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PALAEOMAGNETISM OF THE CARBONIFEROUS AND VARIEGATED LAYERS OF THE MORAVIAN-SILESIAN REGION

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Abstract: The Moravian-Silesian region comprises the Upper Silesian black coal basin. The work to be reported deals with the study of palaeomagnetism of sedimentary rocks of the Upper Visean, Namurian A, and with the explanation of the origin of the so-called variegated layers with the use of petromagnetic and palaeomagnetic methods. It is above all roof slate, where the carrier of palaeomagnetization is finely dispersed pyrrhotite, which proved to be extraordinarily suitable for palaeomagnetic studies. The pole positions inferred on Carboniferous rocks in the Moravian-Silesian region fall into the pole positions so far inferred on Carboniferous rocks of the Bohemian Massif. It suggests the interpretation that the wider area of the Upper Silesian basin on the Moravian side was not much afflicted by palaeotectonic deformations although it is situated in the vicinity of the lithospheric boundary separating the North European Platform from the collision zone of the Alpine-Carpathian tectonic system. With the use of modified Thellier's method it was proved that the so-called variegated layers that form a large body in the area of the Orlov tectonic structure in the Upper Silesian basin correspond to typical erdbrands. These rocks came into existence in the post-Triassic period due to caustic alteration of Carboniferous sedimentary rocks, undoubtedly as a result of the self-combustion of coal seams in air conditions created by the existence of the Orlov tectonic structure.

Key words: Variscides, Upper Silesian Basin, palaeomagnetism, global tecnotics.

Introduction

The Upper Silesian black coal basin situated in the Moravian-Silesian region was recently subjected to palaeomagnetic research (Krs et al. 1992b). Preliminary results show that the studies should be pursued further, especially in respect of the exploitation of roof slates for palaeomagnetic research. These rocks represent material with a micro-organic substance under a high degree of carbonification, and thus extend the possibilities of the palaeomagnetic method.

The area of the Orlov tectonic structure comprises a large body of the so-called variegated layers which pose an obstacle to mining. A demand has arisen to devote a part of the research work to the study of the genesis of these rocks with the use of petromagnetic and palaeomagnetic methods.

The Upper Silesian black coal basin is situated in the vicinity of the distinct lithospheric boundary separating the North European Platform from the Alpine-Carpathian tectonic zone. Palaeomagnetic results were expected to furnish the data for the interpretation of palaeotectonic deformations, in particular of block rotations in the post-Carboniferous period.

Geology of the investigated area

The Carboniferous formation in the Moravian-Silesian region of the Bohemian Massif lies in the east segment of the Central European Variscides. At the east margin of the Bohemian Massif, in the region of Nízký Jeseník Mts., there occurs the Lower Carboniferous (Tournaisian, Visean) which continues without sedimentation interruption from the Upper Devonian sediments. Marine flysch sedimentation gradually filled the sedimentation space and in higher positions was gradually replaced by paralic to continental sedimentation.

Sediments of the Upper Visean, partly also sediments of the Namurian A and caustically altered sediments of the Namurian B were subjected to palaeomagnetic investigations. Within the scope of the research, an explanation of the origin of the so-called variegated layers was sought with the use of modified Thellier's method (Thellier 1941, 1951; cf. Krsová et al. 1989).

The goniatite zones in the Upper Visean of Nízký Jeseník Mts. are divided into several lithostratigraphic units (from older to younger ones): Horní Benešov Formation, Moravice Formation (divided further into Bohdanovice, Cvilín, Brumovice and Vikštejn strata), Hradec Formation and Kyjovice strata. The Kyjovice strata proceed higher as far as the Namurian A. Oriented samples were collected from the Bohdanovice, Brumovice and Kyjovice strata.

The investigated sediments of the Upper Visean to the Namurian B are found in the overlying rocks of the Horní Benešov Formation east of the Šternberk-Janov anticlinorium.

The Moravice Formation represents a complicated lithological complex of flysch sediments of a thickness up to 2 000 m or even more. This complex of fine rhytmite flysch and of laminated clay shales is interlaminated with beds of coarse flysch. The Bohdanovice strata form fine rhytmite flysch with a thick bed of black laminated claystones. The thickness of these strata unit is 500 to 800 m. The Cvilín strata represent a complex of coarse flysch with laminated shales with a strong tuffogenic admixture,

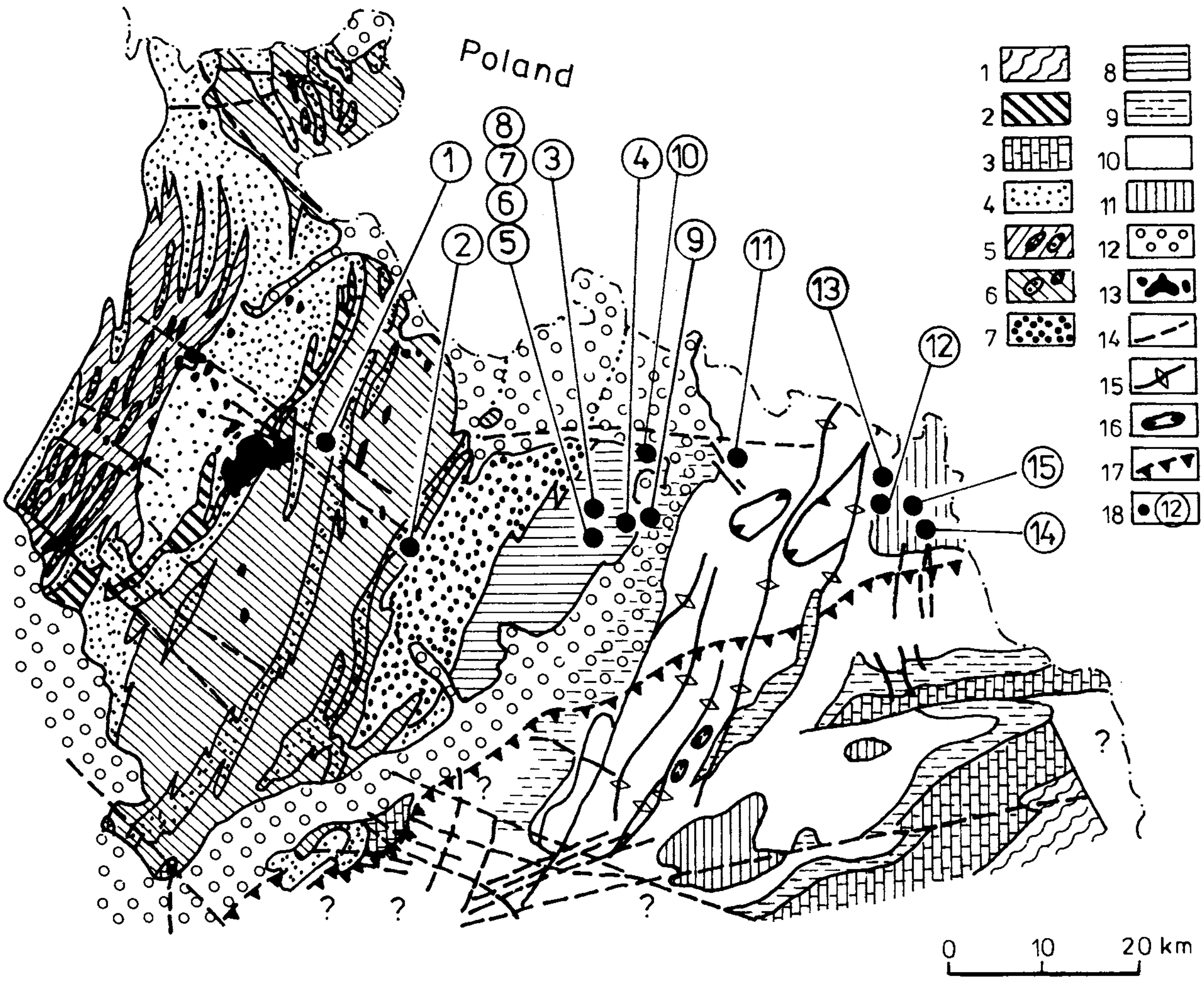

Fig. 1. Geological sketch of the Jeseníky block, Moravian-Silesian region (after O. Kumpera).
Legend: 1 - crystalline rocks; 2 - eugeosyncline Devonian - L. Carboniferous formation; 3 - carbonate formation of Devonian to M.Visean age; 4 - Horní Benešov Formation, M.Visean?; 5 - Andělská hora development, greywackes (M.Visean? - U.Visean?); 6 - Moravice Formation, greywackes; 7 - Hradec Formation; 8 - Kyjovice strata; 9 - Kyjovice strata found beneath younger sediments; 10 - Ostrava Formation; 11 - Karviná Formation; 12 - Neogene and Quaternary sediments (outside the Upper Silesian basin); 13 - Neoidic volcanics; 14 - tectonic lines; 15 - principal anticline structures within the Upper Silesian basin; 16 - principal syncline structures within the Upper Silesian basin; 17 - boundary of nappes of the Outer Carpathians; 18 - localities of collecting of oriented samples for palaeomagnetic investigations.

their thickness being ca 200 m. The Brumovice strata, with a maximum thickness of 800 m, have a thick bed of coarse-grained flysch on their base, in the direction to the overlying rocks this sequence passes into the development of laminated shales with thin beds of calcareous siltstones. The Vikštejn strata, the highest part of the Moravice Formation, are formed of flysch rocks alternating with laminated shales their thickness attaining 250 m.

The Hradec Formation 800 m thick represents flysch greywacke sedimentation with numerous intercalations of siltstones and shales, whose share grows in the direction to the overlying rocks.

The Kyjovice strata are the youngest member of the Kulm complex of flysch sedimentation. In east Jeseník Mts. the thickness of the unit is 800 to as much as 1 000 m. They represent a complex formed by flysch sedimentation of greywackes and shales. To the overlying rocks they pass concordantly to the Ostrava Formation of the Upper Silesian basin (Kumpera 1983).

In the Moravian part of the Upper Silesian basin, the Namurian rocks are represented in the set of collected samples by Ostrava and Karviná formations. The Ostrava Formation comprises a 2 800 m thick complex of paralic sediments with coal seams which alternate with marine sediments. The sampled part belongs to the boundary of the Petřkovice and Hrušov strata in the surroundings of marine horizon Naneta. The Karviná Formation is separated from the Ostrava Formation by a time hiatus in the Prokop seam and represents continental lacustrine-river sedimentation. Sampled was the basal part of the Karviná Formation belonging to saddle strata (Namurian B).

In the west part of the Karviná Basin a large body of the so-called variegated layers was sampled in the east branch of the Orlov fold. The origin of this body was accounted for by the post-sedimentary oxidation-thermal alteration of Carboniferous sediments (Dopita & Králík 1974; Králík 1982). The origin of alterations of variegated layers is accompanied by deep oxidation of coal seams and afflicts the ambient sediments, as well. Due to alterations, the original grey colouring of rocks changes into green and brown-red colouring. Variagated layers constitute a geological phenomenon very unfavourable for mining. Extensive alteration of coal seams results in their extinction, loss

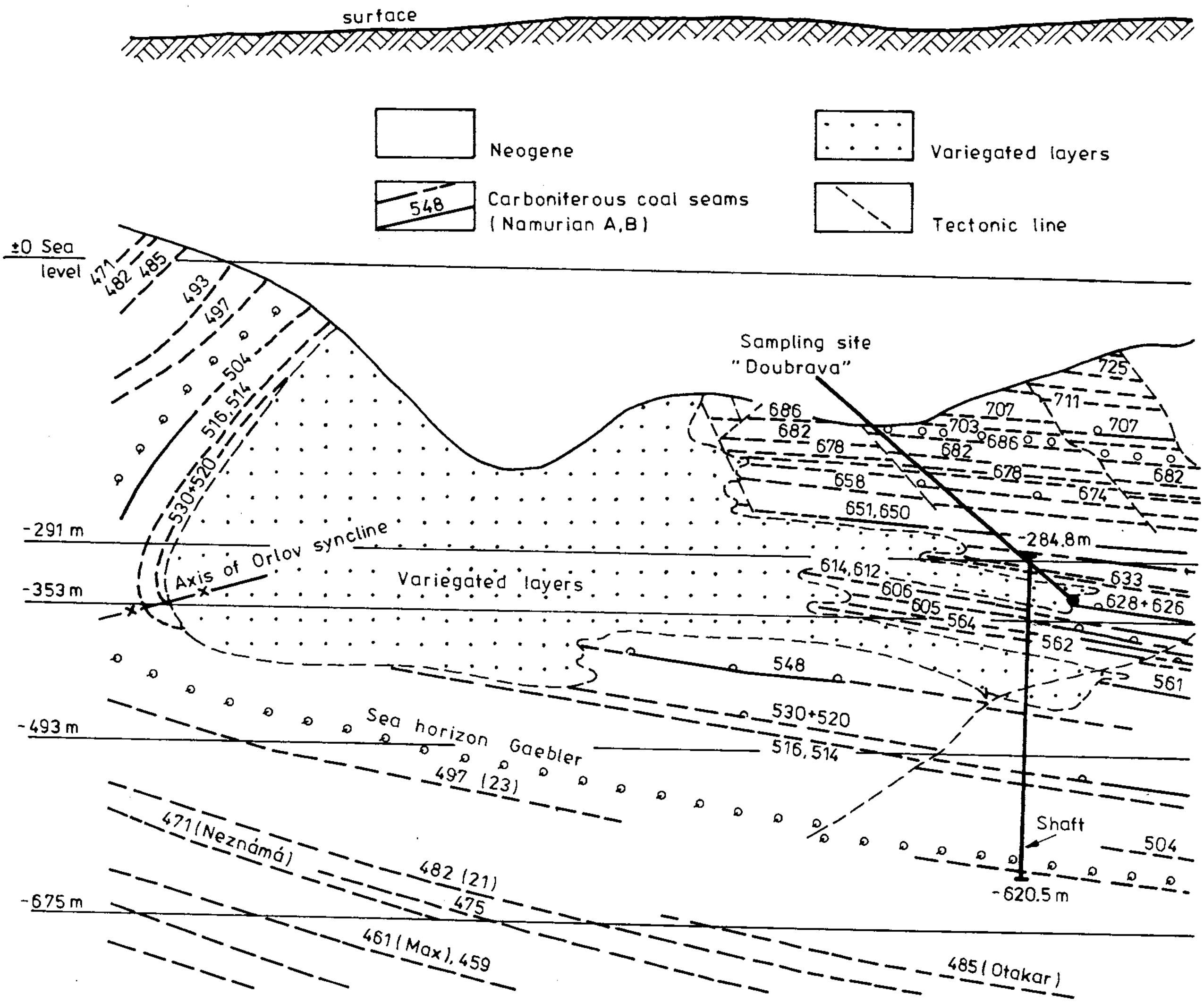

Fig. 2. Cross-section through variegated layers in the wider area of the Orlov tectonic structure, Upper Silesian basin.

of thickness, and in marked changes in the quality of coal. Alterations are related to the relief of the Carboniferous layers and to tectonics. The task of the palaeomagnetic research was to establish the age of these alterations and to rule out a possible synsedimentary origin of alterations.

In the west, the Upper Silesian basin was folded in the course of the Asturian phase of Variscan orogene, while in its east part mainly normal faults originated. The outcropping Carboniferous sediments and coal seams are strongly weathered. In the Tertiary, prior to the Neogene marine sedimentation of the Carpathian Foredeep, extraordinarily intensive erosion of Carboniferous rocks took place.

Survey of oriented samples of the rocks under study and their basic magnetic properties

Samples of sediments of the Upper Visean are presented in Tab. 1 (localities 1 through 10), samples of sediments of the Namurian A in Tab. 2 (locality 11). Tab. 2 also contains samples collected from the so-called variegated layers (localities 12 and 13). In ČSM Mine, Stonava, samples were collected from the Carboniferous sediments (Namurian B) and from the overlying sandstones of Badenian age, the aim being to verify their palaeomagnetic characteristics.

In most localities there were more collection sites (denoted sites A, B, C, etc.). In the localities, where samples were collected for the computation of palaeomagnetic characteristics including palaeomagnetic poles, geographic coordinates are given.

For the collected sample groups we computed the mean values of the moduli of natural remanent magnetization and their standard deviations ($\bar{x}$ and s for J_n in [nT]), the mean values of apparent magnetic susceptibility and their standard deviations ($\bar{x}$ and s for κ in units 10^{-6}[SI]). Remanent magnetic polarization was measured on the spinner magnetometers JR-4 and JR-5, magnetic susceptibility on the kappa-bridge KLY-2 (Jelínek 1966 1973). A part of the samples was subjected to demagnetization with the use of the Schonstedt GSD-1 apparatus, all samples were thermally demagnetized by means of the MAVACS apparatus (Příhoda et al. 1989). The experimental data initially obtained for palaeomagnetic purposes yielded also interpretations concerning the magnetic mineralogy of the rocks investigated (on the basis of blocking temperatures, thermal stability and phase changes manifest by changes in susceptibility under thermal tests). The last column of Tabs. 1 and 2 also contains the minerals that are magnetism carriers.

Table 1: Collection of the Upper Visean sediments, basic magnetic parameters, Moravian-Silesian region.

No. of locality	Site	Geographical co-ordinates	Locality	No. of samples	Age, local stratigraphy	Lithology	n	J_n [nT] $\bar{x}$	J_n [nT] s	ϰ [10^{-6} SI] $\bar{x}$	ϰ [10^{-6} SI] s	Notes, carrier of magnetization
1		49.903°N; 17.697°E	Jakartovice, Rooof-slate mine	6062A, 6063A	U. Visean, Moravice series, Bohdanovice strata	Dark-grey clay shales	12	0.24	±0.06	375	±34	Prevailingly pyrrhotite, some Fe-oxides (?)
2	A	49.805°N; 17.750°E	Nové Těchanovice, Lhotka near Vítkov, Roof-slate mine	6117A÷÷6120A	U. Visean, Moravice series, Brumovice strata	Dark-grey clay shales (roof slates)	8	0.43	±0.16	380	±15	Prevailingly pyrrhotite
	B			6022A÷÷6126A			10	0.56	±0.29	366	±14	
	C			6027A÷÷6030A			6	0.31	±0.09	376	±27	
	D			6031A÷÷6035A			8	0.20	±0.01	377	± 9	
	E			6036A÷÷6038A			6	0.43	±0.07	355	± 8	
3	A	49.853°N; 18.047°E	Budišovice near Hrabyně; Vondruška's quarry	5605A÷÷5611A	U. Visean, Kyjovice strata (lower part)	Greywackes alternating with roof-slates	10	0.30	±0.08	375	±29	Fe-oxides, some pyrrhotite
	B			5612A÷÷5618A			14	0.29	±0.05	353	±15	
	C			5619A÷÷5622A			7	0.41	±0.09	327	±30	
4	A	49.838°N; 18.112°E	Krásné pole, old quarry	5588A÷÷5591A	U. Visean, Kyjovice strata	Greywackes, flysch sedimentation	7	0.49	±0.25	219	±16	Fe-oxides, some pyrrhotite
	B + C			5592A÷÷5595A			6	0.42	±0.36	240	±18	
	D			5596A÷÷5600A			9	0.28	±0.12	221	±18	
	E			5601A÷÷5604A			7	0.51	±0.24	208	±33	
5	A	49.824°N; 18.016°E	Kyjovice-Zátiší	6104A÷÷6109A	U. Visean, Kyjovice strata (lower part)	Grey claystones, flysch sedimentation	13	0.82	±0.10	352	±31	Fe-oxides
	B			6110A÷÷6116A			15	0.70	±0.33	378	±15	
6	A	49.822°N; 18.022°E	Kyjovice-Barta's Mill, Valley of Sezina	6078A÷÷6084A	U. Visean, Kyjovice strata (lower part)	Dark-grey clay shales, flysch sedimentation	14	0.43	±0.13	381	± 8	Fe-oxides (not haematite)
	B			6085A÷÷6090A			12	0.52	±0.13	348	±11	
7		49.829°N; 18.027°E	Kyjovice, Valley of Sezina (700 m S of prev. outcrop	6091A÷÷6094A	U. Visean, Kyjovice strata (lower part)	Dark-grey clay shales, flysch sedimentation	9	0.26	±0.04	306	±24	Pyrrhotite and Fe-oxides
8		49.829°N; 18.027°E	Kyjovice, Valley of Sezina (100 m S of prev. outcrop)	6095A÷÷6103A	U. Visean, Kyjovice strata (lower part)	Dark-grey clay shales, flysch sedimentation	18	0.22	±0.04	300	±14	Pyrrhotite and Fe-oxides
9	A	49.818°N; 18.138°E	Vřesina, old quarry	5692A÷÷5697A	U. Visean, Kyjovice strata (upper part)	Dark-grey clay shales alternating with greywackes, flysch sedimentation	9	0.13	±0.04	272	±27	Privailingly Fe-oxides with unblocking temperature around 400° C. Some pyrrhotite also present.
	B			5698A÷÷5702A			8	0.17	±0.07	304	±31	
	C			5703A÷÷5707A			7	0.24	±0.10	266	±11	
	D			5708A÷÷5710A			5	0.14	±0.07	205	±10	
10	A	49.8[illegible]°N; 18.15[illegible]°E	Děhylov, old quarry	5677A÷÷5681A	U. Visean, Kyjovice strata (upper part)	ditto, partly weathered	9	0.34	±0.14	104	±18	Pyrrhotite and Fe-oxides
	B			5682A÷÷5684A			3	0.29	±0.10	51	± 6	
	C			5685A÷÷5691A			13	0.26	±0.26	237	±17	

Table 2: Collection of the Namurian and Badenian sediments and of erdbrands, basic magnetic parameters. Upper Silesian black coal basin.

No. of locality	Site	Geographical co-ordinates	Locality	No. of samples	Age, local stratigraphy	Lithology	n	J_n [nT] $\bar{x}$	J_n [nT] s	ϰ [10^{-6} SI] $\bar{x}$	ϰ [10^{-6} SI] s	Notes, carrier of magnetization
11	A long cross-section	49.868°N; 18.270°E	Landek near Koblov	5623A÷÷5669A	Namurian A, Ostrava formation, close to boundary of Petřkovice and Hrušová strata	Siltstones rich in detritic coal matter alternating with sandstones	27	1.13	±1.07	179	±95	Fe-Oxides with unblocking temperatures within 200÷400° C. Some samples show goethite.
12			Mine Lazy, Orlová	6043A÷÷6056A	Original sediment: Namurian B-Karviná series, Sedlo strata	Erdbrand[x)] (caustic alteration)	9	8357	±2785	28667	±3800	One-component magnetization of thermo-remanent origin, Fe-oxides with unblocking temperature around 400° C.
13			Mine Doubrava, Doubrava	6057A÷÷6061A	Original sediment: Namurian B-Karviná series, Sedlo strata	Erdbrand[x)] (caustic alteration)	10	2.96	±2.65	233	±27	Multi-component remanence with different unblocking temperatures (Fe-oxides). Carrier of one-component remanence is haematite.
14	A		Mine ČSM, Stonava	6129A÷÷6131A	Namurian B, Karviná series, Sedlo strata	Siltstone	6	0.31	±0.05	300	±10	Fe-oxides (not haematite)
	B			6132A÷÷6134A	Badenian	Sandstone	6	0.72	±0.43	173	±48	

x) So-called variegated layers.

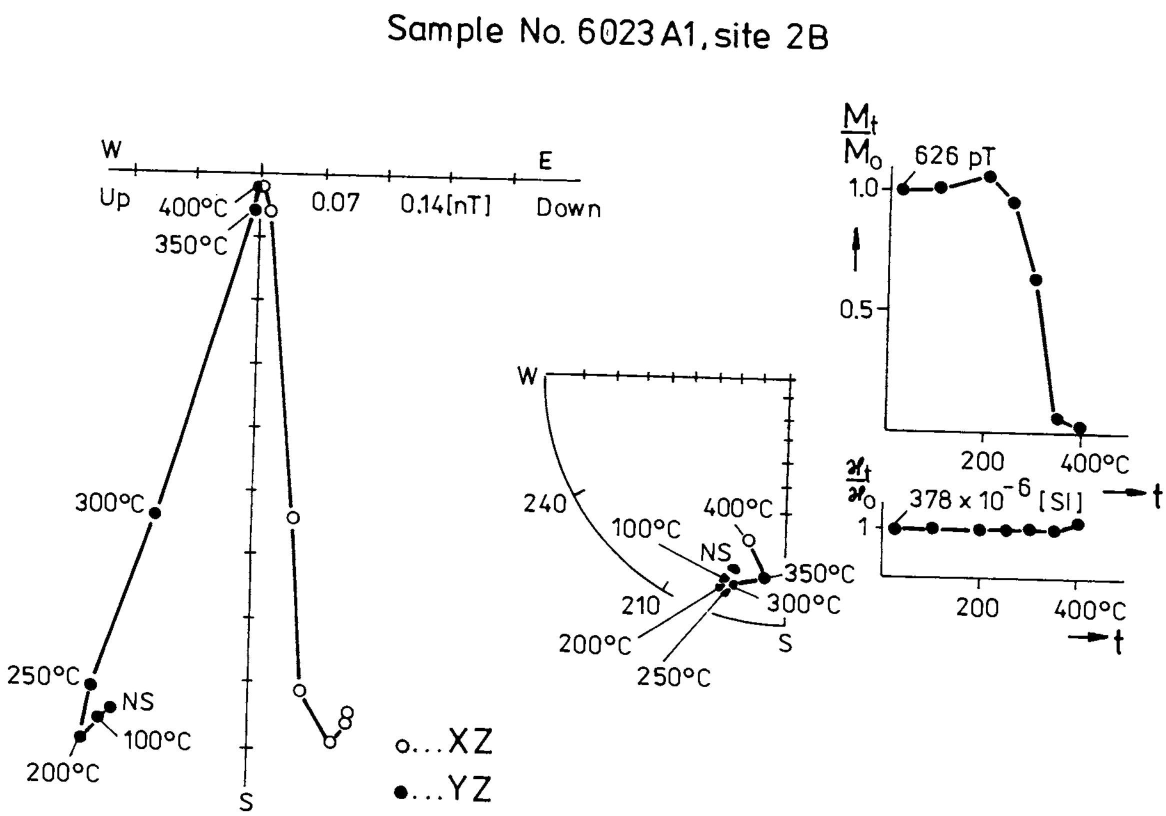

Fig. 3. Thermal demagnetization of a roof-slate, Nové Těchanovice.

With the exception of erdbrand samples (caustically altered sediments from the series of the so-called variegated layers, locality 12) all the samples under investigation belong to groups of weakly magnetic rocks. Interesting results were yielded by the so-called roof slates, in which without any exception the remanence carrier is pyrrhotite. The rocks of flysch sedimentation (sandstones and greywackes) mostly contain Fe-oxides with a blocking temperature of about 400 °C, only intensively weathered rocks also contain goethite. Samples with goethite mostly proved to be unsuitable for palaeomagnetic analysis.

Samples of caustically altered rocks (so-called erdbrands) exhibit different magnetic properties and also different minerals - magnetism carriers. The carrier of one-component remanence of brown-red erdbrands are Fe-oxides with a blocking temperature of about 400 °C, in intensively red erdbrands it is thermally stable haematite. The caustic alteration took place at high temperatures, above the Curie temperature of haematite. Samples of these rocks, thermally stabilized under oxidation conditions (with caustic alteration taking place in air conditions), assumed physical properties suitable for inferring palaeointensity of the geomagnetic pole acting at the time of caustic alteration. Some erdbrands, however, exhibit also multi-component remanence with mutually different values of the blocking temperatures.

Fig. 1 presents a geological sketch of the area under investigation, the localities of sample collection being marked (see Tab. 1). Fig. 2 depicts a cross-section through coal seams and the body of so-called variegated layers, the collection site of erdbrand samples in the Doubrava Mine is marked (see Tab. 2).

Palaeomagnetism of sediments of the Upper Visean and Namurian A

Demagnetization of rock samples by the thermal field was more effective than demagnetization by the alternating field, therefore all samples were subjected to progressive thermal demagnetization with the use of the MAVACS apparatus (Příhoda et al. 1989). For each sample we constructed Zijderveld diagrams, stereographic projections of directions of J_n (natural remanent magnetic polarization), of polarization directions of thermally demagnetized samples, the dependence of the normalized value of the remanent magnetic moment on temperature $M_t/M_o=\phi(t)$, and the dependence of the normalized value of magnetic susceptibility on temperature $\kappa_t/\kappa_o= f(t)$. These data allowed us to test each sample for its suitability for palaeomagnetic and magneto-mineralogical interpretations.

For the sake of illustration, Figs. 3 through 7 give typical examples. Figs. 3 and 4 present the results of thermal demagnetization of two samples of roof slates, in which the main carrier of remanence is fine-grained pyrrhotite, the remanence is prevailingly one-component, the viscous component forms only a small fraction. Figs. 5 and 6 present the results of thermal demagnetization of greywacke. The viscous component of remanence is relatively small, the blocking temperature approaches the value of 430 °C. The dark grey clay shale in Fig. 7, on the contrary, has a strong fraction of the viscous component or of the component of a magnetically soft mineral (hydro-oxides of Fe?). The direction of characteristic magnetization in the temperature interval

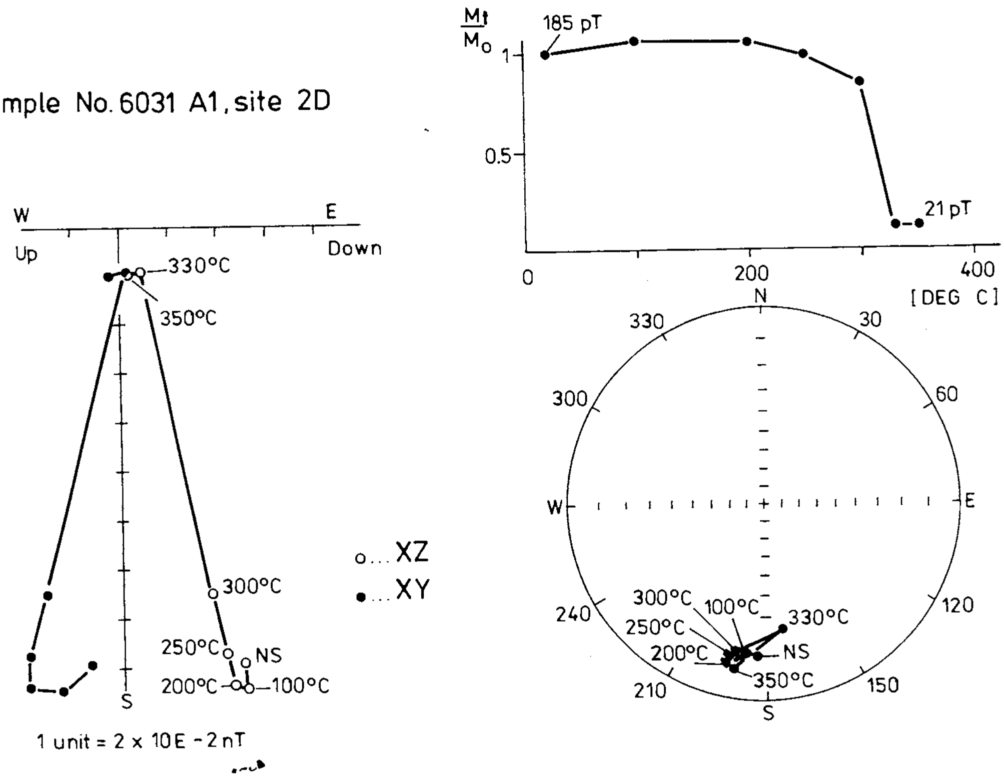

Fig. 4. Thermal demagnetization of a roof-slate, Nové Těchanovice.

250 - 400 °C corresponds to the palaeomagnetic direction.

For each group of samples, collected in a particular locality or collection site, we constructed rewiew statistical tables giving the mean values of magnetization directions and the scatters of the mean directions computed with the aid of Fisher's (1953) statistics. These data are examplified by Tabs. 3 and 4. The samples of pelitic sediments and above all of roof slates were found to have remanence directions close to the palaeomagnetic direction already in their natural state; a typical example is presented in Tab. 3. As opposed to it, more coarse-grained rocks (sandstones and greywackes) have a strong share of the recent magnetization component; a typical example is presented in Tab. 4.

Upper Visean

Rocks of the Upper Visean are statistically richly represented, palaeomagnetically positive results were obtained on 17 collection sites or localities. Samples in natural state exhibit considerable scatters of J_n directions, after thermal cleaning (for different localities the optimum cleaning temperature varied within 250 to 320 °C, in most cases, however, below the pyrrhotite Curie temperature, below 320 °C), see Fig. 8a. Thermal cleaning yielded homogeneous directions of remanence even though there is a marked scatter mainly in the value of palaeodeclination, see Fig. 8b. Tab. 5 gives the numerical values of mean palaeomagnetic directions derived by means of Fisher's (1953) statistics for the respective collection sites or localities inferred under optimum temperature. Also the coordinates of virtual poles are computed.

Differences in the values of palaeomagnetic declination are substantial for various collection sites within the same locality, see Fig. 9. For instance, in locality 2 the difference in the palaeodeclination of collection sites 2C and 2D is 15.7°, in locality 6 this difference between collection sites 6B and 6A amounts to as much as 22.2°. It is obvious then, that the scatters in palaeodeclination are not due to the rotation of bigger of rocks, but the cause is local.

Tab. 6 shows the mean palaeomagnetic directions and the computed positions of palaeomagnetic poles with the respective scatters (dp, dm, α_{95}). In the first line the computation was made from the mean directions of all samples on the basis of so-called strata means. In the second line the computation was made from the mean palaeomagnetic directions for particular collection sites (site means). In the third line are the coordinates of the palaeopole computed by Fisher's (1953) statistics from the virtual pole positions.

From the methodological point of view, of interest is the finding that three different statistical approaches based on somewhat different presumptions, yield practically the same positions of palaeomagnetic poles (palaeopoles). The statistical characteristics of scatters are different, though. The computed pole position from rocks of the Upper Visean falls in the pole positions derived so far on the Carboniferous rocks of the Bohemian Massif. The vicinity of the distinct lithospheric boundary of the North European Platform and the collision zone between the African and the North European Plates is not manifest in the pole position in a more pronounced way.

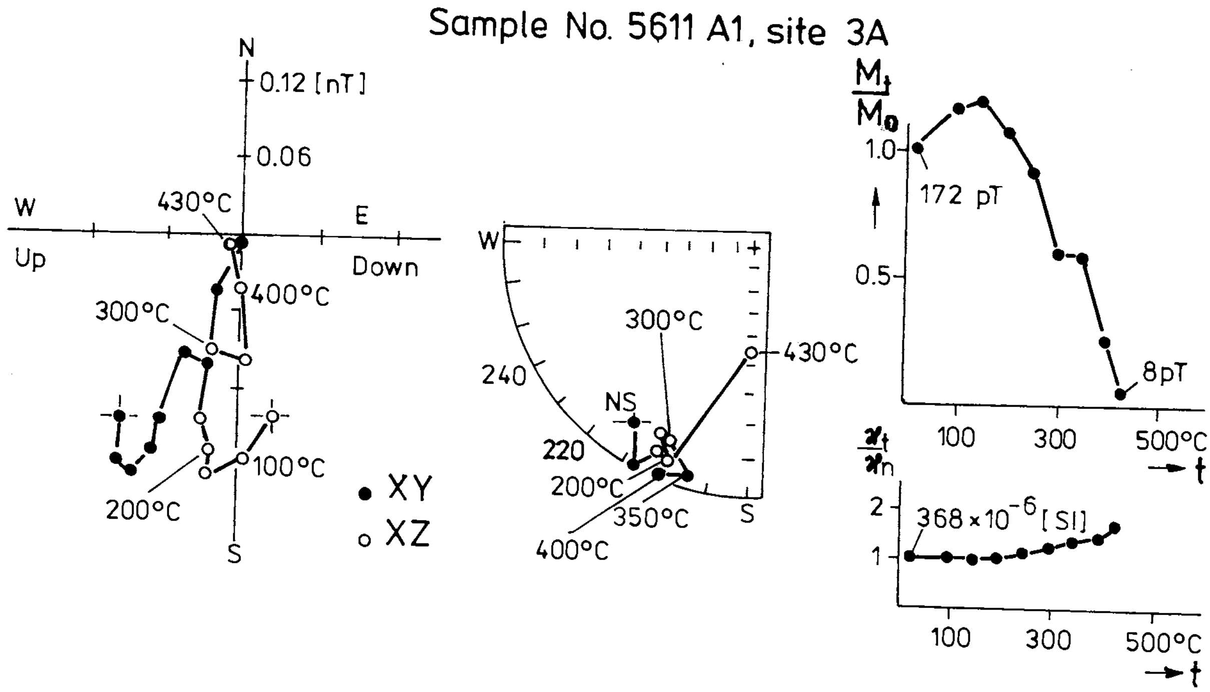

Fig. 5. Thermal demagnetization of greywacke, Vondruška's quarry, Budišovice near Hrabyně.

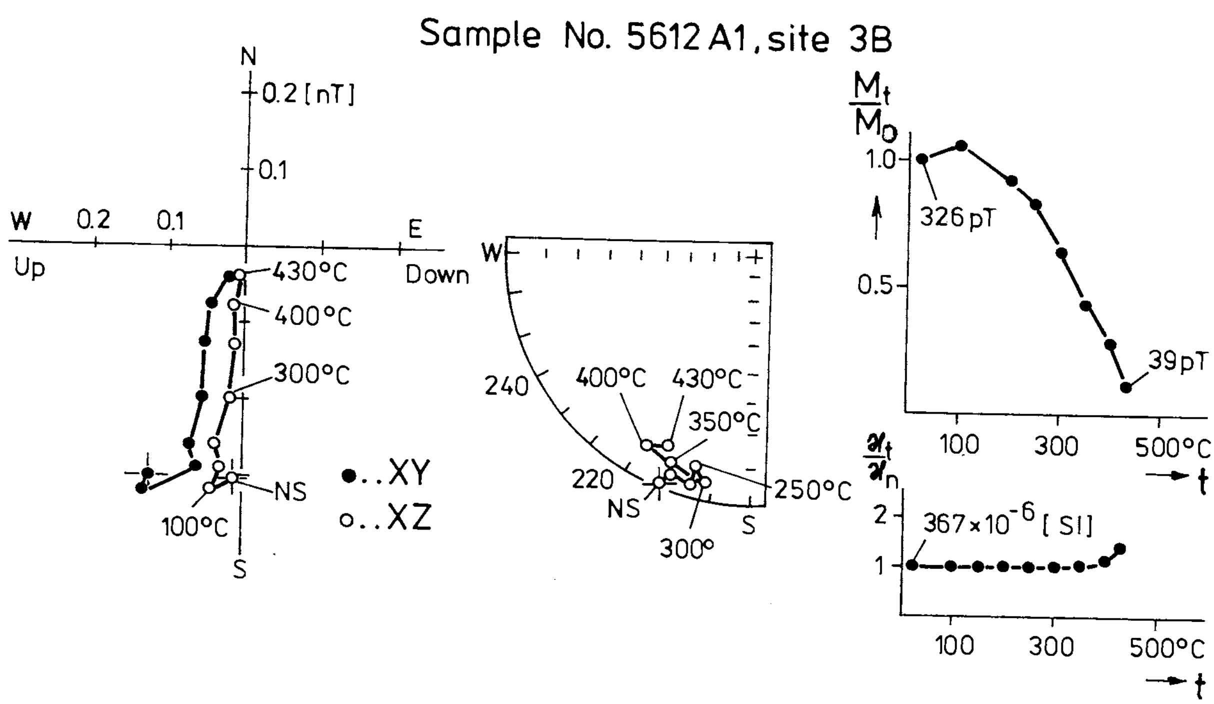

Fig. 6. Thermal demagnetization of greywacke, Vondruška's quarry, Budišovice near Hrabyně.

Namurian A

In outcrops, rocks of the Namurian A occur in the profile about 300 m in length along the Odra river, in locality Landek near Koblov. In Tab. 2 they are given under the number of locality 11. As shown by the results of magneto-mineralogical studies, in these rocks the blocking temperatures vary in the range from 200 to 400 °C, in some samples they are even lower (presence of goethite). Weathered rocks and those with low blocking temperatures did not prove suitable for palaeomagnetic research. The results of progressive thermal demagnetization of rocks of the Namurian A with higher values of blocking temperatures (up to 400 °C) are presented in Fig. 10. Optimum cleaning was achieved at the temperature of 350 °C, cf. Tab. 7.

For geographic coordinates $\phi = 49.868°N$; $\lambda = 18.270°E$ andthe mean directions of remanent magnetization

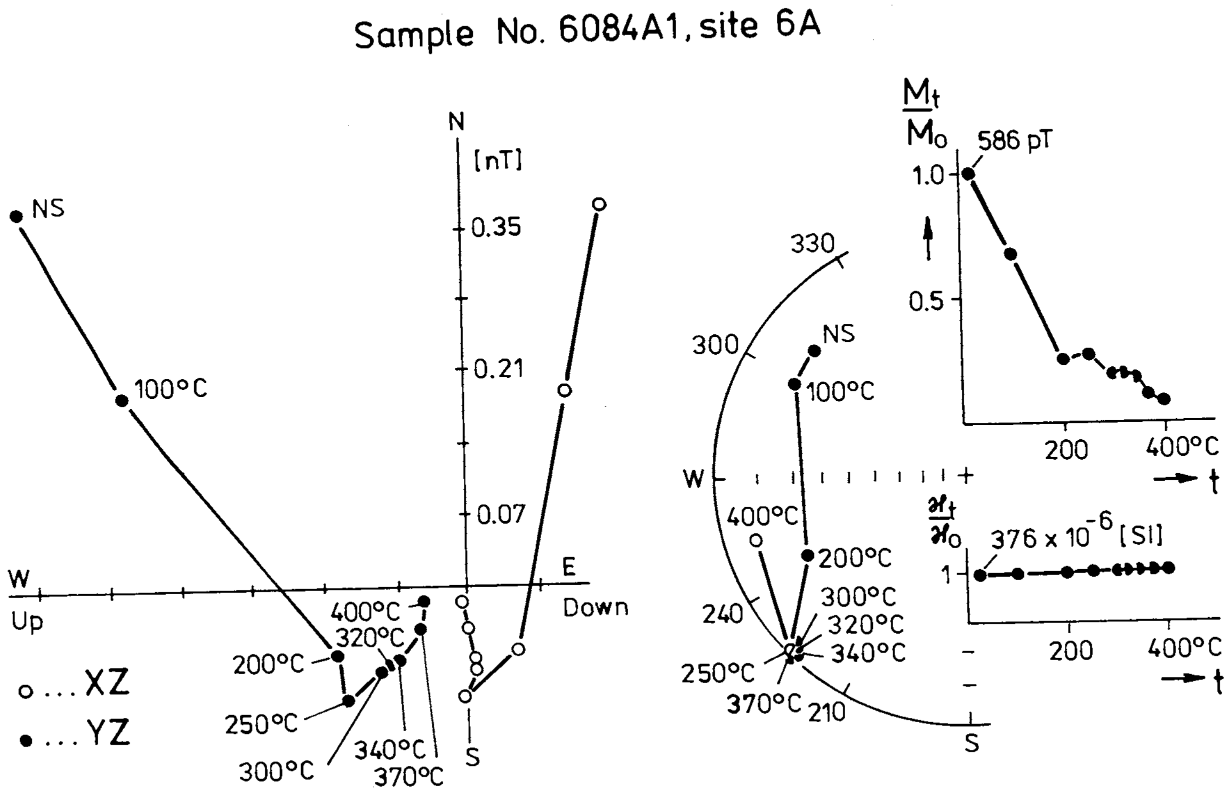

Fig. 7. Thermal demagnetization of a dark-grey clay shale, Barta's Mill, Kyjovice.

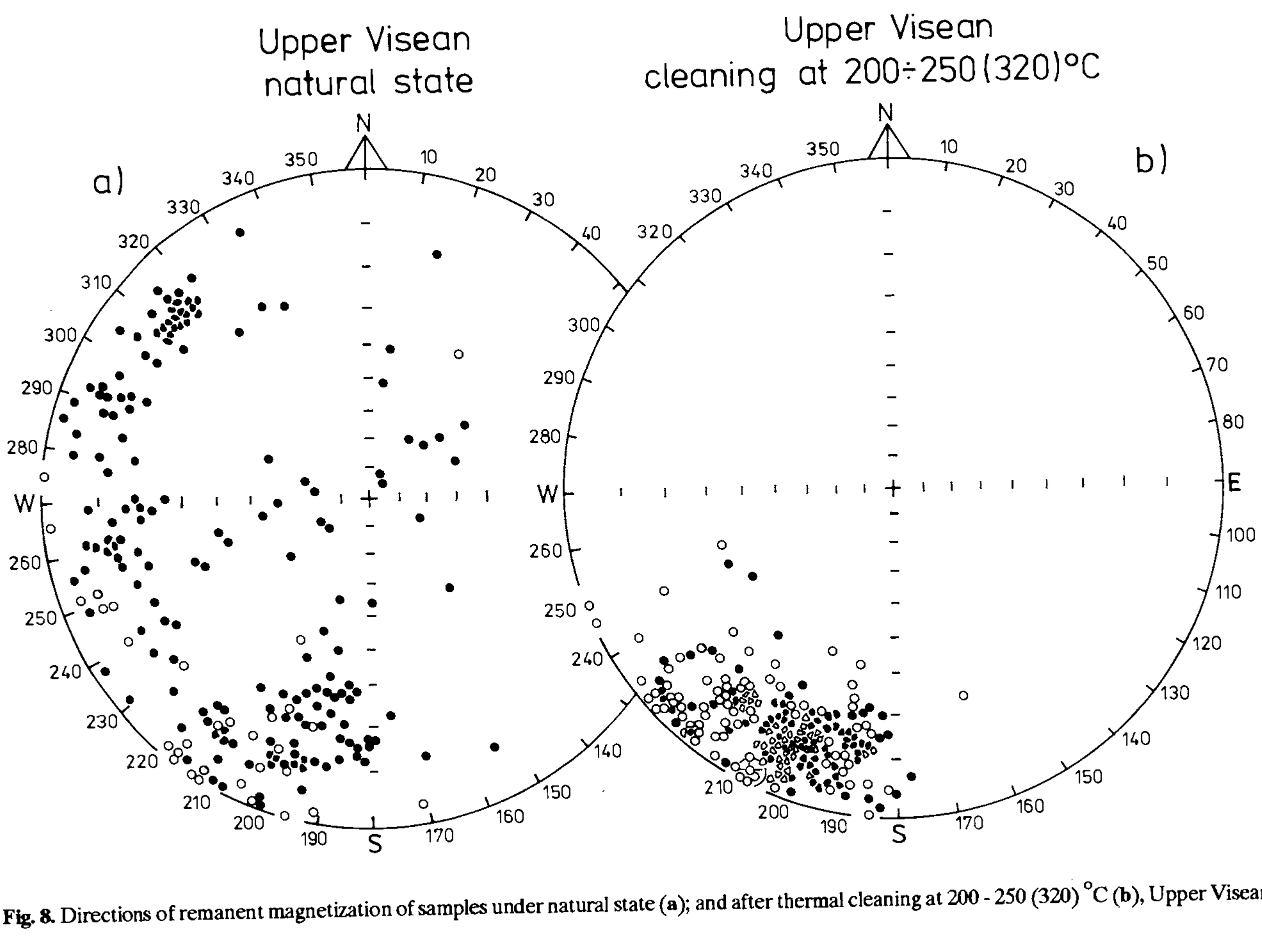

Fig. 8. Directions of remanent magnetization of samples under natural state (a); and after thermal cleaning at 200 - 250 (320) °C (b), Upper Visean.

Table 3: Nové Těchanovice, Lhotka, 6117A - 6120A, site 2A.

Temperature (°C)	Mean directions of remanent magnetization		α_{95}(°)	k	n
	D(°)	I(°)			
20	198.1	-10.4	10.6	28.5	8
100 , 196.7	-10.5	8.2	46.3	8	
200	197.6	-12.8	7.4	56.7	8
250ˣ	194.6ˣ	-11.4ˣ	6.3ˣ	78.6ˣ	8
300	199.1	-7.7	22.4	7.1	8
320	182.6	-15.8	36.7	3.2	8
340	188.1	-16.5	46.4	2.4	8
370	189.5	-26.4	39.9	2.9	8
400	200.8	-36.3	45.6	2.4	8

Table 4: Vresina, 5692A - 5710A, selected samples only, locality 9.

Temperature (°C)	Mean directions of remanent magnetization		α_{95}(°)	k	n
	D(°)	I(°)			
20	235.5	31.9	20.7	3.8	18
100	216.6	12.7	16.7	5.2	18
150	211.6	6.2	15.0	6.3	18
200	213.3	2.3	13.5	7.5	18
250ˣ	213.2ˣ	-0.5ˣ	13.8ˣ	7.2ˣ	18
300	210.2	1.2	15.2	6.2	18
350	228.5	-2.8	21.6	3.5	18
400	253.5	-3.3	32.0	2.1	18

ˣOptimum cleaning by the MAVACS apparatus.

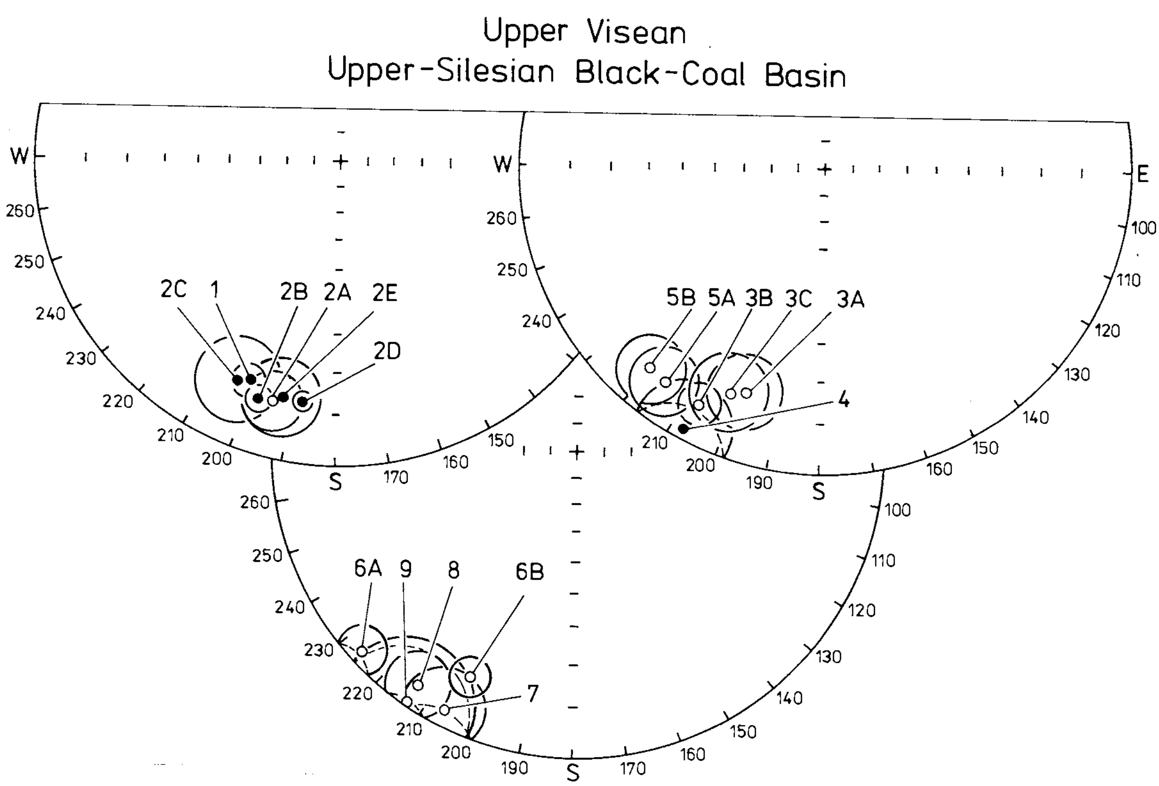

Fig. 9. Site means of remanent magnetization of Upper Visean sediments, cf. Tab. 6.

Table 5: Mean palaeomagnetic directions and virtual pole positions. Upper Visean sediments, Moravian-Silesian region.

Site code	Geographical coordinates		Mean palaeomagnetic directions		α_{95}(°)	k	n	Virtual pole positions		Ovals of confidence	
	Lat.(°N)	Long.(°E)	D(°)	I(°)				Lat.(°N)	Long.(°E)	dp(°)	dm(°)
1	49.903	17.697	201.9	14.7	3.8	129.6	12	29.54	172.54	2.00	3.90
2A	49.805	17.750	194.6	-11.4	6.3	78.6	8	44.27	177.25	3.25	6.39
2B	49.805	17.750	197.6	10.8	2.8	292.8	10	32.68	176.80	1.44	2.84
2C	49.805	17.750	203.7	13.4	10.0	37.2	7	29.77	170.38	5.21	10.21
2D	49.805	17.750	188.0	13.2	2.4	537.6	8	33.09	171.75	1.25	2.45
2E	49.805	17.750	193.2	12.3	8.5	63.6	6	32.81	177.92	4.40	8.65
3A	49.853	18.047	198.2	-14.6	8.7	32.0	10	44.92	172.11	4.57	8.92
3B	49.853	18.047	206.2	- 8.3	4.9	86.7	11	39.24	163.40	2.49	4.94
3C	49.853	18.047	200.6	-13.9	9.5	41.6	7	43.85	169.09	4.96	9.71
4	49.838	18.112	207.2	2.3	9.6	10.0	25	33.93	164.69	4.81	9.61
5A	49.824	18.016	216.5	- 8.5	7.6	30.9	13	35.04	151.59	3.66	7.66
5B	49.824	18.016	220.6	- 8.6	6.9	31.7	15	33.10	147.25	3.51	6.96
6A	49.822	18.022	226.3	- 2.3	4.8	70.0	14	27.45	143.48	2.40	4.80
6B	49.822	18.022	204.1	-11.5	4.4	98.8	12	41.55	165.15	2.27	4.47
7	49.829	18.027	206.3	- 3.8	8.4	38.4	9	37.11	164.30	4.21	8.41
8	49.829	18.027	213.3	- 5.6	6.5	29.1	18	35.16	155.90	3.27	6.52
9	49.818	18.138	213.2	- 0.5	13.8	7.2	18	32.90	157.43	6.90	13.80

D = 206.6°; I = 13.2°; α_{95} = 10.6°; k = 8.8; n = 24, coordinates of the palaeomagnetic pole ϕ_p = 29.90°N; λ_p = 167.74°E; dp = 5.52°; dm = 10.81° were computed. This computation was performed with so-called mean strata directions (strata means). Due to a certain scatter of data and relatively small statistical representation of rock samples, the above mentioned data have to be regarded as preliminary.

Petromagnetic and palaeomagnetic investigations into samples of so-called variegated layers

The next task of palaeomagnetic research in the region of the Upper Silesian black coal basin was dating of the so-called variegated layers. These rocks form an extensive body in the wider area of the Orlov tectonic structure. Opinions on the origin of these rocks vary, and new findings in the fields of petromagnetism and palaeomagnetism can be of good use in elucidating their origin.

Oriented samples were collected from horizontal layers in the Lazy Mine, Orlová, 7th level, 70 cross cut (499 m beneath the surface), and in the Doubrava Mine, Doubrava, 8th level, 8610 cross cut (598 m beneath the surface). The samples were used for investigations of palaeomagnetic directions and for laboratory tests by modified Thellier's method to establish the palaeointensity of the geomagnetic field acting at the time of caustic alteration.

Five samples from the Lazy Mine were thermally demagnetized with the use of the MAVACS apparatus (Příhoda et al.1989). Fig. 11 presents typical results; remanence is one-component, characteristic directions of remanent magnetization do not correspond to Carboniferous, Permian, Triassic, and Cainozoic palaeomagnetic fields. Similar results were furnished by samples from the Doubrava Mine, from which six samples were analyzed. Four samples yielded well defined results, a typical example is given in Fig. 12. These samples suggest similar dating conclusions as the samples from the Lazy Mine.

The proof that remanent magnetization of the samples of the so-called variegated layers from the mines Lazy and Doubrava is of thermo-remanent origin is furnished by the results of the derivation of the geomagnetic field palaeointensity with the use of the modified Thellier's method described in detail in (Krsová et al. 1989). We applied the method of double heating, modified, of course, to the high magnetic vacuum of the MAVACS ap-

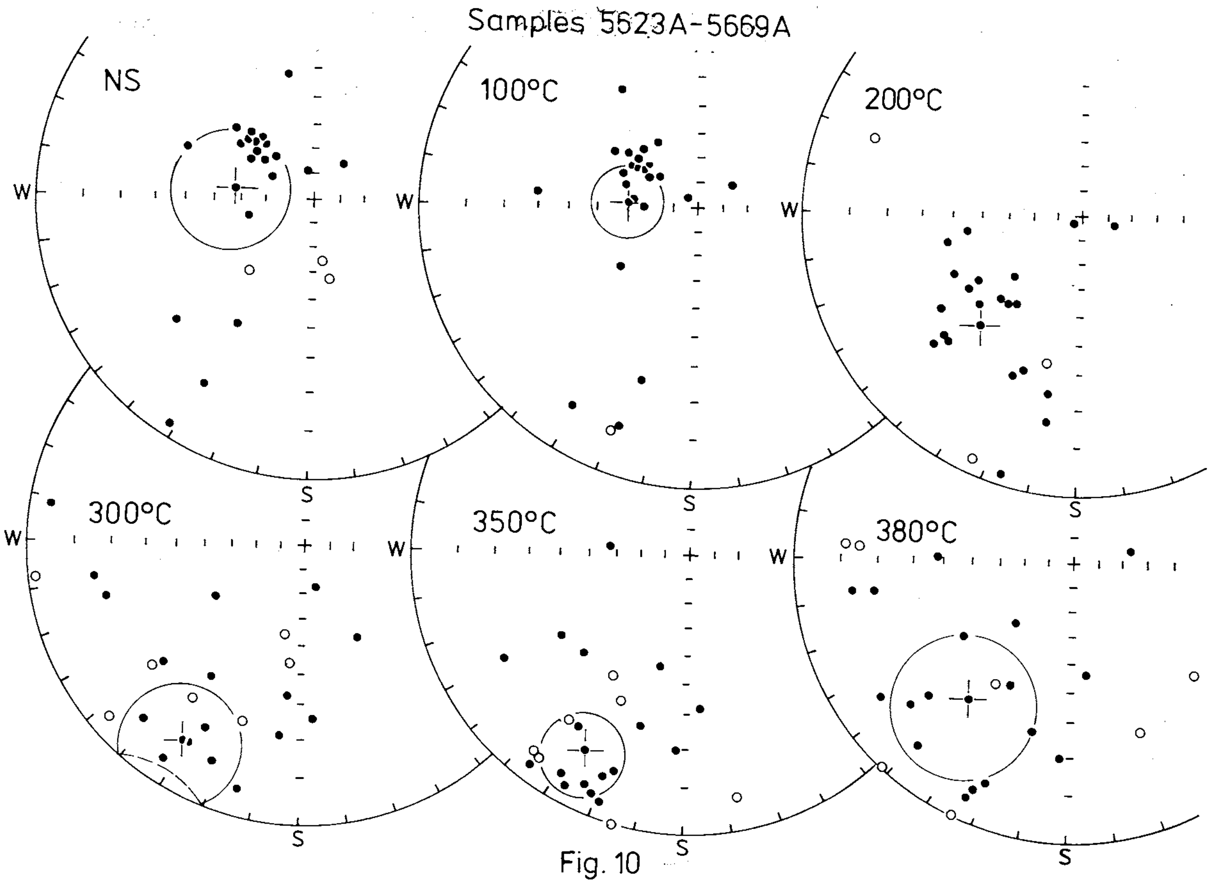

Fig. 10. Directions of remanent magnetization of samples under natural state (NS) and thermally cleaned at 100, 200, 300, 350 and 380 °C, Namurian A, Ostrava Formation, Landek near Koblov.

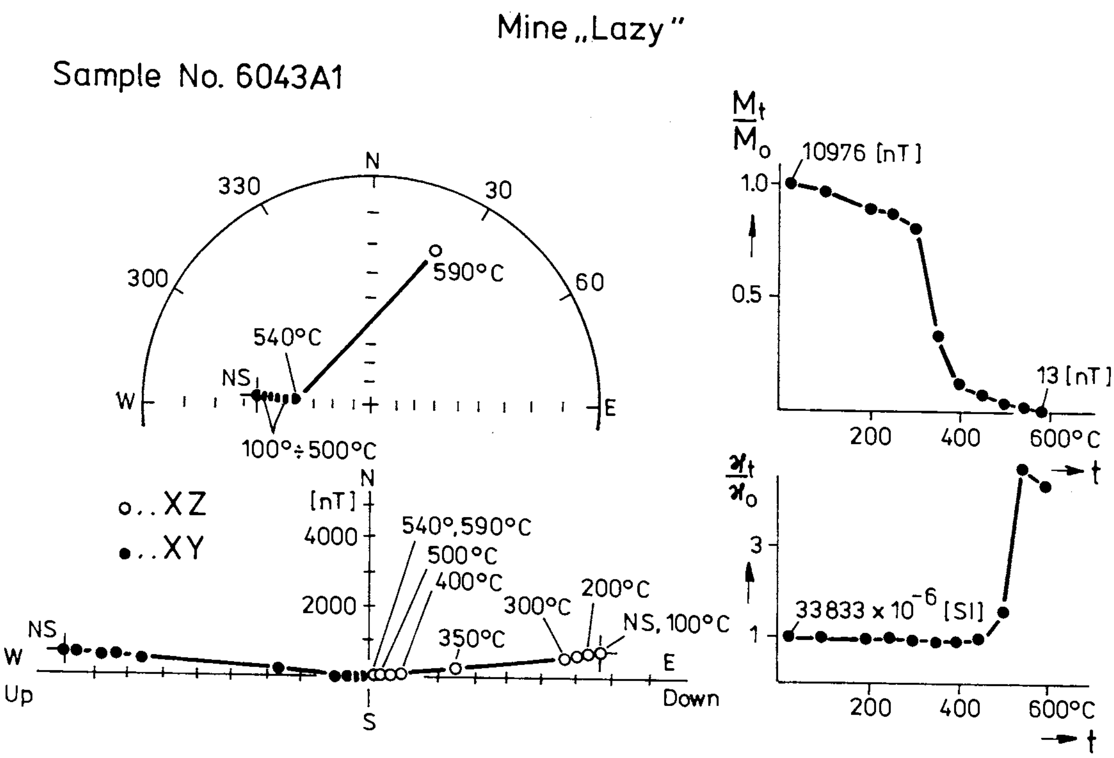

Fig. 11. Thermal demagnetization of a sample of erdbrand. Mine Lazy.

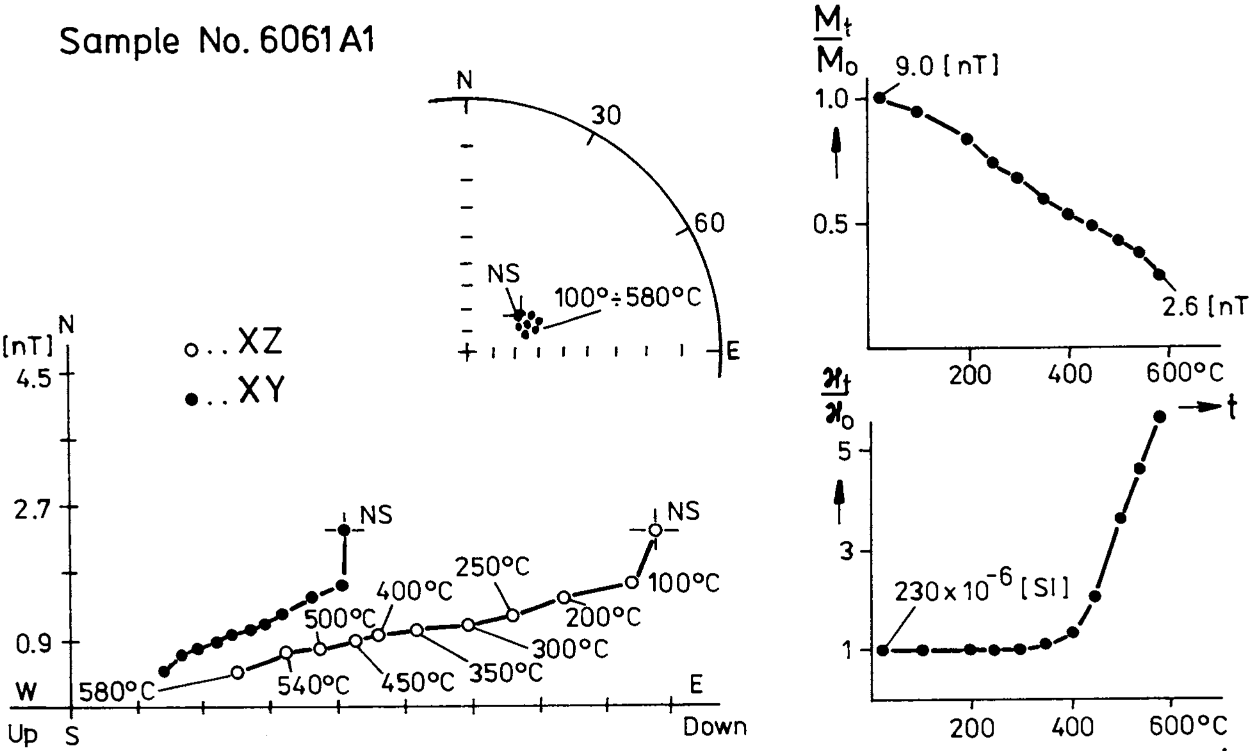

Fig.12. Thermal demagnetization of a sample of erdbrand. Mine Doubrava.

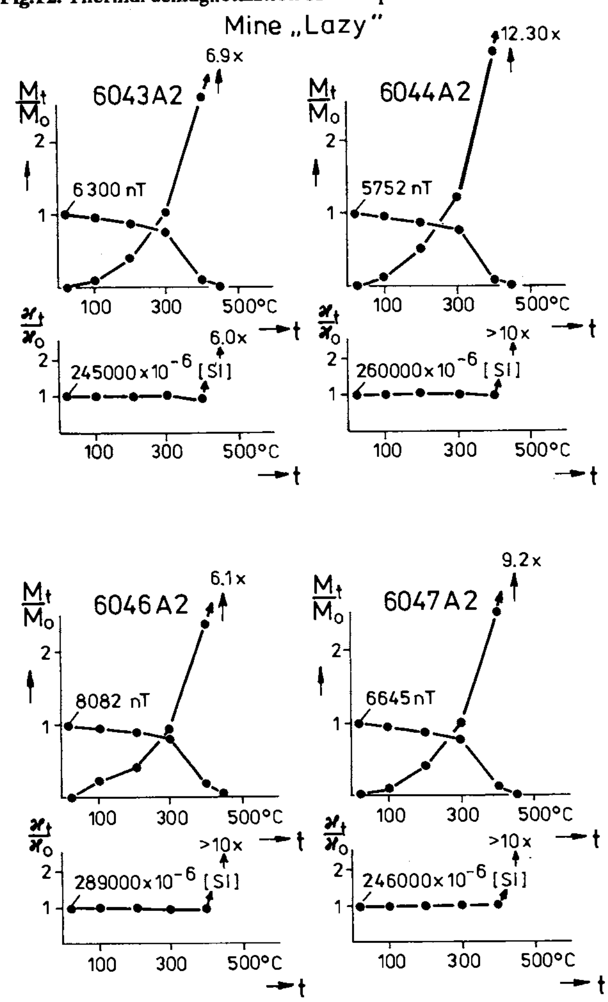

Fig.13. Progressive thermal demagnetization and magnetization curves, erdbrand, Mine Lazy.

paratus. Each sample was first thermally demagnetized in the environment of high magnetic vacuum in the respective temperature interval, after being cooled it was measured and magnetized again by the Earth's field in the same temperature interval. The procedure of progressive demagnetization and magnetization was applied to selected temperature intervals up to maximum Curie temperature of minerals - palaeomagnetism carriers. Concurrently observed were dependences $\kappa_t/\kappa_o = f(t)$, the aim being to verify the formation of phase changes of minerals in the course of the thermal process. Demagnetization in high magnetic vacuum also allowed us to study the space distribution of the partial components of remanence.

The values of parameter $K_p = T_o/T_L$, where T_o is the intensity of the geomagnetic field acting at the time of caustic alteration and T_L is the intensity of the present laboratory (geo)magnetic field, were determined by two methods:

1 - The first method is based on the computation of the total change of moments ΔM_{TC} and ΔM_{TL} in the entire temperature interval with no phase changes having accurred, so that $T_o/T_L = \Delta M_{TC}/\Delta M_{TL}$.

2 - In the other method the value of parameter $K_p = T_O/T_L$ is computed from the dip of regressive lines approximated by points $MT_{ci} = (MT_{Li})$ for each selected temperature t_i. The latter method is especially suitable for samples, in which the drop of the remanent magnetic moment and its growth are more or less continuous with increasing temperature. The computation 1 is presented in Fig. 13, and that 2 in Fig. 14 for locality Lazy. An analogous computation was performed for locality Doubrava, Fig. 15. The derived values of the relationship of palaeointensity to the present intensity for lacality Lazy $K_P = 0.33 \pm 0.03$ (n=4), and for locality Doubrava $K_P = 0.63$ (n=1).

However, these experimental data show that the studied samples of the so-called variegated layers were heated in the past above the Curie temperature of haematite. By their properties they correspond to rocks of the erdbrand type (cf. Krs 1968a; Krsová et al. 1989).

Table 6: Mean palaeomagnetic directions and palaeomagnetic pole positions. Upper Visean sediments, Moravian-Silesian region.

Geographical coordinates		Mean palaeomagnetic directions		α_{95}(°)	n	N	Palaeomagnetic pole positions		α_{95}(°)	Ovals of confidence	
Lat.(°N)	Log.(°E)	D(°)	I(°)				Lat. (°N)	Long.(°)		δ_p(°)	δ_m(°)
49.840	17.980	207.5	-1.5	2.5	<u>203</u>	17	35.59	163.38	-	1.25	2.50
49.840	17.980	205.4	-1.3	6.5	203	<u>17</u>	36.24	165.85	-	3.25	6.50
Mean pole position calculated from virtual pole positions by means of Fisher's (1953) statistics:						17	36.11	164.58	4.5	-	-

Table 7: Landek, 5623A - 5669A, selected samples only, locality 11.

Temperature (°C)	Mean directions of remanent magnetization		α_{95}(°)	k	n
	D(°)	I(°)			
20	276.8	58.3	22.8	2.7	24
100	274.4	62.3	13.5	5.8	24
150	256.9	57.2	15.0	4.9	24
200	222.0	34.1	13.1	6.1	24
250	214.1	18.4	16.0	4.4	24
300	210.2	10.9	15.6	4.6	24
350[x]	206.6[x]	13.2[x]	10.6[x]	8.8[x]	24
380	216.0	26.7	21.7	2.8	24
410	212.2	4.9	18.4	3.6	24

[x]Optimum cleaning by the MAVACS apparatus.

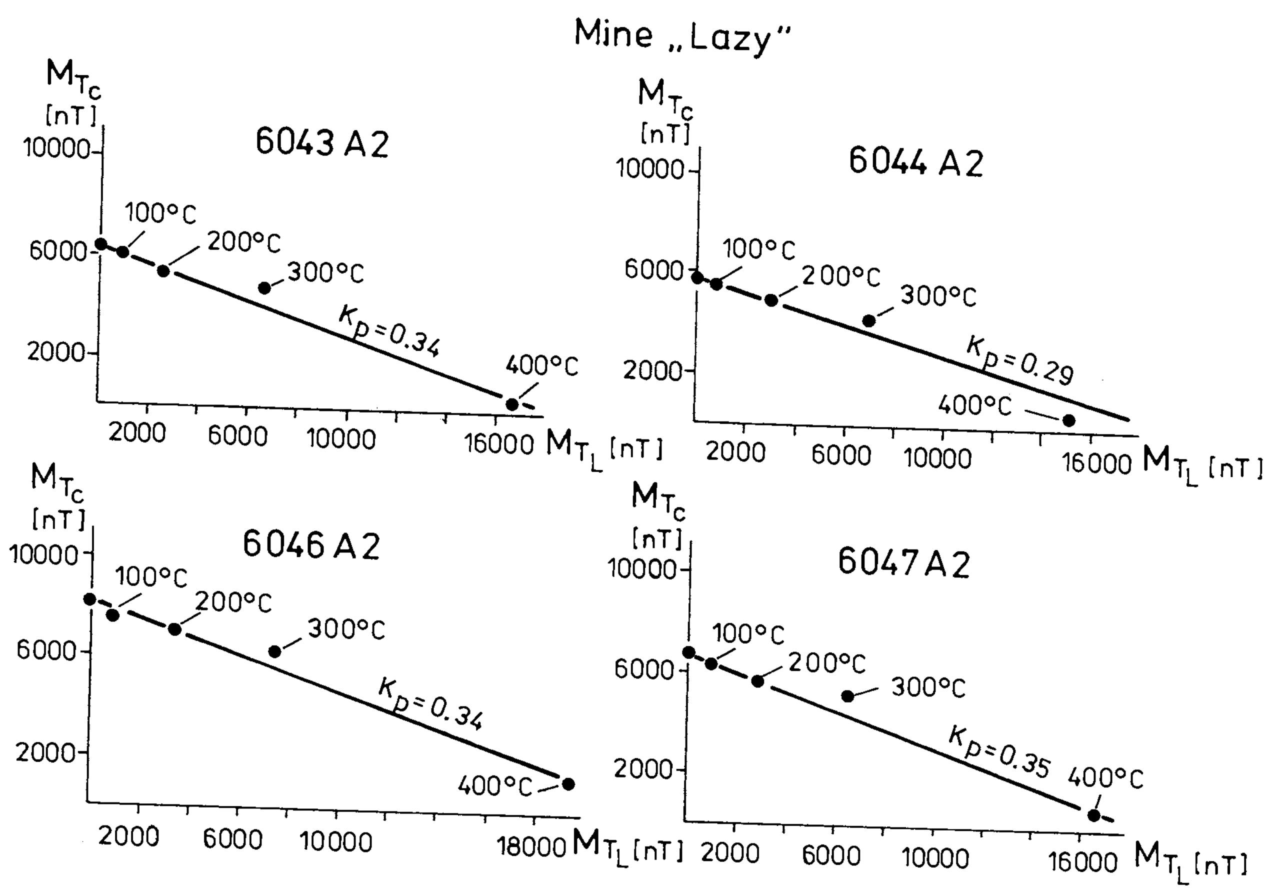

Fig. 14. Dependence of M_{TC} and M_{TL} for respective temperatures, erdbrand, Mine Lazy.

Major results

The petromagnetic and palaeomagnetic research carried out in oriented samples of Carboniferous rocks and of the so-called variegated layers in the Upper Silesian basin and its surroundings provided some methodological and globally tectonic results.

1 - In this study, the majority of palaeomagnetic data were derived in roof slates. These rocks represent pelitic sediments with a finely dispersed graphitic component, the palaeomagnetization carrier is predominantly fine-grained pyrrhotite. Roof slates are sediments with a micro-organic substance with a high degree of carbonification. The origin of fine-grained pyrrhotite could be well accounted for as a product of the thermal and alteration history of original metastable sulphides (greigite and smythite in the original sediment with a microorganic matter), cf. Krs et al. 1992 c.

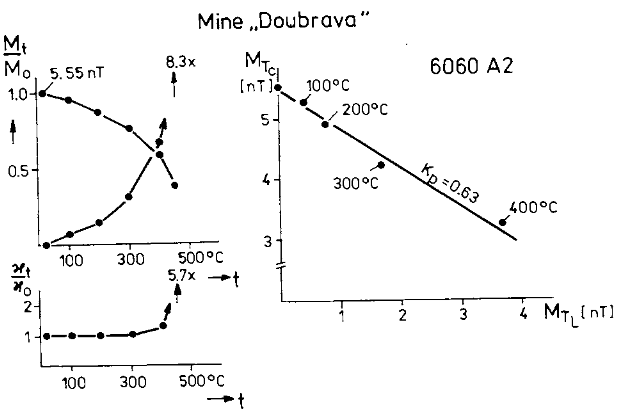

Fig. 15. Progressive thermal demagnetization and magnetization curves, dependence of M_{TC} and M_{TL} for respective temperatures, erdbrand, Mine Doubrava.

2 - The Upper Silesian black coal basin is situated in the proximity of the lithospheric boundary separating the North European Platform from the collision zone of the Alpine-Carpathian system. The palaeomagnetic pole positions derived in rocks of the Upper Visean, Namurian A, and the orientations of palaeomeridians are in good agreement with the pole positions and orientations of palaeomeridians derived in numerous Carboniferous rocks from various basins and furrows of the Bohemian Massif (cf. Krs 1968b), and within the limits of statistical errors they coincide with the results of Lower Permian rocks (Krs et al. 1992a). These findings lead to the conclusion that the area of the Upper Silesian basin was not palaeotectonically much influenced by the nearby lithospheric boundary in the period from the Lower Permian.

3 - The samples of the so-called variegated layers, studied from mines Lazy and Doubrava, displayed suitable properties for the palaeointensity of the geomagnetic field to be derived. Their physical properties correspond to typical erdbrands, i.e. to rocks caustically altered and thermally stabilized in an oxidation medium. Their origin is to be connected with the self-combustion of coal seams in the wider area of the Orlov tectonic structure. The samples with pronounced stable one-component remanence exhibit characteristic remanence directions that point to caustic alteration most likely originating in the Jurassic to the Cretaceous. Palaeomagnetization directions of thermoremanent origin quite reliably preclude the origin in the Carboniferous, Permian and the Triassic.

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