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Jerzy NAWROCKI

Palaeomagnetic constraints for Variscan mobilism of the Upper Silesian and Małopolska Massifs, southern Poland — discussion

INTRODUCTION

Recently, M. Lewandowski (1994) has presented a mobilistic interpretation of my palaeomagnetic data from the Cracow – Silesia region (J. Nawrocki, 1993*a*, *b*) and even considered them as the next palaeomagnetic evidence for large-scale mobility of the Małopolska Block in Variscan time (see also M. Lewandowski, 1993). In fact, that paper has a polemic character and in my opinion ought to be treated as a comment on my "stationary" interpretations, more so that in my earlier works mobilistic interpretations were presented as well (e.g., J. Nawrocki, 1992*a*).

The present paper shows that there are no reliable palaeomagnetic arguments for large scale dextral strike-slip displacement of the Małopolska and Upper Silesian Massifs during the Variscan orogeny, and possible smaller-size tectonic rotations (up to 30°) in the syn-Asturian tectonic phase are less probable than a relative stationary model.

TIME ERROR

"In the Givetian (377±3 Ma) dolomites of NE margin of the USCB the pre-folding age of characteristic component of NRM (CHRM) has been detennined (J. Nawrocki, 1993*a*, *b*). Since the age of tectonic defonnation is estimated to be of syn-Asturian age (ca. 290

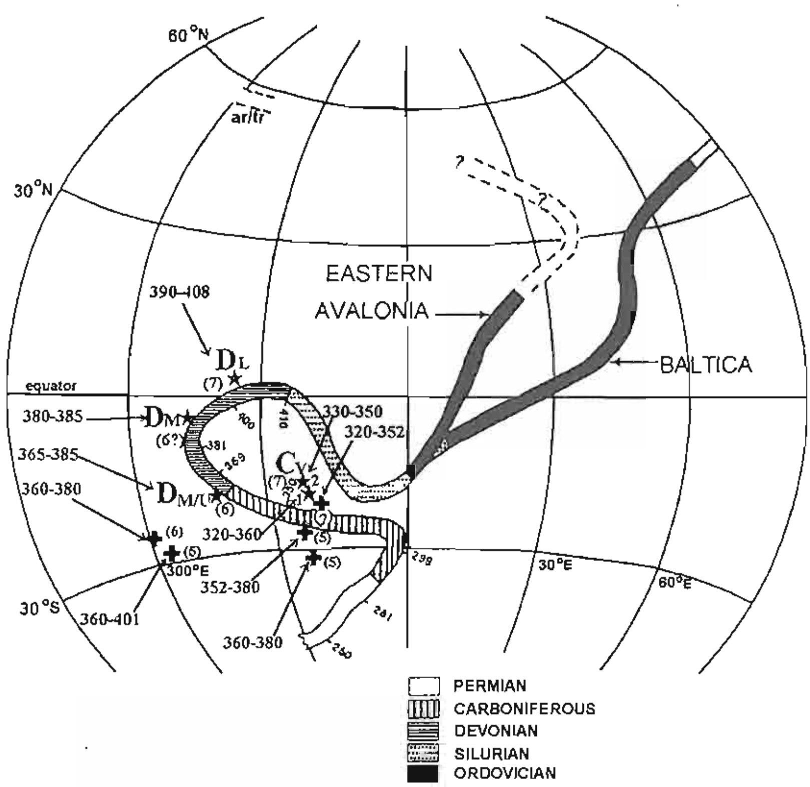

Fig. 1. The most reliable Devonian-Early Carboniferous palaeomagnetic poles from stable Europe (stars) and North America (crosses after Bullard fit *fide* R. Van der Voo, 1990) on a background of the Apparent Polar Wander Path (APWP) for Eastern Avalonia and Baltica prepared by T. H. Torsvik *et al.* (1993); total quality factor (reliability criteria after R. Van der Voo, 1990) is presented in the brackets; upper and lower time limit for each pole is also described; American poles were selected from R. Van der Voo's (1990, 1993) list

D_L — pole after M. A. Smethurst and A. N. Khramov (1992); D_M — after A. N. Didenko and D. M. Pechersky (1989); $D_{M/U}$ — after K. M. Storetvedt and T. H. Torsvik (1985); $Cv_{(1)}$ — after R. L. Wilson and C. W. F. Everitt (1963); $Cv_{(2)}$ — after J. D. A. Piper *et al.* (1991); ages in My; ar — Arenig; tr — Tremadoc

Najbardziej wiarygodne dewońsko-wczesnokarbońskie bieguny paleomagnetyczne z obszaru stabilnej Europy (gwiazdki) i Ameryki Północnej (krzyżyki po przekształceniu Bullarda *fide* R. Van der Voo, 1990) na tle ścieżki pozornej wędrówki bieguna sporządzonej (T. H. Torsvik i in., 1993) dla wschodniej Awalonii i Baltiki, którą skonstruowali T. H. Torsvik i in. (1993); sumaryczny współczynnik jakości (kryteria wiarygodności według R. Van der Voo, 1990) zaprezentowano w nawiasach; przedstawiono również górną i dolną granicę wieku każdego bieguna; bieguny amerykańskie wybrano ze zbiorów R. Van der Voo (1990, 1993)

Bieguny według: D_L — M. A. Smethursta i A. N. Chramowa (1992), D_M — A. N. Didenki i D. M. Pecherskiego (1989), $D_{M/U}$ — K. M. Storetvedta i T. H. Torsvika (1985), $Cv_{(1)}$ — R. L. Wilsona i C. W. F. Everitta (1963), $Cv_{(2)}$ — J. D. A. Pipera i in. (1991); wiek w milionach lat; ar — arenig; tr — tremadok

Ma), it implies that the time error of determination of the age of the CHRM comprises some 90 Ma." (M. Lewandowski, 1994, p. 213).

The investigated dolomites are of Eifelian-Early Givetian age. They occur between Lower Devonian clastic sediments (S. W. Alexandrowicz, 1970) and Late(?) Givetian limestones (M. Narkiewicz, G. Racki, 1987). Palaeomagnetic samples were taken from the middle part of the dolomitic sequence. Because of this, the lower limit of determined time error is even older. Applying only the fold test, the age of magnetization should be bracketed between 290 and 385 Ma. However, other criteria should usually be used for more exact estimation of the time of magnetization.

THE ORIGIN OF NRM

ORIGIN OF MAGNETIC CARRIERS

"Dolomitization, however, is not a precondition, since secondary magnetite may originate in limestones or dolomites due to much later diagenetic processes. A vast literature reports a significant gap between the age of carbonates and the time of acquisition of a chemical remanent magnetization residing in fine-grained diagenetic magnetite."... "...titaniferous iron oxide grains are the only direct evidence for a possible magnetic carrier of the primary magnetization in carbonates." (M. Lewandowski, 1994, p. 213–214).

Dolostones from the Nowa Wioska and Podleśna quarries have eogenetic or early diagenetic origin (S. Śliwiński, 1964). They have never been heated in the geological past (see Z. Bełka, 1993).

North American carbonates were remagnetized during the Permo-Carboniferous Alleghenian orogeny most probably due to crystallization of magnetite mediated by slightly heated orogenic fluids (D. Suk *et al.*, 1993). However, neither Permo-Carboniferous nor Early Permian (observed very often in Europe) remagnetizations occur in the Middle Devonian dolomites from the Siewierz Anticline. Moreover, the *D* direction observed in the Siewierz Anticline does not occur in the younger (Frasnian-Late Tournaisian) limestones from the Dębnik Anticline (situated only 40 km far from Siewierz). Therefore, simple comparison of Siewierz carbonates with North American ones does not seem adequate.

Titaniferous iron oxide grains are not only direct evidence for a possible magnetic carrier of the primary magnetization in carbonates. Primary magnetization in a significant part of carbonate sequences is also based on biogenic magnetite (e.g. J. F. Stolz *et al.*, 1990; N. Sparks *et al.*, 1990). That kind of magnetic carrier may occur in the Siewierz dolostones.

"Another indirect argument for the secondary origin of CHRM in dolostones of the Silesian – Cracow areas is the coexistence of magnetite and sulphides, the latter including magnetic pyrrhotite (max. unblocking temperature ca. 320–330°C, see J. Nawrocki, 1993*a*, Fig. 4)." (M. Lewandowski, 1994, p. 214).

Ferric sulphides do not occur in the unheated dolomites from the Siewierz Anticline. Pyrrhotite occurs only in the very heated (see Z. Bełka, 1993) carbonates from the Dębnik area, where the secondary, Early Permian direction *A* dominates (J. Nawrocki, 1993*a*, 1994). Only in some specimens from two sites were other very dispersed directions, *D1* and *D2*, observed. Because of a very small quantity of specimens and very complicated local tectonics they were not considered in regional tectonic interpretations (*op. cit.*).

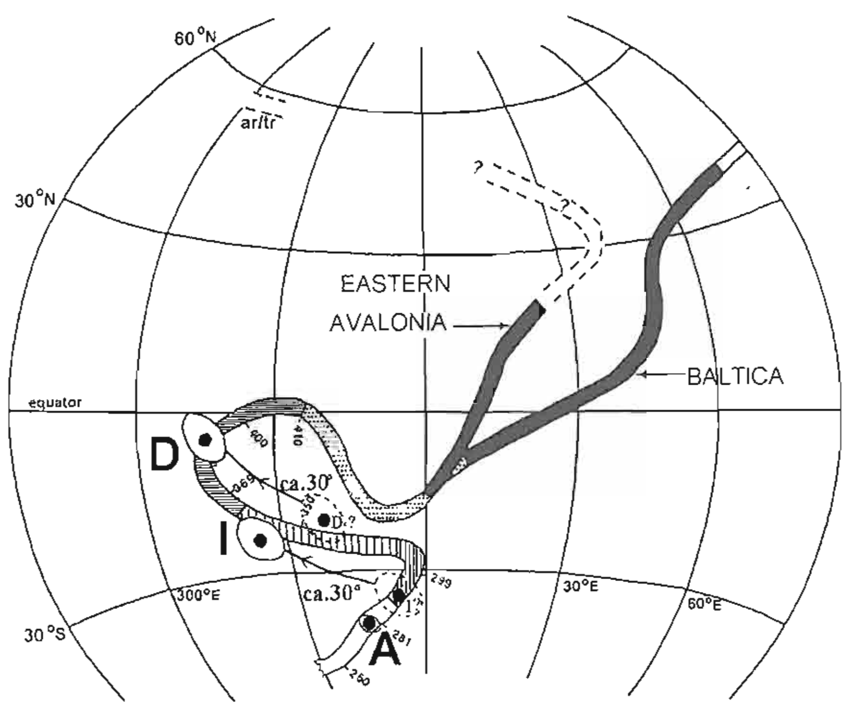

Fig. 2. Palaeomagnetic poles from the Cracow – Silesia region (J. Nawrocki, 1993, 1994) on a background of the APWP prepared (T. H. Torsvik *et al.*, 1993) for Eastern Avalonia and Baltica; the positions of palaeopoles *D* and *I* after their tentative Late Westphalian rotation of ca. 30° (see text) is also presented (symbols with question marks)
Explanations as in Fig. 1

Bieguny paleomagnetyczne z regionu krakowsko-śląskiego (J. Nawrocki, 1993, 1994) na tle ścieżki pozornej wędrówki bieguna sporządzonej (T. H. Torsvik i in., 1993) dla wschodniej Awalonii i Baltiki; zaprezentowano również pozycję biegunów *D* i *I* po ich hipotetycznej, późnowestfalskiej rotacji (symbole ze znakami zapytania) o kąt ok. 30° (patrz tekst)
Objaśnienia jak na fig. 1

HIGH PRECISION OF THE PALAEOMAGNETIC RECORD

"Even if post-depositional processes might have improved the accuracy of the palaeomagnetic record, such strong grouping of individual directions as presented by J. Nawrocki (1993*a*, Fig. 3) suggest secondary alignment of magnetic domains (cf. M. A. Smethurst, A. N. Khramov, 1992). To all appearances, therefore, the primary origin of the *D* related component, as suggested by J. Nawrocki (1993*a*, *b*), is doubtful." (M. Lewandowski, 1994, p. 215).

I suppose that M. Lewandowski (*op. cit.*) was commenting on some *k* values at the "site" statistical level. In this case, parameter *k* should be analyzed at the basic statistical level of "specimens". At this statistical level, parameter *k* is the same as encountered in the case of primary detrital directions. The value of this parameter for directions *D* and *I*, obtained from unheated rocks (Podleśna and Nowa Wioska quarries, Racławka Valley), is between 20.1 and 27.8 (J. Nawrocki, 1993*a*, 1994).

"The swathe-like palaeopole distribution (Fig. 2) suggests two general pulses of mineralization: older (poles *B*, *D2*, *D*) and younger (poles of population *I* and *D1*), the later one also inferred by J. Nawrocki (1993*b*)." (M. Lewandowski, 1994, p. 215).

Even omitting the fact, that according to the author's opinion (J. Nawrocki, 1993*a*, 1994) poles *B*, *D1* and *D2* are not useful for tectonic interpretation it should be noted:

1. In fact, the compared directions are strongly dispersed. They differ from each other by about 15° of arc. Such values are important for M. Lewandowski (1994) but unfortunately only if he proposes mobilistic interpretations. The magnetic polarities inside of each group are also different.

2. Rocks with direction *D1* are only 100 m away from rocks containing direction *D2* (also dolomites). Direction *I* was obtained in the limestones (Racławka Valley) situated only about 300 m from those dolomites. "Pulses of mineralization" must have had a very local character!? I agree that the low temperature (with unblocking temperatures $Tb <$ 420°C) *I* component from Middle Devonian dolomites (Podleśna quarry) has a secondary origin but I do not agree that the medium temperature (Tb = 480°C) *I* component obtained from the Late Famennian limestones of the Dębnik area must have the same origin (see J. Nawrocki, 1994).

3. "Pulses of mineralization" should not be dependent on the given stratigraphical context. However, in the Cracow – Silesia region, a distinct relationship between obtained directions and stratigraphy can be observed. The *D* direction is absent in Frasnian-Tournaisian rocks. The *I* direction does not occur in Namurian-Westphalian rocks.

THE AGE OF MAGNETIZATION

"The basic argument of J. Nawrocki (1993*a*, *b*) for the Givetian age of palaeopole *D* is its compatibility with the Givetian-Frasnian poles for Baltica. However, no palaeomagnetic poles obtained from the Middle-Late Devonian (363–380 Ma) rocks of Baltica are similar to pole *D* ... It is enough to say that none of the Middle-Upper Devonian poles of Britain fall on the 370 Ma sector of APWP, being removed by some 20° eastward..." (M. Lewandowski, 1994, p. 215).

In fact, this chapter is mainly devoted to the reliability of the Devonian-Carboniferous segment of the Apparent Polar Wander Path (APWP) for stable Europe and North America. As is pointed out above, there exist other arguments supporting the Middle Devonian age of palaeopole *D* (e.g., strictly stratigraphical succession of obtained palaeopoles), but I agree that the compatibility of palaeopole *D* with APWP for stable Europe is important.

According to my present knowledge, the Devonian-Early Carboniferous segment of APWP for stable Europe (T. H. Torsvik *et al.*, 1993) is based on the most reliable (best quality) poles, also including the Middle/Upper Devonian pole (Fig. 1). Palaeopole *D* overlaps exactly with the Eifelian pole of the south Urals (obtained from ophiolites and sedimentary rocks). The latter was considered previously as rotated (K. S. Burakov *et al.*, 1984), but later the authors changed their minds (A. N. Didenko, D. M. Pechersky, 1989). Taking into account even only the palaeolatitude obtained from Uralian data (15°N), it is

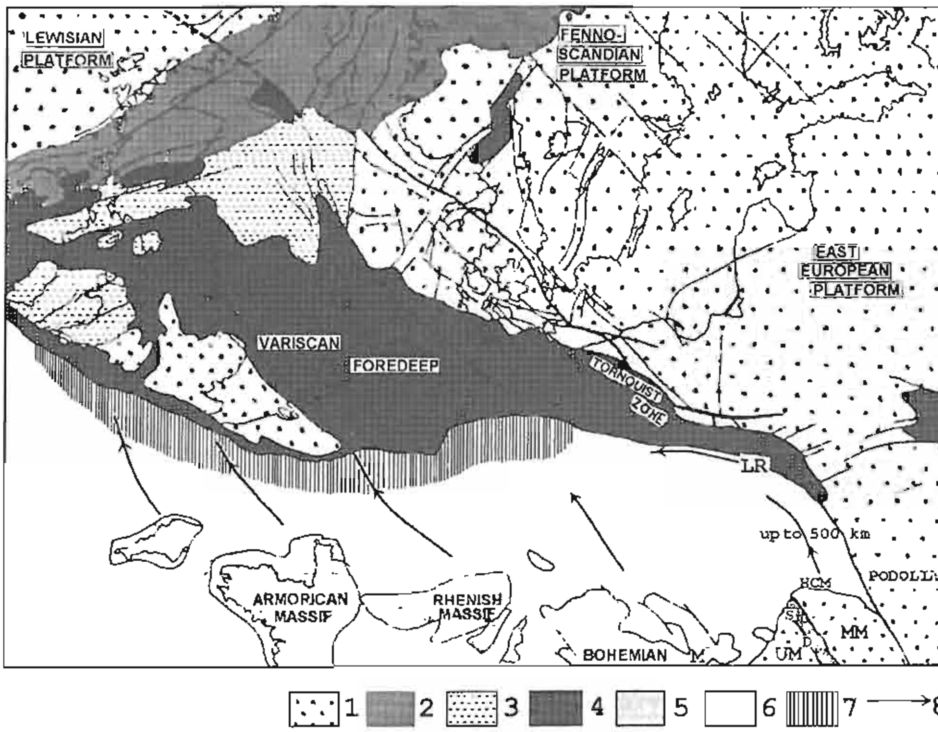

Fig. 3. The structural framework of the Tornquist Zone in Europe (after R. M. Pegrum, 1984, modified) and possible Late Westphalian dextral movement of Małopolska, Upper Silesia and another blocks; this kind of movement could have taken place if poles *D* and *I* were of Visean and Westphalian age, respectively (see text)

UM — Upper Silesian Massif, MM — Małopolska Massif, HCM — Holy Cross Mts., LR — Łysogóry Range, S — Siewierz Anticline, D — Dębnik Anticline, 1 — Precambrian basement, 2 — Caledonian metamorphic orogen, 3 — Caledonian folded Lower Palaeozoic sediments, 4 — Carboniferous Variscan foreland sediments, 5 — Variscan massifs at surface, 6 — Variscan orogen, 7 — area of the Late Variscan tectonic shortening, 8 — direction of Late Westphalian movement

Szkic strukturalny strefy Tornquista w Europie (według R. M. Pegruma, 1984, zmodyfikowany) oraz możliwe późnowestfalskie prawoskrętne przemieszczenie bloku małopolskiego, górnośląskiego i innych; taki rodzaj przemieszczenia mógł mieć miejsce, jeśli bieguny *D* i *I* są odpowiednio wizeńskiego i westfalskiego wieku (patrz tekst)

UM — masyw górnośląski, MM — masyw małopolski, HCM — Góry Świętokrzyskie, LR — obszar łysogórski, S — antyklina Siewierza, D — antyklina Dębnika, 1 — fundament prekambryjski, 2 — metamorficzny orogen kaledoński, 3 — dolnopaleozoiczne osady sfałdowane w epoce kaledońskiej, 4 — karbońskie osady przedpola waryscyjskiego, 5 — masywy waryscyjskie na powierzchni, 6 — orogen waryscyjski, 7 — obszar późnowaryscyjskiego skrócenia tektonicznego, 8 — kierunek późnowestfalskiego przemieszczenia

very difficult to accept that after big rotations, a pole from the south Urals would be situated exactly between Lower and Middle/Upper Devonian poles of stable Europe. Such a big rotation is necessary if we accept Middle Devonian reconstruction of the Old Red Continent presented by M. Lewandowski (1994, Fig. 4B), where the Uralian margin of Baltica is located at ca. 28° north latitude. It should be stressed that Uralian data were also considered as representative for Baltica by M. Lewandowski (1993). The best quality Visean poles of stable Europe (Fig. 1) are located in the area of Middle-Late Devonian average poles of stable Europe and North America presented by M. Lewandowski (1994, Fig. 3).

"Apart from the Early Devonian poles, pole *D* has its counterparts in the younger, namely Namurian-Westphalian poles (Fig. 2c), obtained for some Variscan massifs of Europe (so-called palaeopoles *B*, see J. B. Edel, 1987; J. B. Edel, F. Wickert, 1991). Hence, reliability criterion 7 (dissimilarity of the considered pole to younger poles) is not met in this case, although J. Nawrocki (1993*b*) states otherwise." (M. Lewandowski, 1994, p. 216).

Palaeopoles *B* obtained for some Variscan massifs of Europe (J. B. Edel, 1987; J. B. Edel, F. Wickert, 1991) differ from palaeopole *D* by about 10–35° (approximately 20°). Accepting M. Lewandowski's (*op. cit.*) statement one must accept, for example, that the Late Carboniferous poles of stable Europe are the same as the Early Triassic. This is not the case.

"The position of the Devonian-Permian poles for ORC, are listed by R. Van der Voo (1990, 1993, Table 5.7). They are also shown in the Figure 3, contrasted with the position of pole *D*. ... In conclusion, the dating of pole *D* made by J. Nawrocki (1993*a, b*) was erroneous, since the palaeomagnetic time-scale involved was artificially obtained." (M. Lewandowski, 1994, p. 216).

Most of the Devonian poles from the North American craton are listed with a question mark (R. Van der Voo, 1990) and the upper limit of their age usually reached to Early Carboniferous time (R. Van der Voo, 1993). Good quality Devonian poles are very dispersed (Fig. 1). Therefore, the Devonian "palaeomagnetic time scale" for the North American craton is more artificially obtained than the scale for the European part of the Old Red Continent. The best quality pole of Visean age, characteristic for North America, are similar to the best quality poles of the same age characteristic for stable Europe (Fig. 1). As stated above, the best quality poles of Visean age (Fig. 1) occur in fact in the place where artificially obtained Givetian palaeopoles are located (M. Lewandowski, 1994, Fig. 3).

RELATIVE POSITION OF USM AND BALTICA VS. PALAEOMAGNETIC DATA

"Being impressed by the positive fold test, very good statistical data, and apparent agreement of palaeopole *D* with the supposed Givetian/Frasnian sector of APWP for Baltica, J. Nawrocki (1993*a, b*) assented that the structural identity of USM and Baltica since Middle/Upper Devonian time was proved. Consequently, he had to reject his older data, that formerly gave mobilistic interpretations (i.e., poles *C* and *B*, see J. Nawrocki, 1992*a, b*)... Even if the assumption of the nondipole origin of the *C* component is correct, the acquisition of the component had to be long enough to record perfectly antipodal directions (see J. Nawrocki, 1993*a*, Fig. 15c)... Also important is that, even if the validity of poles *C* and *B* is disproved, the relative stability of USCB (USM) with reference to Baltica is not guaranteed by the position of pole *D* alone." (M. Lewandowski, 1994, p. 217–219).

Several arguments (including the negative polarity test) supporting the thesis about artificial origin of palaeopoles *C* and *B* were already presented (J. Nawrocki, 1993*a*, 1994). Even if they are not convincing for some, it is easy to notice that palaeodirection *D* must be older than *C*, which has distinctly lower inclination and occurs in Westphalian rocks. It

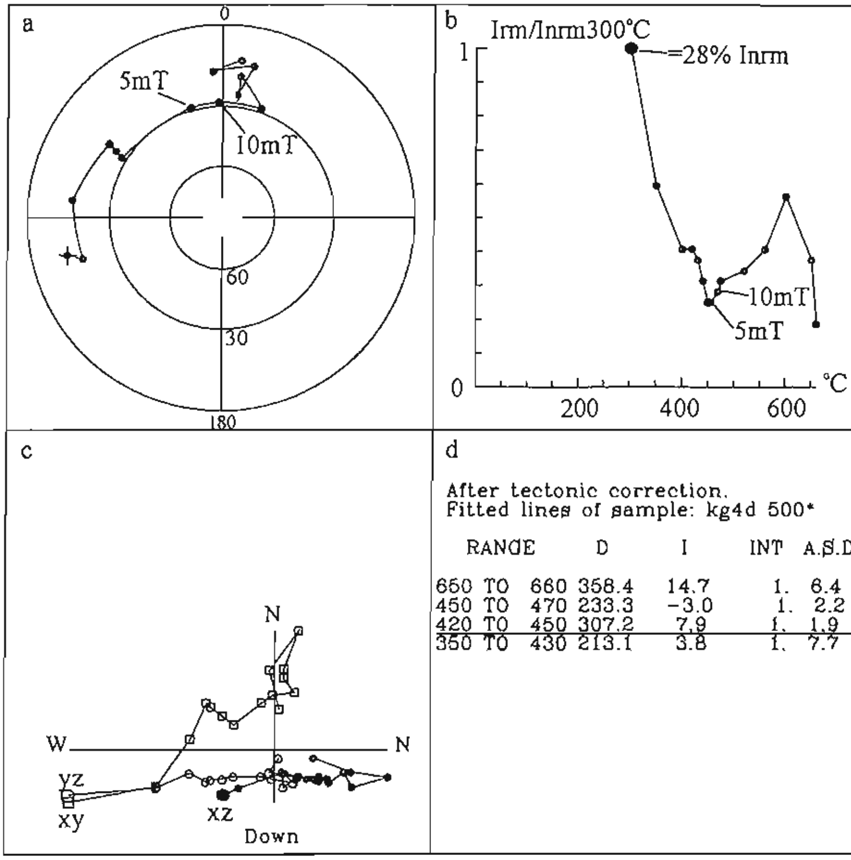

Fig. 4. Results of demagnetization (a — lower hemisphere polar projection of demagnetizing path, b — intensity decay curve, c — orthogonal plot, d — table of characteristic components) obtained from representative specimen of Lower Devonian sandstones from Kielce – Gruchawka locality (southern region of Holy Cross Mts.); after thermal demagnetization up to 450°C, the specimens were subjected to two-gradual alternating field demagnetizations with intensities of 5 and 10 mT; those values were sufficient to remove a component that is identical with the component obtained in the Lower Devonian rocks of the southern region of Holy Cross Mts. by M. Lewandowski (1991); in the table of characteristic components this component is underlined

Crossed symbol on the stereonet — natural remanent magnetization (NRM) direction; *Irm* — the intensity of the remanent magnetization after demagnetization; *Inrm* — the intensity of the NRM; the bigger symbols on the orthogonal plot — NRM components; *x, y, z* — the planes of the projection; the units on the axes are $10^{-5}Am^{-1}$; RANGE — the temperature interval of the calculated line (direction); *D* — declination, *I* — inclination; *INT* — intensity (in $10^{-4}Am^{-1}$); *A.S.D.* — angular standard deviation of the best fit line; the directions are presented at the geographical position of the rock's formation

Wyniki rozmagnesowania (a — projekcja na dolną półsferę ścieżki rozmagnesowania, b — krzywa spadku natężenia, c — diagram ortogonalny, d — tabela składowych charakterystycznych) przykładowej próbki piaskowców dolnego dewonu z odsłonięcia Kielce – Gruchawka (obszar południowy Gór Świętokrzyskich); po termicznym rozmagnesowaniu do 450°C próbkę poddano dwustopniowemu rozmagnesowaniu zmiennym polem magnetycznym o natężeniu 5 i 10 mT, co wystarczyło do usunięcia składowej o parametrach tożsamych składowej otrzymanej na tym obszarze dla skał dolnodewońskich przez M. Lewandowskiego (1991); w tabeli składowa charakterystyczna została podkreślona is impossible that the older palaeopole *D* was rotated significantly less than the younger palaeopole *C*. Pole *D* does not alone guarante relative stability of the USCB. In Late Famennian rocks a well defined pole *I* also occurs, which is located on the Late Devonian/Early Carboniferous segment of the APWP characteristic for stable Europe.

The occurrence of palaeopoles *D* and *I* together allows only one theoretical possibility of their simple mobilistic interpretation. Considering the inclinations characteristic for palaeodirections *D* (21°) and *I* (3°) one could assume that:

1. The first direction (pole) is of Visean age (syn-Sudetian?) and primarily had been located in the area of true Visean poles characteristic for stable Europe (Fig. 2). M. Lewandowski (*op. cit.*, Fig. 3) postulated its Givetian position at that place.

2. The second direction (*I*) is of Westphalian/Stephanian (syn-Asturian?) age. Its inclination corresponds also to the Upper Carboniferous inclinations characteristic for the Polish part of stable Europe.

Then a clockwise (vertical axis) rotation or (and) dextral translation of ca. 30° (with Eulerian pole situated in the central part of Baltica) of the USM must have taken place in Late Westphalian/Stephanian time. However, so far this solution was only theoretical because palaeopole *D* had not been observed in the Frasnian-Tournaisian limestones of the Cracow – Silesia region and palaeopole *I* does not occur in the Namurian-Westphalian rocks of the Upper Silesian Basin. Until then, those palaeopoles will not be obtained, the relative stability of the USM with respect to Baltica during Variscan time should be preferred. Although, considering the still imperfect knowledge of the origin of magnetic carriers occurring in carbonate rocks, a moderate mobilistic model can not be absolutely excluded, all the more that the results of recent investigations can indicate for relationship between structure of magnetization and very detailed mineralogical composition of carbonate rocks (see R. D. Elmore *et al.*, 1994). In particular, the proportion $^{87}Sr/^{86}Sr$ could be useful for palaeomagnetic interpretations.

Syn-Asturian clockwise rotation of ca. 45° of whole pre-Alpine Europe or only Variscan belt (Armorica) is suggested by some palaeomagneticians (J. B. Edel, F. Wickert, 1991; J. B. Edel, M. Lewandowski, 1993). After that rotation, in the Stephanian-Early Permian time a 10–15° northwards drift of Armorica block took place (*op. cit.*). Such motion is not observed in the case of mobilistic interpretation presented here. Rotated pole *I* does not differ from Late Carboniferous/Early Permian poles characteristic for stable Europe (Fig. 2).

The remarks above also refer to the chapter titled "Mobilistic interpretation of the palaeopole from the Siewierz Anticline" (M. Lewandowski, 1994, p. 221–223). Because of this, that chapter will not be commented.

Symbol przekreślony na siatce stereograficznej oznacza kierunek naturalnej pozostałości magnetycznej (NRM); *Irm* — natężenie pozostałości magnetycznej po rozmagnesowaniu; *Inrm* — natężenie NRM; największe symbole na diagramie ortogonalnym — składowe NRM; *x, y, z* — płaszczyzny projekcji; jednostki na osiach w 10^{-5} Am^{-1}; RANGE — przedział temperatury dla liczonej linii (kierunku); *D* — deklinacja; *I* — inklinacja; *INT* — natężenie (w $10^{-4}Am^{-1}$); *A.S.D.* — kątowe odchylenie standardowe linii najlepszego dopasowania; kierunek dowiązany jest do geograficznej pozycji badanej formacji skalnej

CONFIGURATION OF THE OLD RED CONTINENT IN THE MIDDLE DEVONIAN

"It may be seen from Figure 4 that the reconstruction according to R. Van der Voo's pole is more compatibile with Middle Devonian (Eifelian-Givetian) palaeoclimatic sensitive facies pattern distribution (see discussion in B. J. Witzke, 1990). On the other hand, the configuration obtained with J. Nawrocki's concept situates Eifelian-Givetian oolite, anhydrite and gypsum of the Laurentian midcontinent at palaeolatitudes which are definitely too high (50 to 55°)." (M. Lewandowski, 1994, p. 219–221).

According to B. J. Witzke (1990) warm climate facies in Devonian time reached to about 45° south latitude. However, a limited occurrence of shelf carbonates and evaporites is reported in some Devonian profiles of Gondwana, which occupied distinctly higher latitudes at that times (see, e.g., R. Van der Voo, 1988, p. 118–119). On the other hand, a certain modification of the Old Red Continent configuration also can not be excluded (R. Van der Voo, C. Scotese, 1981).

"Moreover, palaeomagnetically determined palaeolatitudes of different regions of Laurentia (J. D. Miller, D. V. Kent, 1986; D. V. Kent, R. Van der Voo, 1990) remain in disagreement with the configuration implied by palaeopole *D* (Fig. 4a), but are otherwise in agreement with the alternative arrangement (Fig. 4b). Also, palaeolatitude derived from the uppermost Eifelian sandstones (Łysogóry Unit, Holy Cross Mts., see M. Lewandowski *et al.*, 1987), is keeping with the reconstruction according to the data by tbe American authors." (M. Lewandowski, 1994, p. 221).

Laurentian palaeolatitudes cited and presented by M. Lewandowski (1994, Fig. 4) are of Late Devonian age and their comparison with Middle Devonian reconstructions is not appropriate. According to my knowledge, uppermost Eifelian sandstones do not occur in the Holy Cross Mts. The author ought to decide if palaeopole from Góra Bukowa Mt. (northern Holy Cross Mts.; pole *DN2*, M. Lewandowski, 1993) is of Emsian age and representative for stable Europe. If it is so, then rotation of Emsian palaeopole from southern Holy Cross Mts. (pole *DS2*, *op. cit.*) and tectonic rotation of this unit would be larger (of about 20°) than rotation assumed by M. Lewandowski (*op. cit.*). Moreover, pole of rotation would be also different from that predicted by this author.

MOBILISM OF MAŁOPOLSKA BLOCK AND PALAEOMAGNETIC DATA FROM USCB

"Considering his factual arguments, I agree with J. Nawrocki (1993*a*) that precision parameter *k* for the CHRM of the Lower Devonian sandstones (M. Lewandowski, 1991) is low. However, we differ in the interpretation of this detail: while J. Nawrocki (1993*a*) sees only a low reliability of palaeomagnetic record, I see a low precision of the CHRM mean (at the specimens level) as a immanent feature of a detrital remanent magnetization (cf. R. Løvlie *et al.*, 1984 ....)" (M. Lewandowski, 1994, p. 223–224).

Other authors (e.g., M. Westphal, 1993) postulate that palaeodirections with *k* are palaeomagnetically useless. My doubts refer also to the palaeomagnetic properties of the Lower Devonian sandstones of the Holy Cross Mts. (southern part). In fact, they contain the direction described by M. Lewandowski (1991) but its coercivity is very low. It is removed by an alternating magnetic field of 5–10 mT (Fig. 3). This kind of component was also isolated in the Namurian/Westphalian clastic rocks of the Upper Silesian and Lublin coal basins and was qualified as useless for tectonic interpretation (J. Nawrocki, 1993*a*, 1994). It most probably originated due to interactions between different phases of magnetic carriers. It seems that Edel's direction *C* (J. B. Edel, 1987) may have the same "artificial" origin (see also J. Reisinger *et al.*, 1994). Summarizing, there is no reliable palaeomagnetic data in the Holy Cross Mts. to prove the hypothesis about large-scale (60°) rotation of this area during Variscan orogeny.

As is presented above, the intermediate solution between very mobile models (M. Lewandowski, 1993; J. Nawrocki, 1992*a*) and relatively stable model (J. Nawrocki, 1993*a*, *b*) of the Variscan tectonic evolution of the area enclosed between Sudetes and East-European Platform edge is theoretically possible considering only the palaeomagnetic data from the Cracow – Silesia region. Moderate (30°) rotation of the Upper Silesia and Małopolska Blocks could have taken place not by the end of the Visean (see M. Lewandowski, 1993) but by the end of the Westphalian. Unfortunately, this solution has a palaeomagnetic countrargument obtained in the Holy Cross Mts., too. The post-folding palaeomagnetic pole characteristic for the Kostomłoty Beds (pole *DS6*, *op. cit.*) does not confirm even such magnitude of rotation unless it is possible that the Kostomłoty area could have been rotated anticlockwise after the Early Carboniferous. One must compare structural direction from Kostomłoty with the general structural trend of the syn-Variscan tectonic units occurring in the southern part of the Holy Cross Mts. On the other hand it should be noted that possible movement of the Upper Silesia Block does not have to indicate the necessity of occurrence of such movement in the Holy Cross Mts. area.

SUMMARY

None of arguments presented by M. Lewandowski (1994) imply the necessity of mobilistic interpretation of palaeomagnetic data obtained in the Cracow – Silesia area. Moreover, the Lower Devonian poles from the southern part of the Holy Cross Mts., implying large-scale (60°) rotation of this unit (M. Lewandowski, 1993; key-poles *DS1*, *DS2*), seem to be very suspect not only due to a low precision parameter *k* but very low coercivity as well.

The localization of palaeopoles *D* and *I* (see Fig. 2), particularly the values of their inclinations, give only one theoretical possibility for simple, moderately mobilistic interpretations. If palaeopole *I* and *D* are of Westphalian and Visean age respectively (their inclinations may be suitable for those ages) then the Late Carboniferous (syn-Asturian?) clockwise rotation of the Małopolska and Upper Silesia Blocks of ca. 30° (most probably expressed as a dextral translation of several hundred kilometres) must have taken place. In this case sinistral offset of the southern part of the Holy Cross Mts. to the southeast (Podolia region; Fig. 2) would be necessary. Such a solution was not considered earlier (J. Nawrocki, 1993*a*, *b*) and here is also found less probable than a relatively stationary model because there are no distinct premises proving an epigenetic origin of key-palaeopoles from the Cracow – Silesia region.

Zakład Geofizyki
Państwowego Instytutu Geologicznego
Warszawa, ul. Rakowiecka 4
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Jerzy NAWROCKI

PALEOMAGNETYCZNE OGRANICZENIA MOBILIZMU WARYSCYJSKIEGO MASYWU GÓRNOŚLĄSKIEGO I MAŁOPOLSKIEGO — DYSKUSJA

Streszczenie

W swoim artykule M. Lewandowski (1994) zaprezentował mobilistyczną interpretację danych paleomagnetycznych uzyskanych na obszarze śląsko-krakowskim (J. Nawrocki, 1993*a*, *b*), traktując je nawet jako następny dowód na wielkoskalowe przemieszczenie masywu małopolskiego w epoce waryscyjskiej (zob. M. Lewandowski, 1993). Przeprowadzona tutaj wnikliwa analiza argumentów jakimi posłużył się ten autor prowadzi do wniosku, że żaden z nich nie wprowadza konieczności mobilistycznego sposobu interpretacji danych z obszaru śląsko-krakowskiego. Ponadto stwierdzono, że dolnodewońskie bieguny z południowej części Gór Świętokrzyskich, implikujące wielkoskalową (60°) rotację tego obszaru (*op. cit.*; bieguny *DS1* i *DS2*), są mało wiarygodne nie tylko ze względu na bardzo niską wartość parametru precyzji *k*, lecz również ze względu na bardzo niską odporność domniemanej składowej dolnodewońskiej na rozmagnesowanie zmiennym polem magnetycznym.

Umiejscowienie paleobiegunów *D* i *I* (fig. 2), w szczególności paleoinklinacji, stwarza tylko jedną szansę ich umiarkowanie mobilistycznej interpretacji. Jeśli przyjmiemy, że paleobieguny *D* i *I* są odpowiednio wizeńskiego i westfalskiego wieku (wartości inklinacji nie przeczą przyjęciu takiej możliwości), wtedy późnokarbońska (synasturyjska?), prawoskrętna rotacja bloku małopolskiego i górnośląskiego o kąt ok. 30° (wyrażona głównie jako kilkusetkilometrowa prawoskrętna translacja) musiałaby mieć miejsce. Przed tym przemieszczniem południowa część Gór Świętokrzyskich znajdowałaby się w okolicy Podola (fig. 2). Takie rozwiązanie nie było rozważane wcześniej (J. Nawrocki, 1993*a*, *b*) i tutaj uznano je za mniej prawdopodobne niż względnie stacjonarny model, ponieważ nie ma żadnych danych dowodzących epigenetycznego pochodzenia kluczowych paleobiegunów z obszaru śląsko-krakowskiego.