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PALEOMAGNETIC STUDY OF TRIASSIC SEDIMENTS FROM THE SILICA NAPPE IN THE SLOVAK KARST, A NEW APPROACH

JADWIGA KRUCZYK[1], MAGDALENA KADZIALKO-HOFMOKL[1], IGOR TÚNYI[2],
PAVOL PAGÁČ[2] and JÁN MELLO[3]

[1]Institute of Geophysics, Polish Academy of Sciences, Ks. Janusza 64, 01-452 Warsaw, Poland
[2]Institute of Geophysics, Slovak Academy of Sciences, Dúbravská 9, 842 28 Bratislava, Slovak Republic
[3]Slovak Geological Survey, Mlynská dolina 1, 817 04, Bratislava, Slovak Republic

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Abstract: Intensive paleomagnetic and rock magnetic study were performed for Triassic limestones from the Silica Nappe in the Slovak Karst. Five exposures situated on the eastern and western side of the Štítnik-Plešivec fault were sampled for this study. In all exposures a secondary component of remanence of normal polarity (N), carried by secondary PSD magnetite was found. In the Silická Brezová exposure (SB) apart from the N component, another secondary component of reversed polarity (R), carried by hematite, was isolated. Both components were acquired after folding. The R component was acquired during the Odra reversal event in the Oligocene (Birkenmajer et al. 1977). Comparison of its direction with the reference data let us conclude that the area belonged during this time to the African affinity. The declination of the R component suggests that after this magnetization period the studied region rotated anticlockwise by about 90° around an intraplate vertical axis together with the whole Pelso megaunit. According to Márton et al. (1995) and Márton & Fodor (1995) the rotation took place in two phases, the first one by about 50° took place in the Early Miocene, the second one, by about 30° — in the Late Miocene. The N component, isolated by us, seems to have been acquired during the Middle Miocene after the first and before the second rotational phases: its declination agrees with a counterclockwise rotation of the Silica Nappe by about 30–40° during the Late Miocene, as postulated by the cited authors. The inclination of the N component is lower, than the expected for Miocene, but agrees with the Miocene results for the Bükk region also belonging to the Pelso block, confirming the idea about the Miocene “southern escape” of the Pelso block (Márton 1993). The final tectonic activity in the study area was connected with formation of the Štítnik-Plešivec fault (Late Tertiary-Quaternary). Our results suggest, that the fault is of rotational type and resulted in different tilting of beds situated on its eastern and western sides.

Key words: Silica Nappe, paleomagnetic directions, Triassic limestones.

Introduction

Paleomagnetic investigations of the Triassic limestones from the Silica Nappe which forms part of the Pelso megaunit were first performed by Márton E. et al. (1988) and Márton P. et al. (1991). The first of the cited papers concerns exposures situated in the Aggtelek Mts. in Hungary, the second one — exposures situated in the Slovak Karst. Their study revealed the presence of the secondary component of natural magnetic remanence (NRM) of normal polarity and some traces of a component of reversed polarity. The latter was not discussed in detail, but the authors hinted that it is a primary Triassic one. The best grouping of normal component found for the Slovak Karst (Márton et al. 1991) calculated after results obtained for five exposures was obtained after 65% unfolding. According to the cited authors the mean direction (D = 319.9, I = 42.4, k = 168, α = 5.9) suggests that the rocks were remagnetized during the Late Cretaceous, and that at that time the studied area belonged to the African affinity. The cited results, as well as other paleomagnetic and stress study performed within the Pelso megaunit indicate, that the whole unit underwent 80° counterclockwise rotation against the stable European plate and that the rotation took place in two episodes: the first one with rotation of about 50° took place at the end of the Early Miocene, and the second one with rotation of about 30° took place at the beginning of the Late Miocene (Márton et al. 1995; Márton & Fodor 1995).

The above mentioned suggestion about premordiality and Triassic age of the reverse component of NRM found in one of the Silica Nappe exposure does not agree with the private communication of Mock & Channel (1993). They studied samples collected along a profile situated between the top and bottom parts of the Silická Brezová exposure. According to their results normally and reversely magnetized beds appear alternatingly along the profile suggesting several succesive reversals. This inconsistency in interpretation of the reverse component of NRM encouraged the present authors to repeat the paleomagnetic study of the Silica Nappe Triassic limestones.

Our first attempt at interpretation was published in abstract form in Kruczyk et al. 1996. There we have stated, that in the SB exposure (one of the six sampled by us) apart from the secondary normal component of remanence, appears a well grouped component of reversed polarity with the direction after bedding correction being: D = 89, I = –54, α = 5, k = 12. We interpreted it as the primary one of Triassic age. Four other exposures revealed the normal secondary component similar to the one isolated in the SB (one exposure gave no interpretable results). The best grouping of the normal component was obtained for the 25% unfolding, D = 322, I = 50, α = 10, k = 66. The closeness of this mean to the mean obtained by Márton et al. (1991) led us to interprete our result in the same way — as synfolding remagnetization component acquired in the Late Cretaceous when the Silica

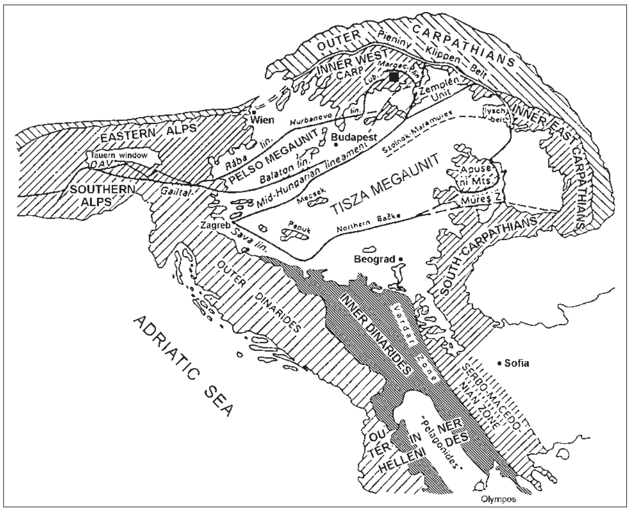


Fig. 1a. The location of the Pelso megaunit (after Márton et al. 1995), the black square denotes the study area.

Nappe belonged to the African affinity. We have also adopted the idea of Márton et al. (1995) and Márton & Fodor (1995) about the two episodes of the counterclockwise rotation of the Silica Nappe.

Despite the apparent logic of the results presented so far, we have decided to proceed with the interpretation of our data and to look more closely at the possible influence of the important tectonic fault Štítnik-Plešivec (S-P) on our results. This fault cuts the area of our study into western and eastern parts leaving three of sampled exposures at its western side. We have decided to check, whether the faulting influenced beds on both sides of the fault in the same way. This paper presents the new, revised approach to our data. In our new analysis we assumed a rotational character of the S-P fault (see Dadlez & Jaroszewski 1994).

Outline of geology and sampling

The Silica Nappe, situated in the area of the Slovak Karst, belongs to the Inner Western Carpathians, as well as to the Pelso megablock — Fig. 1a. The nappe is an allochthonous unit shifted to its present position from the south due to the collision of two fragments of the African and European plates Apulia and Bohemia, in the paleoalpine period. Apart from northward shifting, the Pelso block underwent several rotations and became cut by numerous faults. The tectonic activity in the Silica Nappe is thought to have begun during the Late Jurassic and lasted until the Late Tertiary-Quaternary. The temperatures in the region during tectonic activity did not exceed 200–300 °C.

The region of our study lies within the Silica Nappe on two sides of the Štítnik-Plešivec (S-P) tectonic fault dated as Late Tertiary-Quaternary directed NNW and divided into two branches in its southern segment, see Fig. 1b. Two of the six sampling localities: Silická Brezová (SB) and Silica (S) are situated close to the eastern border of the fault, one — Čoltovo (C) —lies between the two southern branches of the fault. The other three: Drienčany (D), Hrušov (H) and Budikovany (B) are lying close to one another at about 15 km to the west from the fault. The geological sketch map of the studied area with sampling sites is presented in Fig. 1b. Table 1 presents the age and nature of the sampled limestones together with the bedding parameters and number of hand samples collected in the field. Hand samples were cut in the laboratory into standard cylinders for paleomagnetic and rock magnetic purposes.

Technics of experimental study

Standard paleomagnetic investigations of collected material were performed independently in the three paleomagnetic lab-

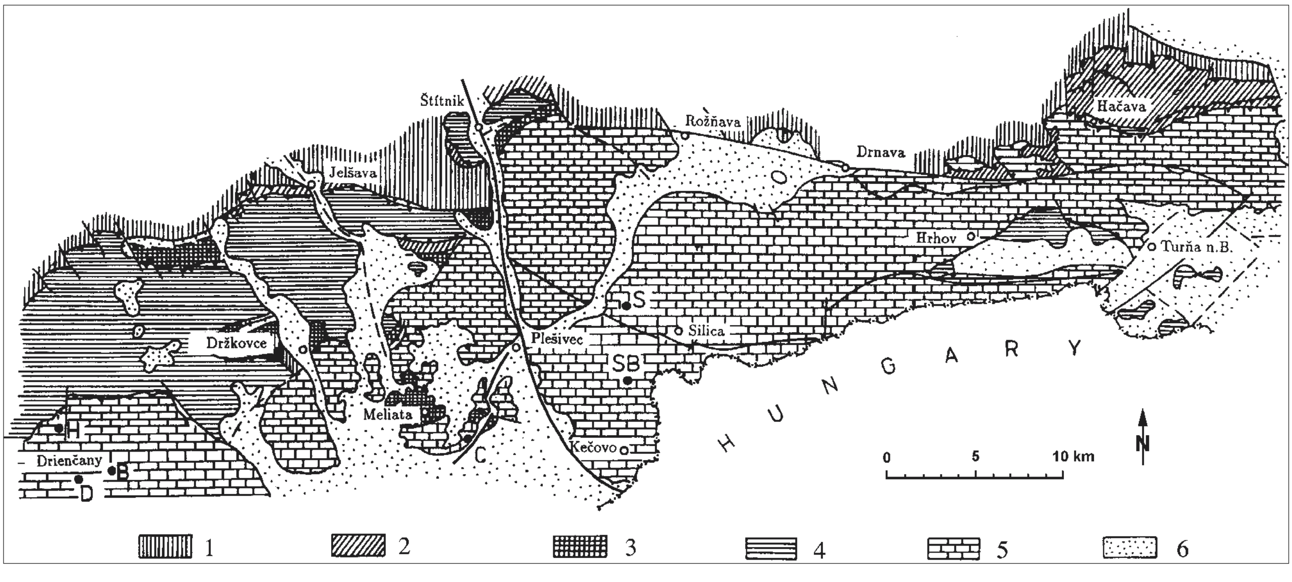


Fig. 1b. Geological map of the studied part of the Silica Nappe. Bold line — Štítnik-Plešivec fault, 1 — Gemeric Unit, 2 — Bôrka Nappe, 3 —Meliata Unit, 4 — Turňa Unit, 5 — Silica Unit, 6 — Tertiary cover. Sampling places are denoted by filled circles: SB — Silická Brezová, S — Silica, C — Čoltovo, H — Hrušov, D — Drienčany, B — Budikovany.

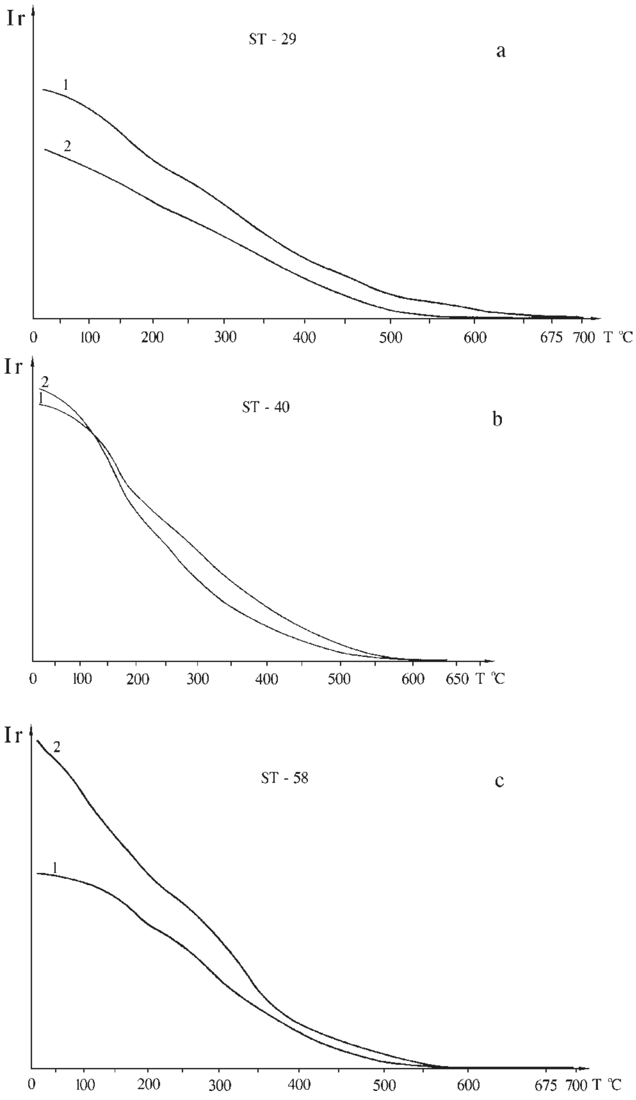


Fig. 2. Typical thermomagnetic curves obtained for Silická Brezová (a), Hrušov (b), Drienčany (c). Ir — isothermal remanence acquired in the field of 1T; 1 — curve of the first heating, 2 — curve of the second heating.

Table 1: Lithostratigraphic characteristics of sampled Triassic limestones.

Locality	Bedding, Az/tilt	Paleonto-logical age	Lithgology	Number of samples
Silická Brezová SB	258/18	Norian	Hallstadt limestones	31
Silica S	298/53	Lower Ladinian	Reiphlin limestones	9
Čoltovo C	35/65	U. Anisian-L. Ladinian	Reiphlin limestones	8
Hrušov H	120/50	Ladinian	Reiphlin limestones	4
Drienčany D	120/35	Ladinian	Reiphlin limestones	10
Budikovany B	120/35	Norian	Hallstadt limestones	8

oratories: Warsaw (Kruczyk, Kadzialko-Hofmokl), Bratislava (Túnyi, Pagáč) and Barcelona (Túnyi). They comprised thermal demagnetization with a non-magnetic furnace (Magnetic Measurements in Warsaw, MAVACS Geofyzika Brno in Bratislava and Schoenstedt in Barcelona) and alternating field demagnetization (2G device in Warsaw). Natural remanent magnetization was measured with the 2G kriomagnetometer in Warsaw, JR5 spinner magnetometer (Geofyzika Brno) in Bratislava, and SQUID in Barcelona. The demagnetization results were analysed in Warsaw with the use of a special program package.

Rock magnetic study comprising identification of magnetic minerals were performed in Warsaw and Barcelona. Magnetic minerals were identified with optical microscopy, by means of thermomagnetic analysis, magnetic hysteresis measurements and IRM acquisition curves. Thermomagnetic analysis consisted of thermal decay in a non-magnetic space of the isothermal remanence Ir acquired in a 1T field in (non-heated) fresh specimens and in the same specimens annealed to 600 °C. The results reveal blocking temperatures of magnetic minerals present in the rock before and after heating. Hysteresis curves were measured with the VSM apparatus of Molspin Ltd with the highest available field of 1T. The obtained parameters of saturation magnetization Is, saturation remanence Irs, coercive force Hc and coercivity Hcr bring information about the kind and grain size of magnetic minerals present in the rock. Measurements of IRM acquisition curves performed with Molspin in Barcelona for fresh and heated specimens also help in identification of magnetic minerals.

Magnetic susceptibility was measured before heating and after each heating step in order to monitor mineral changes that could influence natural remanence. Anisotropy of susceptibility before heating and after the final heating step was also measured. The KLY2 bridge of Geofyzika Brno was used for this purpose, analysis of measurements of susceptibility anisotropy was performed with the ANISO11 program of Jelinek (1977) and the Spheristat Programme.

Magnetic mineralogy

Study of magnetic minerals — carriers of NRM show, that the amount of magnetic minerals in the studied limestones is very low resulting in very low values of natural remanence, saturation magnetization and saturation remanence. Thermomagnetic curves (Fig. 2a,b) suggest, that magnetic minerals comprise mostly fine-grained magnetite accompanied by hematite in the SB and sometime with a small amount of iron hydroxides (as in D — Fig. 2c). Heating in air to 600 °C results in production of new magnetite from nonmagnetic minerals — curves 2 in Fig. 2. Isothermal remanence Ir increased due to heating from several to several tens of times. Most extensive study was performed for the SB limestones, because in this exposure the normal and reversed components were found. Analysis with an optical microscope shows, that the SB limestones are very fine-grained with some pigment of probably magnetite origin visible between the grains. In some specimens cherry-red irregular clusters, probably of hematite origin, were observed. IRM acquisition curves performed for SB material show presence of low and high coercive mineral phases — magnetite and hematite, respectively —Fig. 3a. After heating to 600 °C magnetite decidedly prevails —Fig. 3b.

Study of hysteresis parameters were performed for 7 specimens from SB and 2 from S before heating, after heating to 300 °C and to 600 °C. Fig. 4a,b presents an example of typical hysteresis curves obtained before heating. Presence of diamagnetic minerals is proved by the slope of the curve, Fig. 4a, the same curve after slope correction in shown in Fig. 4b. Slope corrected values of hysteresis parameters are presented in Table 2. Heating to 300 °C does not change them much, Is and Irs increase only after heating to 600 °C. Values of Hc and Hcr obtained for S specimens decrease due to heating, probably as a result of increased a magnetite/hematite ratio. Fig. 5 presents parameters Irs/Is versus Hcr/Hc. According to Day et al. (1977) and Channel & Mc Cabe (1994) the results lie inside the pseudosingle domain (PSD) area of the plot characteristic for magnetite, both before and after heating. This result suggests, that the magnetite grains prevailing in fresh specimens are PSD grains of secondary origin, similar to the new magnetite grains formed due to heating.

Mean magnetic susceptibility (Kmean) of all the studied limestones is very weak and due mainly to paramagnetic and diamagnetic minerals; its values range from -10 to

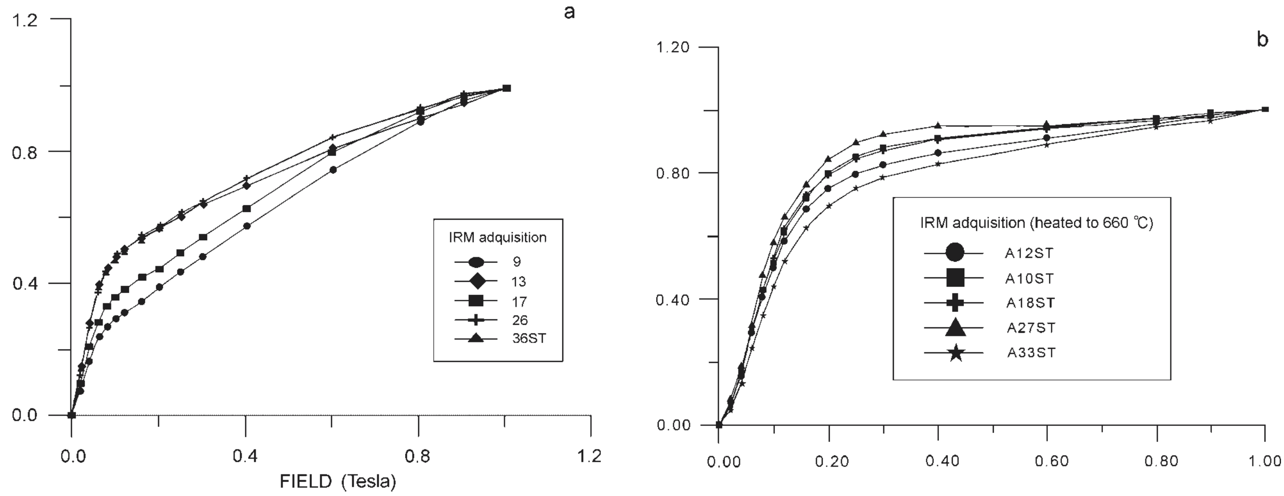
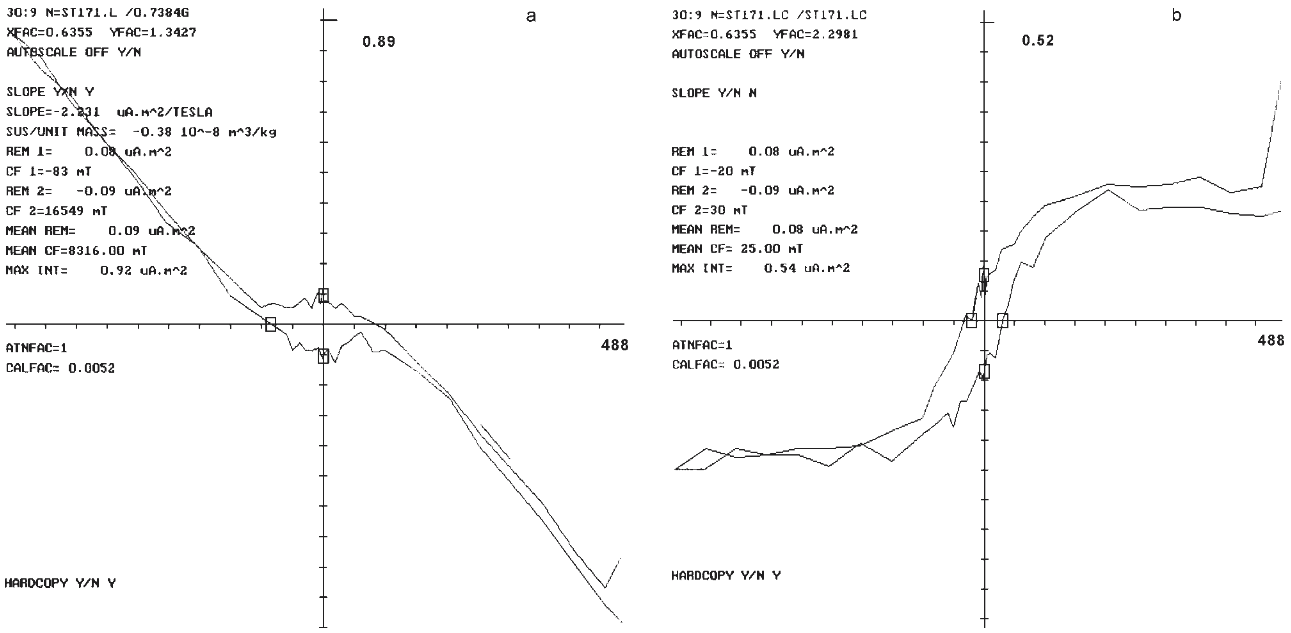


Fig. 3. IRM acquisition curves for specimens from Silická Brezová, (a) — before heating and (b) — after heating to 600 °C.



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30:9 N=ST171.L /0.7384G
XFAC=0.6355  YFAC=1.3427
AUTOSCALE OFF Y/N

SLOPE Y/N Y
SLOPE=-2.231  uA.m^2/TESLA
SUS/UNIT MASS=  -0.38 10^-8 m^3/kg
REM 1=    0.08 uA.m^2
CF 1=-83 mT
REM 2=   -0.09 uA.m^2
CF 2=16549 mT
MEAN REM=    0.09 uA.m^2
MEAN CF=8316.00 mT
MAX INT=    0.92 uA.m^2

ATNFAC=1
CALFAC= 0.0052

HARDCOPY Y/N Y
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30:9 N=ST171.LC /ST171.LC
XFAC=0.6355  YFAC=2.2981
AUTOSCALE OFF Y/N

SLOPE Y/N N


REM 1=    0.08 uA.m^2
CF 1=-20 mT
REM 2=   -0.09 uA.m^2
CF 2=30 mT
MEAN REM=    0.08 uA.m^2
MEAN CF= 25.00 mT
MAX INT=    0.54 uA.m^2

ATNFAC=1
CALFAC= 0.0052

HARDCOPY Y/N Y
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Fig. 4. Typical hysteresis curve showing (a) — diamagnetic slope and (b) — the same curve after slope correction.

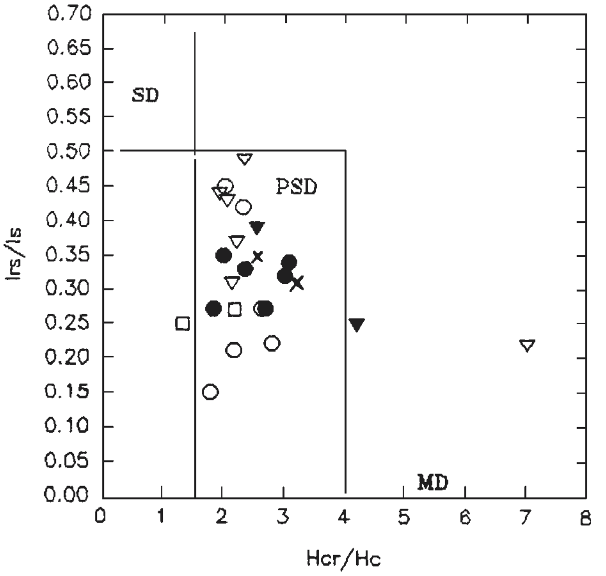


Fig. 5. Hysteresis parameters for Silická Brezová and Silica limestones. Irs — saturation remanence, Is — saturation magnetization, Hcr — remanent coercivity, Hc — coercive force. Single domain (SD), pseudo-single domain (PSD) and multidomain (MD) fields after Day et al. (1997). Open circles — SB before heating, full circles — SB after heating to 300 °C for 30 min, open triangles — SB after heating to 600 °C for 30 min, full triangles — S before heating, open squares — S after heating to 300 °C for 30 min, crosses — S after heating to 600 °C for 30 min.

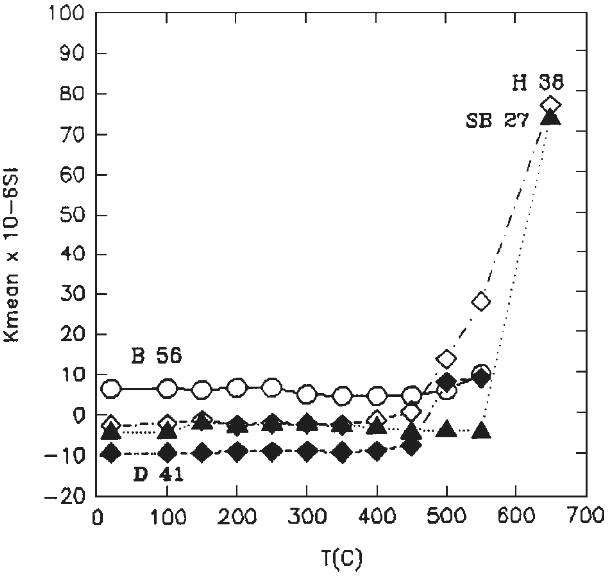


Fig. 6. Mean susceptibility after consecutive heating steps measured for specimens from Silická Brezová (SB), Hrušov (H), Budikovany (B) and Drienčany (D).

10×10^{-6} SI. It increases after heating to 450–550 °C due to formation of new magnetite — Fig. 6. Directions of Kmax (maximum susceptibility) axes obtained for the SB specimens form a semi-regular pattern — Fig. 7. They are distributed along a weakly pronounced girdle roughly perpendicular to the NE-SW direction of tectonic tension suggested by Márton & Fodor (1995) for the Middle Miocene.

Paleomagnetic results

Demagnetization of pilot specimens with thermal and alternating field methods showed, that they respond much better to the temperature, than to the field method. Therefore most of the material was demagnetized thermally. The following figures (Fig. 8a–e) present the typical demagnetization results obtained for material from each exposure. The most numerous group of collected and demagnetized samples comes from the SB exposure. Here, as is seen in Fig. 8a, the NRM is composed of two components — a normal one demagnetized in the temperature range of 300–350 °C, and a reversed one isolated at a high temperature of about 600 °C and posessing much lower intensity. Fig. 9a presents stereographic distribution of both normal and reversed components from this exposure showing, that the grouping of the normal one is better than the reversed. In the S limestones the well pronounced normal component with unblocking temperatures in the range 200–400 °C and direction similar to the direction of N component found in the SB is present. At temperatures higher than about 400 °C, the in-

Table 2: Ranges of hysteresis parameters obtained for the SB specimens and values of hysteresis parameters obtained for the S specimens.

Locality	Temperature °C	Is mA/m^2	Irs mA/m^2	Hc mT	Hcr mT
SB	20 300 600	0.2-0.9 0.3-1.1 0.5-1.2	0.1-0.08 0.08-0.4 0.1-0.4	25-35 26-35 28-45	45-80 60-80 60-105
S	20 300 600	0.28, 0.31 0.26, 0.36 0.75, 1.00	0.07, 0.12 0.07, 0.09 0.23, 0.34	31, 59 36, 37 20, 22	130, 150 50, 80 70, 65

Is - saturation magnetization, Irs - saturation remanence,
Hc - coercive force, Hcr - coercivity of remanence

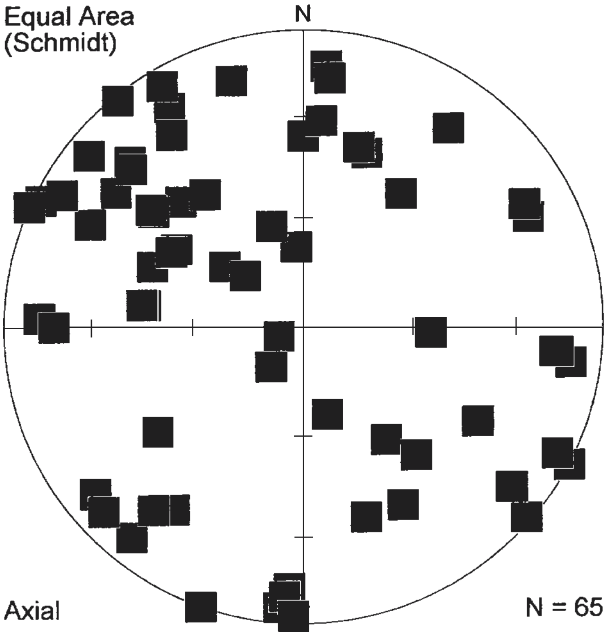


Fig. 7. Distribution of Kmax directions for Silická Brezová.

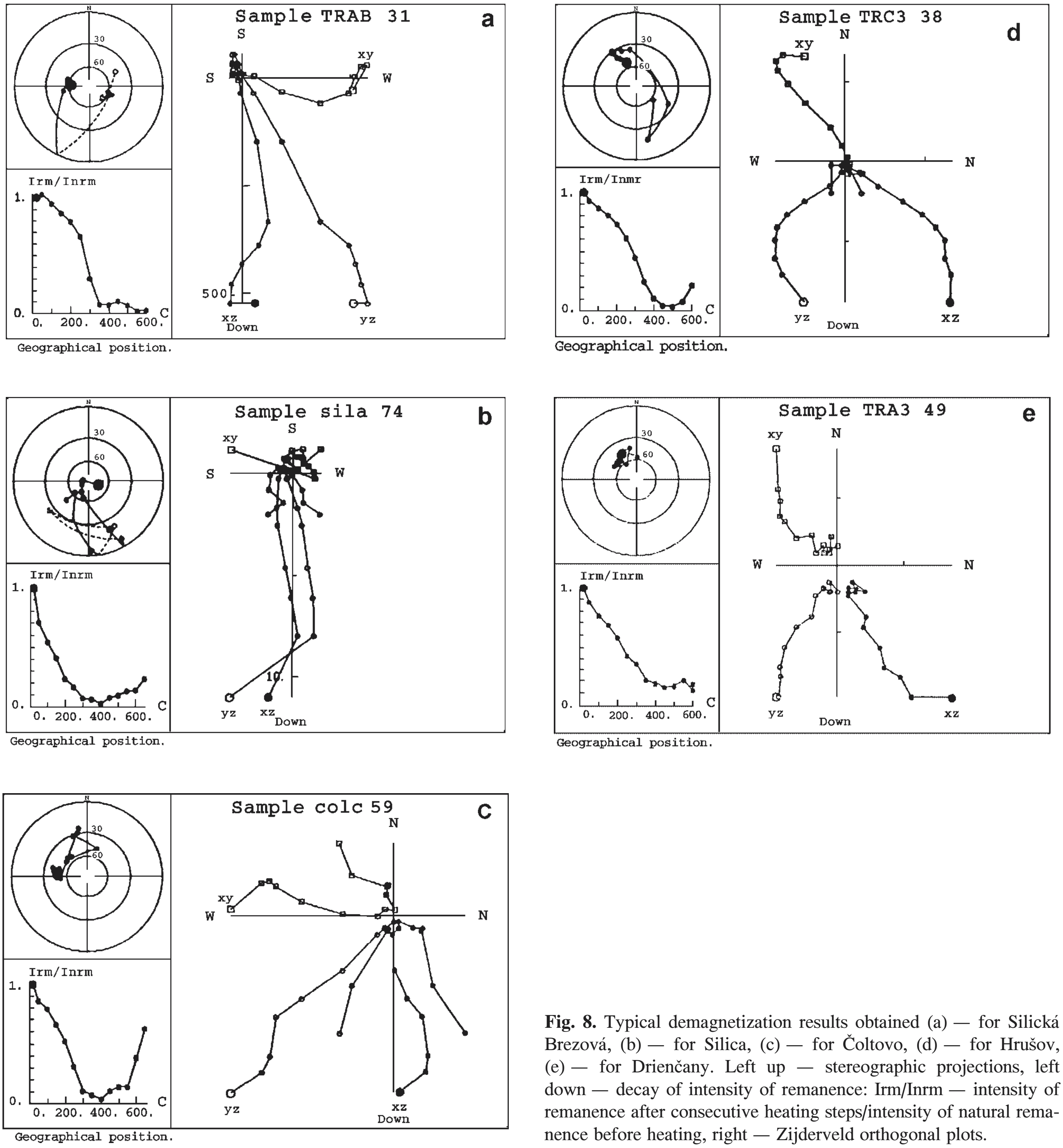


Fig. 8. Typical demagnetization results obtained (a) — for Silická Brezová, (b) — for Silica, (c) — for Čoltovo, (d) — for Hrušov, (e) — for Drienčany. Left up — stereographic projections, left down — decay of intensity of remanence: Irm/Inrm — intensity of remanence after consecutive heating steps/intensity of natural remanence before heating, right — Zijderveld orthogonal plots.

tensity of remanence increases and its directions become erratic, but have reversed polarity — Fig. 8b and Fig. 9b. A similar situation is encountered in the C rocks (Fig. 8c) — the normal component of NRM with declinations smeared within the fourth quadrant and inclinations ranging between 30^o and 65^o is isolated in the 200–400 ^{o}C temperature range. At higher temperatures, the intensity of remanence increases (after 500 ^{o}C very rapidly). This component has reversed polarity and directions scattered throuout the whole stereonet — Fig. 8c and Fig. 9c. In the H and D rocks only the normal component of NRM was found. In the H specimens this component, isolated at temperatures higher than 400 ^{o}C, has well grouped directions — Fig. 8d and Fig. 9d. In the D rocks demagnetization temperatures ranged from 200 to 400 ^{o}C and the isolated directions form a rather scattered group — Fig. 8e and Fig. 9e. From the B exposure no interpretable results were obtained. For each of the presented exposure the mean directions of obtained normal components in situ (bbc) and after correction for the bedding (abc) were calculated. For the SB limestones mean direction was also calculated for the reversed component. The results, together with parameters of Fisher statistics are presented in Table 3a and Fig. 10a,b.

Table 3a: Mean paleomagnetic directions for studied localities calculated in situ (bbc) and after full tectonic correction (abc).

Locality	n	Dbbc	Ibbc	α_{95}	k	Dabc	Iabc	α_{95}	k	Polarity
SB	101	311	61	2	37	293	50	2	37	N
SB	69	98	-69	5	12	89	-54	5	12	R
S	23	329	63	6	30	312	13	6	30	N
C	17	303	58	11	12	1	22	11	12	N
H	18	323	25	4	80	358	65	4	80	N
D	19	322	42	9	14	357	71	9	14	N
Mean normal	5	318	50	16	22	333	48	34	6	N

Table 3b: Mean paleomagnetic directions of **R** and **N** components after 25 % unfolding of all exposures.

Component	D (25%)	I (25%)	α_{95}	k
R	95	-65	5	12
N	322	50	9	66

n — number of entries, Dbbc, Ibbc — declination and inclination before bedding correction, Dabc, Iabc — declination and inclination after edding correction, D (25%), I (25%) — declination and inclination after 25% unfolding, α_{95}, k — Fisherian parametrs

Table 4: Mean directions of normal component **N** calculated for studied exposures with different stages of untilting.

Locality	% untilt	D	I	α_{95}	k	plat
	25	307	59	2	59	
S	25	320	51	6	30	
C	25	327	55	11	12	
H	50	332	47	4	80	
D	50	331	58	9	14	
N Final Mean	**SB,S,C 25 H,D 50**	**324**	**54**	**7**	**113**	**35**

plat - paleolatitude in degrees, other symbols as in Table 2

Table 5: Expected paleomagnetic field directions calculated for the Silica Nappe (lat 48.5N, long 20.5E) after African and European reference data by Westphal et al. 1986, and direction of normal component of NRM obtained for the Silica Nappe by Márton et al. (1991).

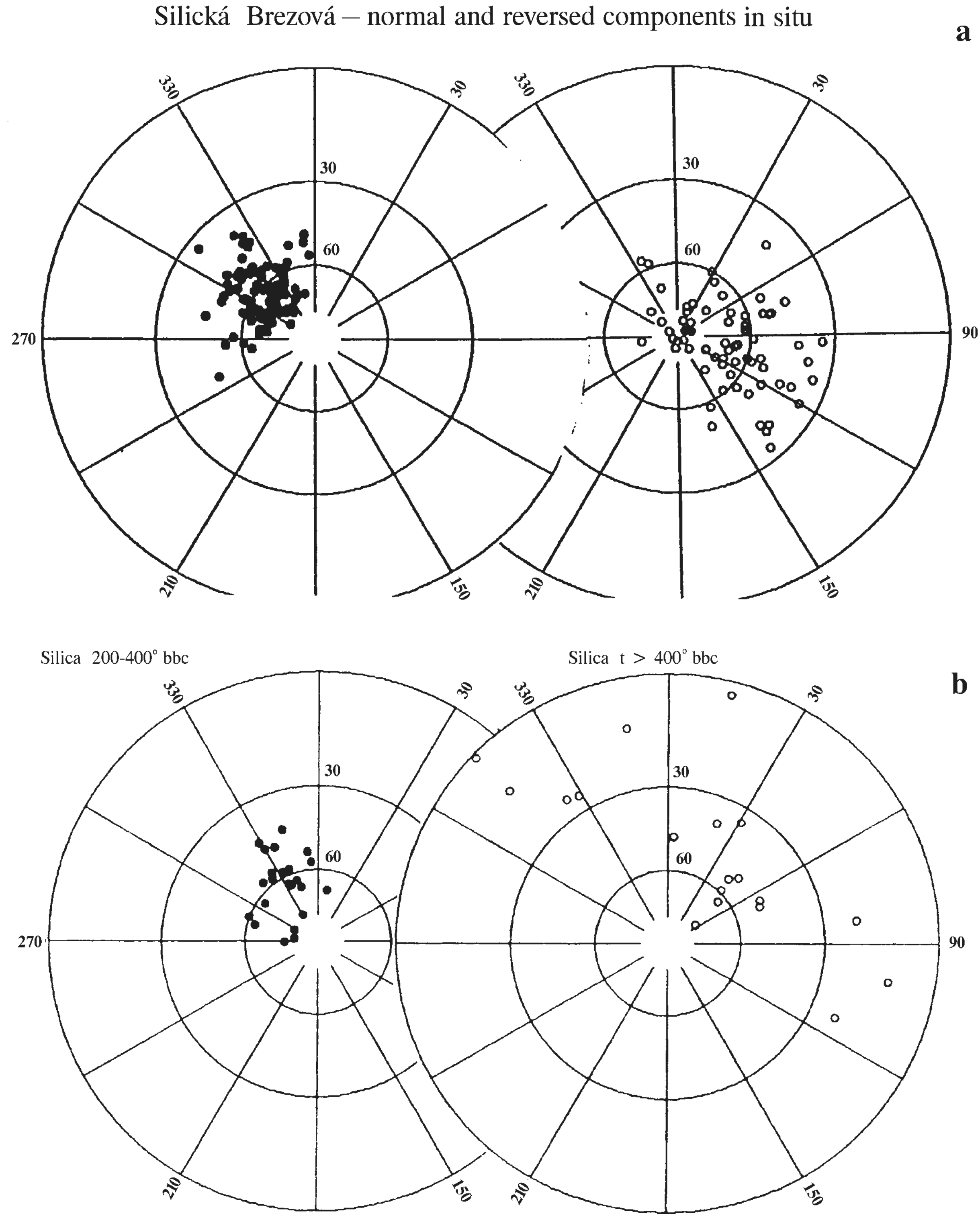
Age	African Declination	African Inclination	European Declination	European Inclination	References
Early Triassic	339.8	28.9	30.8	30.0	Westphal et al. 1986
M -L. Triassic	342.7	44.6	38.8	36.3	“
Jurassic	336.8	36.2	21.7	58.6	“
Late Cretaceous	348.3	48.5	15.0	56.0	“
Late Cretaceous-Paleocene	357.2	52.0	13.1	56.4	“
Paleocene-Eocene	0.4	54.0	11.1	56.6	“
Oligocene	4.2	62.0	20.7	57.7	“
Miocene	5.8	61.6	9.3	60.1	“
Silica Nappe Triassic sediments magnetized in Late Cretaceous	319.9	42.4			Márton et al. 1991

M - L Triassic = Middle-Late Triassic

Discussion of the results

The data presented in Table 3a and Fig. 10a,b indicate that the full bedding correction considerably increases the scatter of mean directions of N component in comparison with the in situ distribution. But in the in situ coordinate system they do not form a very tight cluster and their distribution has a more ellipsoidal, than circular shape. Therefore we have decided to see how incremental unfolding of our exposures influences the scatter of the mean directions. We have calculated appropriate means assuming the 15, 25, 50, 75 % of unfolding (f). As is shown in Fig. 11a the result obtained with 25 % of unfolding of all five exposures gave the best grouping. The distribution of means for this case is shown in Fig. 10c and the obtained mean direction is presented in Table 3b. This result was interpreted as Late Cretaceous remagnetization in our previous work (Kruczyk et al. 1996). The obtained declination suggested CCW rotation of the Nappe by about 25° around the intraplate vertical axis.

The reversed component was isolated in SB and some traces of it were found in the S and C exposures, but the scatter of its directions in the two latter places is too large for calculation by reasonable means. Only the SB results form a cluster tight enough for calculation of the mean (Table 3a, Fig. 9a). There is no possibility for performing a fold test here, but knowing that this component is carried by submicroscopic, probably secondary hematite we suppose that it was acquired after folding and its Triassic age is hardly possible. It should be treated in the same way as the N component isolated in SB and be calculated with the same unfolding parameter. In order to resolve the question of the proper frame of coordinates for both components we took into account the geological situation of sampled localities assuming, that the fault has a rotational character. According to Dadlez & Jaroszewski (1994) a rotational fault is characterized by a curved trajectory and may change the prefaulting structural tilt. According to this definition we have made several trials of calculation of mean N direction assuming different unfolding for exposures situated at both sides of the S-P fault. The exposures SB and S are the “eastern” ones, the exposure C situated between two southern branches of the fault is also treated as an “eastern” one because of similarity of the in situ direction of its N component to N directions obtained for SB and S. The H and D exposures form the “western” group. The results obtained for numerous trials with various values of f show that the best grouping is obtained if the eastern group is unfolded to 25 % and the western one — to 50 % — see Fig. 11b presenting changes of k for f = 0 and f = 25 for the “eastern” group and f changing from 25 to 75 % for the western one. Mean direction is not influenced much with the changes of f, its declination ranges from 319° to 327° and inclination ranges from 54° to 64°. The final best result is presented in Table 4 and Fig. 10d. It confirms our assumption concerning the rotational character of the S-P fault. According to this result the normal component of NRM (**N**) was aquired after folding and before faulting of the study area and the S-P fault changed the bedding tilt on its eastern and western sides in a different way. Faulting resulted in increasing the original tilt of the eastern side by 25 %, and of the western — by 50 % (values


Silická Brezová – normal and reversed components in situ

Silica 200-400° bbc

Silica t > 400° bbc

of f expressed in relation to the present tilt). Taking all said above into account we came to the conclusion, that the mean direction of the normal cmponent of NRM presented in Table 4 presents the direction of the magnetizing field. This component is a secondary one carried mainly by secondary PSD magnetite and is of chemical origin. According to the above discussion we calculated the R component with 25 % of unfolding, the respective result is shown in Table 3b and this result will be the subject of interpretation as the final direction of this component.

In order to discuss the possible ages of the two obtained components of natural remanence we have compared them with the directions expected for the Silica Nappe under the assumption of its African or European affinity, and with the data obtained for the Silica Nappe by Márton et al. (1991), see Table 5.

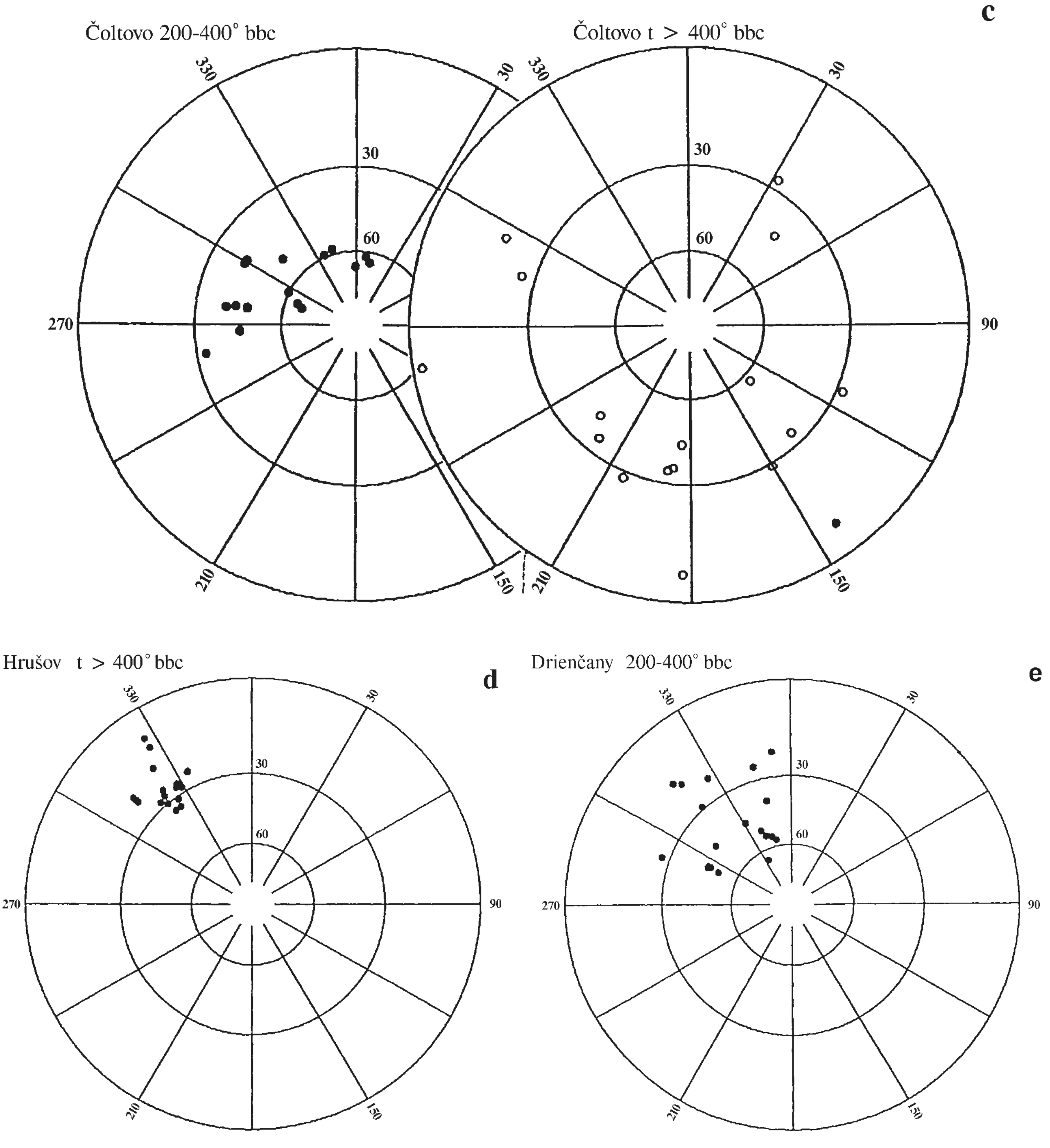


Fig. 9. Stereographic distributions of isolated components of NRM in situ: (a) — Silická Brezová, normal and reversed components, (b) — Silica, normal and reversed components, (c) — Čoltovo, normal and reversed components, (d) — Hrušov — normal components, (e) — Drienčany — normal components. Ranges of unblocking temperatures are shown above each plot with the exception of Silická Brezová.

Comparison of the results obtained here with the reference ones shows the following:

— inclination of the **R** component is close to the expected "African" inclination for the Oligocene, declination of this component implies counterclockwise (CCW) rotation of the study area around an intrablock vertical axis by about 90° during the times following the magnetization event. It was probably acquired during the Odra reversal event determined during study of the Tertiary basaltic rocks in Lower Silesia and dated at about 27Ma, Birkenmajer et al. (1977).

— declination of the **N** component is very close to the declination of the component obtained by Márton et al. (1991), but its inclination is different.

— declination of this component implies CCW rotation of the study area around an intrablock vertical axis by about 30-40° during times following the magnetization event.

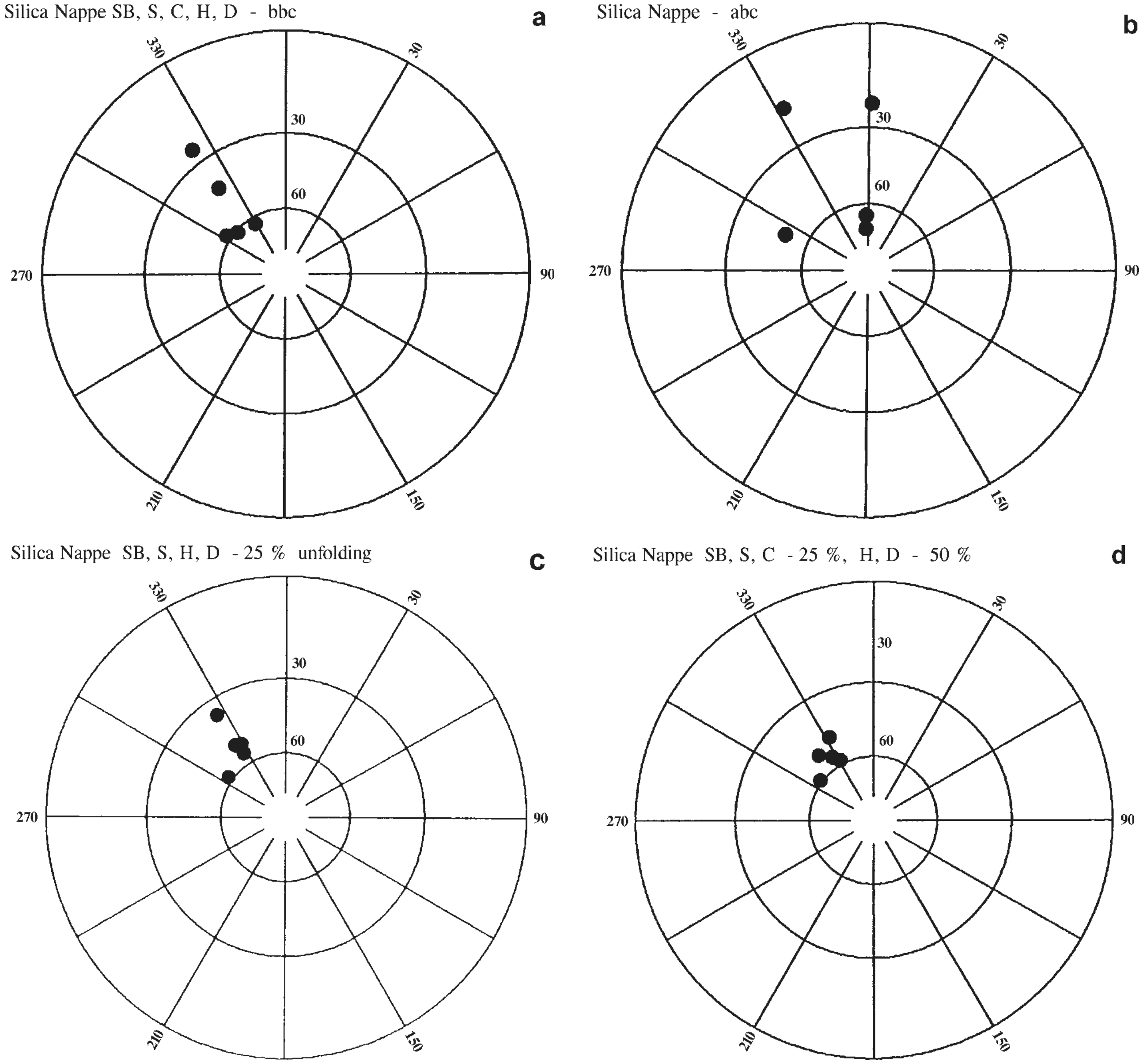


Fig. 10. Mean directions of normal components obtained for all studied localities with the exception of Budikovany: (a) — in situ (bbc), (b)) — after bedding correction (abc), (c)) — after 25% of unfolding of all exposures, (d)) — after 25% of unfolding of Silická Brezová, Silica and Čoltovo and 50% of unfolding of Hrušov and Drienčany.

— inclination of the **N** component is lower, than the one expected for the "African" and "European" Miocene. The paleolatitude calculated for the Silica Nappe from this inclination is 35° and agrees with paleolatitude obtained for the Miocene for the Gemer-Bükk region also belonging to the Pelso block (Márton 1993). The author explains this result as due to the "southern escape" of the Pelso block during the Miocene. Our result confirms this idea.

Sense, angles and possible ages of rotations implied by our results agree with conclusions of Márton et al. (1995) and Márton & Fodor (1995) drawn for the whole Pelso megaunit of which Silica Nappe is only a part. According to these authors the Pelso megaunit underwent two phases of CCW rotation: the first one, by about 50°, took place in the Early Miocene and the second one, by about 30°, took place in the Late Miocene. According to this timing the **N** component obtained here was acquired between both rotational phases and the **R** one — during one of the Oligocene inversion periods.

Conclusions

1. All investigated Triassic limestones became remagnetized during the Tertiary due to the tectonic activity (compressions, extensions, rotations) that took place in the Pelso megaunit.

2. Remagnetization took place after folding.

3. Remagnetization processes took place in two different times.

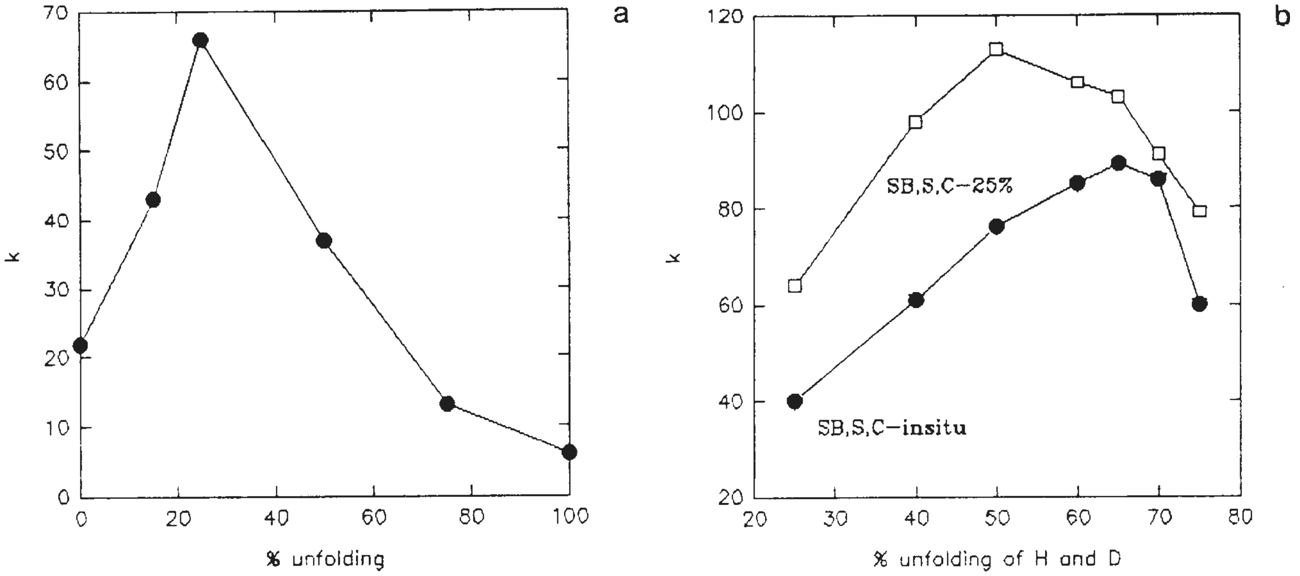


Fig. 11. Scatter parameter k against the % of unfolding f of Silica Nappe exposures (a) — the same f for all exposures (b) — full circles: exposures SB,S,C in situ, hollow triangles: exposures SB,S,C with f = 25 %.

— the reversed component **R** isolated only in one exposure and carried by secondary hematite was formed in the Oligocene, most probably during the Odra reversal event (Birkenmajer et al. 1977). Its declination shows that after its acquisition the study area was rotated counterclockwise by about 90°. It corresponds to the sum of angles of rotation of both CCW Miocene rotational phases.

— the normal component **N** found in all exposures and carried by secondary magnetite was acquired after the first rotational phase during the Middle Miocene. Its declination suggests that after its acquisition the study area was rotated counterclockwise by about 30-40°.

4. The inclination of the **R** component agrees with the inclination expected for the Silica Nappe under the assumption that during the Oligocene it belonged to the African plate.

5. The paleolatitude of the Silica Nappe during **N** remagnetization period agrees with paleolatitude of the Gemer-Bükk region confirming the idea of the “southern escape”of the Pelso Unit.

6. The Štítnik-Plešivec fault that was formed after rotations and remagnetizations changed tilting of the investigated beds lying on both its sides in a different way. It increased the tilt of beds more on its eastern, than on its western side.

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