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THE VARISCAN DIRECTIONS FROM THE UPPER SILESIAN COAL BASIN (S-POLAND)

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Abstract: Middle Devonian dolomites and Namurian - Lower Westphalian clastic sediments from the Upper Silesian Coal Basin were investigated. A total number of 151 hand oriented samples were taken from 8 localities. In the dolomites two secondary directions of Upper Carboniferous and Lower Permian age were isolated. In the clastic sediments three (A1, B, C) directions were obtained. The post-deformational direction A1 is characteristic for the Upper Carboniferous/Lower Permian of the "stable" Europe. The directions similar to A1, B, C occur in various tectonic units from the western part of European Variscides. A geological hypothesis is possible, that weakly consolidated mid-Variscan structure rotated clockwise in the Late Westphalian. As a result of this "hinge" rotation a big shortening of the Variscan basin (mainly Rhenohercynian Zone) might take place. However, in the other hand the anomalous directions C and B could have a non-dispolar origin.

Key words: Upper Silesian Coal Basin, Devonian dolomites, Upper Carboniferous clastic sediments, palaeomagnetic investigation, tectonic interpretation.

Geological setting

The Upper Silesian Coal Basin (USCB) developed in the northern corner of the Moravo-Upper Silesian Massif during the Carboniferous time. Pre-Cambrian crystalline basement of the Moravo-Upper Silesian Massif is covered by the Lower Cambrian red scolithous and grey sandstones (Orlowski 1975). These sandstones are covered by Devonian and Carboniferous sediments (Kotas 1985). In the centre of the USCB, the total thickness of the Upper Carboniferous coal-bearing strata equals about 8.5 km. Late Carboniferous tectonic activity in the area accounts for several stratigraphic gaps in these strata.

The NE boundary of the USCB is delineated by the Cracow Fold Belt (Fig. 1) with Variscan or earlier plutonic bodies (Jarmolowicz-Szulc 1985). Between the Bohemian Massif and the USCB exists a zone of Viseanian flysch. In the western part of the Moravo-Upper Silesian Massif the Viseanian flysch is thrusted over the Westphalian sediments (Kotas 1985). This thrusting was probably synchronous with the thrust of the Bohemian Massif over the Moravo-Upper Silesian Massif (Matte et al. 1990). A major part of the USCB is situated within the area occupied now by the Carpathian Foredeep, and its southernmost parts even beneath Outer Carpathian nappes (Kotas 1985).

Sampling and laboratory methods

A total number of 151 hand samples was taken from the eight localities. Middle Devonian dolomites from the Dubie quarry and Namurian - Lower Westphalian clastic sediments from seven brick-yards (Fig. 1) were sampled. The natural remanent magnetization (NRM) intensities were measured by a JR4 spinner magnetometer. Thermal and alternating magnetic fiels (AF) demagnetizations were carried out by means of non-magnetic furnace and a tumbling demagnetizer with permaloy screens. The magnetic susceptibility was measured by a kappabridge KLY-2.

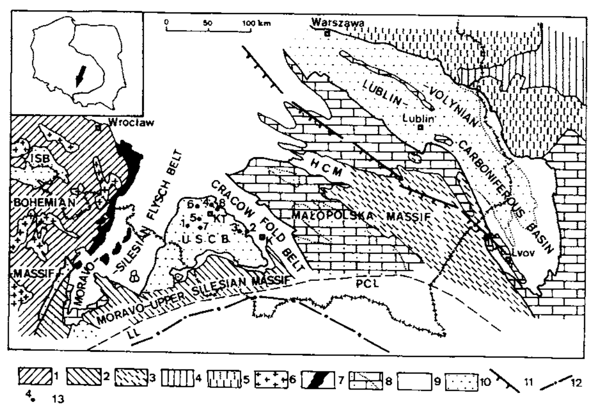

Fig. 1. Regional setting of the Upper Silesian Coal Basin (after Kotas 1985; slightly modified).
Legend: 1 - crystalline basement of the Bohemian Massif; 2 - crystalline basement of the Moravo-Upper Silesian Massif; 3 - Lower Paleozoic formations of the Malopolska Massif; 4 - Pre-Cambrian formations of the East European Platform (EEP); 5 - Lower Paleozoic formations of the EEP; 6 - major Variscan plutonic bodies; 7 - Devonian deep-sea formations; 8 - Devonian epicontinental formations (mainly carbonates, dotted: also Carboniferous carbonates and greywackes); 9 - Carboniferous marine, clastic formations (Variscan flysch, greywackes and early molasse); 10 - Carboniferous clastic, coal-bearing formations (Variscan molasse); 11 - SW limit of the EEP; 12 - Peri-Pieniny Lineament (northern limit of the Inner Carpathian Block); 13 - sampling localites (1 - Czerwionka, 2 - Dubie, 3 - Filipowice, 4 - Grodków, 5 - Kochlowice, 6 - Kozlowa Góra, 7 - Mikolów, 8 - Sarnów). ISB - Inner Sudetic Basin, HCM - Holy Cross Mts., USCB - Upper Silesian Coal Basin, LL - Lednice Line, PCL - Peri-Carpathian Line, K - Cracow, KT - Katowice.

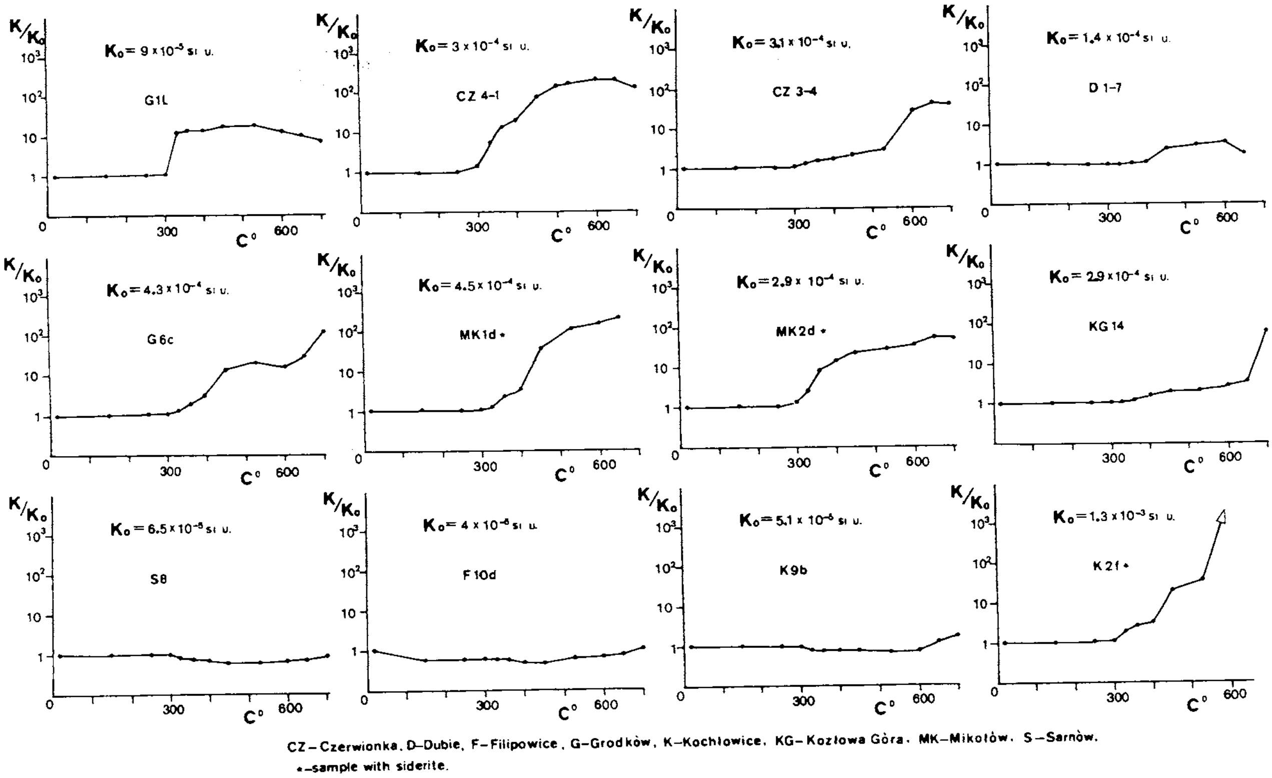

Fig. 2. Magnetic susceptibility changes after subsequent heating of some investigated specimens from the Upper Silesian Coal Basin. Siderite was indicated by means of X-ray analysis.

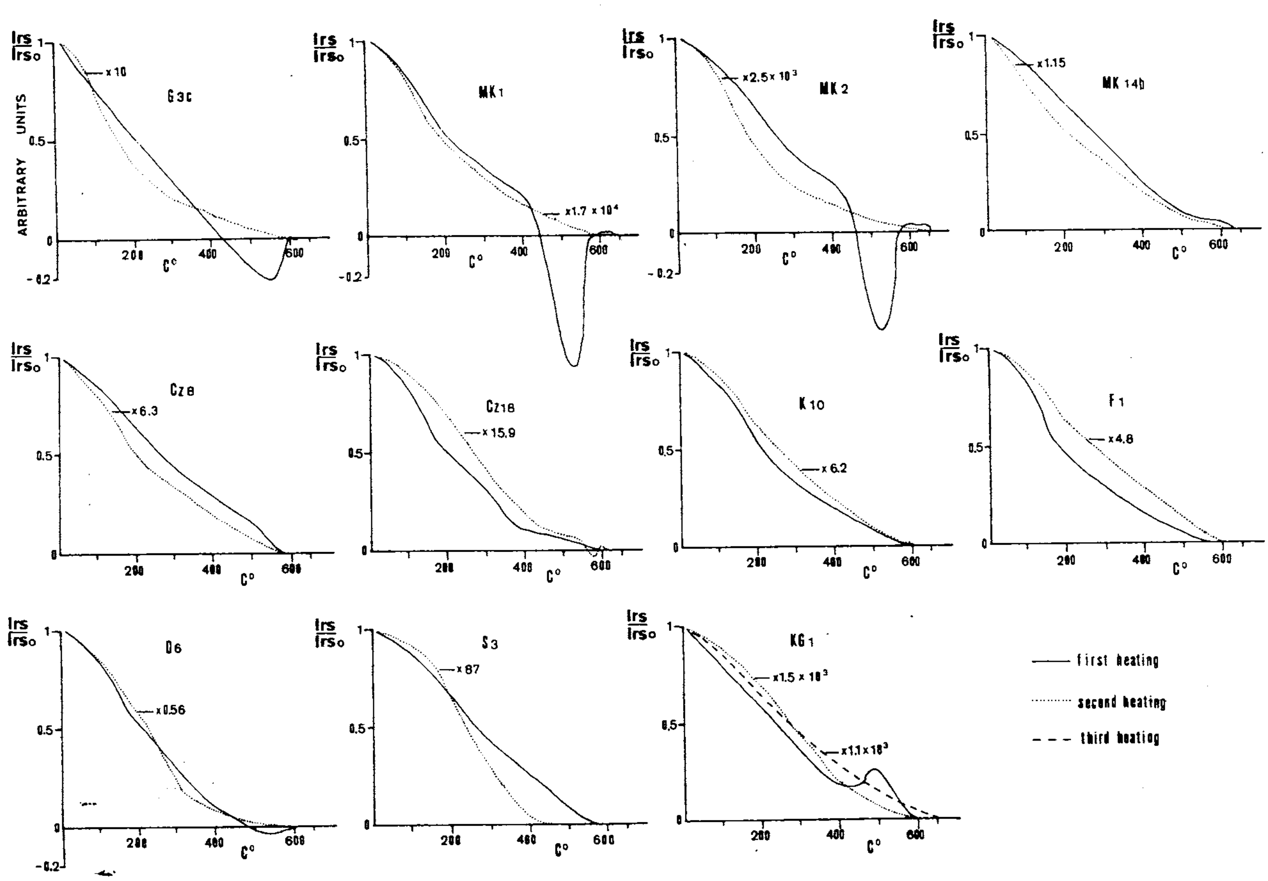

Fig. 3. Examples of intensity decay curves of saturation remanence during heating (G3c, MK1, MK2, Cz18, KG1 - Namurian and Early Westphalian mudstones and claystones, MK14b, Cz8, K10, F1, S3 - Namurian and Early Westphalian sandstones, D6 - Middle Devonian dolomites).

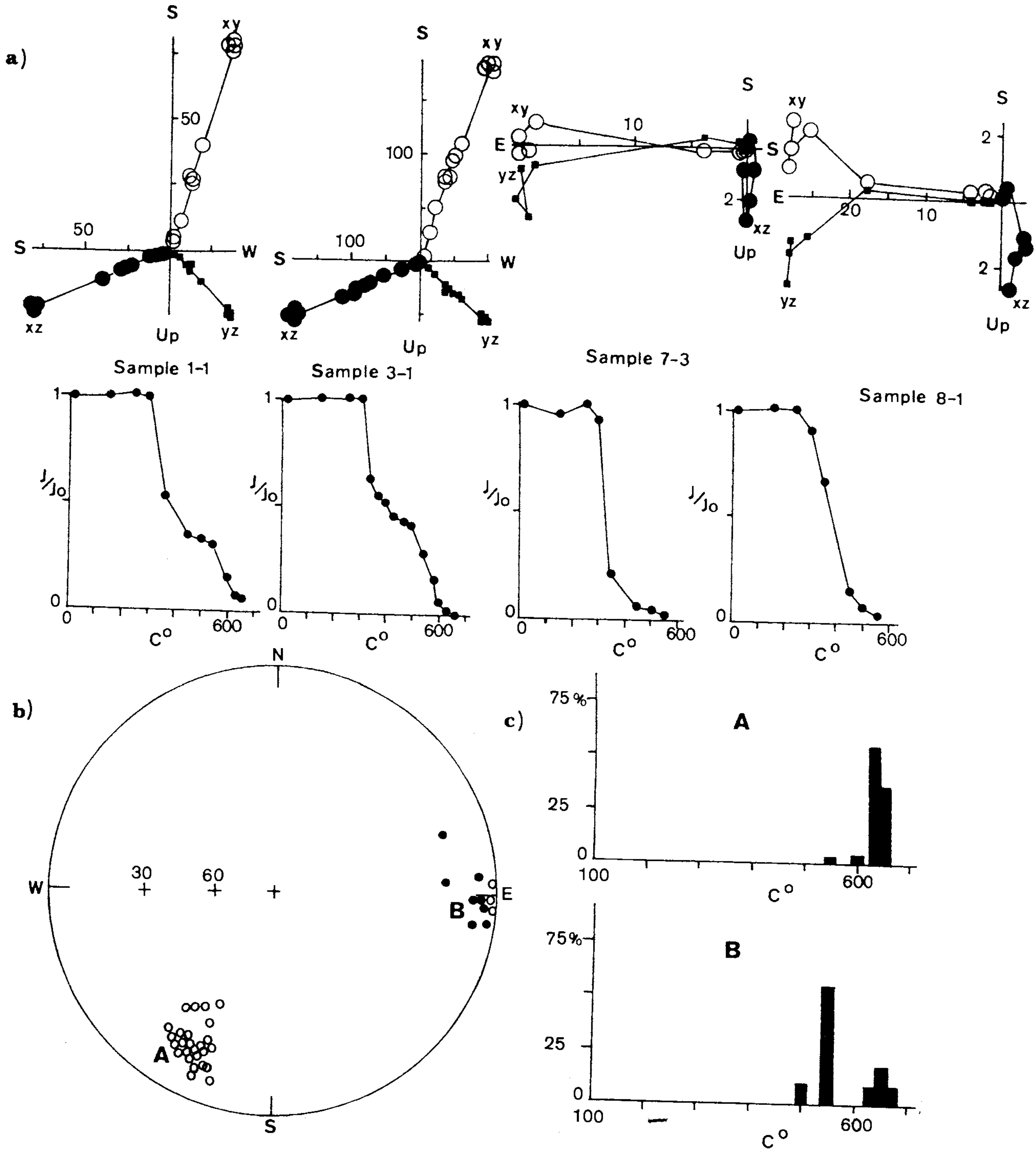

Fig. 4. Orthogonal projections (magnetization units 8 x $10^{-5}Am^{-1}$). a - demagnetizing curves; b - stereographic projections of characteristic components, and c - maximum unblocking temperature diagrams of the Middle Devonian dolomites from Dubie quarry.

At temperatures of 300 - 400 °C a great increase of magnetic susceptibility was observed in many samples (Fig. 2). In these cases thermal demagnetization was applied at first (up to 300 °C) and later AF method was used. Other samples were demagnetized using thermal method only.

For statistical calculations, a computer program by Kirschvink (1980) was used. Line fit was accepted as representative for the NRM component, if the max. angular deviation was less than 12°. The mean direction from each investigated locality was considered as reliable if its fisherian parameters (K and α_{95}) were good enough (Van der Voo 1990).

In order to identify the carriers of NRM a thermomagnetic analysis was carried out. Additionally some polished sections and the results of X-ray analysis were also studied.

Table 1: Palaeomagnetic results from the Upper Silesia.

Locality	Rock type and age	No	n/N	Cat.	D	I	α_{95}	K	D_c	I_c	α_{95}	K	T_b	Remarks
Czerwionka	sandstones, mud-	28	19	A1	203	1	7	21	204	-5	7	21	250, > 430	
(50.1 N, 18.6 E)	stones: Namurian		9		204	1	9	34	204	-4	8	39		
			19	B	253	-3	9	14	255	5	9	16	300, > 380	
			10		254	-6	9	28	255	2	9	29		
			25	C	142	10	9	11	141	-4	9	11	350	
			11		134	9	13	14	135	-6	11	17		
Dubie	dolomites: Middle	13	28	A	207	-16	3	92	208	-6	3	103	630	
(50.1 N, 19.6 E)	Devonian		10		207	-16	4	125	208	-7	4	150		
			11	B	90	1	8	32	90	4	5	79	550	
			5		92	-4	13	35	91	2	8	84		
Filipowice	sandstones:	15	5	*B	255	11	19	16	253	4	20	14	250 - 300	
(50.2 N, 19.4 E)	Namurian		3		253	11	13	90	252	7	16	60		
			12	C	310	-9	13	13	312	1	13	12	450 - 500	
			8		310	-7	13	18	312	-3	13	18		
Grodków	claystones, mud-	10	5	*A1	204	-7	21	13	203	16	24	11	-	thermal demagnet. only in the range 20 - 300°C
(50.4 N, 19.1 E)	stones: Namurian		3		204	-4	31	16	205	20	37	12		
			11	B	256	-3	12	15	255	-2	14	27	-	
			5		255	-2	15	27	254	1	10	61		
			10	*C	137	-14	15	11	138	10	15	11	-	
			5		135	-5	22	13	135	14	19	16		
Kochlowice	sandstones:	20	20	A1	200	1	8	17	200	-7	9	13	250, > 360	
(50.3 N, 18.8 E)	Namurian		11		197	2	9	24	198	-6	10	22		
			8	*B	260	1	13	19	260	-1	13	18	250, 600	
			3		262	-1	19	40	261	-3	21	34		
			12	C	149	10	11	15	149	5	13	13	380	
			8		150	7	13	19	149	0	14	16		
Kozlowa Góra	claystones, mud-	25	35	A1	206	-6	5	24	207	20	5	26	250 - 330	
(50.4 N, 18.9 E)	stones: Namurian		15		205	-6	6	40	206	20	6	48		
			10	B	259	-5	11	19	260	8	11	20	> 400	
			8		258	-5	12	21	258	8	11	23		
			9	C	143	-10	18	9	144	3	15	13	380	
			5		139	-10	25	10	142	-3	14	30		
Mikolów	mudstones: Early	25	29	A1	203	-1	6	21	203	-4	6	20	250	thermal demagnet. only in the range 20 - 300°C
(50.1 N, 19.0 E)	Westphalian		15		202	-1	6	35	202	-2	7	32		
			12	B	240	-1	11	15	241	2	12	14	250	
			8		241	-3	12	23	242	-1	12	22		
			13	C	150	6	10	17	151	4	10	16	-	
			7		146	3	13	22	146	2	13	22		
Sarnów	sandstones:	15	22	A2	18	31	5	35	12	23	6	29	300	
(50.4 N, 19.2 E)	Namurian		9		19	31	9	33	13	24	10	26		
			6	*B	249	6	25	8	251	6	26	7	> 440	
			3		247	-1	12	103	247	1	12	104		
			6	*C	310	-11	21	10	311	-8	23	9	380	
			3		310	-12	28	19	310	-18	24	25		

No, total number of samples: n/N, number of specimens and number of samples which carry the considered direction: Cat., cathegory of paleodirections: D, I, in situ mean declination and inclination: D_c, I_c, tiltcorrected declination and inclination: α_{95}, K, Fisher statistic parameters: T_b, blocking temperatures. The directions with asterisk were not considered in the summary statistics (Tab. II).

Magnetic properties

Thermomagnetic and other analyses revealed the presence of Fe-oxides and rarely Fe-hydroxides (Fig. 3, sample F1) in the rocks investigated. The main carriers of NRM are magnetite and maghemite. Sometimes geothite and hematite occur.

Microscopic analyses indicate that hematite and maghemite are connected with partially corroded grains of magnetite and with tectonic fissures. Major part of samples contained siderite and pyrite. First of all these minerals are responsible for a great increase in magnetic susceptibility during heating (Fig. 2). In some samples a self-reversal process took place at temperature of 430 - 590 °C (Fig. 3, sample G3c, MK1, MK2, D6?).

Palaeomagnetic results

In the dolomites of the Middle Devonian age (13 samples) two directions were isolated. Fig. 4a shows typical examples of orthogonal plots. The high temperature component A (Fig. 4b, c) is almost identical ($D = 207°$ $I = -16°$, $K = 125.5$, $\alpha_{95} = 4.3$, $T_b = 630$ °C) with the Birkenmajer & Nairn (1964) direction from the Lower Permian volcanites outcropping in the vicinity of the dolomites. The second component B (based mainly on magnetite) is dinsinctly different than the direction described above (Fig. 4b, c; Tab. 1) but similar to the component B from the Carboniferous sediments.

In the clastic sediments of the Namurian and Lower Westphalian age (138 samples) three directions (A1, B, C; Tab. 1) were isolated. These directions have similar, equatorial inclination. Typical orthogonal projections, the maximum unblocking temperatures and amplitude of demagnetizing field for each category are presented in the Figs. 5, 6 and 7. The direction C of mixed polarity (Fig. 8c, d) is characterized by low values of coercivity (15 mT) and blocking temperatures in the range of 350 - 500 °C. This direction is connected with a multidomain magnetite and/or titanomagnetite which were observed in the polished sections. It is probably primary. The direction C with NW declination can be interpreted as a reversed one, because a migration from the direction C with SE declination to the directions B and A1 must be connected with a large anticlockwise rotation of the investigated unit. There is as yet no geological evidences for this type of rotation in the area discussed.

The directions A1 and B have higher coercivity and lower blocking temperatures than the direction C. Because of the similar range of these parameters their separation was based mainly on a density analysis. The direction B has not cumulative distribution unlike the direction A1. Because of this its reliabity is doubtful. The value of parameter W (Tab. 2) indicates that the direction A1 has most probably secondary post-deformational origin. The polarity test seems to be necessary in this case.

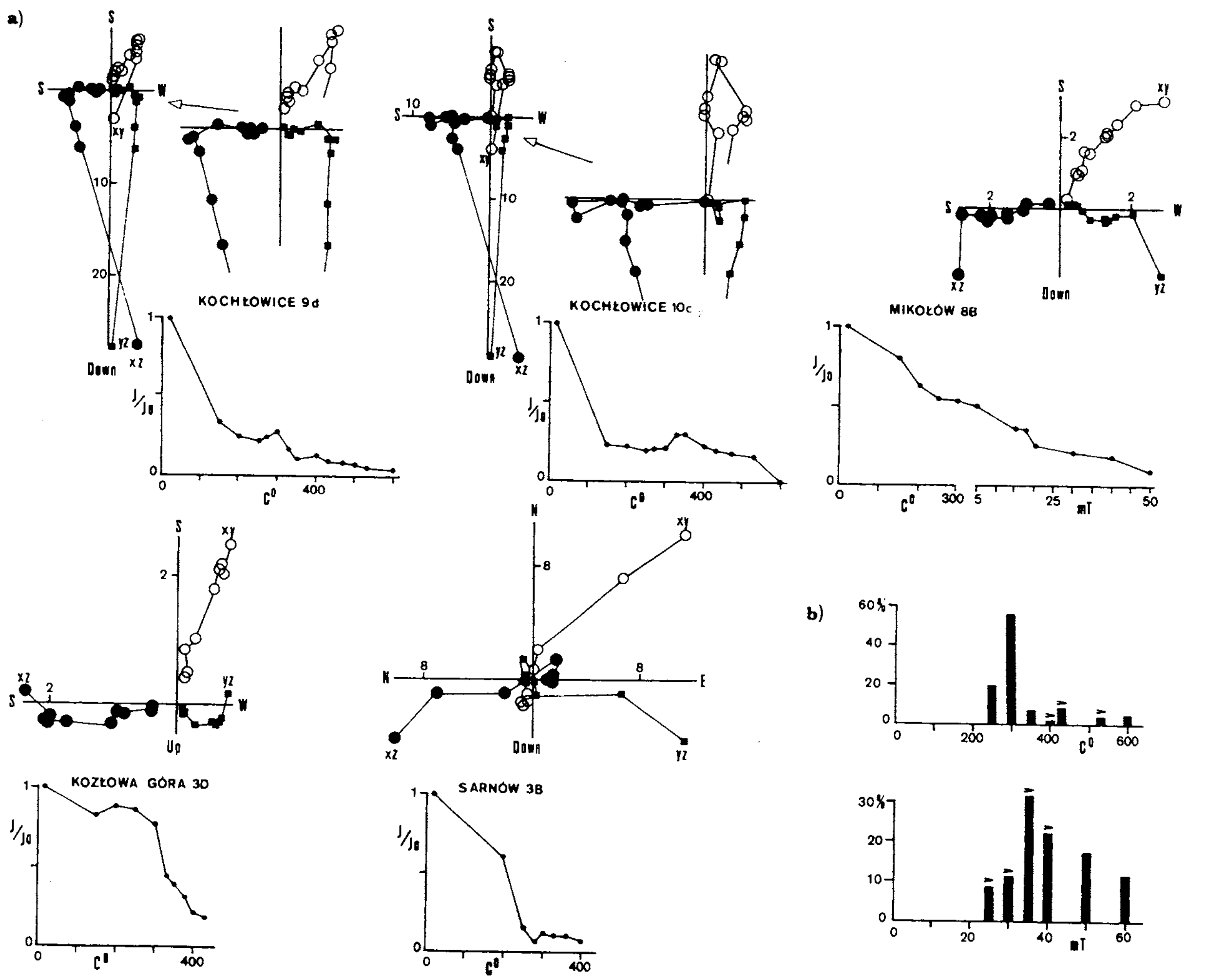

Fig. 5. a - Typical orthogonal projections and demagnetization curves of specimens with the direction A1 from the Namurian and Lower Westphalian sediments. b - The maximum unblocking temperature and coercivity diagrams (symbol ">" indicates the highest temperature and field applied during demagnetization; the blocking values are most probably higher).

Discussion

Mean directions and pole positions for the investigated area are presented in the Tab. 2. The postdeformational direction A1 corresponds to the Late Carboniferous - Early Permian directions from the "stable" Europe (Piper 1987).

Directions similar to A1, B, C occur in various tectonic units from the Western Part of the European Variscides (Fig. 9, Edel 1987; Edel & Wickert 1991). If we presume dipolar origin of the directions C and B, we must consider the geological implications of their presence. Relocation of palaeodirection from position C to B and A1 should reflect clockwise rotation of investigated geological units (the Moldanubian and Saxothuringian Zones, the Moravo-Upper Silesian and Malopolska Massifs). In the time of rotation these units would have to be already joined together.

According to Edel (1987) migration of pole from the position B to A1 is connected with the clockwise rotation of the whole of Europe (Fig. 10c). New data from England (Piper et al. 1991) seem to support this hypothesis. As a result of relocation from the position B to C (not reported from the "stable" Europe) the opening of a wide Variscan basin is desired. Its closure could take place as a result of clockwise rotation of a mid-Variscan tectonic block (Nawrocki 1991, 1992). The rotating unit (Variscia) could origin due to accretion of Perigondwanian (Cadomian ?) terranes (Van der Voo 1988) close to the SW edge of the East European Platform (Fig. 10a). In the author's opinion (1992) the movement closing the Variscan basin could be of hinge type (Fig. 10b). Another mechanism is proposed by Lewandowski (1992) who compensated for the angle of rotation with a large dextral strike-slip movement along the East European Platform edge with its rotation pole near Lake Ladoga. A similar solution has also been presented by other geologists (Arthaud & Matte 1977; Martinez-Catalan 1990). The possibility of relocating the subduction zone to the western part of the Variscan Fold Belt is an advantage of this hypothesis. However a number of geological facts known in the western foreland of the East European Platform do not fit this model. The fronts of the Carboniferous overthrusts are directed towards the edge of the East European Platform (Požaryski & Karnkowski 1992). The Rhenohercynian zone is shortened considerably just in the direction of the northern foreland of the Variscan Fold Belt (Behrman et al. 1991).

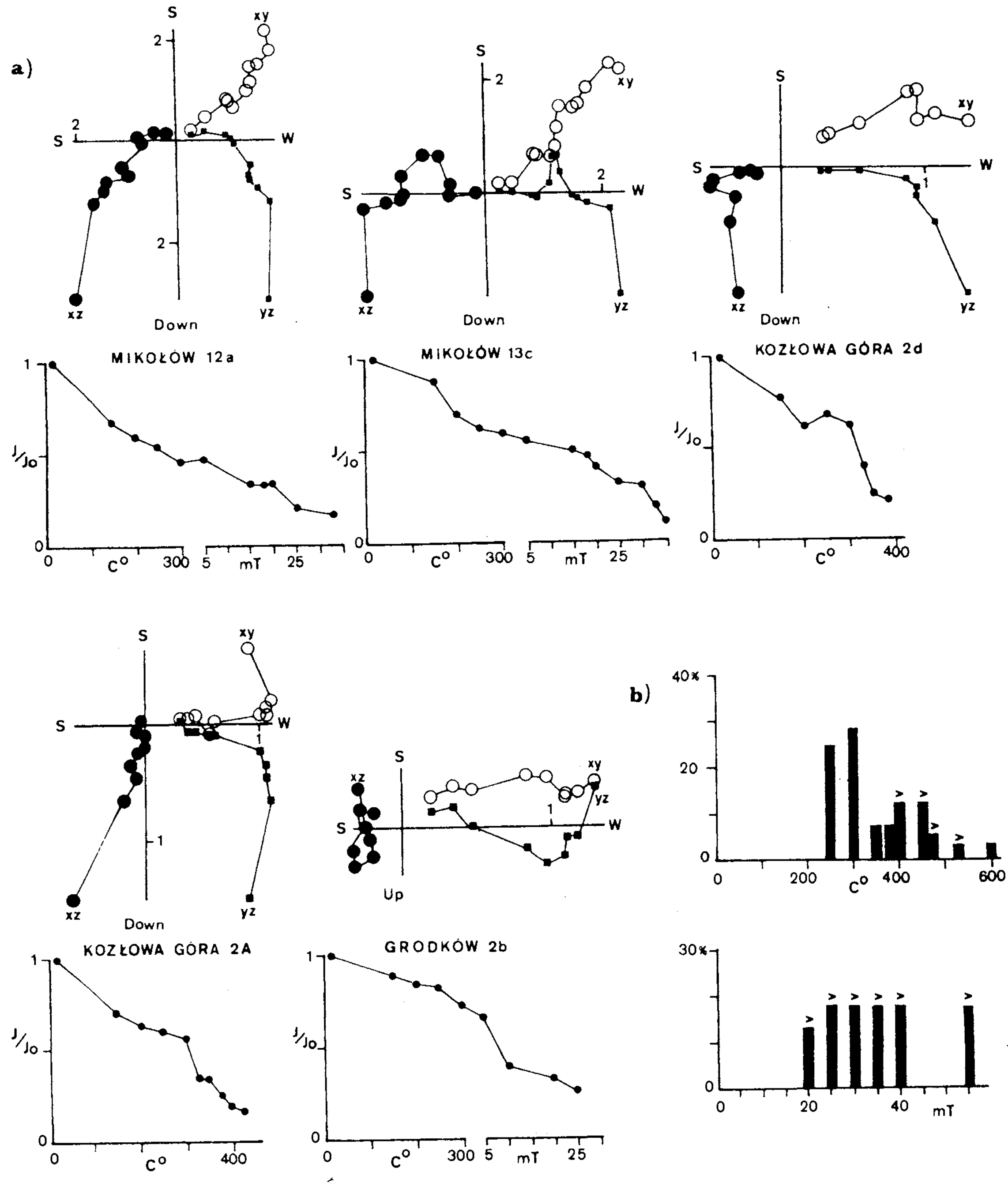

Fig. 6. a - Typical orthogonal projections and demagnetization curves of specimens with the direction B from the Namurian and Lower Westphalian sediments. **b** - The maximum unblocking temperature and coercivity diagrams.

Table 2: Summary of the palaeomagnetic results from the Upper Silesia.

Dir.cat.	Mag.-age	Tb (C°)	N/n	T.C.	D	I	α_{95}	K	W	VGP °N	VGP °E
A	Autunian	630	1/10	a	207	-16	4	125	0.9	-42	342
A1	Late West.-Autunian	≤300, ≥600	4/50	a	202	-1	6	259	6.3	-37	351
B	Late West.-Steph.	≤300, ≥600	5/36	b	256	2	10	54	0.8	-8	301
C	Namurian-Early West.	380 - 500	5/39	b	321	1	8	100	0.5	30	242

Dir. cat., cathegory of palaeodirection: Mag.-age, probable age of the magnetization: T_b, blocking temperatures: N/n, number of localites and number of samples (which had been used): T.C.-a, in situ mean directions; b, with tectonic correction: D,I, mean declination and inclination: α_{95}, K, Fisher statistic parameters: $W=K_a/K_b$ (K_a, in situ K parameter; K_b, with tectonic correction K parameter): VGP, coordinates of the virtual geographic south pole.

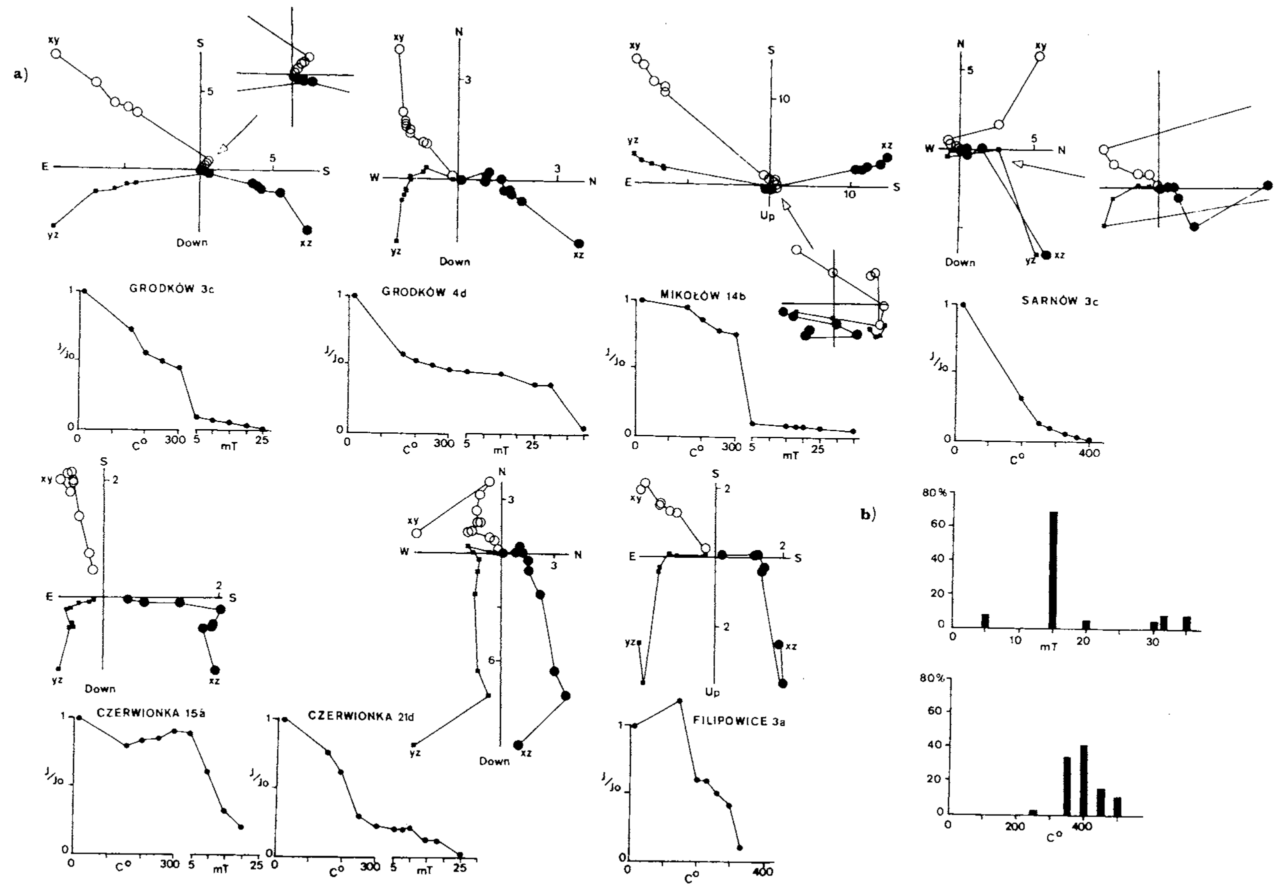

Fig. 7. a - Typical orthogonal projections and demagnetization curves of specimens with the direction C from the Namurian and Lower Westphalian sediments; **b** - The maximum unblocking temperature and coercivity diagrams.

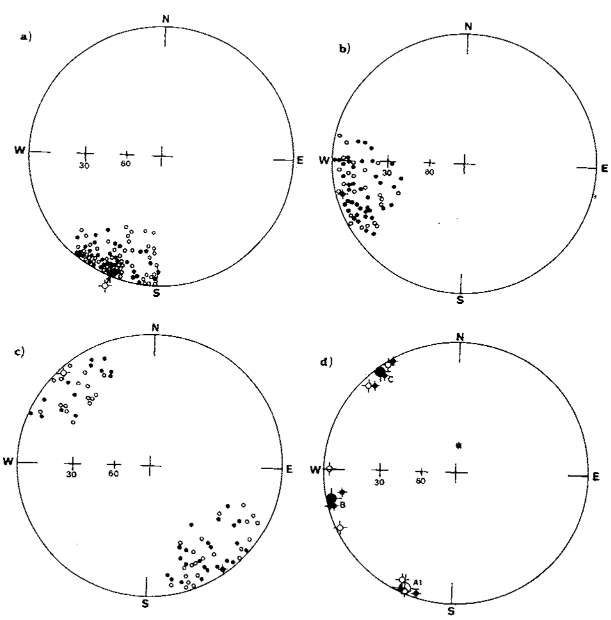

Fig. 8. Charactaristic components of NRM A1 - **a**, B - **b**, C - **c** (crossed symbol denotes mean ones), and **d** - mean directions for the localites from the Upper Silesian Coal Basin. Mean directions for the whole investigated area are indicated by big crossed circles. An asterisk denotes the present local field direction.

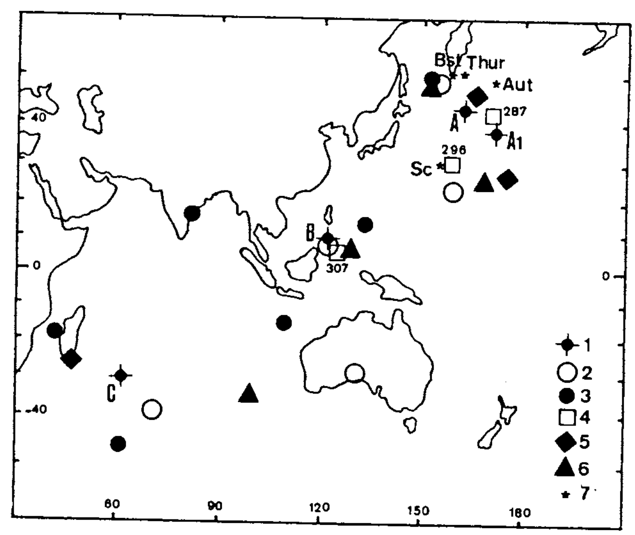

Fig. 9. Mercator projection of the virtual geomagnetic north poles of the investigated rocks from the Upper Silesian Coal Basin against a background of the Upper Paleozoic poles from the western part of European Variscides drawn up by Edel & Wickert (1991).
Legend: 1 - poles from this paper; 2 - poles from Moldanubian southern Vosges; 3 - poles from the northern Vosges; 4 - poles from dated rhyolites from Schwarzwald; 5 - poles from the Spessart; 6 - poles from the Odenwald; 7 - reference poles for the Autunian, the Thuringian and Late Buntsandstein.

At this stage of investigations a non-dipolar origin of the directions C and B can not be exluded. A large departure from the geocentric axial dipole occurred probably during the Eocene (Westphal 1993). In some rock artificial directions may be originated. They can be explained by the diagenetic magnetite formation model in which shortly after burial, the remanence carried by newly formed secondary magnetites is superposed on the initial remanence carried by primary magnetite (Van Hoof et al. 1993). Such origin of the direction C is possible because of its frequent occurrence in the same sample together with the direction A1.

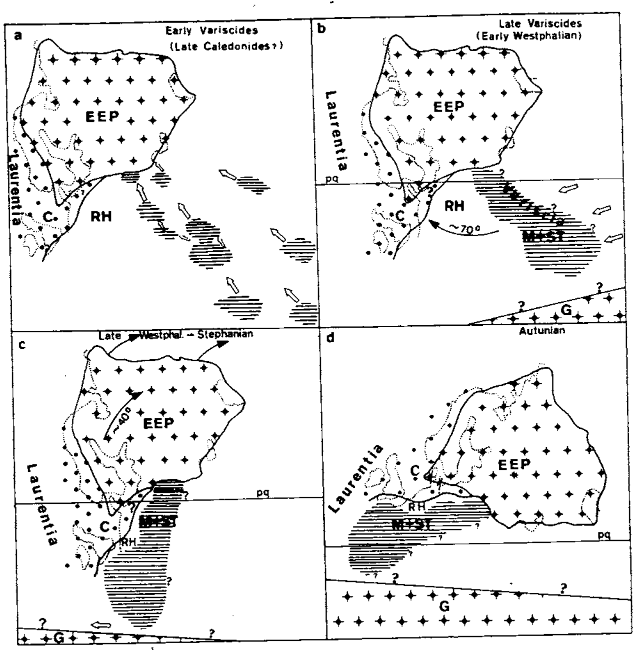

Fig. 10. Hypothetic model of evolution of the European Variscides derived respectively from the palaeomagnetic directions obtained in different places of the European Variscan Belt.
C - European Caledonides; EEP - East European Platform; G - Gondwana; RH - Rhene-Hercynian; M+ST - Moldanubian and Saxothuringian; pq - palaeoequator.

Conclusions

1 - Palaeomagnetic poles B and C separated in the western part of the European Variscides also occur in the Namurian and Early Westphalian clastic rocks from the Upper Silesian Coal Basin.

2 - Relocation of palaeodirection from position C to B could be connected with the Westphalian clockwise hinge rotation of the mid-Variscan structure.

3 - Two secondary directions occur in the Middle Devonian dolomites from Dubie quarry. The main component A was formed due to the influence of neighbouring Lower Permian volcanic intrusion. However, in the other hand it can not be excluded that the directions B and C have non-dipolar origin. Because of this their geotectonic interpretation is only tentative.

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