The Fehér hegy Formation: Felsitic ignimbrites and tuffs at Ipolytarnóc (Hungary), their age and position in Lower Miocene of Northern Hungary and Southern Slovakia

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Abstract. The paleomagnetic study shows that the Gyulakészi Formation of felsitic volcanic rocks and those rocks in Bukovinka Formation have different paleomagnetic properties compared to the ignimbrites and tuff in the vicinity of Ipolytarnóc. They differ in magnetic polarity and size of rotation, and thus must be of different age. The new volcanic formation the Fehér hegy Formation includes the felsic volcanic rocks in the vicinity of Ipolytarnóc village.

Introduction

In the Lower Miocene of the Southern Slovakia and Northern Hungary the felsitic ignimbrites and tuffs (volcanic rocks of rhyolite/rhyodacite composition) occur. On the territory of Southern Slovakia such rocks outcrop in the frame of the Bukovinka terrestrial Formation together with gravel/conglomerate, sand/sandstone and mottled clay. In the Northern Hungary felsitic volcanic rocks have been described in terms of an independent formation the Gyulakeszi Formation. Terrestrial deposits as gravel/ conglomerate, sand/sandstone and mottled clay are included into the Zagyvapálfalva Formation. The ignimbrites and tuffs at Ipolytarnóc building up the Fehér hegy hill have been considered as a part of Gyulakeszi Formation. It was evident that the Bukovinka Formation is an equivalent to both Zagyvapálfalva and Gyulakeszi formations. Both, the Bukovinka Formation and the Zagyvapálfalva Formation in Hungary are considered to be Upper Eggenburgian in age. The Gyulakeszi Formation is considered to be Lower Ottnangian in age (Vass in Vass ed., 1983; Hámor, 1974, fide Bartkó, 1985).

Results of paleomagnetic study of the ignimbrites and tuffs occurring nearby Ipolytarnóc (Fehér hegy) studied in detail, pointed out that those rocks had completely different paleomagnetic properties, and do not belong to Gyulakeszi and Bukovinka formations (Márton et al., 2007).

The paper methodically refers the paleomagnetic studies of the Lower Miocene felsitic volcanics of the area of interest published by several authors (Márton and Márton, 1996; Márton et al., 1996; Pécskay and Karatson et al., 1998; Karatson et al., 2000; Póka et al., 2004; Márton et al., 2007). Data are critically evaluated and conclusions important for the topic of the paper are drawn from the data.

Geological background

As described above, the main portion of the Lower Miocene ignimbrites and tuffs occur in Bukovinka Formation of Cerová vrchovina Highland together with gravel/conglomerate, sand/sandstone and mottled clay. The formation is correlated with the Upper Eggenburgian. In Hungary the felsitic volcanic rocks are gathered into Gyulakeszi Formation, considered to be Lower Ottnangian in age and terrestrial deposits are included in the another formation – Zagyvapálfalva Formation, Upper Eggenburgian in age. Both Bukovinka and Zagyvapálfalva formations discordantly cover the Fiľakovo and/or Pétervásara formations attributed to Eggenburgian (Hámor, 1974, fide Bartkó, 1985; Vass in Vass et al., 1979, 1983; Bartkó, 1985). Detailed paleomagnetic study of felsitic ignimbrites and tuffs had shown that those rocks may be subdivided according to paleomagnetic properties into two groups. The first group consists of almost all ignimbrite and tuff bodies in Bukovinka and Gyulakeszi formations with an exception of the Fehér hegy and surrounding ignimbrite and tuff bodies. Former belong to the second group.

The ignimbrite and tuff bodies in Bukovinka Formation have reverse magnetic polarity and their declination exhibits rather large counter-clockwise (CCW) rotation compared with recent magnetic field. The angle of rotation varies from 66° to 97°. The measured sites are as follows: at villages Pleš, Čakanovce and NE of Lipovany village (samples Nos. 1–3, Fig. 1, Tab. 1). Identical paleomagnetic properties have been measured on felsitic volcanic bodies of Gyulakeszi Formation, sites: at villages Gyulakeszi, Nemti, Kisterénye, at abandoned coal mine Rákoczitelep and in Mátraszele – Kazár quarry. (Nos. 4–9, Fig. 1, Tab. 1). Polarity is reverse and angle of declination varies CCW 64° to 120°.

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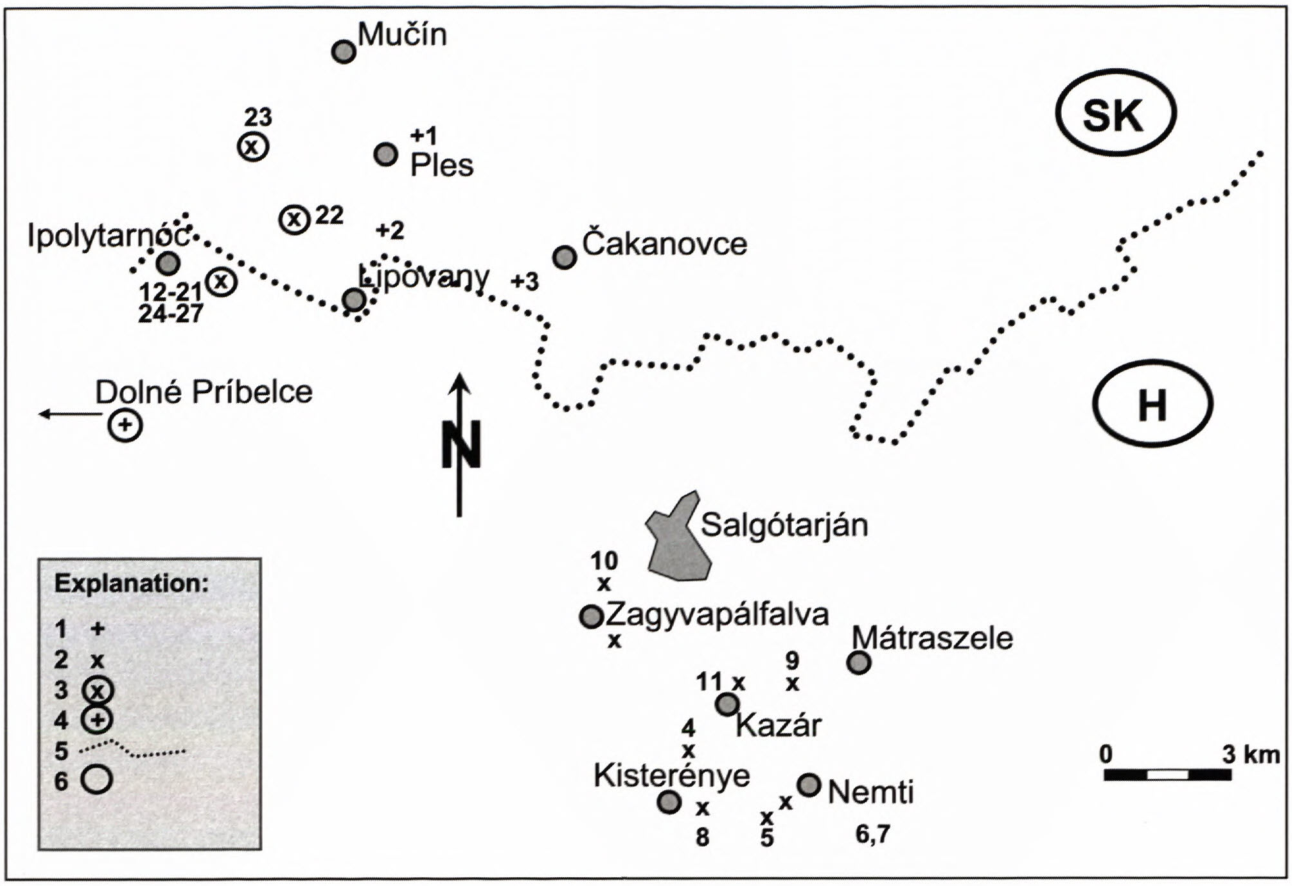

Fig. 1. Situation scheme of sampled sites. 1 – samples of Bukovinka Formation, 2 – samples of Zagyvapálfalva and Gyulakeszi formations, 3 – samples of Fehér hegy Formation, 4 – sample of a siltstone, Karpatian in age, 5 – state boundary, 6 – villages.

Similar paleomagnetic properties appear in the mottled clays of the Zagyvapálfalva Formation measured on sites: at villages Zagyvapálfalva and Kazár (Nos. 10 and 11, Fig. 1, Tab. 1). The polarity is reverse and CCW rotation varies between 63° and 76°. The felsitic volcanics of Bukovinka and Gyulakeszi formations as well as Zagyvapálfalva Formation most probably originated either during the reverse event of the chronozone C5D, having numeric age of 17.235–18.056 Ma and correspond with the Lower Ottnangian (No. 3 in Fig. 3 left side). Another possibility is that mentioned rocks came to origin during the chronozone C5E (18.056–18.748 Ma) more exactly during its lover reverse event corresponding to Upper Eggenburgian (18.500–18.748 Ma, No. 2 in the left side of the Fig. 3) and/or during the chronozone C 6 its lower event 19.70–20.04 Ma B.P. (No. 1 in the left side of Fig. 3). Numeric time calibration is after Strauss et al. (2006). The last possibility is convenient with the reliable radiometric age 19.6 Ma of a layer of felsitic tuff inside the Bukovinka Formation (Kantor et al., 1988, Fig. 3).

Felsitic ignimbrites and tuffs, outcropping at village Ipolytarnóc and building up the Fehér hegy hill, occur directly above the sandstone bench with the Mammalian foot prints on the surface. They are of normal magnetic polarity and of CCW rotation by 32° (an average value of measured varying between 20° and 38°, Nos. 12–21, Fig. 1). Such paleomagnetic properties clearly show that volcanic rocks originated by another volcanic activity as above mentioned ignimbrites and tuffs. Because of relatively small CCW rotation, those rocks originated after the first Lower Miocene rotation (approx. 50°-60° CCW) and before the second rotation, so they must by younger in comparison with felsitic volcanic rocks of the Bukovinka and Gyulakeszi formations.

The ignimbrites originated from the hot clouds of volcanic ash. The temperature of the clouds achieved 800–1100 °C, which was enough for the heating of the subjacent rocks and lost of their remanent magnetization by the overprint with the new one from the time of overheating. The bench of sandstone with foot prints is located beneath thin layer of tuff and 4 to 5 m thick mass of ignimbrite (the original thickness was probably reduced by intravolcanic erosion) should be heated enough to lose its remanent magnetization and obtained actual magnetization in the time of hot clouds eruptions. Because of this the paleomagnetic properties of the sandstone bench are the same as properties of overlaying ignimbrite. The sandstone is of normal magnetic polarity and CCW rotation varies between 21° and 48°. Four measurements of the sandstone were done (Tab. 1, Nos. 24–27, Fig. 1). The flora studied by many authors associates with the foot prints bearing sandstone. Hably (1985) concludes that the flora association, represented by the leaves of raining forest trees, is the same as flora association from the site Lipovany (NE from the village, Tab. 1, No. 3) occurring in the frame of Bukovinka Formation and des-

Tab. 1 Magnetic polarity and rotation angle of sampled rocks.

	Site of Sapling	Chronostratigraphy	Litostratigraphy and Rock Type	Polarity	CCW Rotation
1.	Pleš	Late Eggenburgian	Bukovinka Fm. Felsitic Ignimbrite/Tuff	R	57°
2.	Lipovany NE	Late Eggenburgian	Bukovinka Fm. Felsitic Ignimbrite/Tuff	R	66°
3.	Čakanovce	Late Eggenburgian	Bukovinka Fm. Felsitic Ignimbrite/Tuff	R	84°
4.	Rákoczi Telep	Early Ottnagian (Late Eggenburgian)	Gyulakeszi Fm. Ignimbrite	R	89°
5.	Gyukeszi	Early Ottnagian (Late Eggenburgian)	Gyulakeszi Fm. Ignimbrite	R	83°
6.	Nemti	Early Ottnagian (Late Eggenburgian)	Gyulakeszi Fm. Ignimbrite	R	97°
7.	Nemti	Early Ottnagian (Late Eggenburgian)	Gyulakeszi Fm. Ignimbrite	R	120°
8.	Kisterénye – Nemti	Early Ottnagian (Late Eggenburgian)	Gyulakeszi Fm. Ignimbrite	R	107°
9.	Matraszele - Kazári Quarry	Early Ottnagian (Late Eggenburgian)	Gyulakeszi Fm. Ignimbrite	R	77°
10.	Zagyvapálfalva	Late Eggenburgian	Zagyvapálfalva Fm. Mottled clay	R	107°
11.	Kazár	Late Eggenburgian	Zagyvapálfalva Fm. Mottled clay	R	77°
12.	Borókás Creek	Late Ottnamgian	Fehérhegy Fm. Tuff	N	28°
13.	Borókás Creek	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	37°
14.	Borókás Creek	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	35°
15.	Borókás Creek	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	32°
16.	Puhakő Quarry	Late Ottnamgian	Fehér hegy Fm.Bentonite	N	28°
17.	Puhakő Quarry	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	24°
18.	Puhakő Quarry	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	29°
19.	Bokrókás Creek	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	21°
20.	Botos Creek	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	26°
21.	Learn. Path	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	38°
22.	Lipovany NW	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	28°
23.	Mučín	Late Ottnamgian	Fehér hegy Fm.Ignimbrite	N	20°
24.	Borókás Creek	Late Eggenburgian	Zagyvapálfalva Fm. Foot print Sandstone	N	37°
25.	Borókás Creek	Late Eggenburgian	Zagyvapálfalva Fm. Foot print Sandstone	N	36°
26.	Borókás Creek	Late Eggenburgian	Zagyvapálfalva Fm. Foot print Sandstone	N	31°CW
27.	Borókás Creek	Late Eggenburgian	Zagyvapálfalva Fm. Foot print Sandstone	N	46°
28.	Dolné Príbelce	Karpatian	Siltstone	R	30°

For detail paleomagnetic data see paper Márton et al. in press (Tab. 1) and Túnyi et al. (2003).

cribed by Němejc (1967) and Knobloch in Papp et al., eds. (1973). The age of flora association is Upper Eggenburgian in age. Between felsitic volcanics of Fehér hegy hill and Zagyvapálfalva/Bukovinka formations including the sandstone with Mammalian foot prints and tuff layer with rich flora of rain forest seams to be a relatively large stratigraphic gap and the Pôtor coal bearing Member / Kisterénye Member and lower part of the Plachtince Member are missing (Fig. 3).

Definition of the Fehér hegy Formation

Different paleomagnetic properties and different age of felsitic volcanics near the village of Ipolytarnóc (Nos. 12–21 and 24–27 including the tuff and/or ignimbrites outcropped NW of Lipovany and SW of Mučín villages (Nos. 22 and 23, Fig. 1) should be excluded from the Gyulakeszi and Bukovinka formations, respectively. In accordance with the Codex of Stratigraphy we suggest for

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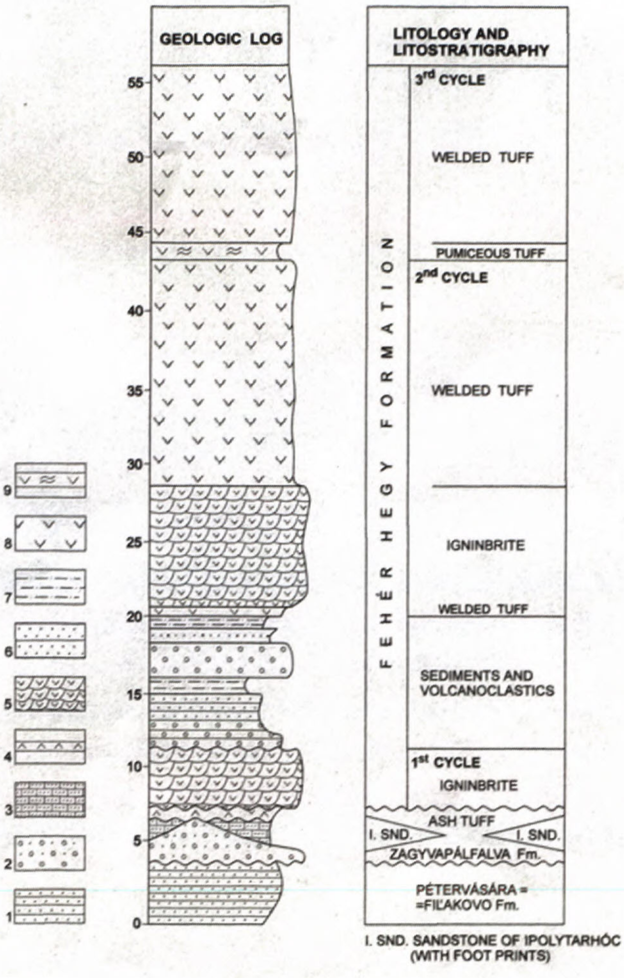

Fig. 2. Geological log at Ipolytarnóc foot prints site and Fehér hegy hill (according to Korpás 1998–2003, modified). 1 – friable glauconitic sandstone, 2 – conglomerate, 3 – sandstone with foot prints, 4 – ash tuff rich in leaf imprints, 5 – ignimbrite, 6 – tuffaceous sandstone, 7 – tuffaceous siltstone, 8 – welded tuff, 8 – pumiceous tuff.

those rocks the status of a new formation called after type section Fehér hegy Formation.

The type section of the Fehér hegy Formation is situated on the southern slope of the Gyartánykö Hill, 2.3 km E of railway station Ipolytarnóc, Ipolytarnóc village The access to the type section is from the Borokás árok Creek, 100 m WSW from Natural museum hall (conservation hall) protecting the footprints sandstone outcrop.

The reference section is on the SE slope of Fehér hegy Hill in a gorge 0.8 km WSW of the type section. The access to the section is from the Botos árok Creek (Fig. 3).

Lithology of the Fehér hegy Formation in its stratotype locality 0.8 km NE from the eastern margin of the village Ipolytarnóc on the SE slopes of Fehér hegy hill was described by Bartkó (1985) and Korpás (2003). The formation is laying directly on the sandstone of Zagyvapálfalva Formation, bearing the Upper Eggenburgian Mammal foot print covered by a layer of ash tuff thick less than 1 m. The Fehér hegy Formation is subdivided into 3 cycles generated by the different short volcanic pulses (Fig. 2).

The first cycle is built up by the ignimbrite thick up to 5 m. The ignimbrite is followed by the sediments or volcanosedimentary rocks thick up to 10 m. The sediments are represented by the conglomerate, sandstone and siltstone. The sediments contain volcanic admixtures being formed mostly by the fragments of volcanic rocks.

The second cycle of volcanic rocks starts with the layer of welded tuff thick 0.5 m, overlaid by the ignimbrite thick as much as 10 m, being followed by felsitic biotitic welded tuff thick 19 m.

The third cycle starts with a layer 1 m thick of pumiceous tuff, followed by 10 m thick mass of welded tuff. The whole sequence is thick up to 42 m.

Age of Fehér hegy Formation

From the above description it follows that Fehér hegy Formation came into being at times between the 1st Lower Miocene CCW rotation by 50° to 60° and 2nd one by 30° CCW. The first rotation occurred at 17.7 Ma, which dates it to the Ottnangian after or at the end of sedimentation of the Pôtor/Kisterénye members of the Salgótarján Formation and second rotation took place at 16.5 Ma in the Upper Karpatian or after the Karpatian (Fig. 4). Because of it the Miocene rocks older as 17.7 Ma show the 80°-90° CCW rotation. In the time interval between 17.7 and 16.5 Ma beside the sedimentary rocks, at least two horizons of felsitic tuff, or tuffaceous rocks occur. The first is in Plachtince and/or Mátranováki members of the Salgótarján Formation and the second is in Sečianky Member of the Modrý Kameň Formation corresponding to the Garáb Schlier Formation in the Hungary, both Karpatian in age.

The siltstone of the Sečianky Member was sampled at Dolné Príbelce village (No. 28, Tab. 1, Fig. 1). The paleomagnetic properties of the sample show the reverse polarity and CCW rotation by 30° (Túnyi et al., 2003). The tuff occurring in the Sečianky Member could not be an equivalent of ignimbrites of the Fehér hegy Formation. On the other hand the Plachtince Member originated during the Upper Ottnangian and the normal magnetic polarity event. So the tuff inside the Plachtince Member may be an equivalent of the Fehér hegy Formation. The Fehér hegy Formation is younger by at least 0.5 Ma up to 2.5 Ma in comparison with the Gyulakészi and Bukovinka formations (Fig. 4).

After submitting this paper, another one dealing with the paleomagnetic properties and consequent age estimation of the Miocene pyroclastic rocks in the Bükk Mts. and their forelands appeared (Márton et al., 2007). Two rhyolite tuffs, studied paleomagnetically (sites Bukkszék Oldalfőke and Törokkréti patak, Nos. 15 and 16 in quoted paper), are of normal polarity and declinations are of 228° and 329° resp. Both tuffs by their paleomagnetic properties and supposed age (17.2 Ma) seam to be coeval with the Fehér hegy Formation. Our correlation indicates that volcanic activity forming the Fehér Hegy Formation was not a local one, but has the equivalents in the Bükk forelands.

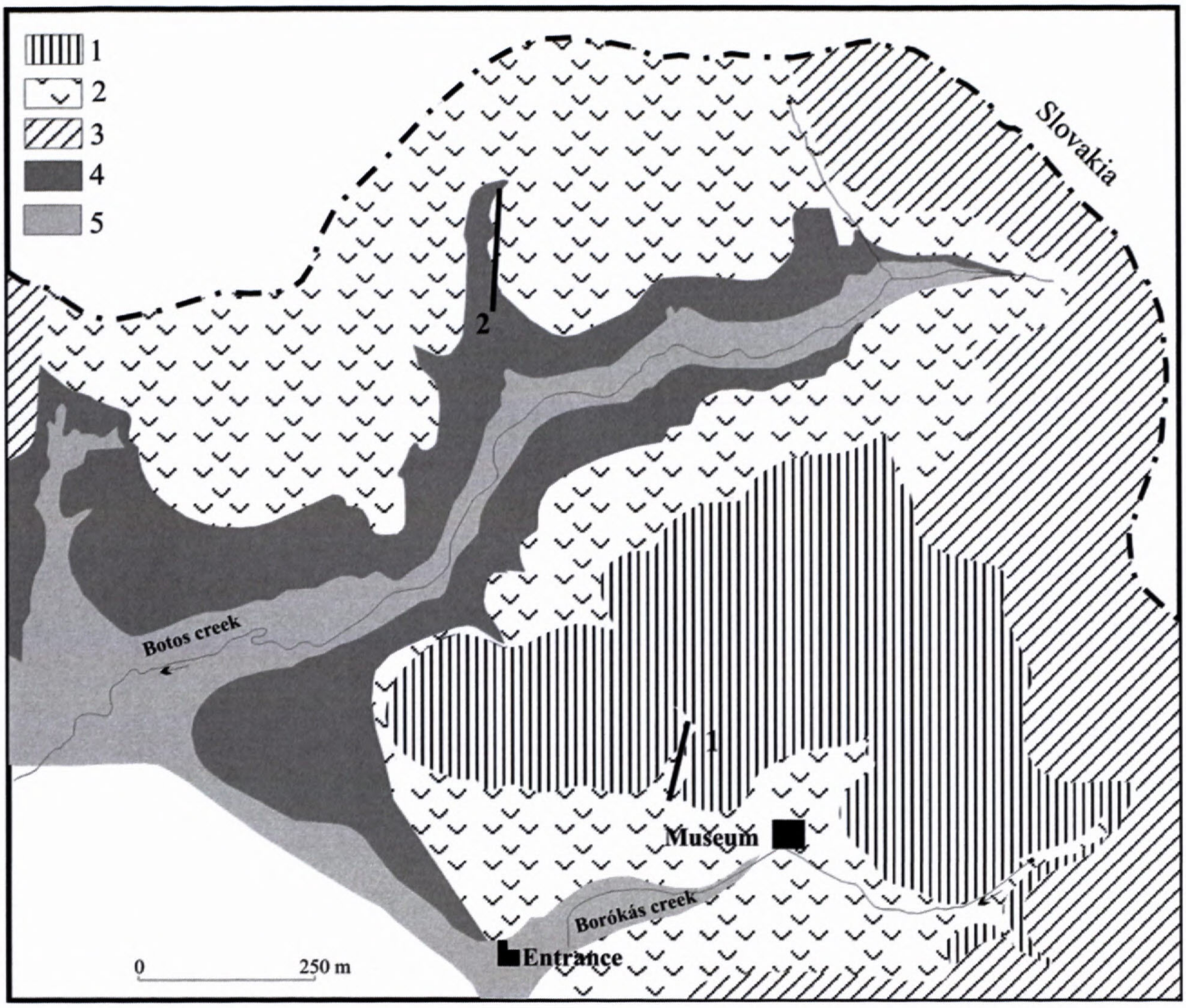

Fig. 3. Schematic geologic map of the surroundings of Ipolytarnóc footprints site (according to Bartkó 1985, simplified) and the situation of the Fehér hegy Formation type (1) and reference (2) sections.
Explanations: 1 – tuffaceous sandstone with pebbles of ignimbrite, conglomerate, Upper Ottnangian ?, 2 – ignimbrites of Fehér hegy Formation, Upper Ottnangian, 3 – mottled clay of Zagvapálfalva / Bukovinka formations, Upper Eggenburgian. 4 – sandstone of Pétervásara / Fiľakovo formations, Lower Eggenburgian, 5 – sandy claystone / siltstone of Pétervásara / Fiľakovo formations, Lower Eggenburgian.

Conclusions

The main portion of the Lower Miocene felsic tuff and ignimbrites occurs in the terrestrial Bukovinka Formation (gravel/conglomerate, sandstone, mottled clay and felsitic volcanic rocks) of the Upper Eggenburgian age. In the Northern Hungary, the terrestrial deposits are included into the Zagyvapálfalva Formation and felsitic volcanic rocks into Gyulakeszi Formation considered to be Lower Ottnangian in age. The paleomagnetic study of Lower Miocene felsitic ignimbrites and tuffs has shown that these rocks can be subdivided into two groups. First and older group has the reverse magnetic polarity and larger CCW rotation (80°–90°). The second one, occurs exclusively at the village of Ipolytarnóc, NW of the village Lipovany and SW of the village Mučín. The rocks of second group are of normal magnetic polarity and their rotation is smaller (about 30°). Because of it the felsitic tuff and/or ignimbrite of the second group are separated from the Gyulakeszi and Bukovinka formations, and the new formation was described obtaining its name after the type locality Fehér hegy hill. This formation is younger than the first block rotation at 17.7 Ma and older than second rotation at 16.5 Ma. The normal polarity event occurred in the Upper Ottnangian, so the Fehér hegy Formation is of this age. The foot prints sandstone has the same paleomagnetic properties as the Fehér hegy Formation, but according the flora assemblage from overlying fine tuff layer it belongs to Zagyvapálfalva Formation of Eggenburgian age. Its original paleomagnetic properties are overprinted by slowly cooling hot ash clouds generating the ignimbrite.

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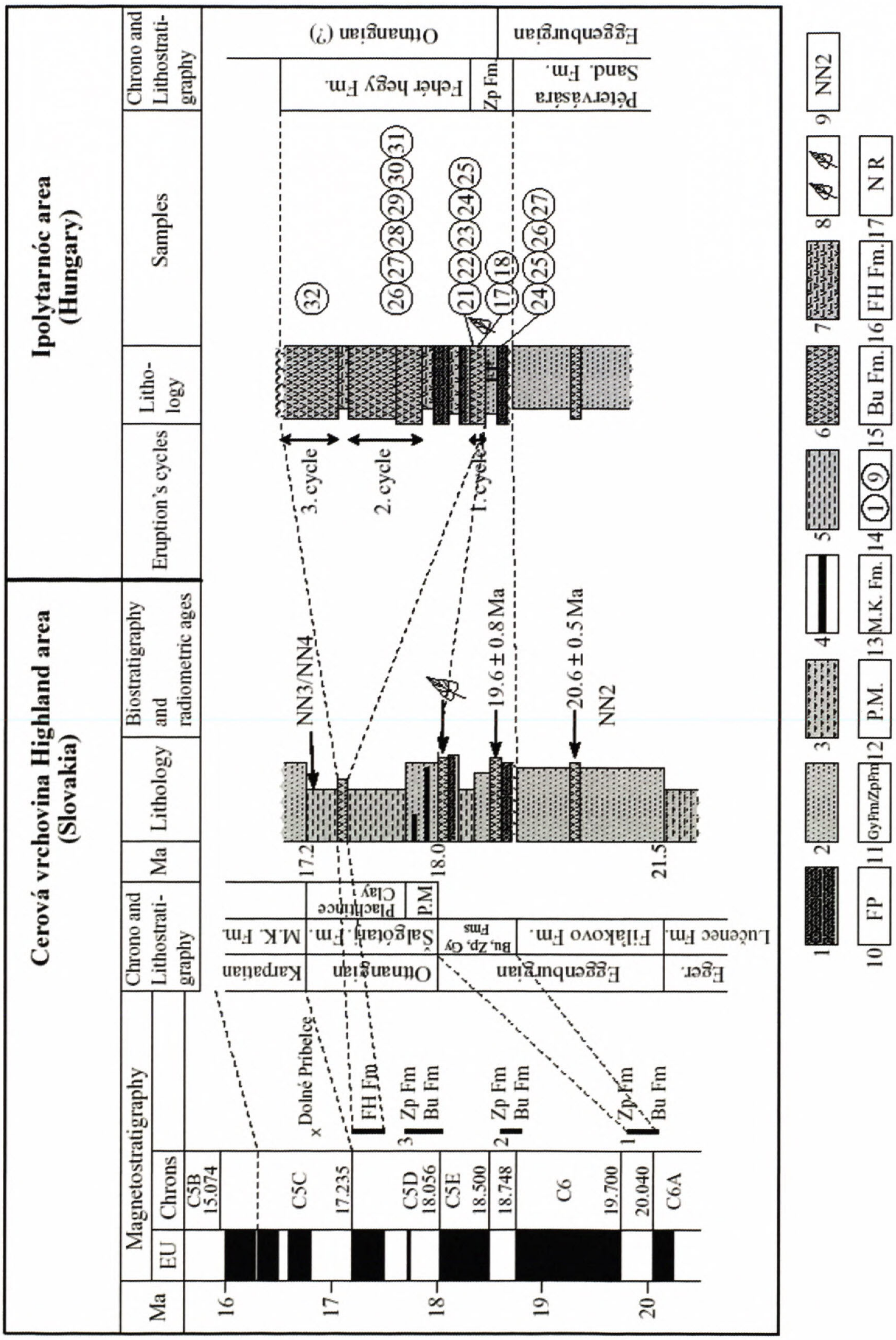

Fig. 4. Correlation chart of Lower Miocene rocks of the Cerová vrchovina Highland area in Slovakia (lithology after Vass, 2002) and Ipolytarnóc area in Hungary (after Bartkó, 1985 in Korpás, 2003). In the former major part the Ottnangian is missing. 1 – conglomerate, 2 – sandstone, 3 – siltstone , 4 – coal seams, 5 – clay/claystone, 6 – felsitic tuff and ignimbrite, 7 – tuffaceous siltstone/claystone, redeposited tuff, 8 – leaf imprints, 9 – nannoplankton zone, 10 – foot prints, 11 – Zagyvapálfalva and Gyulakészi formations, 12 – Pôtor Member coal seam bearing, 13 – Modrý Kameň Formation, 14 – number of sampled site, 15 – Bukovinka Formation, 16 – Fehér hegy Formation, 17 – N: normal polarity, R: reverse polarity.
Numbers 1, 2, 3 of Fig. 3. left side – explanation see in the text.

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