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ROTATION OF THE SOUTH SLOVAK PALEOGENE AND LOWER MIOCENE ROCKS INDICATED BY PALEOMAGNETIC DATA

EMÖ MÁRTON[1], DIONÝZ VASS[2] and IGOR TÚNYI[3]

[1]Eötvös Loránd Geophysical Institute, Columbus út 17-23, 1145 Budapest, Hungary
[2]Dionýz Štúr Institute of Geology, Mlynská dolina 1, 817 07 Bratislava, Slovak Republic
[3]Geophysical Institute, Slovak Academy of Sciences, Dúbravská 9, 842 28 Bratislava, Slovak Republic

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Abstract: In northern Hungary more than 50 geographically distributed sites in Cenozoic, mainly Miocene extrusive igneous rocks and sediments displayed counter-clockwise rotated declinations. The sites form two groups that differ in the angle of the declination deviation from the present north: the older group is characterized by 50°-60°, the younger by 30°. These paleomagnetic data were interpreted as significant of two rotation events, both taking place in the lower(mid) Miocene. The total rotation significantly exceeds that of the SW part of the Transdanubian Central Range of the Carpatho-Pannonian area.

Existing tectonic models do not take into account relative rotation within the Transdanubian Central Range during the Cenozoic, neither can they accommodate a 80°-90° counter-clockwise rotation.

In order to follow up the regional occurrence of such rotations, we collected 130 samples from 11 sides (mainly sediments) in the Slovak part of the Buda and/or Hungarian Paleogene Basin (HPB).

As a result of stepwise thermal and AF demagnetization we obtained useful magnetic signal from more than half of the collected samples. Nevertheless, the successful sites permit us to extend towards the North the outlines of the area showing excess counter-clockwise rotation with respect to the SW part of the Transdanubian Central Range.

Between the Ottnangian and the mid-Badenian the northern area of the HPB moved northward (in the order of 500-1000 km).

Key words: Paleogene, Lower Miocene, Buda or Hungarian Paleogene Basin, Fiľakovo/Pétervására and Novohrad/Nógrád Basins, paleomagnetism, declination rotation.

Introduction

Following the observation of an about 80° counter-clockwise declination rotation in a Late Oligocene clay from Eger (Márton P. 1983) NE Hungary, systematic paleomagnetic studies started in the region on Cenozoic rocks. Though the results of these studies were only very recently summarized in a publication (Márton & Márton 1996), several internal and published reports (Márton E. 1990; Márton P. 1987, 1990, 1991), and presentations at international conferences (Márton E. 1991; Márton & Márton 1991) in presented years demonstrated the power of the paleomagnetic method in discovering important tectonic events in the Carpatho-Pannonian area.

The hard facts emerging from the paleomagnetic investigations are the followings. In NE Hungary, in the area of the Buda and/or Hungarian Paleogene Basin (HPB) sediments and igneous rocks of Ottnangian and older Cenozoic ages are characterized by about 80° westerly declination; Karpatian (and perhaps lowermost Badenian) rocks exhibit about 30° westerly declination; finally the declination of the products of the Middle-Late Miocene calc-alkaline volcanism is aligned with the present north. The inclinations for the first group are definitely shallower than the expected one at the present geographical latitude.

Since the paleomagnetic sampling points are numerous, geographically distributed and represent both igneous and sedimentary sites and localities, the results are of regional significance. From the time-dependence of the paleomagnetic elements, declinations and inclinations, we are able to recognize two phases of important displacements during the Cenozoic: the first, accompanied by a counter-clockwise rotation of about 40-50°, took place in the Ottnangian, after a tectonically relatively uneventful, long period (from Late Eocene to Ottnangian); the second, manifested in an additional 30° counter-clockwise rotation happened close to the Karpatian-Badenian boundary. Between the Ottnangian and the mid-Badenian, the northern area of the HPB, probably at the time of the first rotation, moved northward (in the order of 500-1000 km).

Rotation of such large magnitude and timing were not predicted by any of the tectonic models of the Carpatho-Pannonian area. We think, therefore, that the geographical limits of the recently recognized tectonic unit must also be found with the paleomagnetic method. That is why the authors of the present paper started a joint project in the Slovak part of the HPB and the short term Lower Miocene Basin.

Geology and sampling

The studied area belongs to the epicontinental Paleogene Basin system spread in Hungary and Southern Slovakia (HPB)

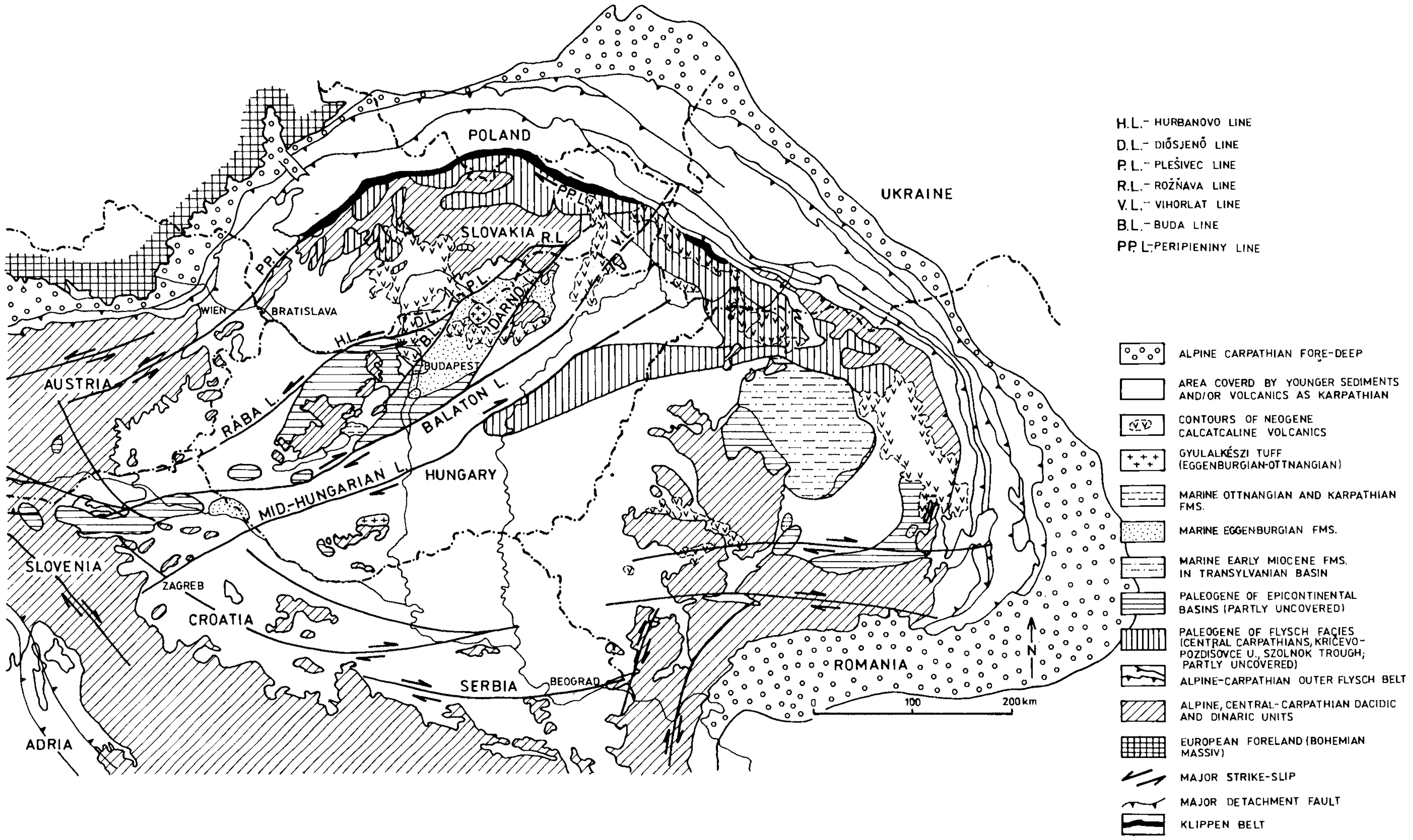

Fig. 1. Geological sketch map of the Carpatho-Pannonian region.

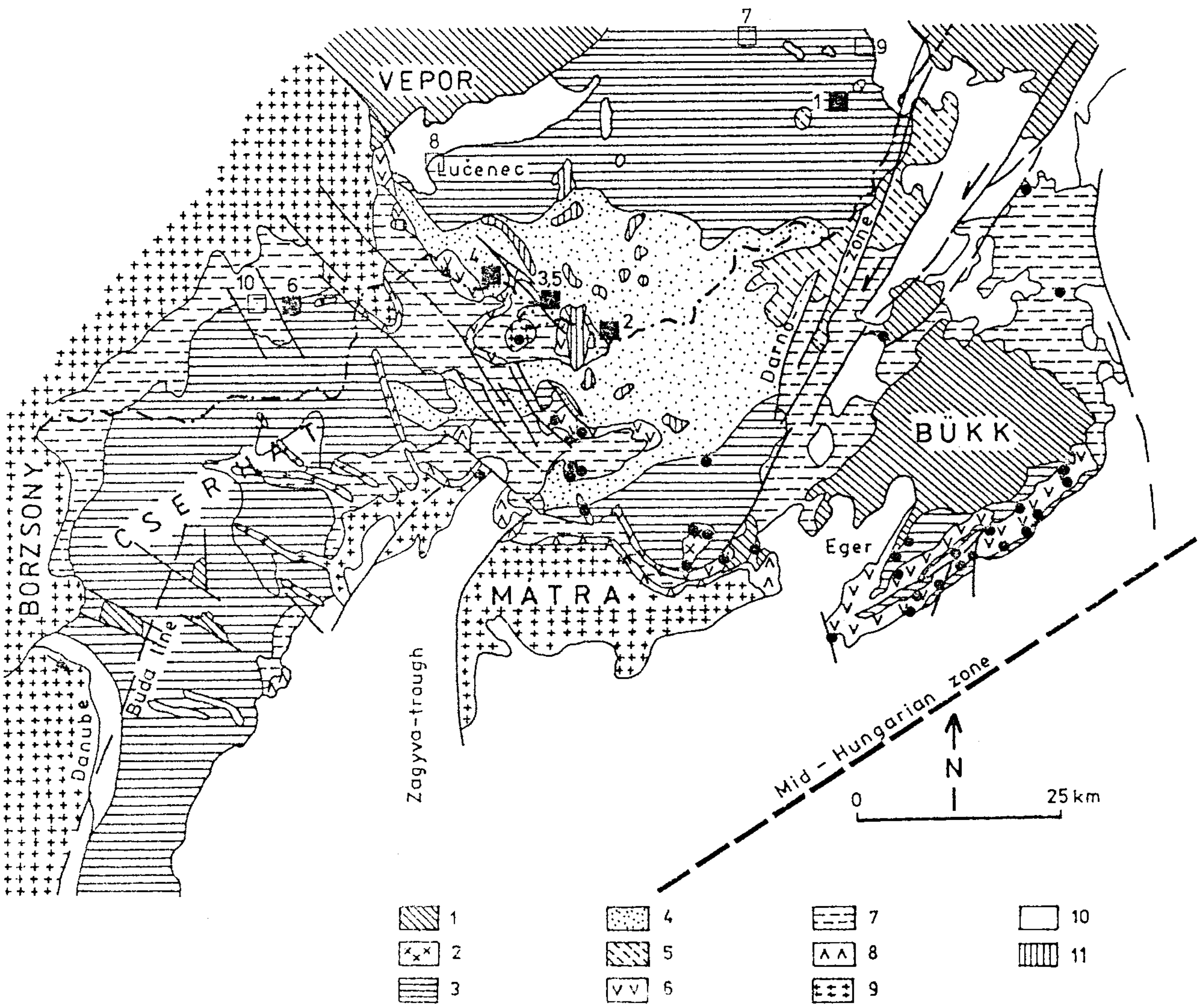

Fig. 2. Simplified geological map of the NE part of Hungarian Paleogene Basin system. Fiľakovo-Pétervására and Nógrád Basin with the sampling localities. *Large symbols:* Sampling points of the Slovak side (solid symbols; successful ones, hollow symbols; rejected ones; for numbers refer to Fig. 3). *Small symbols:* Successful sampling points on the Hungarian side. *Key to geology:* **1** — pre-Cenozoic rocks, **2** — Eocene andesites, **3** — Northern part of the Hungarian epicontinental Paleogene Basin system, **4-5** Fiľakovo-Pétervására Basin: **4** — Fiľakovo-Pétervására Formation partly covered by upper Szécsény schlier; **5** — upper Szécsény and Putnok schlier, Eggenburgian, **6** — Gyulakeszi rhyolite tuff (Eggenburgian - Ottnangian) and/or rhyodacite tuff in Bukovinka Formation (Eggenburgian), **7** — Nógrád - Novohrad Basin. Ottnangian and Karpatian, **8** — "middle rhyolite tuff" and/or Tarr tuff; Upper Karpatian - Lower Badenian, **9** — Middle (and Upper) Miocene volcanics, **10** — Middle to Upper Miocene sediments, **11** — Upper Miocene to Pleistocene basalts.

(Fig. 1), where the onset of Cenozoic sedimentation was diachronous. The marine transgression came from the SW (according to present coordinates) after a long period of subareal exposure, when karst-bauxites were formed (Dudich 1977; Dudich & Kopek 1980). The transgression started earliest in the Carinthian Bay (Cuisinian), and reached the NE part of the Bakony in the Bartonian. Further to the NE, Late Eocene marine sediments are also widespread, as in the Dorog Basin and at the southern margin of the Bükk Mts.

During the Oligocene the SW parts of the HPB system were uplifted and suffered an "intra-Oligocene" denudation (Telegdi-Roth 1927) meanwhile in the NE part an euxinic sea persisted during the Kiscellian (Báldi 1986). In the Late Kiscellian the sea rapidly extended further to the NE part of the basin system and for the first time during the Cenozoic it also penetrated the S Slovak part of the basin system. The transgression is marked by an extensive sheet of coarse clastics with coal seams (Hárshegy sandstone, Hostišovce Member). They grade into bathyal claystone/siltstone (Kiscell clay, Lenártovce Member of the Číž Formation) with turbiditic intercalations. At the end of the Kiscellian there was a regressive event marked by the basinward shift in facies and by prograding deltas (e.g. Rapovce delta in the Lučenská kotlina Depression).

The Egerian marine transgression crossed the northern margin of the Kiscell clay. Shallow marine clastics (Panica Member, Törökbálint and Eger sandstones) and organodetritic carbonate rocks (Budikovany Member) gradually passed into bathyal siltstone (Szécsény schlier). The end of Egerian is marked again by regression with prograding deltas (e.g. Opatová delta in the Ipeľská kotlina Depression).

With the end of the Egerian the basin conditions changed essentially. The connection with the Mediterranean Sea was closed

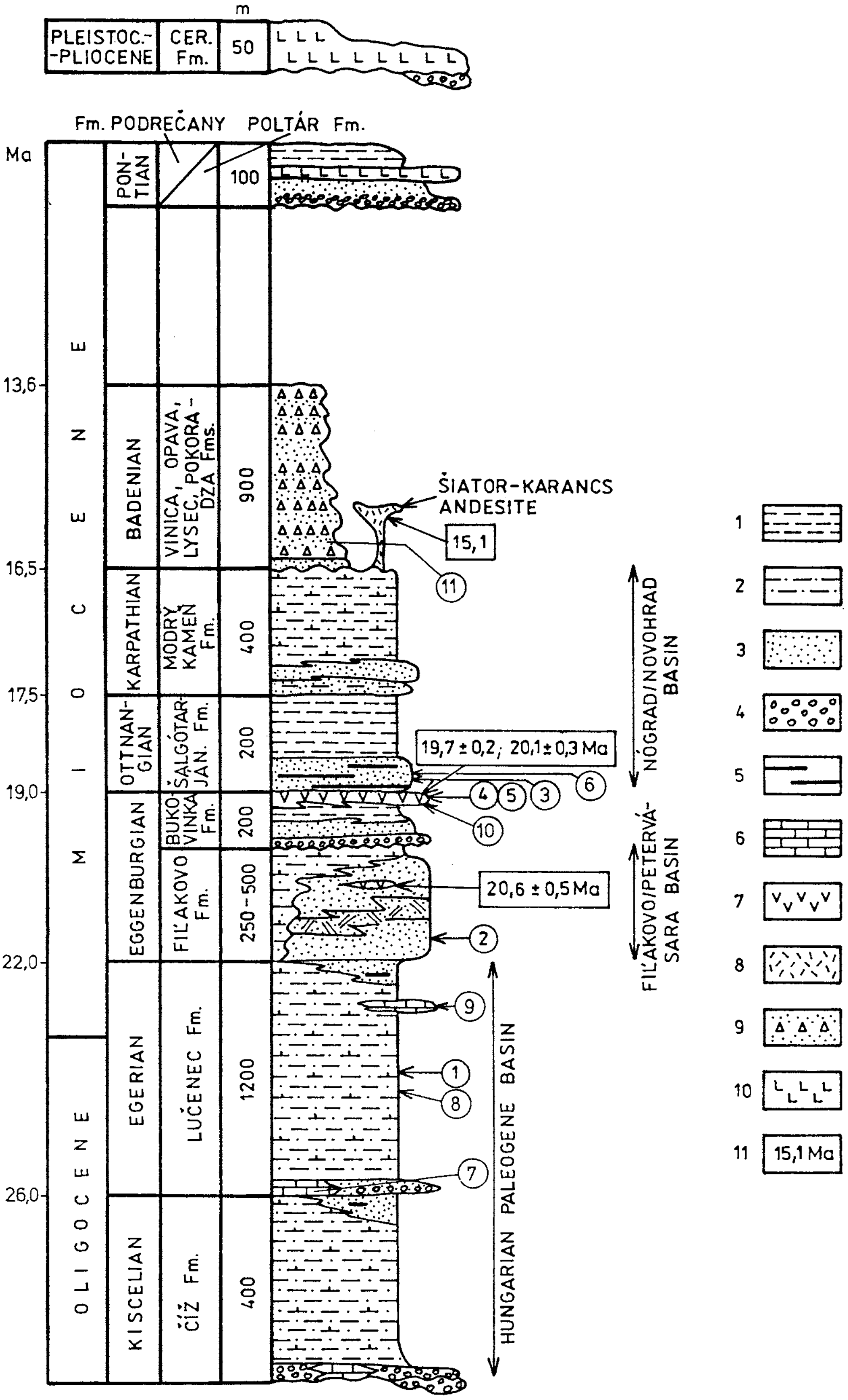

Fig. 3. Litho- and chronostratigraphy of the Tertiary Southern Slovakia. 1 — Clay; 2 — Calcareous siltstone; 3 — Sand-conglomerate; 4 — Gravel-conglomerate; 5 — Coal seams; 6 — Limestone; 7 — Rhyodacite tuff, ignimbrite; 8 —Andesite; 9 — Andesitic volcanoclastics; 10 — Basalt; 11 — Radiometric age (million years). *Paleomagnetic sampling points: 1* — Tomaľa, *2* — Tachty, *3* — Čakanovce, *4* — Lipovany, *5* — Čakanovce (Rhd. ignimbrite), *6* — Veľké Straciny, *7* — Budikovany, *8* — Lučenec, *9* — Bretka, *10* — Dolné Plachtince, *11* — Pláštovce (periphery).

and the basin extension reduced. From the beginning of the Eggenburgian the remaining basin is called the Fiľakovo-Pétervására Basin. On the margins of the basin shallow water clastics (tidal dominated coastal environment: Fiľakovo Formation, Pétervására Formation and littoral sandstone, rich in fauna: Budafok sandstone, Lipovany sandstone), in the centre siltstone (apparently continuous from the Egerian Szécsény schlier) were deposited. The clastics are intercalated with acidic tuffs (radiometric age 20.5 ± 0.5 Ma, Repčok in Vass & Elečko et al. 1992), bentonitized in places. In the Late Eggenburgian the sea completely retired from the area and fluviatile sedimentation took place (Bukovinka and/or Zagyvapálfalva Formation). At the same time, extensive volcanic activity of a rhyodacite nature occurred (radiometric age from the Bukovinka Formation is 19.8 ± 0.2 and 20.1 ± 0.3 Ma: Kantor et al. and Repčok in Vass & Elečko et al. 1992). Tuffs and welded tuffs deposited on land seem to be younger in the Salgótarján Basin (Gyulakeszi rhyolite tuff Formation, radiometric age: 17.6 ± 0.8 Ma) and southern margin of the Bükk (16.8 ± 0.8, 17.5 ± 0.5, all by Pécskay in Márton & Márton 1996).

From the beginning of the Ottnangian the region subsided again (Nógrád-Novohrad Basin). The transgression of the sea was preceded by sedimentation in rivers, swamps and lakes, occasionally invaded by the sea (Salgótarján Formation). The marine deposits of the Modrý Kameň and Egyházasgerge Formations beginning with the transgressive clastics graded into basinal Garáb schlier covered by the products of a new volcanic activity (Tarr tuff Formation) at the Karpatian-Badenian boundary. (K/Ar age at the southern margin of the Bükk Mts.: 17.2 ± 2.3 Ma, 17.0 ± 0.7 Ma, both by Pécskay in Márton & Márton 1996). The Nógrád-Novohrad Basin disappeared when the magma started to come from deeper-seated centers giving rise to calc-alkaline andesites.

The oldest sedimentary rock which we sampled on the territory of Southern Slovakia is a carbonaceous friable siltstone from the brickyard of Tornaľa (locality No. 1, Figs. 2, 3). It belongs to the Lučenec Formation. The Egerian age of the sampled rocks and the whole Lučenec Formation is well proved by molluscs, foraminifers and the calcareous nannoplankton of the NP24, 25 and NN1 zones (Ondrejičková 1962; Kantorová, Lehotayová & Ondrejičková in Vass & Elečko et al. 1989; Šutovská 1990).

The next locality (No. 2) is an old quarry in the village of Tachty SE of Fiľakovo. Here Tachty sandstone, a member of the Fiľakovo Formation was sampled. The Eggenburgian age of the Fiľakovo Formation is documented mainly by calcareous nannoplankton of the NN2 zone (Lehotayová 1984) and by foraminifer assemblages (Kantorová in Vass & Elečko et al. 1992). The radiometric age of the acidic tuff coming from the formation of 20.5 ± 0.5 Ma (Repčok in Vass & Elečko et al. 1992) support the Eggenburgian age of the formation.

Two sites were sampled in the rhyodacite tuff and/or ignimbrite of the Bukovinka Formation. Locality No. 4 comes from a gravel pit nearby the village of Lipovany, SE of Lučenec and locality No. 5 comes from an artificial outcrop SW of the village of Čakanovce, to the south of Fiľakovo. The Eggenburgian age of the tuff (ignimbrite obtained by the K/Ar method: 19.8 ± 0.2 Ma and by F.T. method: 20.1 ± 0.3 Ma (Kantor et al. and Repčok in Vass & Elečko et al. 1992). Apart from the radiometric data the Late Eggenburgian age of the Bukovinka Formation is also proved by the presence of tropical to subtropical flora (Němejc 1967; Knobloch & Němejc in Steininger & Seneš et al. 1971). The flora excludes the Ottnangian age, because the Ottnangian was a period of climatic cooling (Rögl & Steininger 1984).

The last two localities come from the Pôtor coal bearing member of the Salgótarján Formation. Both are friable sandstones. Locality No. 3 is at the already mentioned artificial outcrop near Čakanovce. The samples were taken just above the coal seam resting on the rhyodacite tuff sampled as No. 5. Locality No. 6 is an abandoned sand pit E of the village of Veľké Straciny, SE of the town of Veľký Krtíš. The sampled siltstone is cross-bedded, the azimuth and the inclination of the cross-bedding varies from 202/12 to 290/15, so the current by which the sediment was deposited had a direction from the ENE to the WSW. The environment of the deposition was fluviatile, the current was in lower flow regime. The age of the Pôtor Member is considered to be Ottnangian (but the uppermost Eggenburgian is not excluded) according to the stratigraphic position between the Bukovinka Formation (beneath) and Plachtince Member of the Salgótarján Formation (above). The Ottnangian age of the Plachtince Member is proved by foraminifers and by calcareous nannoflora of the NN3/NN4 zones (Kantorová & Lehotayová in Vass et al. 1987).

Apart from the above described sampling sites and localities, five others were also sampled (Figs. 2, 3). Since they did not yield tectonically useful results, their detailed description is omitted. In summary, the samples were collected at 10, geologically distributed points, (Tab. 1) both in sediments and in rhyolite tuffs (more or less welded), and are of Late Oligocene to Badenian age. The samples were mostly drilled (113 cores). Occasionally, hand samples (12 in number) were also taken from rather unconsolidated or obviously inhomogeneous sediments. The samples were magnetically oriented, since

Table 1: Sampling localities and sites in S Slovakia (see Fig. 2 and 3).

locality rock type	coordinates		1992	1993
	φ°	λ°		
Čakanovce rhyolite tuff (5) sandstone (3)	19.80	48.21	dip: 295°/6° 8 cores 2 hand samples	8 cores 5 cores, 2 hand samples
Bretka (9) limestone	20.35	48.49	dip: 150°/26° 9 cores	
Tornaľa (1) calcareous siltstone	20.31	48.43	dip: horizontal 2 hand samples 4 cores	16 cores
Budikovany (7) limestone	20.10	48.50	dip: 290°/3° 2 hand samples	
Tachty (2) sandstone	19.95	48.18	dip: horizontal 5 cores	8 cores
Lučenec (8) calcareous siltstone	19.70	48.32	dip: 208°/5° 10 cores	
Lipovany (4) rhyolite tuff	19.72	48.22	visible foliation: 140/10 5 cores	10 cores
Veľké Straciny (6) sandstone	19.45	48.20	dip: 242°/7° 4 cores	11 cores
Dolné Plachtince (10) rhyolite tuff	19.32	48.21	7 cores	
Plášťovce (11) sandstone	18.96	48.16	dip: 270°/15° 4 hand samples 3 cores	

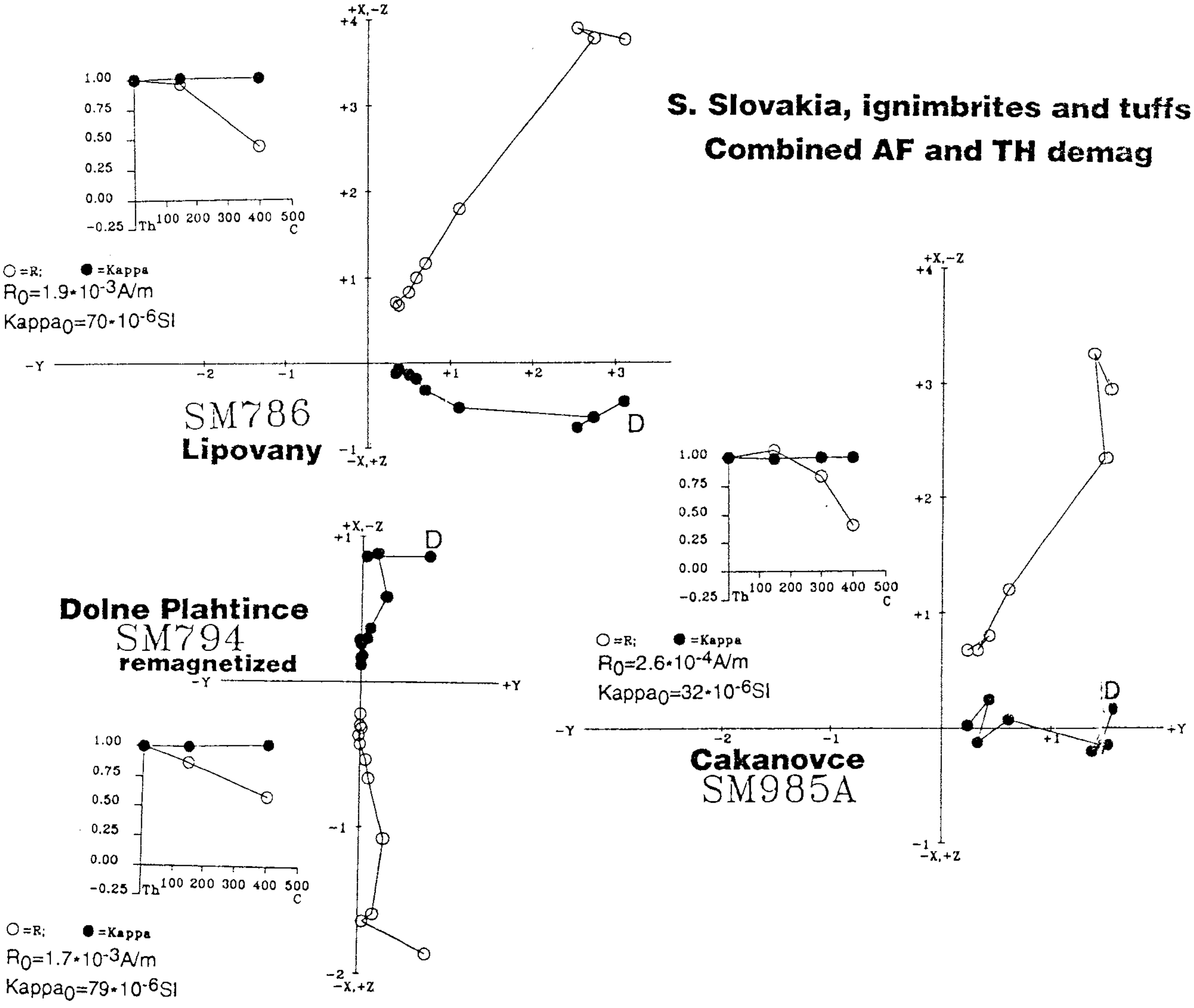

Fig. 4. Tuffs, more or less welded. The behaviour of the natural remanence (NRM) on demagnetization. Orthogonal (Zijderveld plots) of the declination and the Z component versus Y component, together with the normalized intensity (R) and normalized susceptibility (Kappa) versus temperature curves. R_0: initial NRM intensity, $Kappa_0$: initial susceptibility. *Demagnetization steps:* **SM786:** NRM, 10 mT, 150, 400 °C, 40, 50, 60, 70, 80 mT; **SM794:** NRM, 10 mT, 150, 400 °C, 40, 50, 60, 70, 80, 90, 100 mT; **SM985A:** NRM, 150, 300, 400 °C, 40, 50, 60 mT.

no strong magnetization was expected to be possessed by them. The samples were cut into standard size specimens (2.2 mm long cylinders or cubes of 8 cm^3 volume).

Measurements and results

The collection was divided into two parts. One set of specimens was processed in the Paleomagnetic Laboratory of ELGI in Budapest, the other half in the Paleomagnetic Laboratory of the Slovak Academy of Sciences in Bratislava. In the ELGI, the measurements of the remanence were made on a two-component Cryogenic magnetometer and JR-4 spinners. Thermal demagnetization was done in a Schonstedt oven, AF treatment in a Schonstedt demagnetizer (peak field 100 mT) and an AF demagnetizer built in the Technical University in Budapest (peak field 240 mT). Susceptibility and anisotropy of susceptibility was measured in the natural state and the former remeasured after each heating step using KLY-2 kappabridge.

In the Geophysical Institute of the Slovak Academy of Sciences, JR-4 magnetometer measured the remanence, KLY-2 the susceptibility in the natural state and after each heating step. The MAVACS (Přihoda et al. 1989) system combined with demagnetizers was employed to demagnetize the samples. In the framework of a Slovak-Spanish bilateral program, several pilot samples were demagnetized and also IRM acquisition experiments made in Barcelona by I. Túnyi.

The magnetic signal at one locality (Budikovany) was too weak for proper measurement and cleaning. Some of the other localities yielded statistically sufficiently well-defined paleomagnetic signals, though at each locality one or more samples had to be rejected from the final calculations. The reason for rejection was in all cases, except one, extreme instability on demagnetization. The exception is the rhyolite tuff at Čakanovce where the criteria for acceptance was not stability

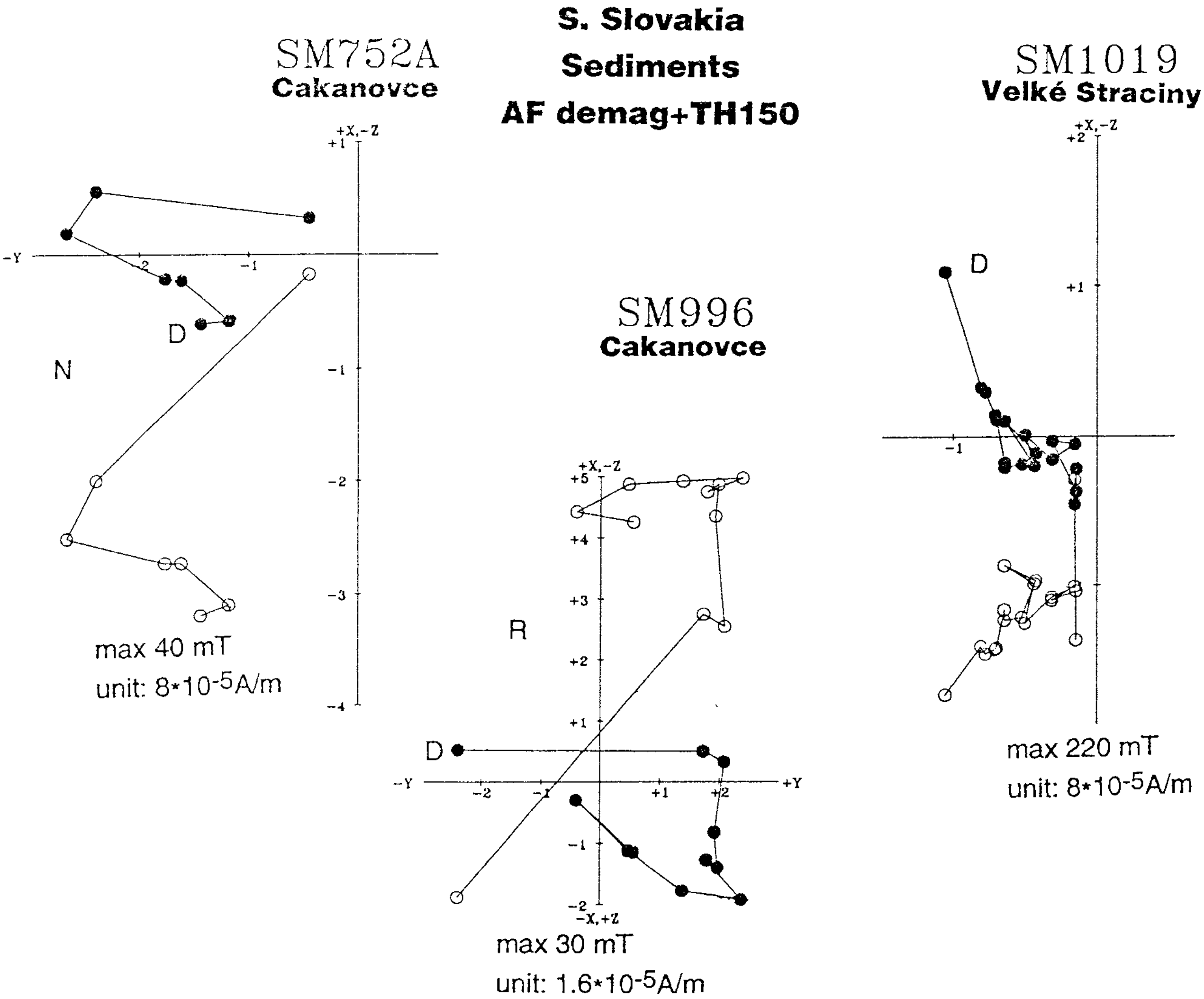

Fig. 5. Sediments. The behaviour of the NRM on demagnetization. Orthogonal (Zijderveld plots). Key as for Fig. 4. *Demagnetization steps:* **SM752A**: NRM, 5, 10, 15, 20, 30, 40 mT; **SM996**: NRM, 5, 10, 11, 12, 15, 20, 30 mT; **SM1019**: NRM, 5, 8, 10 mT, 150 °C, 12, 15, 20, 25, 30, 35, 40, 50, 80, 120, 220 mT.

Note: SM752A is of normal, SM996 is of reversed polarity of the same direction. Demagnetization curve of the first shows proper decay of the NRM (after the removal of an overprint component) towards the origin: that of the second starts to exhibit moderate instability; complete demagnetization is therefore impossible.

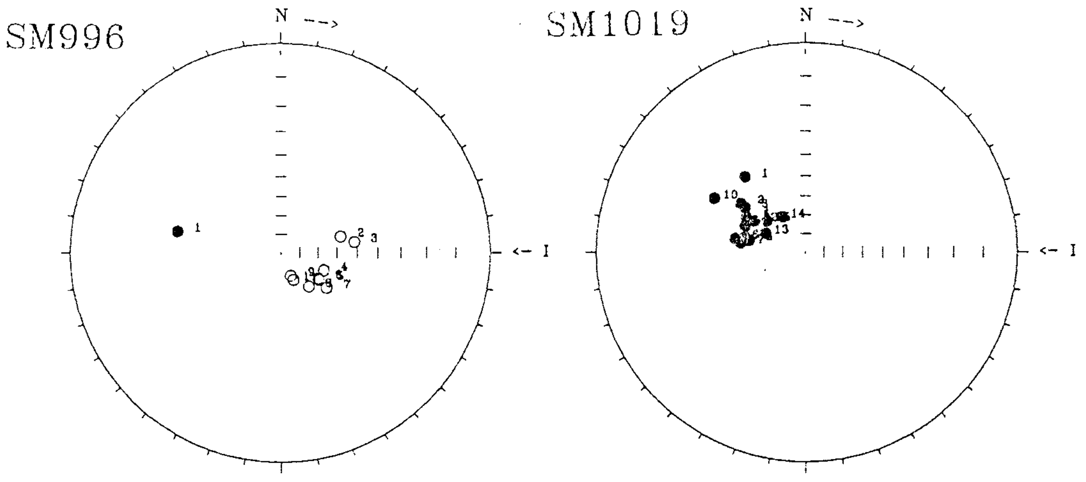

Fig. 6. Stability of the direction of the remanence, after removal of an overprint components. Stereographic projection. *Solid symbols:* normal; *Hollow symbols:* reverse polarity. Numbers denote cleaning steps. **SM996**: Čakanovce, sandstone; **SM1019**: Veľké Straciny, sandstone.

Table 2: Paleomagnetic results from S Slovakia.

	rock type age	N/No	D° D°_C	I° I°_C	k	α°_{95}	demag	remark
Čakanovce (5) 730-750 984-991	rhyolite tuff Eggenburg	7/16	116 114	-58 -51	16 16	15 15	TH, AF	each direction is the average of two sisters
Čakanovce (3) 750-752 992-996	silstone Eggenburg	7/8	116 115	-56 -49	21 21	14 14	TH, AF	
Lipovany (4) 785-789 999-1008	ignimbrite Eggenburg	13/14	84 86	-60 -62	52	6	TH, AF	corrected for plane of visible foliation
Velké Straciny (6)	silstone Ottnangian	11/15	305 298	45 40	16 16	12 12	TH, AF	
Tachty (2) Selected samples	sandstone Eggenburg	3/10	292 292	36 36	62 62	16 12	TH, AF	more than 10 samples collected several disintegrated
Tomala (1)	schlier Egerian	10/22	304 304	33 33	10 10	16 16	TH, AF	selected components
Overall mean before tilt corrections								
5, 3, 4, 6 +2, 1			112 115	-57 -49	46 30	14 12		
Overall mean after tilt corrections								
5, 3, 4, 6 +2, 1			110 113	-51 -46	40 35	15 12		

Key: N/No: Number of successful/collected samples. D°, I°: paleomagnetic mean declination, inclination before tilt correction. D_c°, I_c°: paleomagnetic mean declination, inclination after tilt correction. k, α°_{95}: statistical parameters precision parameter and half angle of confidence at the 95% level. TH, AF: thermal and alternating field demagnetization.

in itself, but also agreement between sister specimens. The localities, we considered unsuccessful, exhibited either large scatter (and instability) or were fully overprinted in the present field.

Concerning the method of demagnetization, combination of the AF and thermal methods yielded the best results (Figs. 4, 5).

After the measurement of the NRM in the natural state, the welded tuffs were subjected in Budapest to AF demagnetization in a moderate field, followed by thermal demagnetization in two or three steps. Finally AF demagnetization was employed again in several steps. As Fig. 4 shows this enabled us to isolate a single component remanence for each of the three sites in (welded) tuffs. Of the three sites, however, Dolné Plachtince (a long exposed, rather porous tuff) yielded a characteristic magnetization aligned with the present field direction. The other two exhibit a stable component of reversed polarity with a significantly different declination from the present. In Bratislava the specimens that were thermally demagnetized yielded much the same results.

The clastic sediments yielding paleomagnetic results were basically AF demagnetized in Budapest, sometimes with the insertion of a single heating step of 150 °C. Apart from a few cases (Fig. 5, SM752A), the complete reduction of the NRM intensity was prevented by instability. Surprisingly, sediments hardly responded positively to mainly thermal treatment (exception locality 1, SM961).

Nevertheless, we have every reason to assume that the remanence of the sediments which we suggest interpreting in terms of tectonics (Tab. 2) is practically free of overprint, since *1* — the direction viewed on stereographic projection is reasonably stable after the first few steps of cleaning (Fig. 6); *2* — normal and reversed polarity remanences are 180° apart (Fig. 5, SM752A and SM996A); *3* — welded tuff and sediment from the same artificial outcrop yield the same result (Tab. 2, Figs. 5, 3); *4* — the consistency between localities is fairly good (Tab. 2, overall mean directions).

As was mentioned earlier, some of the sampled sediments exhibit visibly oriented fabric due to water flow. Measurements of susceptibility anisotropy also reveal more or less oriented fabric for all sites and localities with dominant foliation practically coinciding with bedding planes or "foliation" planes. Lineation was subordinate, through clearly discernible in some cases (Fig. 7). The maximum susceptibility directions are aligned with the current direction at Veľké Straciny, so one may assume that it was not only the Earth's magnetic field, but also the flow current that influenced the remanence direction. Nevertheless, the bias cannot be significant, partly because the current was of low energy, partly because other paleomagnetic samples with different anisotropy distribution define very similar paleomagnetic directions (Fig. 7, Tab. 2).

Discussion and conclusion

The paleomagnetic results of Tab. 2 represent a short interval in the stratigraphic column (Fig. 3). Since the site and locality mean directions cluster, we calculated an overall mean direction, which is $D = 295^\circ$ $I = 49^\circ$ ($k = 30$ $\alpha_{95} = 12^\circ$) before, and $D_c = 293^\circ$ $I_c = 46^\circ$ ($k = 35$ $\alpha_{95} = 12^\circ$) after tilt correction (in both cases, Lipovany is taken before correction for plane

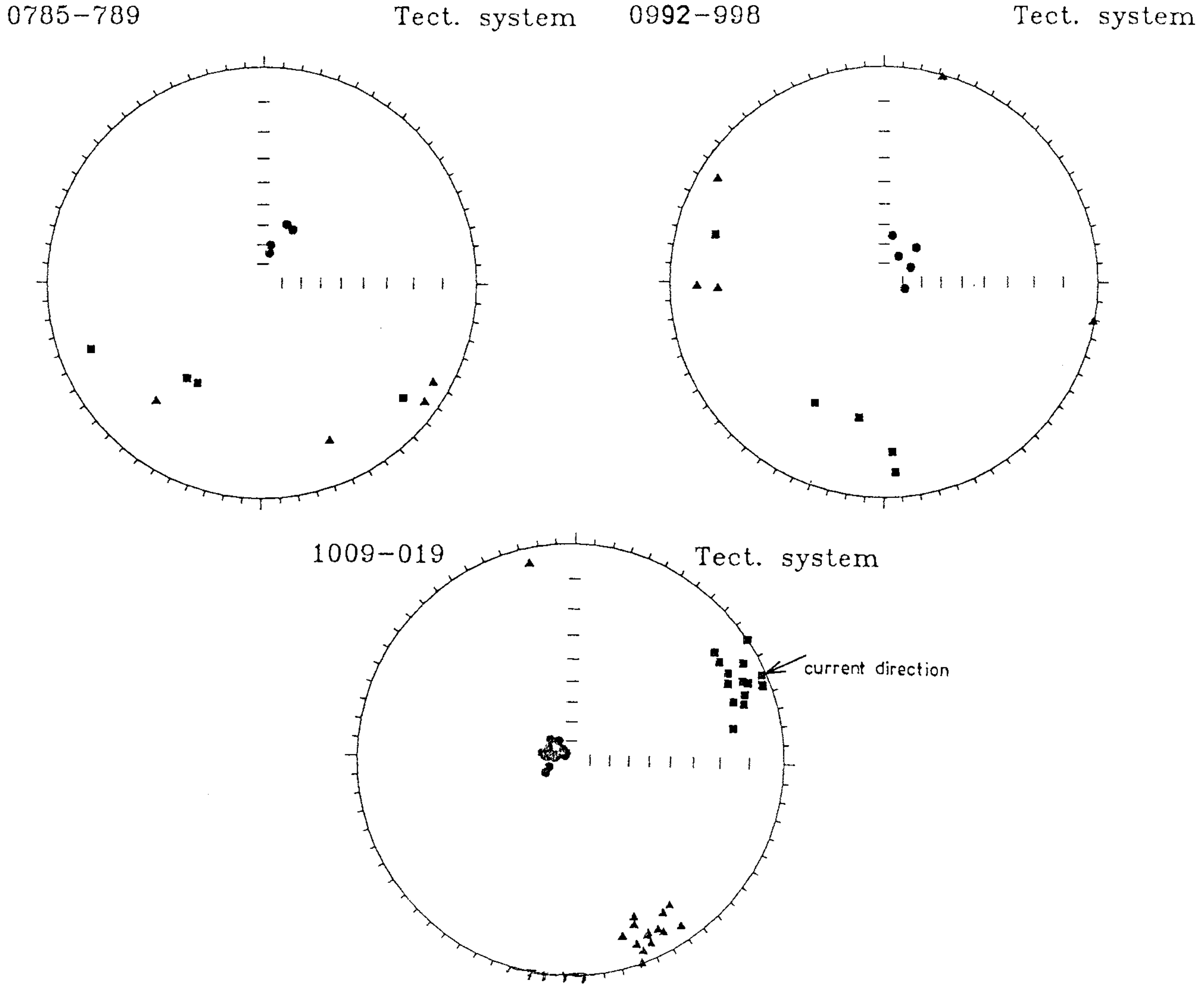

Fig. 7. Anisotropy of susceptibility: **0758-789 Lipovany**, welded tuff; mean susceptibility: 60-70*10-6SI, degree of Anisotropy: 1.7-2.4 %. **0992-998 Čakanovce**, sandstone; mean susceptibility: 60-70*10-6SI, degree of Anisotropy: 3.0-3.9 %. **1009-019 Veľké Straciny**, sandstone; mean susceptibility: 118-147*10-6SI, degree of Anisotropy: 1.3-2.6 %. Dots: minimum; Triangles: intermedier; Squares: maximum susceptibility directions. Stereographic projection, all with positive inclinations.

of visible foliation). However, if we base the calculations on the good quality results, omitting localities 2 and 1, the mean inclinations and the statistics change somewhat: D = 292° I = 57° ($k = 46$ $\alpha_{95} = 14°$) before, and $D_c = 290°$ $I_c = 51°$ ($k = 40$ $\alpha_{95} = 15°$) after tilt correction.

As is clear from the data, the mean declination is influenced neither by tilt corrections nor by number of sampling points considered in the calculation. The value between 295° and 290° agrees with the pre-Karpatian declinations observed in NE Hungary (Márton & Márton 1996). Thus we can conclude that the present day S Slovakia participated in the same Ottnangian and Early Badenian rotations mentioned in the introduction.

The tectonic interpretation of the inclination is more problematic since the "fold test" is not conclusive. Depending on the mode of calculation the inclination varies between 57° and 46°. On the Hungarian side mean inclinations determined for ignimbrites from the Bükk Mts., and the Nógrád Basin as well as sediments from the Nógrád Basin (Eggenburgian and Ottnangian in age) are 49°, 54° and 46°, respectively (Márton & Márton 1996).

Since the inclinations calculated in different ways from S Slovakia and those observed on different groups and types of rocks in the Hungarian side of the Paleogene Basin overlap, we see it as a further support for the tectonic continuity across the state border.

There is another important aspect of the inclinations. They are systematically shallower than the present one, implying that the whole area travelled northward after the Ottnangian. Data from the Hungarian side indicate that inclinations were also shallow before the Eggenburgian (the Late Eocene to the Egerian) as it is suggested for Tornaľa. Thus the paleomagnetic inclinations suggest that the HPB changed it's more southerly than present position during a single well-defined period, i.e. between the Ottnangian and mid-Badenian.

One would expect that climatic changes indicated by fauna and flora may be, at least loosely, correlated with paleomagnetic changes.

As we know from geological observation, the climate was humid in the Bartonian (coal bearing Dorog Formation) as it was in the Late Kiscellian (coal seams in the Hárshegy sand-

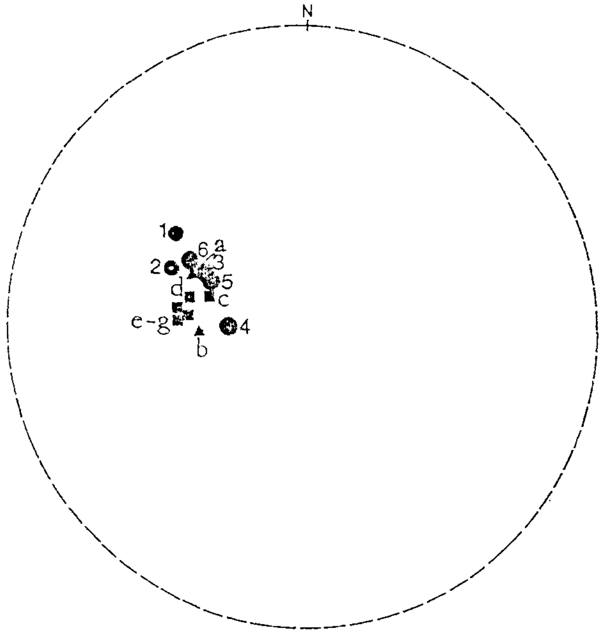

Fig. 8. Site and locality mean paleomagnetic direction for S Slovakia (1-6 see Tab. 2) compared with regional paleomagnetic directions for the Salgótarján Basin. Ottnangian sediments (**a**) and welded tuffs (**b**), respectively and for the Bükk area (Eocene andesites (**c**) and welded tuffs (**d**) of Ottnangian age) and locality mean paleomagnetic directions (**e-g**) for Eocene limestone, Egerian siltstone (Bükk area) and Eggenburgian siltstone (Ipolytarnóc).

stone and the Hostišovce Member) period. The first period was warm, during the second Boreal fauna appeared (Cavalier 1979 fide Báldi 1986). The climate was also humid during the Egerian and an increase of southern influence, i.e. warming took place (Báldi 1986) with a drastic change to arid climate (Vass et al. 1979). In the Late Eggenburgian tropical and subtropical flora characterizes the area (Němejc 1967; Knobloch & Němejc in Steininger & Seneš et al. 1971), while the Ottnangian is known as a period of climatic cooling (Rögl & Steininger 1984).

From the above comparison, we may conclude that climatic changes were more frequent than paleomagnetic events and do not seem to have been related.

Returning to the tectonic aspects of the paleomagnetic observations from the northern area of the HPB, and short term Lower Miocene Basins we must emphasize that the successful paleomagnetic data from S Slovakia are confined to a very short time interval (the Late Egerian-Ottnangian, i.e. about 6.5 Ma). Thus, from the paleomagnetic data available, we are not able to suggest or support any tectonic model that deals with the pre-Late Egerian situation i.e. concerning the possible changing configuration of different tectonic units separated by the tectonic lines crossing the HPB (Fig. 1).

On the contrary, the paleomagnetic data by Márton & Márton (1996) and the present study constrain quite well the tectonic models for later times since the consistency of the data suggests that the northern area of the HPB must have been practically "sealed" from the Late Egerian on. This means that small-scale relative movements, like the one causing the lateral redistribution of the Lučenec Formation, in the Egerian age (Vass et al. 1993), cannot be excluded, but the plausibility of large-scale movements, or at least, the timing of them, like the ones suggested e.g. by Csontos et al. (1991) must be reconsidered.

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