MIOCENE VOLCANISM OF CSERHÁT MTS (N.HUNGARY): AN INTEGRATED VOLCANOTECTONIC–GEOCHRONOLOGIC STUDY

T. PÓKA[1], T. ZELENKA[2], E. MÁRTON[3], Z. PÉCSKAY[4] and I. SEGHEDI[5]

[1]*Hungarian Academy of Sciences, Research Centre for Earth Sciences, Laboratory for Geochemical Research (H–1112 Budapest, Budaörsi út 45. Hungary; poka@geochem.hu),*

[2]*Hungarian Geological Survey (H–1143 Budapest, Stefánia út 14. Hungary; zelenka@mgsz.hu),*

[3]*Eötvös Loránd Geophysical Institute of Hungary, Palaeomagnetic Laboratory. (Columbus 17–23, H–1145 Budapest, Hungary; paleo@elgi.hu),*

[4]*Institute of Nuclear Research of the Hungarian Academy of Sciences (H–4026 Debrecen, Bem tér 18/C. Hungary; pecskay@atomki.hu),*

[5]*Romanian Academy, Institute of Geodynamics "Sabba S. Stefanescu" (19–21, Jean–Louis Calderon Str., 70201 Bucharest 37. Romania; seghedi@geodin.ro).*

Abstract: On the basis of the new geochronological data and the field observations on volcanostructural characters it was given a new evolutionary conception of the Miocene volcanism of Cserhát Mts. According to the new results the volcanic evolution of the Cserhát was connected with the Mátra volcano tectonically and in timing at the beginning and closing periods of volcanic activity. In the time of paroxism (Badenian) formed relatively independent volcanic structures of the Mátra and Cserhát volcanoes.

Key words: Miocene volcanism of Inner Carpathian Volcanics Arc; Miocene Rhyolite Tuff Horizons; paleomagnetism of Miocene volcanic komlexes; K/Ar age of Miocene volcanics.

Introduction

The Cserhát Mts is part of the Miocene Inner Carpathian volcanic arc, a hilly area situated between the Börzsöny and the Mátra Mts. It is a volcanic structure built up by policentric domes, stratovolcanoes of medium size and a radial system of dykes.

In the early stage of research **J. Noszky** (1912-1937) and **Z. Schréter** (1940) played the main role. The excellent geological map (scale 1:75 000) of the Cserhát Mts. was published by **J. Noszky** (1937). In the 60-s the petrography, petrochemistry and the stages of volcanic activity were studied by **P Árkai** (1967), **Gy. Buda** (1965), **T. Póka** (1968). A team of the Geological Institute of Hungary under the leadership of **G. Hámor** undertook a bio-and litostratigraphic, tectonic and paleogeographic reambulation and new mapping of the area and the Nógrád Basin next to it (**G. Hámor**, 1985). Connected to this research **Kad. Balogh** (1979) measured a number of K-Ar radiometric age data of volcanic rocks (Hámor, G. et al, 1979). **E. Márton and P. Márton** were the

first to measure the paleomagnetism of the different volcanic formations in the mentioned areas (1968, 1996).

At that time, the exact age of both the acidic and the intermediary volcanic rocks was in many cases questionable. The problem of a magmagenetic and volcanotectonic connection between the Mátra and Cserhát volcanogenic sequences was controversial. Some authors considered the Cserhát volcano a marginal facies and a radial dyke system of the Mátra volcano. They assumed that it became morphologically separated from the Mátra Mts only after the Miocene, by the formation of the Zagyva Valley. In the past years for solving the open questions the authors of the present paper performed integrated and coordinated team work comprising volcanologic, petrographic, and geochronologic (paleomagnetism and K/Ar dating) research, in order to settle the problems sketched above. The complex geophysical (gravimetric, geomagnetic and seismic) measurements and the reinterpretation of the earlier borehole profiles have contributed considerably to the succes of this revision.

Structural pattern of the basement (Fig. 1)

- In the Northern part of the Cserhát Mts., the border of the Vepor-Gömör Unit is represented by the Diósjenő lineament of ENE-WSW strike. The oil exploratory wells drilled area (Szécsény) intersected 1000 m of Oligocene Schlier and sandstone and were stopped in Paleozoic metamorphites (amphibolite, gneiss).

-At the Eastern border of the area there is the Zagyva Graben of NNE-SSW direction. This is a frontier zone between the basement units of the Bükk Mts (Dinaric-type Triassic) and the Transdanubian Central Range (Alpine-type Triassic). This tectonic graben has depths increasing to 4000 m from the western sharp escarpment of the Mátra Mts to the Galga Valley of the Middle Cserhát.

-On the SW border of the Cserhát, the basement (consisting of Triassic carbonates) **rises the the surface** (at Csővár and Nézsa) while in the Middle Cserhát it was hit by the borehole Nagykökényes-1 at 3310 m depth.

-**In the S part** (under the young basin sediments) there is a strong magnetic anomaly due to the **buried Darnó lineament**, with Mesozoic diabase-ophiolite suites which can be traced as far as Tóalmás.

-**Beyond the Zagyva Graben, under the NE part of the Cserhát** (at Nagybátony) some drills encountered Oligocene sediments (2000 m thick), **Jurassic andesites and Carboniferous-Permian sediments in an overturned fold**.

Volcanotectonism and geochronology of the Miocene volcanic complex (Fig.2).

1.Volcanic activity started with the Lower Rhyolite Tuff complex (Gyulakeszi Rhyolite Tuff Formation). It underlies the lower coal seam of the three coal beds of the Salgótarján Brown Coal Formation (J. Noszky 1935, Z. Schréter 1940, G. Hámor, 1985). Recent K/Ar dating and paleomegnetic measurements seem to indicate two ignimbritic erruptions of rhyolite of different age. They are separated from each other by redeposited tuff breccia with eroded gravel and coal shales (the so called "cover coal-bed"). Some boreholes around Kazár detected welded pumiceous rhyolite tuff. The same type is known on the surface at Mátraszele. **The K/Ar age of this tuff is 21.4 ±2.3 My (Kad. Balogh), its paleomagnetic polarity is reversed, and it shows a rotation of W 80^{o}.** In the area of Kisterenye and Rákóczitelep the mostly non-welded, zelitic pumiceous rhyolite tuffs with amphiboles and biotites and its layered varieties, deposited in water, lay directly under the coal seam. **Their K/Ar age is 18.1±1.1 -17.1±1.6 My, their paleomagnetic polarity is reversed and they have been rotated**. On the base of the airborne magnetic anomalies and the date of the gravity map the NNE-SSW tectonic line of Zagyva Graben and the ENE-WSW oriented Diósjenő lineament cross each other in this area. According to the thickness of the ignimbritic tuffs and the pumices the eruption center of this complex might have been in this area. The Lower Rhyolite Tuff complex can be traced on the surface in the NW-part of the mountains to Ipolytarnóc. Southwards, in downfaulted position, it makes up a 1 to 5 m thick horizon, as in water deposited tuffs and gravelly tuffites, with the grain size decreasing southwards.

2. The intermediary volcanic activity began with the Lower Andesite Complex of Karpatian age (Hasznos Andesite Formation). The pyroxenic amphibole andesites and pyroxene andesites as well as their pyroclastics are products of submarine eruptions. They are underlain by the Karpatian Schlier in the former tectonic graben. The Andesite Complex is built up alternatively by hyaloclastic breccias and vesicular andesite lava flows with some interbedded sediments (sandy clays). Outcrops of the Lower Andesite Complex are known only at some places: at Mátraverebély (Macskavölgy), Nagybátony (Sulyomtető) and Tar (Gömör-hegy) and Mátraszöllős, in the Middle Cserhát at Cserhátszentiván on a tectonically uplifted block. **At Cserhátszentiván it has reversed polarity and had a rotation of W 80^{o}. K/Ar data could not be obtained because of the strong decomposition of the rocks**. Out of the system of the Zagyva Graben - beside the mentioned outcrops - the Lower Andesite Complex does not occur. **The Lower Andesite Complex in the Cserhát Mountains is in close genetic and tectonic connection with the Karpatian volcanic phase of the Mátra volcano**.

3. The Karpatian/Badenian Middle Dacite Tuff (Tar Dacite Tuff Formation) is the second phase of the acidic volcanism in the Cserhát Mts. The biotitic-pyroxenic, pumiceous dacite tuffs overlie the Garáb Schlier and the Hasznos Andesite Formation. Its outcrops are known at Tar,

Mátraverebély, Nagybátony in the E-part of Cserhát and at Nagybárkány and Alsótold in the Middle Cserhát. The eruption centre of the Karpatian Dacite Tuff may be situated in the volcano-tectonic graben of Csevice Valley at Tar There some boreholes penetrated slightly welded ignimbrites and some small dacitic bodies as well. The hydrotermally altered rocks (carbonatic veins with opal, clayey alteration) also refer to a nearby neck (**G. Hámor**, 1985). W-direction from Tar, in a distance of 5-10 km the thickness of the tuffs is reduced (50-70 m) and the pumices are only of about 1 cm. The tuffs were partly deposited in water, with bentonitic interbeds. Farther, to W and S, in a distance of 15 km, the thickness of the tuffs is more reduced (15-20 m) and far away, in the Western Cserhát (Bercel, Piliny) the pumices are only 2-3 mm in diameter. **In the surrounndings of Alsótold these tuffs have reversed polarity and have rotated to W with 30^{o}. Their K/Ar age is 14.79-16.63 My.**

4. The most intense phase of the intermediary volcanic activity of the Cserhát is the widespread Middle Andesite Complex (Mátra Nagyhársas Andesite Formation). This stratovolcanic complex of Badenian age is situated at the W and E rims of the 12 to 15 km wide Zagyva Graben divided into two parts (N and S) by deep faults of NNE-SSW strike. This complex makes up the High Cserhát, a ridge lifted by NW-SE striking reverse faults crossing the graben along the line between Pásztó and Alsótold. The complex of the pyroxenandesites is overlain by Badenian sandy marl, and consists of various in water deposited hyaloclastic breccias, vesicular pyroxenandesite lava flows and andesite tuffs. According to the data of boreholes near to the eruption centres it is 250 to 350 m thick, but at some places it forms subvolcanic bodies which intruded into the Middle Dacite Tuff (lakkolith near Zsunypuszta). The middle andesitic lavas erupted in several (at least two) phases. There is a classic stratovolcanic outcrop near Sámsonháza (a protected geological site), where the eroded relief between two lava flows and tuffs is well visible. The upper part of the section consisting of pelletic tuffs deposited in shallow water and partly on land and by scoriaceous and vesicula lava flows. **According to the paleomagnetic masurements this complex has not rotated and shows normal polarity. The K/Ar age of the lower andesite flow is 14.99±0.61 My.**

The volcano-structure of the Cserhát is characterised by the well developed system of andesite dykes 10 to10 km long and up to 15 to 20 m wide. They become thinner and thinner and became closed moving from the central part to the W and N parts of the area of study. These are fissure volcanoes which at some places grow thicker and form coarse crystalline pyroxen andesite bodies of subvolcanic character (at Szanda, Bercel, Bér, Hollókő). Locally from their upper level start glassy, vesicular lava flows of which only thin veils have been preserved. **According to the K/Ar data the andesite dykes developed in two cycles. The older ones are the dykes of WNW-ESE**

and NW-SE direction in the SW and W parts of Cserhát (Váchartyán, Püspökszilágy, Bercel, Szanda, Mohora, Hollókő). **Their age is 14-15 My. The dykes of NNW-SSE strike in the N-Cserhát (at Szécsény, Kisgéc) and the lakkolite near Zsunypuszta are younger (13.5 ±0.60 My). All dykes have reversed polarity and have not rotated**.

5. The product of the last phase of the acidic volcanic activity is the Upper Rhyolite Tuff (Galgavölgy Rhyolite Tuff Formation). According to recent evidence the outcrop of rhyodacite tuffs near Tar (Fehérkőbánya) - earlier elected the *locus typicus* of the Middle Dacite Tuff - displays no rotation, its polarity is reversed and its K/Ar age is only 12-13 My. Therefore this 125 m thick outcrop is the best known occurrence of the Upper Rhyodacite Tuff in the Cserhát Mts. The profile is built up by non-welded tuff with a lot of big pumices (> 10 cm) and lapillis of various types of andesite (and some mesosoic gabbro from the basement). It suggests the vicinity of the eruption centre. The outcrop has been preserved on a block downfaulted along the Csevice Valley near Tar. On the top of the outcrop lay andesite tuffs and some andesite blocks of the Upper Andesite Formation of the Mátra volcano ("cover andesite").

6. The closing phase of the volcanic activity in the Cserhát Mts is the Upper Andesite (Kékes Andesite Formation). The pyroclastics of this complex overlie the Upper Rhyolite Tuff. This fine-grained tuff sequence developed step by step with alternating beds of rhyodacitic and andesitic tuffs passing into andesite tuffs. In the upper horizon there are andesite blocks, ash flows and brecciated, subaerically deposited pyroclastics. In boreholes this complex is 80 to 140 m thick. On the Kőerdőtető (N of Tar) the pyroxene andesite lava flows indicate the vicinity of the eruption centre. **The K/Ar age of the upper glassy andesite lava flow in the Csevicés Valley is 13.1±0.5 My**. In the Szentkút valley (near Mátraverebély) the closing lava flow of the volcanic complex is petrographically and in radiometric age analogous with the Upper Andesite of the Mátra volcano; it is the youngest product of the Cserhát volcanic activity as well.

Conclusions

At the initial and final phases (Karpatian and Upper Badenian/Sarmatian) the volcanic evolution of the Cserhát was connected with the Mátra volcano both in structure and timing. In the Badenian (that is in the time of paroxysm) the volcanotectonic evolution of the volcano resulted in relatively independent volcanic structures of the Mátra and Cserhát volcanoes.

Acknowledgements

This project was granted by **National Research Found No. T 030541**. Many thanks to Dr. E. Dudich, P.Sipos, E.Áchel for their scientific and technical help in the construction of the publication.

References

Árkai, P. (1967): Correlation of quantitative petrographic characteristics of pyroxene andesites in the volcanic complex of the southwestern Cserhát Hills. Annales univ. Sec. Geol. XI. pp.

Buda, Gy. (1965): A Középső-cserháti piroxénandezit telére földtani vizsgálata.-Geological study on the pyroxene andesitic dykes of the Middle Cserhát. D. Sc.Univ. Thesis., Bp. ELTE.

Hámor, G. - Jámbor, Á. - Ravaszné Baranyai, L. - Balogh, Kad. - Árva-Soós, E. (1979): K/Ar dating of Miocene pyroclastic rocks in Hungary. Annales Géologiques des Pays Hellenéniques. Hors Série. 2. 491-501. Pp.

Hámor, G. (1985): A Nógrád-cserháti kutatási tereület földtani viszonyai.- Geological conditions of the Nógrád-Cserhát study area.. -Geologica Hungarica ser. Geologica. 221- 307 p.

Márton, P., Márton, E. (1968): Palaeomagnetic study on andesites from the Cserhát Mountains (in Hungarian). *Magyar Geofizika*, IX/6. 224-230.

Márton, E., Márton, P. (1996): Large scale rotations in North Hungary during the Neogene as indicated by palaeomagnetic data. From: Morris, A. & Tarling, D. H. (eds), *Palaeomagnetism and Tectonics of the Mediterranean Region*, *Geological Society Special Publication* No. 105, 153-173.

Noszky, J. (1940.): A Cserhát hegység földtani viszonyai.-Geological conditions of they of the Cserhát Mts. Magyar Tájak Földtani Leírása, Budapest, 3. 1-284 p.

Póka, T. (1968): An undifferenciated stratovolcanic marginal facies of the Intra-Carpathian volcanic girdle (Cserhát Hills, NE Hungary) Annales Univ. Sci. Bud. sec. Geol. Tom. XII. pp.37-47.

Schréter, Z. (1940): Nagybátony környéke.- Surroundings of Nagybátony. Magyar Tájak Földtani Leírása, Budapest, 2. 1-154.

Fig. 1.

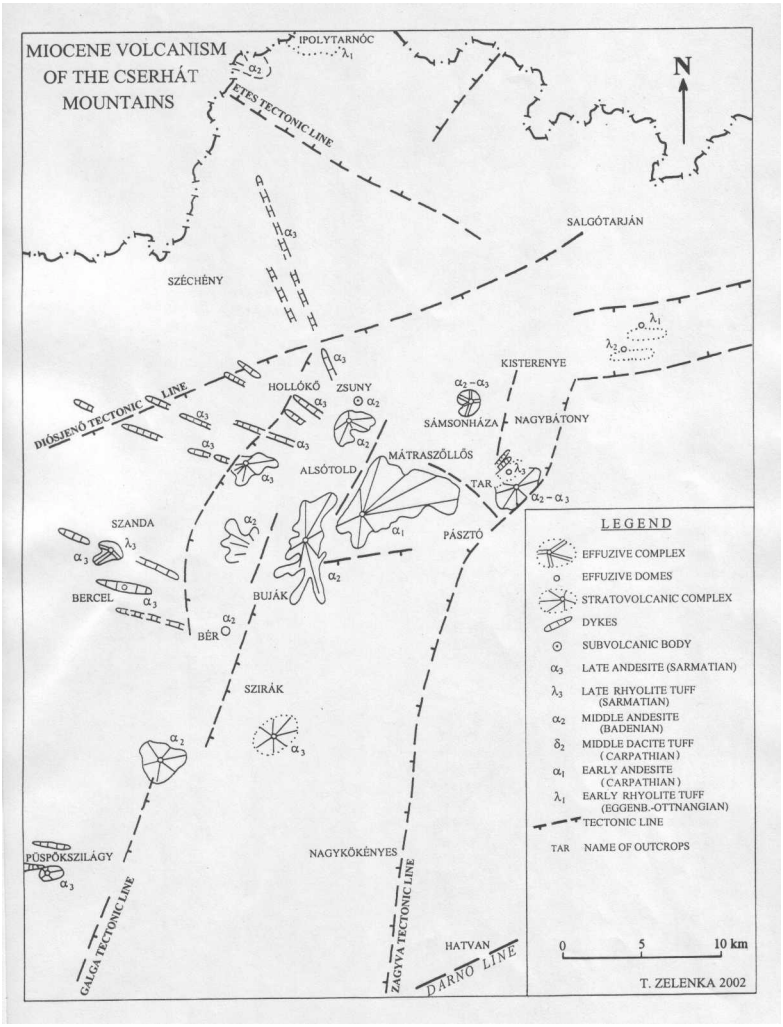
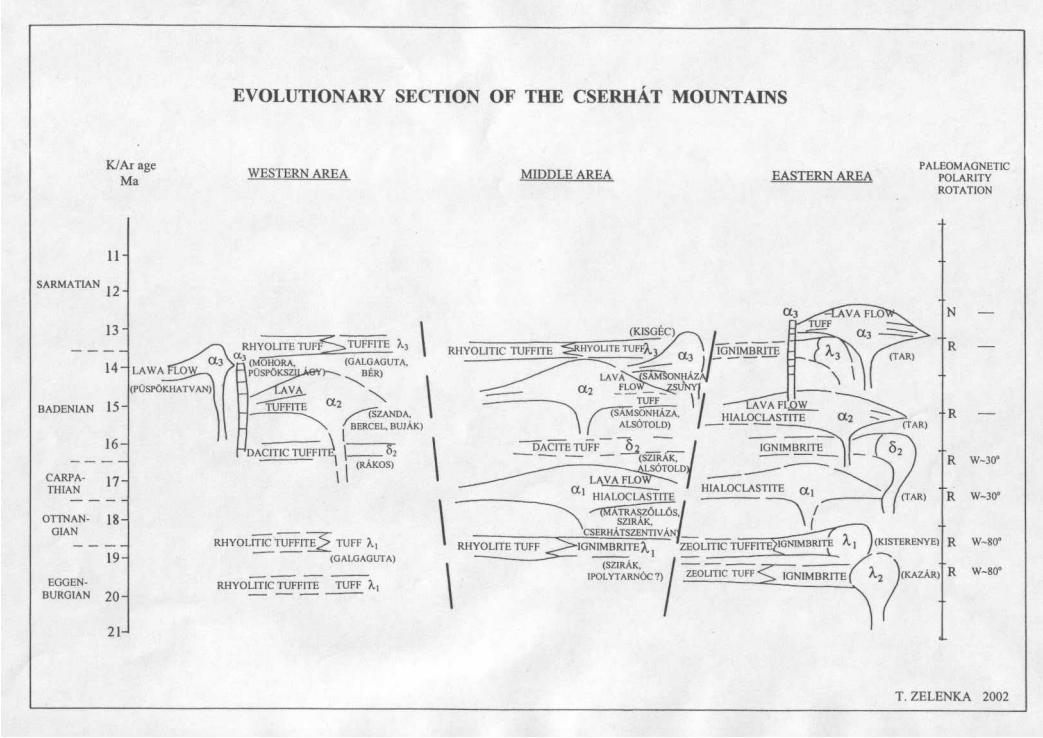


Fig. 2.


EVOLUTIONARY SECTION OF THE CSERHÁT MOUNTAINS
K/Ar age Ma
WESTERN AREA
MIDDLE AREA
EASTERN AREA
PALEOMAGNETIC POLARITY ROTATION
SARMATIAN
BADENIAN
CARPA-THIAN
OTTNAN-GIAN
EGGEN-BURGIAN
11
12
13
14
15
16
17
18
19
20
21
LAWA FLOW (PÜSPÖKHATVAN)
RHYOLITE TUFF (MOHORA, PÜSPÖKSZILÁGY)
TUFFITE (GALGAGUTA, BÉR)
LAVA TUFFITE (SZANDA, BERCEL, BUJÁK)
DACITIC TUFFITE (RÁKOS)
RHYOLITIC TUFFITE
TUFF (GALGAGUTA)
RHYOLITIC TUFFITE TUFF
(KISGÉC)
RHYOLITIC TUFFITE
RHYOLITE TUFF
LAVA FLOW (SÁMSONHÁZA ZSÚNY)
TUFF (SÁMSONHÁZA, ALSÓTOLD)
DACITE TUFF (SZIRÁK, ALSÓTOLD)
LAVA FLOW HIALOCLASTITE (MÁTRASZÓLLÓS, SZIRÁK, CSERHÁTSZENTIVÁN)
RHYOLITE TUFF IGNIMBRITE (SZIRÁK, IPOLYTARNÓC ?)
IGNIMBRITE
LAVA FLOW
TUFF
LAVA FLOW HIALOCLASTITE
IGNIMBRITE
HIALOCLASTITE
ZEOLITIC TUFFITE IGNIMBRITE (KISTERENYE)
ZEOLITIC TUFF IGNIMBRITE (KAZÁR)
(TAR)
(TAR)
(TAR)
N
R
R
R
R
R
W~30°
W~30°
W~80°
W~80°
T. ZELENKA 2002