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Palaeomagnetism of the Lower Palaeozoic rocks from the Western Sudetes, SW Poland — preliminary report*

Palaeomagnetic studies of the Lower Ordovician metagranites an metavolcanic rocks from the Izera – Karkonosze Block and Góry Kaczawskie, respectively, revealed the presence of two characteristic directions with their poles located on the Apparent Polar Wander Paths (APWP) of Eastern Avalonia and Baltica. None of the poles fits to the APWP of Armorica Block, even after possible tectonic corrections. The pole *K* obtained from the Izera granite of Kościelniki quarry fits to the Late Ordovician-Early Silurian segment of Baltica and Eastern Avalonia paths, and the pole *M* isolated from the Kaczawa metavolcanic rock of Marciniec hill is located on their Middle Carboniferous segment. The palaeopole *M* was recorded most probably during the Visean metamorphism of the Kaczawa complex. The palaeopole *K* could have been recorded during "soft" collision of Baltica and Eastern Avalonia. On the other hand palaeopole *K* is located in the Early Ordovician segment of the APWP of Avalonia, if we assume a moderate (30°) northward tilt of the Izera unit. The obtained data do not allow to speak about separation of the Izera and Kaczawa terranes during the Ordovician.

INTRODUCTION

The Western Sudetes, occupying the northeastern part of the Bohemian Massif (Fig. 1), are recently accounted for by highly controversial geodynamic models. While many workers see them as an eastern continuation of the Saxothuringian Zone and thus an integral part of the Variscides (W. Franke *et al.*, 1993; A. Żelaźniewicz, W. Franke, 1994), some others propose a collage of Caledonian terranes and subsequent Hercynian reworking (G. J. H. Oliver *et al.*, 1993; Z. Cymerman, M. A. J. Piasecki, 1994). Palaeontological evidence pointing to continuities within and across the stratigraphic boundaries of the Palaeozoic systems in several Ordovician-Lower Carboniferous successions of the Sudetes make the Caledonian model hardly tenable (Z. Urbanek, 1975; J. Haydukiewicz, 1990; I. Chlupač, 1993; A. Żelaźniewicz, S. Cwojdziński, 1996).

*Contribution to the EUROPROBE meeting, Wrocław-Książ, April 1996.

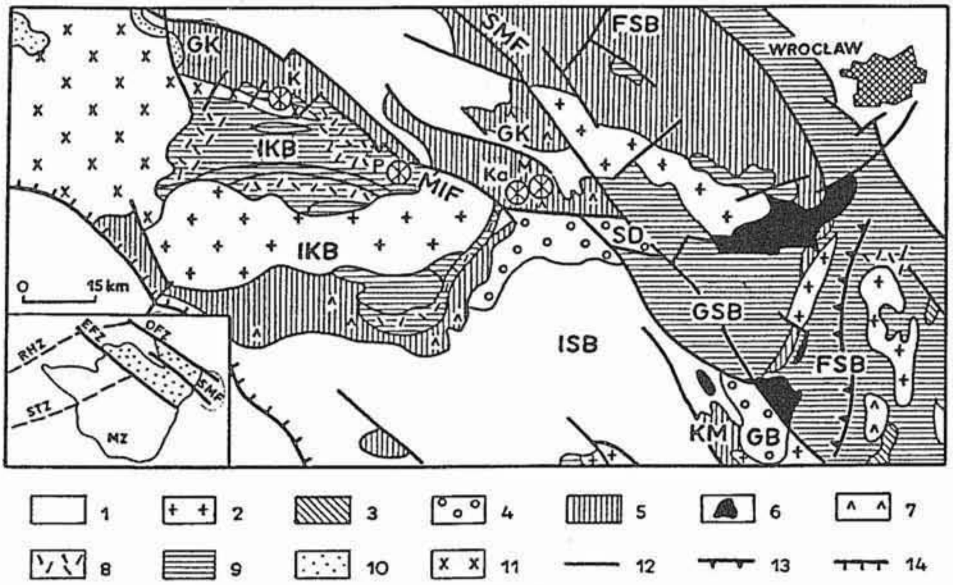


Fig. 1. Geological sketch of the Western Sudetes with location of samples for palaeomagnetic investigations (crossed circles); inset: the Sudetes in the Bohemian Massif

1 — Upper Carboniferous-Mesozoic cover; 2 — Variscan granitoids; 3 — Devonian of the Moravo - Silesian Zone; 4 — unmetamorphosed synorogenic deposits of Late Devonian-Early Carboniferous age; 5 — Ordovician-Lower Carboniferous metasediments; 6 — Sudetic ophiolite; 7 — metabasites; 8 — Lower Ordovician granitoids; 9 — Neoproterozoic-Lower Cambrian metamorphic succession; 10 — Lusatian graywacke of Vendian age; 11 — Upper Proterozoic granitoids; 12 — faults; 13 — "Moldanubian" Thrust; 14 — Lusatian Thrust; EFZ — Elbe Fault Zone; FSB — Fore-Sudetic Block; IKB — Izera - Karkonosze Block; ISB — Intra-Sudetic Depression; GB — Góry Bardzkie Mts.; GSB — Góry Sowie Block; GK — Góry Kaczawskie Mts.; SD — Świebodzice Depression; K — Kościelniki; Ka — Karczmisko crag near Mysłów; KM — Kłodzko metamorphic massif; M — Marciniec hill; MIF — Main Intra-Sudetic Fault; MZ — Moldanubian Zone; OFZ — Odra Fault Zone; P — Pilchowice dam; RHZ — Rhenohercynian Zone; SMF — Sudetic Marginal Fault; STZ — Saxothuringian Zone

Szkic geologiczny Sudetów Zachodnich z zaznaczeniem miejsc pobrania próbek do badań paleomagnetycznych (przekreślone kółka); w prostokącie: Sudety na tle masywu czeskiego

1 — pokrywa górnokarbońsko-mezozoiczna; 2 — granitoidy waryscyjskie; 3 — dewon morawsko-śląski; 4 — niezmetamorfizowane synorogeniczne osady późnego dewonu-wczesnego karbonu; 5 — zmetamorfizowana sukcesja ordowicko-dolnokarbońska; 6 — ofiolit sudecki; 7 — metabazyty; 8 — granitoidy dolnoordowickie; 9 — zmetamorfizowana sukcesja neoproterozoiczno-dolnokambryjska; 10 — wendyjskie szarogłazy łużyckie; 11 — granitoidy górnoproterozoiczne; 12 — uskoki; 13 — nasunięcie „moldanubskie"; 14 — nasunięcie łużyckie; EFZ — strefa uskokowa Łaby; FSB — blok przedsudecki; IKB — blok karkonosko-izerski; ISB — depresja śródsudecka; GB — Góry Bardzkie; GSB — blok Gór Sowich; GK — Góry Kaczawskie; SD — depresja Świebodzic; K — Kościelniki; Ka — skałka Karczmisko koło Mysłowa; KM — metamorfik kłodzki; M — wzgórze Marciniec; MIF — główny uskok śródsudecki; MZ — strefa moldanubska; OFZ — strefa uskokowa Odry; P — tama Pilchowice; RHZ — strefa reńsko-hercyńska; SMF — sudecki uskok brzeżny; STZ — strefa saksońsko-turyngska

On the other hand, there are three occurrences of the Upper Devonian conglomerates with pebbles derived from easy indentifiable sources nearby (Góry Sowie Block, Kłodzko metamorphic massif, ophiolitic rocks). Using that as one of arguments, J. Don (1990) proposed the Main Intra-Sudetic Fault (MIF) as a major fracture boundary between the Caledonian and Variscan elements in the Sudetes. G. J. H. Oliver *et al.* (1993) and J. D.

Johnston *et al.* (1994) went on yet further and took the MIF as a collision suture between Baltica and a variety of tectonostratigraphic terranes originally derived from Gondwana. This model neglects, among others, the above-mentioned stratigraphic continuities in the Palaeozoic successions throughout the Sudetes and hence is criticized (P. Aleksandrowski, 1994; A. Żelaźniewicz, W. Franke, 1994). Moreover, speculative designation of the Sudetic suscpect terranes differ widely between proponents, which makes the concept difficult to accept uncritically.

Palaeomagnetic data may potentially help in unravelling palaeogeographic position of rocks of the same age, and thus terranes embodying them, by determining their separation, velocity and direction of drift and sense of rotation. Unfortunately, palaeomagnetic studies on rocks from polyphase orogenic zones like the Sudetes are very difficult. This is due to widespread remagnetizations caused by multiple thermal and mineralization events. Moreover, palaeomagnetic directions obtained from the deformed rocks even of determined age could have been obscured by rotation removing them from their position at the time of magnetic acquisition (see e.g. D. Setiabudidaya *et al.*, 1994). Therefore caution must be exercised while interpreting the palaeomagnetic data.

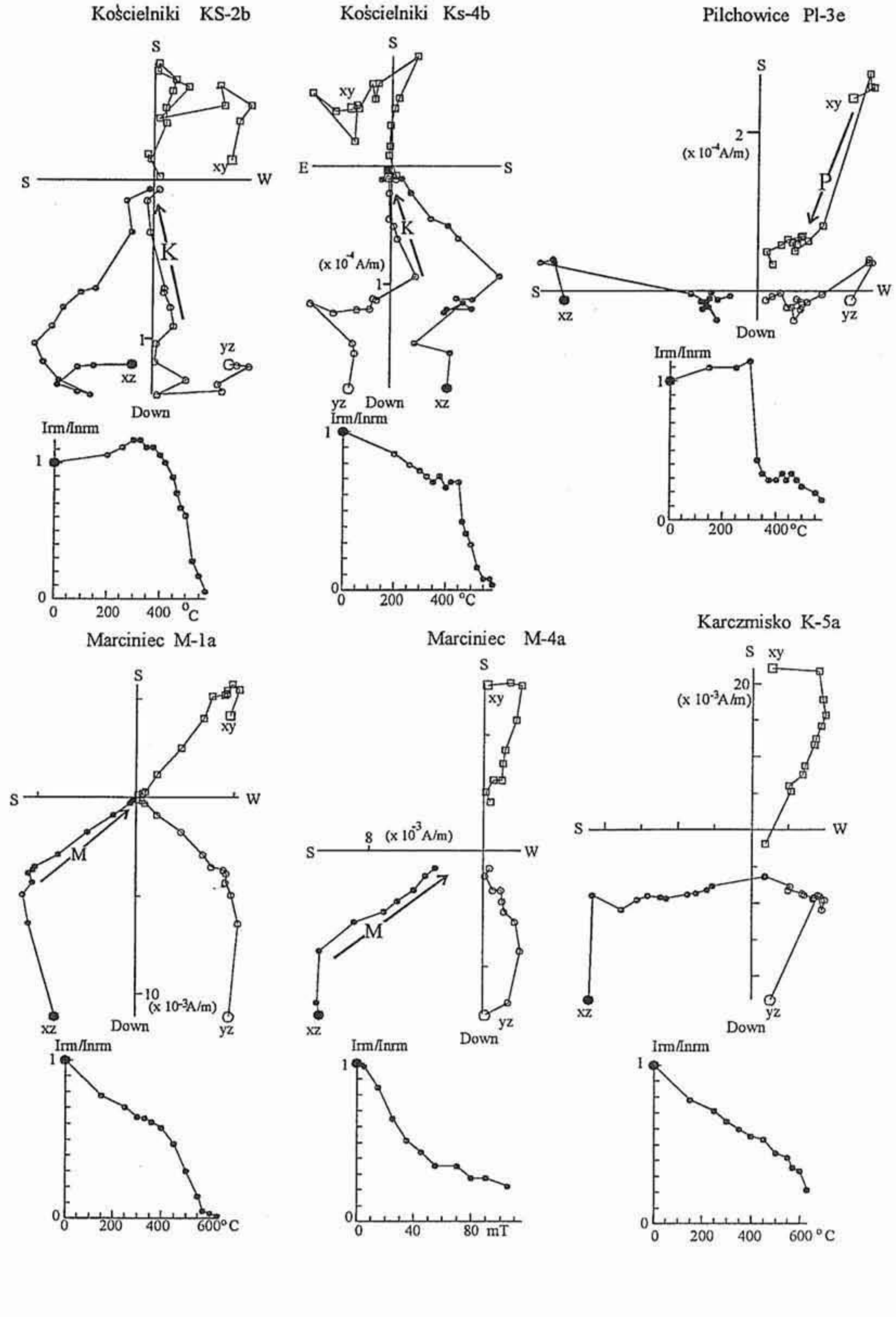
Having in mind the potential of the MIF to weld lithospheric plates or terranes, separated during the Ordovician by ca. 3000 km wide Tornquist Sea, we have attempted to get some relevant information from palaeomagnetic measurements made on the Ordovician rocks lying on either side of the MIF, i.e. on the opposite sides of the Tornquist Sea (Fig. 1).

GEOLOGICAL SETTING

We collected samples from gneisses of the Izera – Karkonosze Block (IKB) occurring to the south of the MIF, considered a critical plate suture (G. J. H. Oliver *et al.*, 1993), and from acid volcanic rocks of the Góry Kaczawskie Mts. (GK) to the north of it. The sampled localities were selected to have the IKB and GK rocks on two different terranes designed by Z. Cymerman and M. A. J. Piasecki (1994).

The Izera – Karkonosze Block in its northern part, from which our samples have come, consists mostly of (meta)granites emplaced during the Early Ordovician 515–480 Ma interval as shown by U-Pb multigrain (A. Korytowski *et al.*, 1993; S. Philippe *et al.*, 1995) and Pb-Pb single grain zircon ages (A. Kröner *et al.*, 1994), roughly consistent with Rb-Sr whole rock (errochrone) ages of 500–460 Ma provided by M. Borkowska *et al.* (1980). These granites, widely retaining their original igneous textures, became later heterogeneously deformed in superposed, generally subvertical zones of localized ductile shearing (A. Żelaźniewicz, 1996). The age of this polyphase shearing remains largely undetermined. However, younger dextral transpressional regime well seen in the MIF zone must have occurred under greenschist facies conditions during the Visean, after the deposition of the Visean limestones in the GK but before the intrusion into the middle of the IKB of the Variscan Karkonosze Granite that yielded a Rb-Sr whole rock isochron age of 324±11 Ma (C. Pin *et al.*, 1988). On intruding the granite exerted some contact effect on its country rock within a ca. 500 m wide thermal aureole.

The Góry Kaczawskie succession of (Cambrian?) Ordovician-Early Carboniferous age consists of the Ordovician sandstone-shale sediments passing upwards into the Silurian-


Kościelniki KS-2b
Kościelniki Ks-4b
Pilchowice Pl-3e
Marciniec M-1a
Marciniec M-4a
Karczmisko K-5a
xy
xz
yz
Down
K
P
M
(x 10^{-4}A/m)
(x 10^{-3}A/m)
Irm/Inrm
200
400 °C
600 °C
40
80 mT

Middle to Upper Devonian pelagic clayey-siliceous deposits subjected during the Early Carboniferous to widespread turbiditic redeposition within sedimentary-tectonic melanges (Z. Baranowski *et al.*, 1990; Z. Urbanek *et al.*, 1995). The Ordovician-Silurian sedimentation was accompanied by bimodal volcanism bearing a within-plate, alkaline signature, maturing with time toward N-MORB pillow basalts. Although the basaltic volcanism has not been dated more closely as yet, the acid element of this bimodal volcanogenic suite yielded a U-Pb multigrain zircon age of 511±39 Ma (unpublished data of C. Pin, *cf.* R. Kryza, A. Muszyński, 1992).

The Góry Kaczawskie succession experienced some blueschist metamorphism at $P >$ 12 kb and 300–400°C followed by regional greenschist overprint at $P < 8$ kb and T 350–450°C (R. Kryza, 1996). The unpublished geochronological data of H. Maluski are consistent with the Ar-Ar ages obtained for the Železný Brod metabasites in the South Karkonosze (Rýchory Mts.), yielding ca. 360 and 340 Ma for blueschist and greenschist metamorphism, respectively (H. Maluski, F. Patočka, 1996). The greenschist event swept also the IKB rocks in the MIF zone at the dextral transpressional contact with the Góry Kaczawskie succession (A. Żelaźniewicz, 1996).

SAMPLING AND LABORATORY METHODS

20 hand oriented samples were taken from the (meta)granites of the Izera – Karkonosze Block in two localities. One is an abandoned quarry east of Kościelniki (12 samples), the other is a craggy cliff near the Pilchowice dam (8 samples). In both cases, in spite of proximity to the MIF, the sampled rocks are very little deformed and have well preserved texture of a coarse-grained porphyritic granite. The granite from Kościelniki is dated at 500±12 Ma (U-Pb multigrain abraided zircon age: S. Philippe, personal communication). The granite from Pilchowice is undated, but nearby locality of the same rock up the course of the Kwisa river has rocks with U-Pb zircon age of 514±11 Ma (A. Korytowski *et al.*, 1993).

In the Góry Kaczawskie Mts. sampled were acid metavolcanic rocks occurring on the southwestern slope of the Marciniec hill (15 samples) and in the crag Karczmisko (5 samples). The Marciniec rock is foliated and folded, and coarse-grained Karczmisko keratophyre has much poorer record of penetrative deformation, yet it is much steepened by almost 90° likewise the surrounding metasediments. It is the rock from Marciniec that

Fig. 2. Results of demagnetization (orthogonal plots and intensity decay curves) of Early Palaeozoic magmatic rocks from the western part of Sudetes

x, *y*, *z* — the planes of the projection, *Inrm* — the intensity of the natural remanent magnetization, *Irm* — the intensity of the remanent magnetization after demagnetization; orthogonal plots were prepared *in situ* coordinates

Wyniki rozmagnesowania (diagramy ortogonalne oraz krzywe spadku natężenia) wczesnopaleozoicznych skał magmowych z zachodniej części Sudetów

x, *y*, *z* — płaszczyzny projekcji, *Inrm* — natężenie naturalnej pozostałości magnetycznej, *Irm* — natężenie pozostałości magnetycznej po rozmagnesowaniu; projekcje ortogonalne wykonano w układzie bez korekcji tektonicznej

Table 1

Palaeomagnetic data from the Early Palaeozoic granitoids and metavolcanites of the Western Sudetes

Locality	Rocks, age	$N_0/N/n$	D	I	α_{95}	K	F	L	dp	dm	$Tbmx$ [°C]	P
Kościelniki	granitoids, 511 Ma	12/8/20	190	48	3.8	76.6	10S, 27N*	6E, 16E*	3.2	4.9	575	1.04–1.06
Marciniec	metavolcanites, 510 Ma	15/13/35	206	23	3.2	56.8	25S	349E	1.8	3.4	630	1.03–1.07
Pilchowice	granitoids, 514 Ma(?)	88/7/27	179	–1	4.9	33.6	39S	12E	2.4	4.9	450	1.04–1.08

N_0 — number of samples investigated; N — number of samples with characteristic direction; n — number of specimens with characteristic direction; D — declination; I — inclination; α_{95}, K — Fisher's statistic parameters; F, L — latitude and longitude of the southern palaeomagnetic pole; dp, dm — error of the distance between site and palaeopole, and palaeodeclination error; $Tbmx$ — maximum blocking temperatures; P — degree of magnetic susceptibility anisotropy; * — pole coordinates after assumed tectonic correction

yielded the above-mentioned U-Pb zircon age of ca. 511 Ma. Keratophyres of Karczmisko remain undated. Accordingly, both the IKB gneisses and GK acid metavolcanic rocks are of the same Early Ordovician crystallizational/emplacement age.

Accordingly, it may be assumed that the magnetic carriers were primarily magnetized during the Early Ordovician at the time of intrusion and extrusion, of the IKB and GK rocks, respectively. In both cases remagnetization is to be expected during the Visean greenschist metamorphism, in particular in the Kaczawa rocks which were deformed at that time.

Unfortunately, the position of the palaeohorizons in the sampled rocks at the time of magnetization is difficult to determine. For the GK samples tectonic correction was made according to the attitude of the bedding foliation plane observed in the neighbouring metasediments. In the Izera granite outcrops there is no reliable geological evidence for a tectonic tilt, yet some authors assume some northward tilt of the Izera rocks caused by the ascent of the Karkonosze Granite (S. Mazur, R. Kryza, 1994).

Several core specimens with 2.2 cm diameter and 2.2 cm lenght were drilled from each sample. Each specimen has been subjected to stepwise demagnetization in nonmagnetic oven with mimetal screens. The natural remanent magnetization (NRM) of specimens was measured by means of *JR-5* spinner magnetometer. Demagnetization and measurements were carried out in a cage reducing the ambient field by about 95%. Magnetic susceptibility was measured using *KLY-2* susceptibility bridge. The thermomagnetic method, in which the saturation remanence versus temperature is observed, was used to determine the nature of magnetic carriers. The principal component analysis as presented by J. L. Kirschvink (1980) was used to determine the components of NRM and their unblocking temperature spectra.

RESULTS OF DEMAGNETIZATION AND MAGNETIC SUSCEPTIBILITY ANISOTROPY INVESTIGATIONS

GRANITOIDS

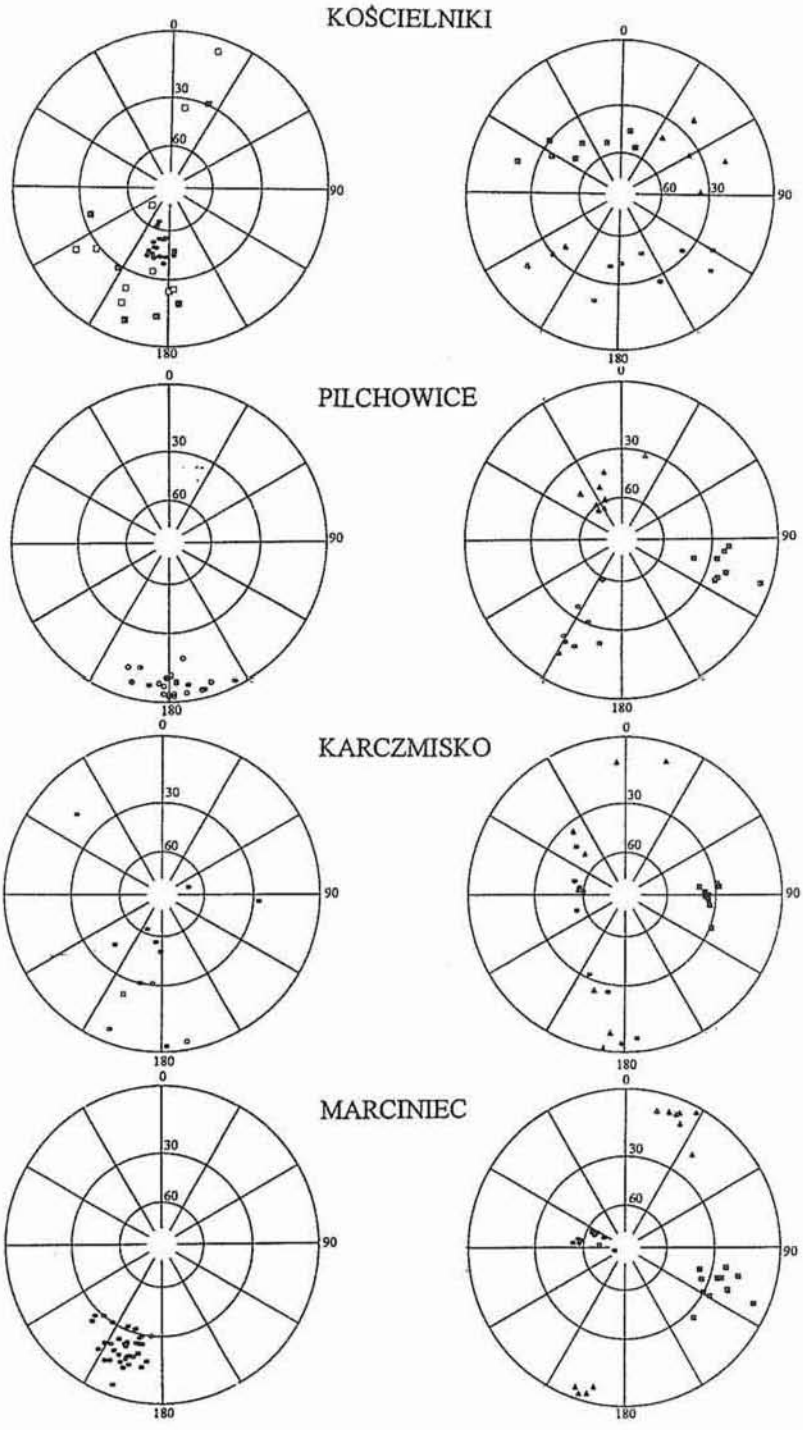
Kościelniki. The NRM intensities fluctuated here from 0.3 to 2.5 x 10^{-4}A/m. In most of specimens only one component of NRM (labelled *K*) with maximum blocking temperatures of about 575°C was isolated (Fig. 2). A little fluctuation of this component during subsequent heating is a permanent feature observed on the demagnetization path but all the obtained high-temperature characteristic directions are very well clustered (Tab. 1, Fig. 3). In some specimens low-temperature components also occurred. Unfortunately, they are very scattered (Fig. 3). The degree of Anisotropy of Magnetic Susceptibility (AMS) *P* ranges from 1.039 to 1.065. The main axes of anisotropy are dispersed (Fig. 3). Hardly some characteristic directions correspond to the minimum anisotropy axes obtained for the same specimen. These features are consistent with the obvious lack of tectonic fabric and metamorphic overprint in the sampled granite and emphasize the significance of the component *K* possibly acquired at the time of intrusion or during its cooling.

Pilchowice. The NRM intensities of Pilchowice granite varied from 0.4 to 3.6 x 10^{-4}A/m. Major decrease of the NRM intensities during thermal demagnetization took place at temperature range of 300–350°C (Fig. 2). At those temperatures component with shallow inclination (labelled *P*) was removed. Most of specimens revealed also the presence of low temperature components with steep inclinations, most probably of recent(?) origin. The main axes of the AMS are grouping very well (Fig. 3) but none of them corresponds to the direction *P*. The degree of anisotropy varies from 1.037 to 1.084. Equatorial values of inclination may show that the acquisition of the component *P* mostly likely occurred during the Carboniferous overprint at the MIF zone. The pronounced AMS corresponds well with the foliation-normal shortening during the Visean dextral transpression.

METAVOLCANIC ROCKS

Marciniec. The NRM intensities were here much higher than those observed in the Izera granite and fluctuated from 6.5 to 18 x 10^{-3} A/m. During thermal demagnetization, after removing a low temperature component, at the temperature range of 250–630°C only one component (labelled *M*) was observed (Fig. 2). Alternating field demagnetization experiment revealed also the presence of the component *M* (Fig. 2), whose internal homogeneity at the sample and locality levels is very good (Tab. 1). The magnetic susceptibility anisotropy axes are grouping distinctly at the right angle to the structural grain of the GK produced by the SSW-vergent overall shortening of the Kaczawa complex during the Early Carboniferous times. Yet the direction *M* does not correspond to the AMS (Fig. 3). The degree of anisotropy *P* varies from 1.034 to 1.069.

Karczmisko. The intensities of NRM of metakeratophyre from the Karczmisko crag were slightly lower than those noted in the samples from Marciniec, and varied from 1.8 to 5.6 x 10^{-3}A/m. Although in single specimens the characteristic directions, separated at the


KOŚCIELNIKI
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MARCINIEC

temperatures up to 630°C, are very distinct (Fig. 2), their clustering at the sample and locality level is very poor (Fig. 3). The degree of magnetic susceptibility anisotropy *P* fluctuated between 1.045 and 1.162. The anisotropy axes (Fig. 3) are clustered in the way characteristic for the secondary tectonic deformation when so-called "pencil" structures are formed (R. Kligfield *et al.*, 1983).

MAGNETIC CARRIERS

Thermomagnetic curves prepared for the metavolcanic rocks from the Karczmisko crag and the Marciniec hill show the presence of hematite with blocking temperatures of about 675°C (Fig. 4). Significant decrease of isothermal remanence at lower temperatures indicates the likely presence of another magnetic mineral. During the demagnetization experiment the largest decrease of the NRM intensity was observed at the temperature range of 400–550°C and in the demagnetizing field not higher than 50 mT (Fig. 2). Therefore it is very probable that magnetite is also an important magnetic carrier in the investigated rocks.

The largest decrease of isothermal magnetization of the Izera granite samples takes place at temperatures below 600°C, although a small hematite "tail" is also observed (Fig. 4). However, the shape of demagnetization curves (Fig. 2) indicate that magnetite is the main carrier of remanence in the Kościelniki granite. A significant increase of isothermal remanence after the first heating was noted in the sample from Pilchowice (Fig. 4). This increase together with a sharp decrease of the NRM intensity at the temperature range of 300–330°C (Fig. 2) may indicate that ferric sulphide (pyrrothite?) is the main NRM carrier in this granitoid.

DISCUSSION OF THE RESULTS

The palaeopoles *K* and *M* taken *in situ* or tectonically corrected fit well the Apparent Polar Wander Paths (APWP) of Baltica and Eastern Avalonia (Fig. 5). None of palaeomagnetic poles isolated here fits the APWP of Armorica. It should be stressed, however, that the APWP of Armorica is as yet very tentative (see V. Bachtadse *et al.*, 1995). The palaeopole *P* is located away from the two mentioned paths. This fact may be related either to local tectonic rotation on the MIF zone during the Visean dextral transpression, or taken as artefact. However, some Permian palaeopoles from the Sudetes have been found rotated

Fig. 3. Stereographic projections of the characteristic components of the remanent magnetization (on the left) and the main axes of magnetic susceptibility obtained from the Sudetic Lower Palaeozoic rocks

The low temperature components from Kościelniki and maximum susceptibility axes are marked by squares; in the susceptibility graphs circles mark the minimum susceptibility axes, triangles — intermediate susceptibility axes

Projekcje stereograficzne składowych charakterystycznych pozostałości magnetycznej (z lewej strony) oraz głównych osi podatności magnetycznej otrzymanych z sudeckich, dolnopaleozoicznych skał magmowych

Niskotemperaturowe składowe z Kościelnik oraz osie maksymalnej podatności zaznaczono kwadratami; na projekcjach osi podatności magnetycznej kółkami zaznaczono osie minimalnej podatności, natomiast trójkątami — osie pośredniej podatności

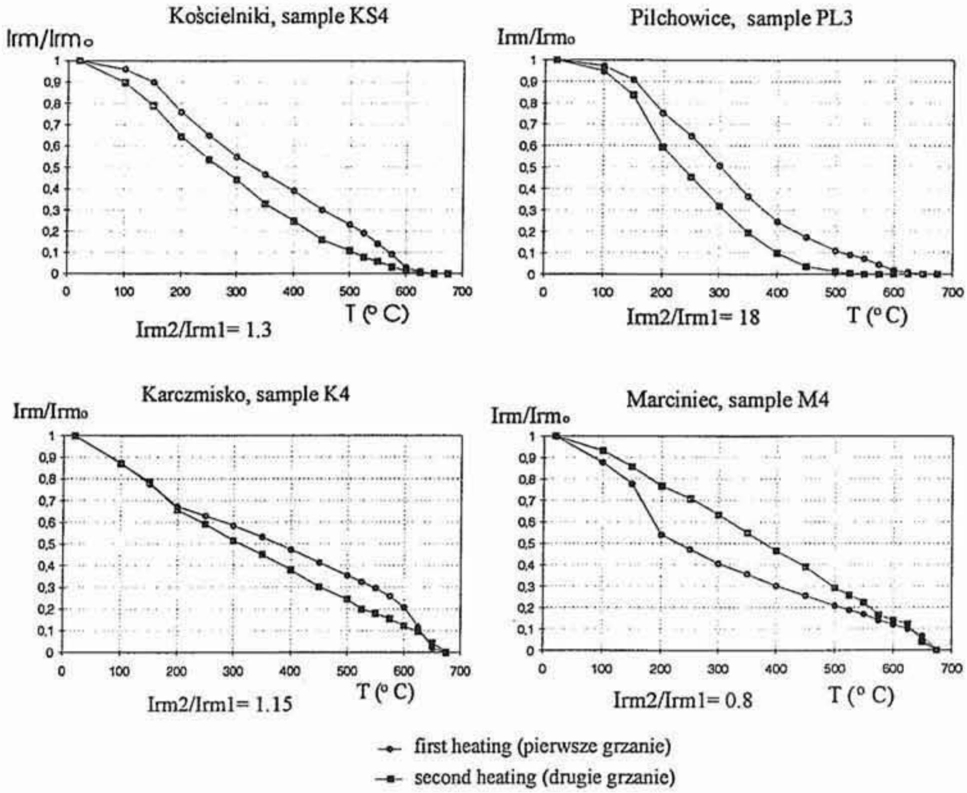

Fig. 4. Examples of intensity decay curves of isothermal remanence (saturated in 1 Tesla field) during heating of Early Palaeozoic magmatic rocks from the western part of Sudetes

Irm_0 — isothermal remanence before heating, *Irm* — isothermal remanence during heating, *Irm*1— isothermal remanence before first heating, *Irm*2 — isothermal remanence before second heating

Przykłady krzywych spadku natężenia pozostałości izotermicznej (nasyconej w polu 1 tesli) z biegiem wygrzewania wczesnopaleozoicznych skał magmowych z zachodniej części Sudetów

Irm_0 — pozostałość izotermiczna przed grzaniem, *Irm* — pozostałość izotermiczna w trakcie grzania, *Irm*1 — pozostałość izotermiczna przed pierwszym grzaniem, *Irm*2 — pozostałość izotermiczna przed drugim grzaniem

anticlockwise by 15° from the expected positions (J. Nawrocki, 1995). All the palaeopoles most probably were little affected by tectonic stress, because they are not convergent with the axes of anisotropy of magnetic susceptibility, which otherwise is consistent with low amount of strain record in both the IKB and GK rocks. A large scatter of characteristic directions in the metavolcanic rock from Karczmisko could be connected with relatively greater degree of anisotropy.

If the coincidence of the palaeopoles *K* and *M* with the APWP of Baltica and Avalonia is not accidental, we can assume that the palaeopole *M* is of the Visean age and fits the APWP of Baltica, while palaeopole *K* is of the Late Ordovician age and fits the APWP for Avalonia (Fig. 5).

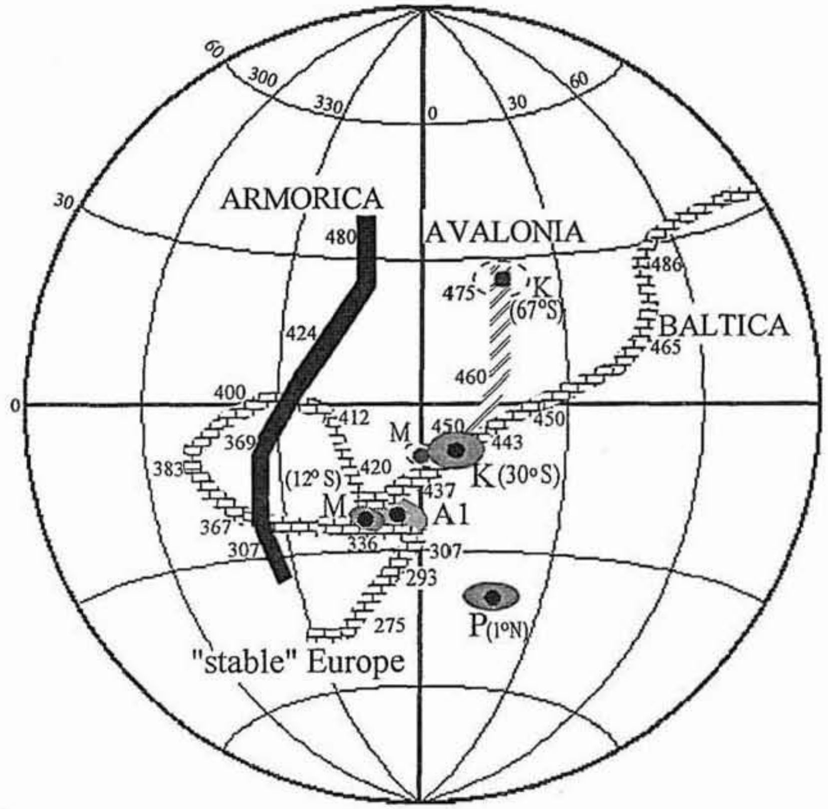

Fig. 5. Apparent Polar Wander Paths for Baltica (T. H. Torsvik *et al.*, 1992), Eastern Avalonia (T. H. Torsvik *et al.*, 1993) and Armorica (T. H. Torsvik *et al.*, 1990), and pre-Permian palaeomagnetic poles from Sudetes

A1 — pole from the Sudetic ophiolite (M. Jeleńska *et al.*, 1995), *K, M, P* — poles presented in this paper; poles with ovals of confidence drawn by dashed line are shown after tectonic correction; 30° of northward (azimuth 15°) tilt of the Kościelniki granite was assumed (see S. Mazur, R. Kryza, 1994); numbers in the brackets indicate the palaeolatitudes of investigated area calculated according to the palaeopole; ages in Ma

Ścieżki pozornej wędrówki paleobieguna charakterystycznego dla Baltiki (T. H. Torsvik i in., 1992), wschodniej Awalonii (T. H. Torsvik i in., 1993) i Armoryki (T. H. Torsvik i in., 1990) oraz przedpermskie paleobieguny z Sudetów

A1 — biegun z ofiolitu sudeckiego (M. Jeleńska i in., 1995), *K, M, P* — bieguny przedstawione w tym artykule; bieguny z owalem ufności wykreślonym linią przerywaną naniesiono po korekcji tektonicznej; przyjęto, że skierowany ku północy (azymut 15°) upad granitu z Kościelnik wynosi 30° (patrz S. Mazur, R. Kryza, 1994); liczby w nawiasach oznaczają paleoszerokości geograficzne miejsca badań odnoszące się do danego paleobieguna; wiek w milionach lat

The Late Visean age of the palaeopole *M* is very probable because at that time the studied metavolcanites were subjected to greenschist metamorphism (R. Kryza, A. Muszyński, 1992). Poles positioned much alike the pole *M* were isolated from the Sudetic ophiolite by M. Jeleńska *et al.* (1995, Fig. 5, pole *A1*). They have been interpreted as Silurian ones because of the isotopic U-Pb zircon data (G. J. H. Oliver *et al.*, 1993) pointing to crystallization time of the gabbro protolith. However, Silurian and Carboniferous segments of the APWP for Baltica lie very close to each other. Therefore the Late Visean age of the pole *A1* is quite likely as well. The Carboniferous palaeopoles convergent with *M* and *A1* were also noted in the other parts of the Variscan orogen (J. B. Edel, F. Wickert, 1991).

Mechanism of acquisition of the palaeopole *K* is not clear. If it is really of Late Ordovician-Early Silurian age, then its acquisition could be connected with "soft" collision of Baltica and Eastern Avalonia that took place just at that time (see T. H. Torsvik *et al.*, 1993). However, the solution assuming a moderate (≈ 30°) syn-Variscan northward dipping of studied granitoids can not be excluded. Then palaeopole *K* corrected in such a way is located in the Early Ordovician segment of Avalonian APWP (Fig. 5), hence close to the emplacement age of the studied granite. This place at least northern part of the Izera–Karkonosze Block on the Early Ordovician Avalonia and can require collision with Baltica by the Late Ordovician when the two APWP paths met. However, it should not necessary mean that the Góry Kaczawskie Mts. were part of the Baltica. With illegible Early Ordovician directions in our samples, the Kaczawa complex may, in view of the data in hand, by that time belong to either Baltica or Avalonia, if tectonic corrections for the observed folding of the Marciniec rocks are carefully made.

In the Pilchowice, Marciniec and Karczmisko samples similar maxima of the magnetic anisotropy axes (Figs. 3, 5) are probably related to the Visean principal tectonic stress operating along the SSW–NNE direction. Magnetic lineation observed in the neighbouring, post-orogenic Variscan Karkonosze Granite (H. Diot, M. P. Mierzejewski, 1994) is obviously younger and perpendicular to those recognized in the IKB and GK.

It should be noted that the scatterd AMS pattern observed in the samples from Kościelniki is completely different from other samples and consistent with little strain.

CONCLUSIONS

It follows from this study that:

— separation of parts of the Sudetes (suspect terranes) by the Tornquist Sea during the Ordovician cannot be inferred from the currently obtained palaeomagnetic data;

— no evidence exists for any large-scale strike-slip displacements along the MIF zone (alleged Baltica-Gondwana suture of G. J. H. Oliver *et al.*, 1993) at least from the Late Ordovician onwards, which precludes the Caledonian oblique collision in the Sudetes;

— by the Carboniferous the Sudetes were all assembled within Baltica and Avalonian segments of the Laurussia;

— during the Ordovician at least the IKB, and possibly both IKB and GK, might be linked to Avalonia;

— there is no indication in the Sudetes for connection with Armorica during the whole Palaeozoic;

— limited number of the studied localities and lack of well defined pre-Permian structural controls on palaeohorizons do not allow at the moment to draw more precise conclusions.

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PALEOMAGNETYZM SKAŁ DOLNEGO PALEOZOIKU Z ZACHODNIEJ CZĘŚCI SUDETÓW — KOMUNIKAT WSTĘPNY

Streszczenie

W wyniku badań paleomagnetycznych dolnoordowickich metagranitów i metawulkanitów z bloku izersko-karkonoskiego i Gór Kaczawskich wyodrębniono dwa kierunki charakterystyczne, których bieguny ulokowane są na ścieżce pozornej wędrówki bieguna paleomagnetycznego charakterystycznego dla wschodniej Awalonii i Baltiki. Żaden z biegunów nie nawiązuje do ścieżki armorykańskiej, nawet po wykonaniu możliwej korekcji tektonicznej. Biegun *K*, który otrzymano z granitów izerskich odsłaniających się w Kościelnikach, położony jest na późnoordowickim-wczesnosylurskim segmencie ścieżki bałtycko-awalońskiej. Biegun *M*, który wyodrębniono z metawulkanitów kaczawskich, opróbowanych na wzgórzu Marciniec, ulokowany jest na środkowokarbońskim segmencie tej ścieżki. Biegun ten zapisał się najprawdopodobniej w wyniku wizeńskiego metamorfizmu, jaki objął kompleks kaczawski. Biegun *K* mógł się utrwalić z jednej strony w wyniku „miękkiej" kolizji Baltiki i wschodniej Awalonii. Z drugiej jednak strony biegun ten lokuje się na wczesnoordowickim fragmencie ścieżki awalońskiej, jeśli założymy umiarkowany (30°), północny upad jednostki izerskiej.