.85            | 17.74 |
| $\text{Fe}_2\text{O}_3$ | 8.33*         | 7.75* | 8.98*             | 8.93* | 9.46* | 8.07* | 4.60            | 3.37   | 2.56  | 3.56             | 4.54  |
| FeO                     |               |       |                   |       |       |       | 5.04            | 5.69   | 5.40  | 4.13             | 4.84  |
| MnO                     | 0.19          | 0.11  | 0.17              | 0.24  | 0.16  | 0.14  | 0.20            | 0.22   | 0.13  | 0.15             | 0.19  |
| MgO                     | 2.03          | 1.71  | 6.57              | 2.39  | 4.47  | 3.12  | 4.77            | 4.75   | 3.41  | 3.69             | 4.01  |
| CaO                     | 10.24         | 8.58  | 8.35              | 2.17  | 6.07  | 5.91  | 7.38            | 8.54   | 7.99  | 9.40             | 7.60  |
| $\text{Na}_2\text{O}$   | 3.34          | 3.18  | 2.87              | 5.36  | 2.46  | 3.70  | 2.52            | 2.80   | 2.26  | 3.02             | 3.51  |
| $\text{K}_2\text{O}$    | 2.28          | 2.84  | 2.85              | 1.91  | 3.49  | 3.55  | 2.12            | 1.28   | 2.79  | 2.38             | 2.38  |
| $\text{P}_2\text{O}_5$  |               |       |                   |       |       |       | 0.22            |        | 0.24  | 0.37             | 0.38  |
| $\text{H}_2\text{O}^-$  |               |       |                   |       |       |       | 0.90            | 0.46   | 0.88  | 0.83             |       |
| $\text{H}_2\text{O}^+$  |               |       |                   |       |       |       | 2.30            | 2.63   | 1.26  | 3.00             |       |
| $\text{CO}_2$           |               |       |                   |       |       |       | 1.60            | 0.79   | 1.38  |                  |       |
| $\text{SO}_2$           |               |       |                   |       |       |       |                 | 0.20   |       | 0.14             |       |
| LOI                     | 3.96          | 5.41  | 4.7               | 7.96  | 7.55  | 8.07  |                 |        |       |                  | 2.45  |
| Total                   | 99.48         | 99.47 | 99.44             | 99.92 | 99.69 | 99.71 | 100.48          | 100.65 | 99.46 | 100.19           | 99.99 |
| Mg #                    | 36.24         | 33.97 | 63.04             | 38.42 | 52.42 | 47.40 | 52.19           | 53.33  | 48.16 | 51.36            | 48.47 |
| V                       | 65            | 35    | 105               |       | 120   | 205   |                 |        |       |                  |       |
| Cr                      | 70            | 90    | 48                |       | 24    | 14    | 22              | 20     | 21    |                  |       |
| Zr                      | 154           | 165   | 141               |       | 151   | 181   | 148             | 154    | 196   |                  |       |
| Y                       | 26            | 18    | 29                |       | 30    | 30    | 25              | 26     | 30    |                  |       |
| Rb                      | 54            | 98    | 111               |       | 133   | 152   | 62              | 47     | 143   | 79               |       |
| Sr                      | 462           | 623   | 367               |       | 312   | 481   | 445             | 457    | 461   |                  |       |
| Ba                      | 635           | 1226  | 803               |       | 831   | 1028  | 956             | 723    | 869   |                  |       |

The marked with star values are total iron oxides

Table 2

*K-Ar dates for the basic rocks from Kapinovski graben and Kushla region, Eastern Rhodopes*

| Sample No | Locality       | Dated fraction | LOI % | K %  | $^{40}\text{Ar}$ rad ccSTP/g $\times 10^{-6}$ | $^{40}\text{Ar}$ % | Age Ma           |
|-----------|----------------|----------------|-------|------|-----------------------------------------------|--------------------|------------------|
| 12        | Gorski Isvor   | w.r.           | 4     | 1.64 | 2.066                                         | 51.7               | 32.11 $\pm$ 1.35 |
| 14        | Djerovo        | w.r.           | 4.7   | 2.17 | 2.640                                         | 55.5               | 31.03 $\pm$ 1.27 |
| 13        | Gorski Isvor   | w.r.           | 5.41  | 2.41 | 2.949                                         | 59.4               | 31.21 $\pm$ 1.26 |
| 15        | Dolno Kapinovo | w.r.           | 7.91  | 2.49 | 3.214                                         | 41.4               | 32.90 $\pm$ 1.50 |
| 16        | Dolno Kapinovo | w.r.           | 7.55  | 2.78 | 3.582                                         | 43.8               | 32.84 $\pm$ 1.46 |
| 17        | Gorno Kapinovo | w.r.           | 8.07  | 2.92 | 3.518                                         | 37.4               | 30.73 $\pm$ 1.48 |

al.(1989) are shown in Table 1. In the Kaloticho region only one occurrence of basalt (sample 10) is known on Bulgarian territory, and another one in North Greece (sample 11). Only sample 3 (lava) and samples 7 and 9 (later dykes) from Zvezdel volcano are included in Table 1.

Yanev et al.(1989, Fig. 3) have classified samples analysed from Zvezdel volcano and Kaloticho region as intermediate between basalts and basaltic andesites or shoshonites respectively because of their silica content (49-53 %). The volcanics from the Kaloticho region (samples 10 and 11) and the lavas from Zvezdel volcano (sample 3) are transitional (shoshonitic) types while the later dykes in the above volcano are calc-alkaline ones (samples 7 and 9).

## K-Ar age determination

The samples shown in Table 2 were analyzed according to standard techniques in the laboratories in Debrecen, Hungary. Atomic constants suggested by Steiger, Jäger, (1977) were used for calculating age.

The all K-Ar dates are similar but there is a negative correlation between K contents and the ages of the dykes located in the terrigenous complex (Table 2, samples 12, 13, 14 and 17). Probably the samples with a higher K content are more altered, and they have a bigger quantity of water (Table 2, LOI taken from Table 1). The dykes (Table 2, samples 15 and 16) cutting the basement have higher content of water but their ages have high value. Thus, these analytical data do not allow to conclude whether the K-Ar dates of the investigated samples are real ages or they reflect some influence of hydrothermal alteration. Therefore, it is more correct to take time-span (31 - 32.55)  $\pm$  1.3 Ma as the probable age for these rocks.

According to the K-Ar determinations (Eleftheriadis and Lippolt, 1984) the volcanism in the Kaloticho region on Greece territory starts with andesites (about 34 Ma) and develops a main phase at 30  $\pm$  1 Ma. The similar K-Ar determination (33 Ma, Innocenti et al., 1984) was carried out on an andesitic lava from the Kaloticho region. The

close dates 31.5 and 33 Ma are determined respectively for the monzonitic intrusion and andesite flow from the Zvezdel volcano (Lilov et al., 1987).

The geographic location and the similar petrochemical characteristics and K-Ar dates for the dykes examined and the rocks from the Zvezdel volcano and Kaloticho region seems to confirm the synchronous Early Oligocene formation of these rocks.

## Conclusions

The age of the basic dykes and small bodies from Kapinovo graben and Kushla volcano-tectonic structure is (31 - 32.5)  $\pm$  1.3 Ma, i.e., Early Oligocene (Rupelian - Odin, 1982). They are located along fractures with E-W to NW-SE strike. 2). The time-span of the formation of the dykes corresponds as a whole to the time-span of the paroxysmal volcanic events in the East Rhodope Volcanic Area (Harkovska et al., 1998; Lilov et al., 1987). 3). The age 30 - 33 Ma (Lilov et al., 1987) of the voluminous calc-alkaline and shoshonitic volcanism in the Bulgarian part of the Eastern Rhodopes and 33 Ma (Innocenti et al., 1984) and 30-34 Ma (Eleftheriadis, Lippolt, 1984) for the similar magmatic activity developed in the region of Kaloticho, Western Thrace, fully coincide with the age of basic dykes and small bodies in Kapinovo graben and Kushla volcano-tectonic structure, respectively.

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