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DOES THE EAST EUROPEAN BRANCH OF THE CALEDONIDES EXIST?

CZY ISTNIEJE WSCHODNIOEUROPEJSKA GAŁĄŹ KALEDONIDÓW?

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Abstract. Since the beginning of the introduction of the concept of the East European branch of the Caledonides by Limanowski (1922), there has been much discussion on the trend of this branch towards the southwest of the East European craton. The extreme interpretations were given by Stille (1950), and later by Dadlez (1994). According to those authors, the East European branch of the Caledonides could trend along the entire course of the south-eastern boundary of the East European craton, from the western Baltic Sea to Ukraine. Analysis of existing geological data, in relation to the current geotectonic theories, puts in doubt the existence of this branch. The proved Caledonian structures, which could be considered as orogenic, are located exclusively in the West Pomeranian segment of the East European craton foreland. The other parts of the foreland should be considered either a lowered marginal edge of the craton or blocks of Avalonian origin.

Key words: Caledonides, geotectonics, foreland of the East European craton, Middle Europa.

Abstrakt. Od początku wprowadzenia pojęcia wschodnioeuropejskiej gałęzi kaledonidów przez Limanowskiego (1922) trwa dyskusja dotycząca przebiegu tej gałęzi na południowy zachód od kratonu wschodnioeuropejskiego. W skrajny sposób przedstawiał go Stille (1950), a później Dadlez (1994). Według nich wschodnioeuropejska gałąź kaledonidów przebiegałaby wzdłuż całej południowo-wschodniej granicy kratonu wschodnioeuropejskiego, od zachodniego Bałtyku po Ukrainę. Analiza istniejących danych geologicznych, w nawiązaniu do obowiązujących dzisiaj teorii geotektonicznych, stawia w wątpliwość istnienie tej gałęzi. Udokumentowane struktury kaledońskie, które można by uznać za orogeniczne, znajdują się wyłącznie w zachodniopomorskim segmencie przedpola kratonu wschodnioeuropejskiego. Pozostałe fragmenty tego przedpola trzeba uznać bądź za obniżoną, brzeżną krawędź kratonu, bądź za bloki pochodzenia awalońskiego.

Słowa kluczowe: kaledonidy, geotektonika, przedpole kratonu wschodnioeuropejskiego, Europa środkowa.

INTRODUCTION

The term "Caledonian folding epoch" was introduced almost simultaneously by Suess (1886) and Bertrand (1887) (*fide* Stille, 1950). Suess (1886, *fide* Stille, 1950) considered the Grampian Mountains in Scotland, where the Silurian age was determined on the basis of the existence of a regional unconformity between the Lower Devonian Old Red Sandstone and the underlying folded rocks, as the Caledonian stratotype. The term "Caledonia" originates from the Celtic words "forest scrub", as the northern part of Scotland was called.

The classic Caledonides, i.e. fold belts whose main structures had formed in early Paleozoic times and completed their development not later than the Middle Devonian, are thought to be represented by the Caledonides of the British Isles and

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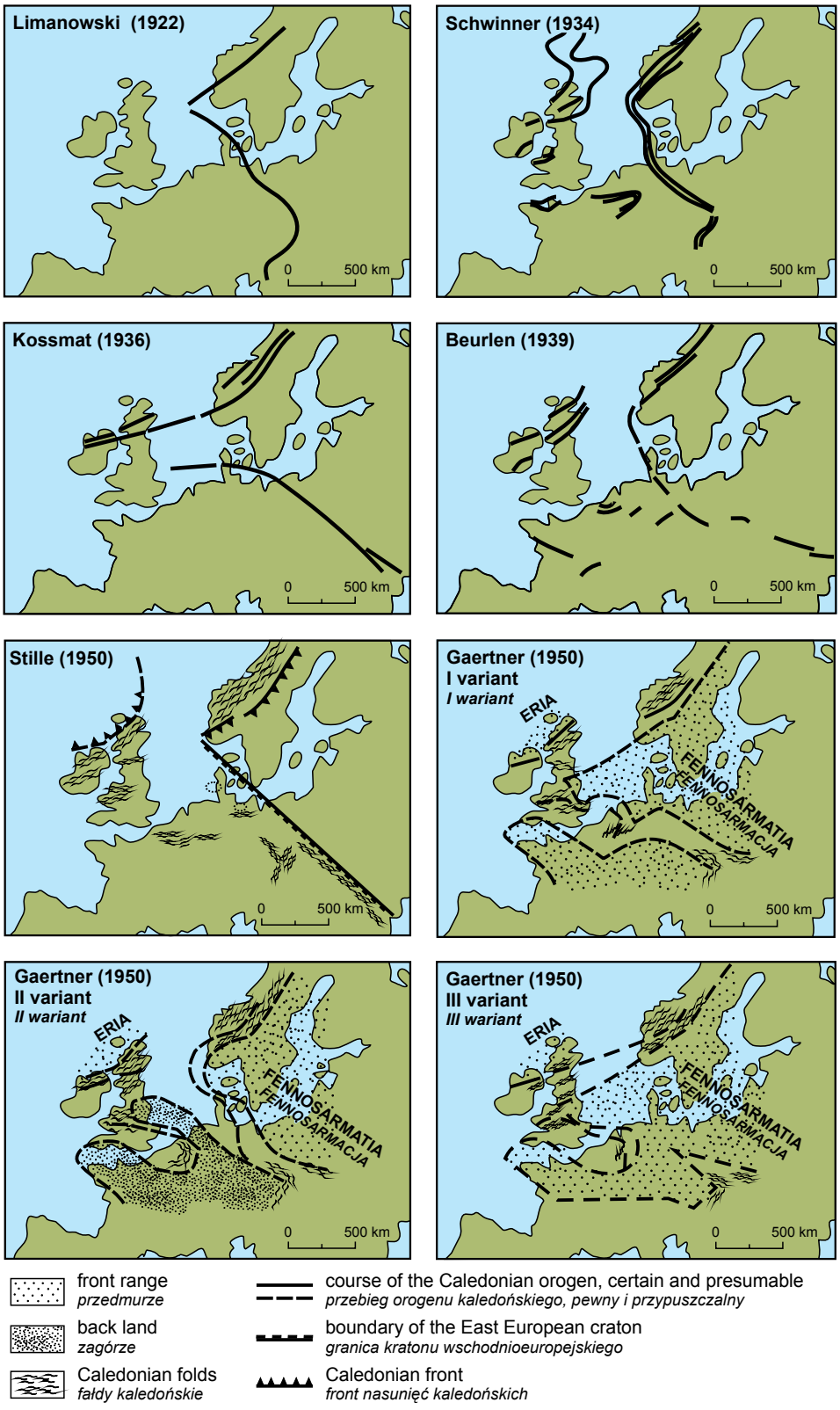

Fig. 1. Caledonian fold belts in Europe after different authors

Obszary fałdowań kaledońskich w Europie, według różnych autorów

Scandinavia, as well as of northern and eastern Greenland and Spitsbergen. Caledonian fold belts are also known from the east of North America (Appalachians, Newfoundland), and from Central Asia (central Kazakhstan, western Mongolia and the Sayan-Altai region).

Since then, there has been a discussion about the so-called East European (Fennosarmatian) branch of the Caledonides. For the first time, the idea of its existence was presented by Limanowski (1922). He believed that the Scandinavian and East European Caledonides end under the North Sea and, as a single chain, they stretch towards Scotland. According to Limanowski (1922), the East European branch of the Caledonides trends towards the SE as far as the northern Adriatic Sea (Fig. 1). However, it should be clearly stated that, in Poland, the branch was thought to have trended through the south-western part of the country, and not along the edge of the East European Platform (Fennoscandia). Only in the later works, the East European branch was located further east, along the Teysseyre-Tornquist line.

This paper is a brief summary of the research and views on the East European branch of the Caledonides, conducted and postulated from the beginning of last century until the present. The authors also wish to express their own view on the above issues, based primarily on the results of own research.

HISTORY OF THE PROBLEM

In the early 1950s, the view that the East European branch of the Caledonides does exist (Fig. 1) was supported by well-known geologists such as Bubnoff (1926), Schwinner (1934), Kossmat (1936), Beuerlen (1939) and Zwerger (1948). Their opinions were not widely discussed. But there were also voices against the existence of the branch. Among the opponents of this thesis at that time were Bailey and Holtedahl (1938), and later Kölbel (1959). A wider discussion of the views of those authors can be found in Mizerski and Skurek-Skurczyńska (2000).

An important contribution to the discussion about the Caledonides of Central and Eastern Europe was a work by Stille (1950). He distinguished two Caledonide branches in Europe (Fig. 1). The first one – circum-Laurentian (Erian) – included the Caledonides of England, Scotland, Brabant Massif and the Ardennes, and the second one – circum-Fennoscandian – included the Caledonides of Scandinavia, western Sudetes, southern part of the Holy Cross Mountains (Kielcides), Dobrogea, as well as the so-called Caledonian ridge that stretched north-west of Dobrogea.

At the same time, v. Gaertner (1950) presented three different possible trends of the Caledonides in Europe (Fig. 1), including the East European branch.

Further attempts to explain the presence of the Caledonian fold zone along the south-western edge of the East European craton were undertaken by Sandler and Glushko (1955), Gofshtein (1957), Glushko (1958), as well as Shatski and Bogdanov (1961). A sketch-map presented by Gofshtein (1957) illustrated the Caledonian fold zone adjoining in the southwest directly to the structures of the Ukrainian Shield, and going into the territory of Poland in the northwest (Fig. 2). However, those works did not result in a clear explanation of the problem, although the sketch-map presented by Gofshtein (1957) was met with great acclaim. Differences in the views concerned the exact location of the fold belt, its length, width, and the role of Caledonian tectogenesis in the formation of the folded fringe of the East European craton.

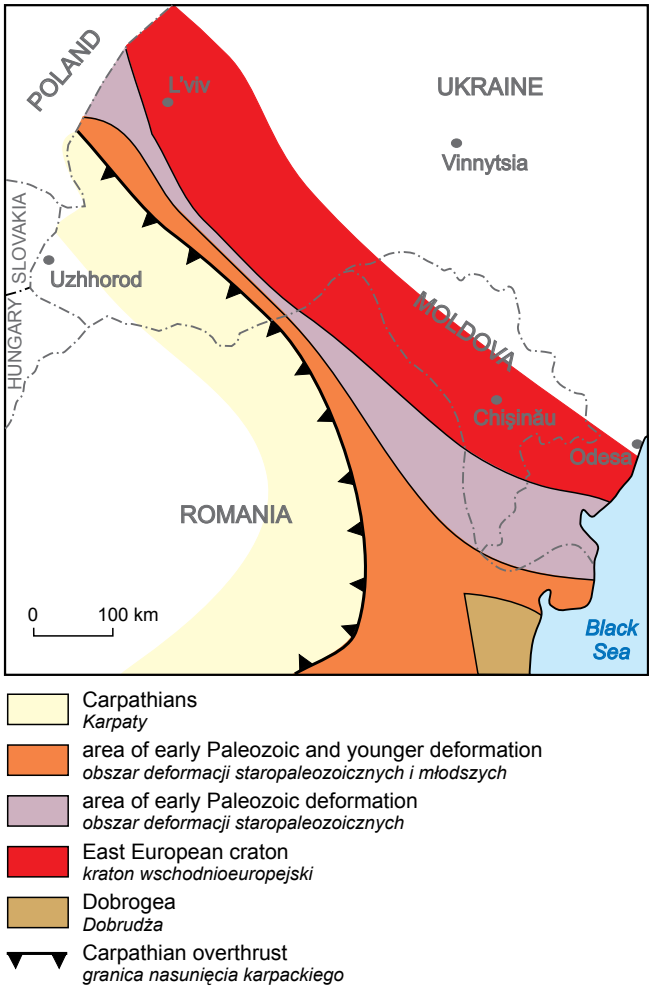

Fig. 2. Age of tectonic deformation in the south-western foreland of the East European craton (after Gofshtein, 1957, modified)

Wiek deformacji na południowo-zachodnim przedpolu kratonu wschodnioeuropejskiego (wg Gofshteina, 1957, zmodyfikowany)

Of great importance were the works by Znosko (1962, 1964, 1986), who argued for a model of Stille (1950). He believed that the Caledonian deformation zone extends along the entire stretch of the south-western edge of the East European craton (Fig. 3). He presented this view repeatedly (e.g. 1964, 1984, 1992) based on the results of deep drilling experiments and seismic soundings. These views were shared, to varying degrees, by, among others: Khizhniakov (1963, 1969), Bush *et al*. (1973), Dikenshtein *et al*. (1975), Garetski and Kolchanov (1987), as well as by Pożaryski (1990, 1991), Pożaryski *et al.* (1992), Dadlez (1994), Dadlez and Jaroszewski (1994), Dadlez *et al*. (1994), Pożaryski and Nawrocki (2000). The view of the occurrence of the Caledonian fold zone along the south-western edge of the East European craton was particularly clearly presented by Pożaryski (1990), Pożaryski *et al*. (1992), as well as by Dadlez (1994) (Fig. 4).

However, the works of Mizerski (Mizerski, 1995, 1996, 2000, 2004; Mizerski, Skurek-Skurczyńska, 2000; Mizerski, Stupka, 2005) put in doubt the existence of the Caledonian fold zone along the entire south-western edge of the East European craton, as well as its continuation into the territory of Ukraine.

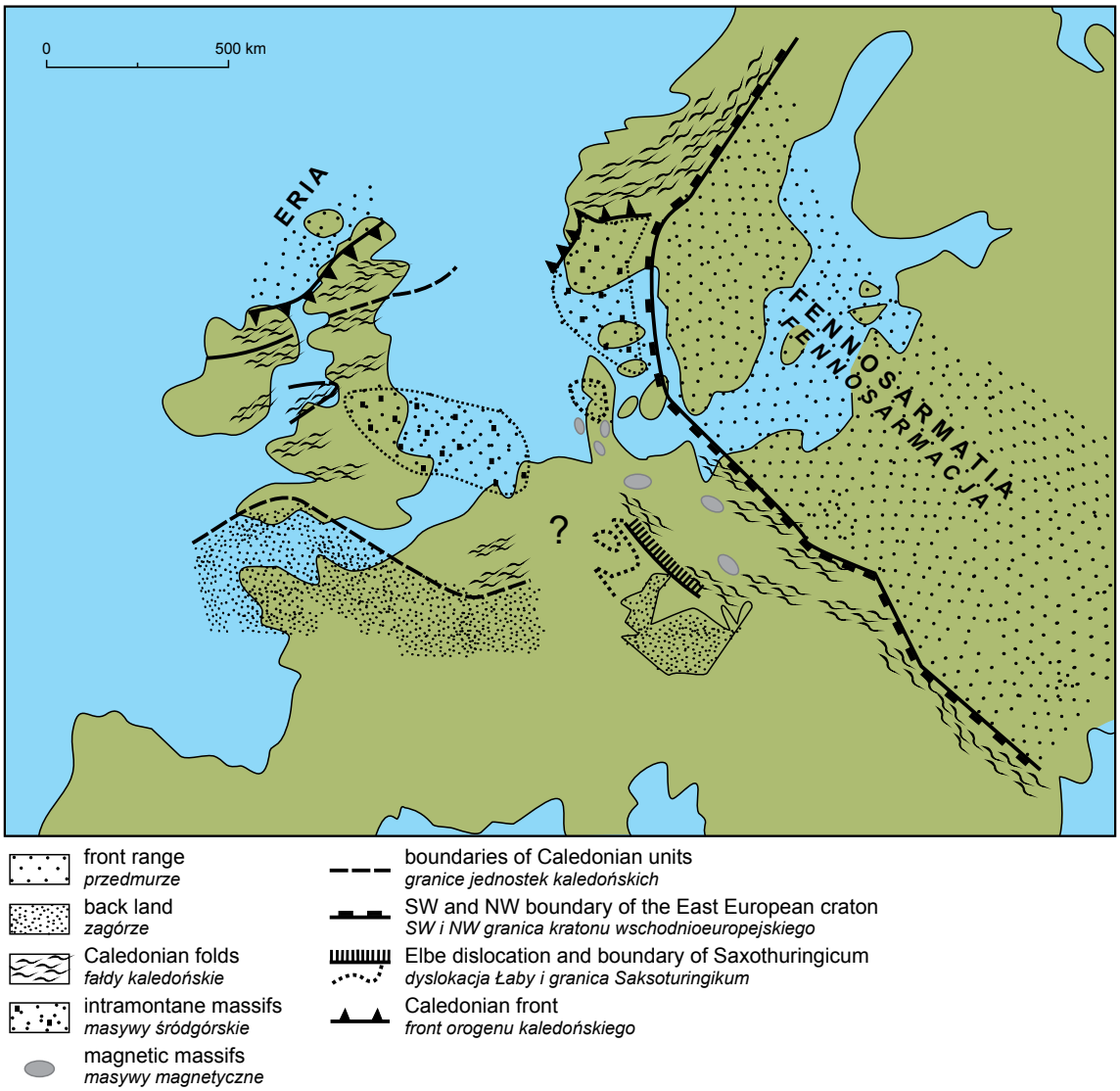

Fig. 3. Areas of the Caledonian folds in middle Europa (after Znosko, 1962)

Obszary fałdowań kaledońskich na obszarze Europy (wg Znoski, 1962)

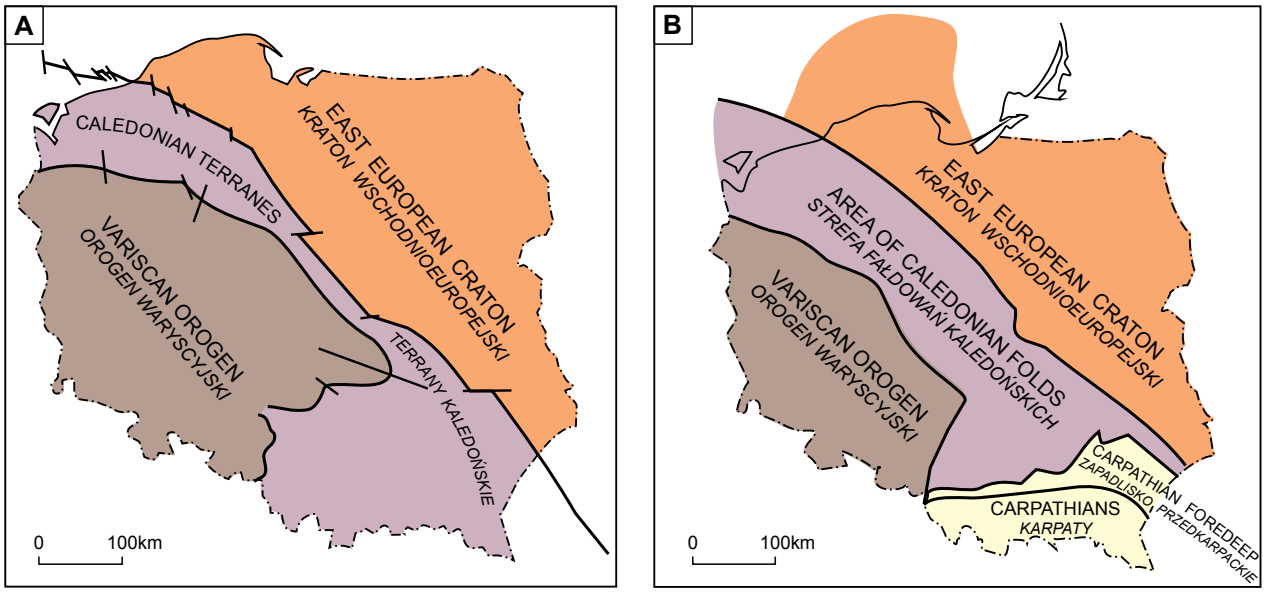

Fig. 4. Caledonian fold belt in Poland after Pożaryski (1990) – A, and Dadlez (*In*: Dadlez, Jaroszewski, 1994) – B; modified

Obszar fałdowań kaledońskich w Polsce wg Pożaryskiego (1990) – **A** i Dadleza (*W*: Dadlez, Jaroszewski, 1994) – **B**; uproszczone

EAST EUROPEAN BRANCH OF THE CALEDONIDES – A PLATE TECTONIC APPROACH

In some papers of the 1970s and 1980s, the European Caledonides were treated as parts of a single fold system, disrupted during the formation of the Atlantic Ocean (Fig. 5). In a diagram of connection of the circum-Atlantic continents, the British and Scandinavian Caledonides extend into the structures of Newfoundland, northern Appalachians and Mauretanides. Compared to the single homogeneous belt, the East European branch of the Caledonides (if we accept its existence) is a relatively narrow limb, drawn by various researchers parallel to the Trans-European Suture

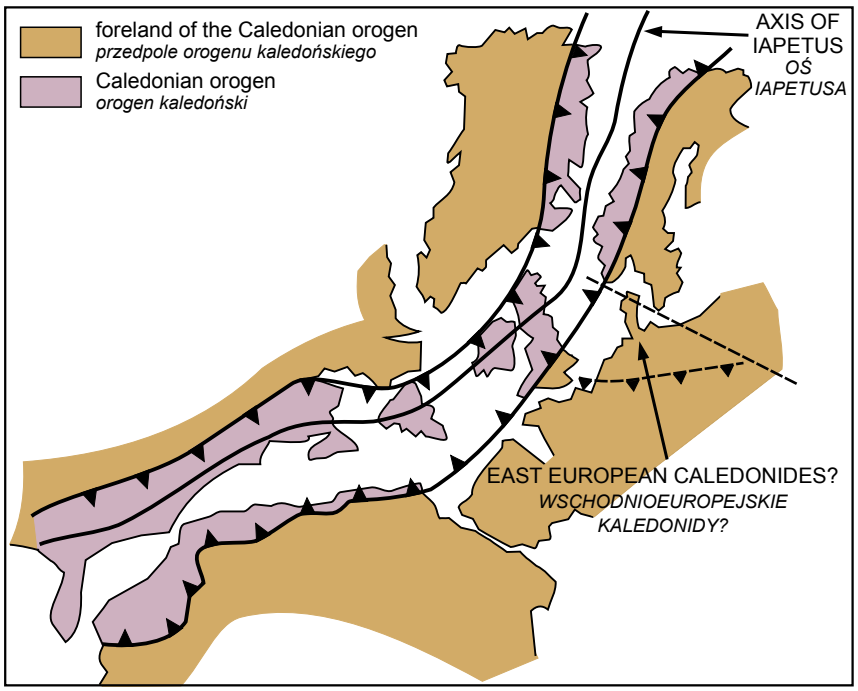

Fig. 5. Caledonian orogen in Europe and North America

Orogen kaledoński w Europie i Ameryce Północnej

Zone (TESZ) from Denmark to western Ukraine, where even today the zones of early (Kokhanivka Zone) and late (Rava Rus'ka Zone) Caledonides are presented in tectonic sketch-maps. Therefore, simple questions arise: can the East European branch be considered as part of a global Caledonian fold zone? If so, what caused its unusual position? Did it develop autonomously, or its origin was associated with the processes controlled by the global regularities of geological evolution? Which stress fields and geodynamic conditions were responsible for the creation of this branch?

If we assume the existence of the East European branch of the Caledonides, then, in accordance with the principles of plate tectonics, we should infer that it has a character of an orogen formed in a collision zone (and here is the fundamental question: what collided with the East European craton?). However, if it was an orogen, it should have at least a slight evidence of metamorphism and the presence of igneous rocks (including ultrabasic rocks) and possibly ophiolitic associations. Whereas, in the border zone of the East European craton from Denmark to Ukraine, these rocks have not been found and no geophysical data indicate that they could be there.

It can obviously be assumed that the lack of formations typical of orogens in the East European branch of the Caledonides results from the fact that there are Caledonian externides in the zone adjoining the craton. But then, there should be at least traces of internides in the hinterland. However, nobody has found these so far.

Caledonian orogens are identified based on a mobilistic concept of plate tectonics. Taking into account that:

- we do not know what collided with the East European craton to have been responsible for the formation of the East European branch of the Caledonides;
- there are no signs of tectonic, magmatic and metamorphic evidence typical of orogens both in the near-border zone of the craton and in the hinterland;

it can be inferred that the formation of the East European branch of the Caledonides (if it exists) cannot be considered from the mobilistic viewpoint, but should be explained by other geotectonic reconstructions. However, we must be aware that the fixistic theory of continuous or episodic accretion of continents, responsible for the formation of fold belts, was already more than 40 years ago considered unreliable. Thus, the opinion on the existence of the East East European branch of the Caledonides requires consideration in the light of theoretical tectonics.

DEFORMATION IN OLD-PALEOZOIC ROCKS IN THE FOREFIELD OF THE EAST EUROPEAN CRATON BETWEEN RADOM AND RAVA RUS'KA

The problem of the presence and age of tectonic deformation in Paleozoic rocks of the foreland of the East European craton was raised in publications many times: Mizerski and Skurek-Skurczyńska (2000), Mizerski and Stupka (2005), and Żaba and Poprawa (2006) discussed in detail the problems of Paleozoic tectonic deformation in the regions of Pomerania, Łysogóry and Małopolska. Those publications clearly state that the SW foreland of the East European craton can be divided into several blocks: Pomeranian, Radom-Łysogóry and Małopolska-Leżajsk blocks (Buła and Habryn, 2011). The Małopolska Block, in the area of Ukraine, continues into the Rava Rus'ka and Kokhanivka unit.

In the Rava Rus'ka and Kokhanivka unit, tectonic deformation is observed both in the lower and middle Paleozoic. The deformation developed as a result of horizontal stress oriented towards the craton. The folding of Paleozoic rocks was disharmonious in relation to the basement, and was due to diverse movements, both horizontal and vertical. This deformation, found in the older Paleozoic and Devonian rocks, fades away in rock series of the same age (Stupka, 2004; Mizerski, Stupka, 2005; Stupka, Mizerski, 2007) and is bounded at the base by flat decollement surfaces (Stupka, 1991, 2002). Below these surfaces, the strata lie almost horizontally and display no tectonic deformation. Analysis of the tectonic deformation shows that the compressional process began by the Late Devonian, and the main phase of deformation occurred in the Carboniferous during the final phase of the formation of young massifs of continental crust in Europe.

It could be suggested that the Rava Rus'ka and Kokhanivka zones may be of an Avalonian origin, like some blocks within the TESZ. However, this view has to be very questionable, since there is no tectonic deformation that clearly indicates a collision of the Avalonian Block with the East European craton.

The authors are of the opinion that the type of rock formations, style of tectonic deformation and general style of the geological structure and development of crustal fragments adjoining the Ukrainian Shield to the SW, prove that they are part of the old East European craton, with which they developed as a whole during late Precambrian and Phanerozoic times. There is no basis for distinguishing an epi-Caledonian consolidation zone in this area. The development of this part of the foreland occurred on a gradually subsiding craton edge.

Within the Małopolska segment of the foreland of the East European craton, tectonic deformation in the Paleozoic developed during three phases: Cadomian (early Caledonian?), late Caledonian and Variscan (Mizerski, 2004). These are both continuous and discontinuous large-, medium- and small-scale deformations. Much of the continuous deformation formed as a result of both normal and reverse faulting activity. Distinct angular unconformities allow identification of three structural levels within the Paleozoic succession. The evolution of none of these levels ended with their consolidation, because the tectonic deformation was not accompanied by metamorphism, and magmatic processes (resulting mainly in the formation of veins) occurred sporadically and over a limited area.

The deformations of all age groups within the Małopolska Block end in the T – T Zone and do not continue in the area of East European craton. These gaps only partially overlap in age with the stratigraphic gaps observed within the Małopolska Block. Stratigraphic gaps are not related to angular unconformities there. These gaps only partially overlap in age with the stratigraphic gaps observed within the Małopolska Block.

The problem of the nature of early and late Caledonian movements within the Małopolska Block was settled in many works; among which those of Głazek (1995) and Liszkowski *et al.* (1998) deserve special attention. Those authors fully share the views of Mizerski (1996) that there is no reason to suspect the existence of the Caledonian orogen in the Holy Cross area (its southern part is located in the Małopolska Block). The presence of generally weak early and late Caledonian deformation within the Małopolska Block should be explained by its position in an epicratonic zone and its mobility related to this position, characteristic of the lowered parts of the East European craton. Thus, it should be stressed once again that the views of the existence of the Caledonian orogen in the Holy Cross area (Dadlez, 1994; Dadlez *et al*., 1994; Znosko, 1964, 1986) are not supported by actually existing geological facts.

There are three (early Caledonian, late Caledonian and Variscan) structural complexes and one (Variscan) structural level in the Paleozoic of the Radom-Łysogóry Block (Mizerski, 1995). Tectonic movements at the Cambrian/Ordovician and Silurian/Devonian transitions did not cause any restructuring of the Paleozoic succession. Angular unconformities between different structural complexes are minimal or absent. These unconformities and stratigraphic gaps developed only as a result of vertical movements that led to a shallowing of the sedimentary basin, and locally to changes in sedimentation from marine to lagoonal and continental. The only clear angular unconformity caused by intense tectonic movements that resulted in the formation of strong fold and fault deformation, is the unconformity between the Permo-Triassic and the underlying Paleozoic rocks. Deformation that was produced during the Variscan epoch took place in the foreland of the NE'ward-thrusting Sudetic orogen.

To the east, the Radom-Łysogóry Block adjoins the Lublin and Podlasie segment of the East European craton. Stratigraphic gaps observed in the cratonic section find their manifestation in the Paleozoic of the Radom- Łysogóry Block. The similarity of sedimentation history in both of these units allows advancing a thesis that they evolved in a close connection with each other, and different tectonic histories of these two areas are caused by differences in the rigidity of both these elements. The Radom-Łysogóry Block developed in the mobile, plunging foreland of the East European craton and therefore it was prone to deformation associated with the tectonic stress transmitted from the orogenic area (Mizerski, 2004).

From the above considerations it follows that the tectonic deformation associated with the Caledonian tectonic epoch, occurring in the foreland of the East European craton from the Radom segment in Poland to the Ukrainian segment of the foreland, is local in nature. Furthermore, the Caledonian tectonic structures occurring in some areas do not continue in the others. The history of sedimentation and tectonic evolution of these areas of the foreland shows that the Caledonian deformation is not orogenic in character and is rather related to the mobility of the craton's foreland.

TECTONIC DEFORMATION WITHIN THE POMERANIAN SEGMENT OF THE FORELAND OF THE EAST EUROPEAN CRATON

In the Pomeranian Block, upper Paleozoic deposits unconformably overlie lower Paleozoic deposits. It follows from both a cartographic analysis of maps and drilling materials. It is illustrated in geological cross-sections by Karnkowski (1980). The nature of this deformation is not fully clear. Even Franke (1989), who thought them to have been the evidence of late Caledonian orogenic movements, was formerly of the opinion that the possibility of disharmonious deformation should be taken into account (Franke, 1967). Such a possibility could be supported by the fact that the lithologies of the lower and upper Paleozoic are completely different. The nature of the contact between the lower and upper Paleozoic level (complex?) has not been recognized in detail. The interpretations made for the classic borehole Gościno IG1 (Czermiński, 1967; Dadlez, 1967, Hajłasz, 1967), as well as for the Toruń 1 borehole (Dadlez, 1982; Pożaryski *et al*., 1992; Dadlez *et al*., 1994; Żaba, Poprawa, 2006) and the Polskie Łąki PIG1 borehole are by no means unambiguous. The paper by Żaba, Poprawa (2006) significantly contributed to the knowledge on the nature of tectonic deformation in the Paleozoic deposits. However, it concerned mainly the description of structures and their genetic and geometric relations. The age and nature of the deformation was discussed by those authors in a very cautious way. So, is it necessary to assume an orogenic activity of Caledonian movements to explain the existence of different types of deformation in the lower Paleozoic? It should be taken into account that the Paleozoic rocks of the area were deeply buried in Mesozoic times. Experimental research clearly shows that, in the lower parts of a subsiding graben, the rocks must undergo folding to compensate the decreasing surface area occupied by the subsiding rocks (Mizerski, Skurek-Skurczyńska, 2000). Thick Devonian sandstone-carbonate deposits must behave in such a case quite differently than the underlying lower Paleozoic clay-mud rocks, which are much more susceptible to continuous deformation. Thus, it cannot be excluded that the Caledonian unconformity in Pomerania does not have to be of typical tectonic origin, as claimed by Franke (1967) in his early views.

FINAL REMARKS

The above-presented facts and considerations on the East European branch of the Caledonides show that the views of its existence should be considered unproven. Caledonian deformation is observed along the SW edge of the East European craton, but it occurs in a limited area. Between the zones of Caledonian deformation, there are also zones (crustal blocks) lacking deformation of this age. The amount of reconnaissance of the existing Caledonian structures is variable. In some areas they are traceable on the surface, in others – they are hidden deep under the cover of younger rocks. It makes difficult any reliable comparison of these deformations.

While discussing on the nature of Caledonian deformation in the four discussed-above crustal blocks from the SW foreland of the East European craton, it should be noted that deformation of this age is not orogenic in character within the Radom-Łysogóry, Małopolska and Rava Rus'ka-Kochanowo blocks. The only area where the Caledonian orogen would be suspect is Pomerania. However, there is lack of geotectonic evidence in the region, which could indicate the existence of the orogen. The data on thermal history of the craton and its foreland should also be taken into account. All the data from the region of the so-called Pomeranian Caledonides and from the Precambrian platform prove that the thermal histories of the two areas are identical (Grotek, 1999). According to the authors, it indicates that the Caledonian deformation in Pomerania cannot be considered as orogenic deformation. The conclusion is that the views of the existence of the East European branch of the Caledonides as a branch of the Scandinavian Caledonides, should be regarded as having no confirmation in the existing geological facts. Then, how should the Caledonian deformation in the foreland of the craton be treated?

As regards the Caledonian deformation zone in Pomerania, the deformation can be treated as orogenic only if we consider the Pomeranian Block to represent a terrane – an alien element within the foreland of the craton. However, it is difficult to find any connection of this alleged terrane with any Caledonian orogen, from which it could have been detached. Other elements of the foreland of the East European craton occupied in the Paleozoic the same position as at present (see Żelaźniewicz *et al*., 2009).

In the Paleozoic, the SW foreland of the East European craton was segmented into blocks by major fault zones (Krauss, 1977; Mizerski, 1995) that continued into the craton area. This fragmentation of the foreland favoured differences in the mobility of its segments and, consequently, in the sedimentation rate and lithology.

The mobility and high sedimentation rate, resulting in the formation of a thick succession in a relatively shallow basin, suggest that, in the Paleozoic, the SW foreland of the East European craton may have been a transitional zone between the old platform and the Variscan basin of Western Europe, but the nature of this zone was passive. Moderately intense folding movements occurred in the foreland, which manifested themselves at different times in various segments of the craton's foreland. This area shows all features typical of the epicratonic fold zone (Mizerski, 1991, 1998).

The tectonic deformations of different ages in the epicratonic fold zone were a response to the processes that occurred in the Variscan basin of Western Europe.

REFERENCES

BAILEY E.B., HOLTEDAHL O., 1938 — Palaeozoische Tafeln und Gebirge. Abt. 2. Northwestern Europe Caledonides. *Reg. Geol. Erde*, **2**: 1–76.

BEURLEN K., 1939 — Erde und Lebensgeschichte. 462 ss. Verlag Quelle und Mayer. Leipzig.

BUBNOFF S., 1926 — Geologie von Europa. 344 ss. Berlin.

BUŁA Z., HABRYN R., 2011 — Precambrian and Paleozoic basement of the Carpathian foredeep and the adjacent Outer Carpathians (SE Poland and western Ukraine. *Ann. Soc. Geol. Pol.*, **81**: 221–239.

BUSH W.A., GARETSKI R.G., KIRIUKHIN L.G.,1973 — O pogrebiennoi zonie kaledonskoi skladchatosti vdol iugozapadnogo ogranichenia Voskochno-Evropeiskoi platformy. *Dokl. AN SSSR.*, **208**, 2: 409–412.

CZERMIŃSKI J., 1967 — Metamorficzne podłoże dewonu w Gościnie k. Kołobrzegu. *Kwart. Geol.,* **11**, 3: 693–697.

DADLEZ R., 1967 — Najnowsze profile podłoża cechsztynu w północno-zachodniej Polsce. *Kwart. Geol.,* **11,** 3: 572–585.

DADLEZ R., 1982 — W sprawie interpretacji profilu starszego paleozoiku w otworze Toruń 1. *Prz. Geol.,* **30**: 273–277.

DADLEZ R., 1994 – Debates about the pre-Variscan tectonics of Poland. *Bull. Pol. Acad. Sc. Earth Sc.*, **42**, 2: 137–144.

DADLEZ R., JAROSZEWSKI W., 1994 — Tektonika. 743 ss. Wyd. Nauk. PWN, Warszawa.

DADLEZ R., KOWALCZEWSKI Z., ZNOSKO J., 1994 — Some key problems of the pre-Permian tectonics of Poland. *Geol. Quart.*, **38**, 2: 169–190.

DIKENSHTEIN G.H., SOLOVIOV B.A., KHAIN V.E., 1975 — K problemie raionirovania Sredniei Evropy po vozrastu skladchatogo osnovania. *Geotektonika*, **3**: 3–14.

FRANKE D., 1967 — Die erste Aufschluss im tieferen Paläozoicum Norddeutschlands und seine Bedeutung für tektonische Gliederung Mitteleuropas. *J. Geol.*, **1**: 119–165.

FRANKE D., 1989 — Variscan plate tectonics in Central Europe – current ideas and open question. *Tectonoph.*, **169**: 221–228.

GAERTNER R.V., 1950 — Erwägungen über präpermische Gebirgszusammenhänge und im Untergrund von Norddeutschland. *Geol. Jb.,* **64**: 123–158.

GARETSKI R.G. & KOLCHANOV V.P., 1987 — Iugo-zapadyi krai Vostochno-Evropeiskoi platformy. *Geotektonika*, **3**: 97–100.

GLUSHKO V.V., 1958 — Osnovnyje cherty tektoniki Predkarpatskogo progiba w prolegajushchei chasti Russkoi platformy. *Geol. Sbor. Lv. Geol. Ob.*, **5-6**: 7–24.

GŁAZEK J., 1995 — A Caledonian Orogen in Poland? *Nacht. Deutsch. Geol. Ges.*, **54**: 74–75.

GOLFSHTEIN I.D., 1957 — K voprosu o kaledonskom obramlenii Russkoi platformy. *Izv. AN SSSR, ser. Geol.*, **5**: 64–68.

GROTEK I., 1999 — Origin and thermal maturity of the organic matter in the Lower Palaeozoic rocks of the Pomeranian Caledonides and their foreland (northern Poland). *Geol. Quart*. **43**, 3: 297–312

HAJŁASZ B., 1967 — O znalezieniu *Tentaculites sp.* w otworze Gościno IG1. *Kwart. Geol.*, **11,** 3: 697–698.

KARNKOWSKI P., 1980 — Przekroje geologiczne przez Niż Polski. Wyd. Geol., Warszawa.

KHIZNIAKOV V.V., 1963 — Geologicheskoie strojenie i perspektivy nieftiegazonosnosti Lvovskogo paleozoiskogo progiba. Geologia i nieftonazonosnost territori USSR, Moskwa, Gostotekhnizdat: 189–202 ss.

KHIZNIAKOV V.V., 1969 — Vozrast drevnich skladchatykh sooruzhenii, obramliaiuschchikh jugo-zapadnuiu okrainu Russkoi platformy i kharakter ikh sothlenienia z niei. *Geol. geokh. Gor. Isk.*, **20**: 3–11.

KÖLBEL H., 1959 — Stand und Ergebnisse der Kartierung des tieferen Untergrundes Nordostdeutschlands und angrenzeder Gebiete. *Ber. Geol. Ges.*, **4**, 2–3: 115–156.

KOSMATT E., 1936 — Paläogegraphie und Tektonik. Berlin.

KRAUSS M., 1977 — Zur Mobilität tektonischer Einheiten des westlichen Teils der Osteuropäischen Plattform. Wiss. Z. EMA Uniw. Greifswald., 1–2.

LIMANOWSKI M., 1922 — O krzyżowaniu się łańcuchów Europy środkowej w Polsce i o liniach analogicznych biegnących pod tymi łańcuchami. *Spraw. Państw. Inst. Geol*., **1**, 4–6: 44 ss.

LISZKOWSKI J., BARLIK M., ŚLEDZIŃSKI J., 1998 — Geotectonics and geodynamics of the Teisseyre-Tornquist Zone. *Rep. on Geodesy*, **4,** 34: 1–113.

MIZERSKI W., 1991 — Ewolucja tektoniczna regionu łysogórskiego Gór Świętokrzyskich. *Rozpr. Uniw. Warsz*., **262**: 1–141.

MIZERSKI W., 1995 — Geotectonic evolution of the Holy Cross Mts. in Central Europe. *Biul. Państw. Inst. Geol*., **372**: 1–47.

MIZERSKI W., 1996 — Czy w Górach Świętokrzyskich są Kaledonidy? *Prz. Geol*., **44**: 381–385.

MIZERSKI W., 1998 — Podstawowe problemy tektoniki i tektogenezy utworów paleozoicznych Gór Świętokrzyskich. *Prz. Geol*., **46**, 4: 337–342

MIZERSKI W., 2000 — Tektonika i tektogeneza paleozoiku Gór Świętokrzyskich. *Pr. Inst. Geogr. WSP w Kielcach*, **46**, 4: 67–125.

MIZERSKI W., 2004 — Holy Cross Mountains in the Caledonian, Variscan and Alpine cycles – major problems, open questions. *Prz. Geol*., **52,** 8/2: 774–779.

MIZERSKI W., SKUREK-SKURCZYŃSKA K., 2000 — Problemy tektoniki zachodniego przedpola platformy wschodnioeuropejskiej w Polsce – fakty, interpretacje, otwarte kwestie. *Biul. Państw. Inst. Geol.*, **393**: 115–133.

MIZERSKI W., STUPKA O., 2005 — Zachodni i południowy zasięg kratonu wschodnioeuropejskiego. *Prz. Geol*., **53,** 11: 1030–1039.

POŻARYSKI W., 1990 — Kaledonidy środkowej Europy orogenem przesuwczym złożonym z terranów. *Prz. Geol.*, **38,** 1: 1–9

POŻARYSKI W., 1991 — The strike-slip terrane model for the North German-Polish Caledonides. *Publ. Inst. Geoph. Pol. Acad. Sc.,* **A-19**, 236: 3–15.

POŻARYSKI W., GROCHOLSKI A., TOMCZYK H., KARNKOWSKI P., MORYC W. 1992 — Mapa tektoniczna Polski w epoce waryscyjskiej. *Prz. Geol.*, **40**: 643–651.

POŻARYSKI W., NAWROCKI J., 2000 — Struktura i lokalizacja brzegu platformy wschodnioeuropejskiej w Europie Centralnej. *Prz. Geol.*, **48**: 703–706.

SANDLER J.M., GLUSHKO V.V., 1955 — Skladchatyi silur v severo-zapadnoi chasti Lvovskoi oblasti. *Dokl. AN SSSR*, **103**, 4: 685–688.

SCHWINNER R., 1934 — Die Germanische Nord-Süd Senke. *Geol. Rundsch*., **25**: 26–38.

SHATSKI N.S., BOGDANOV A.A., 1961 — O miezhdunarodnoi tektonicheskoi karte Evropy. *Izv. AN SSSR, ser. Geol.*, **4**.

STILLE H., 1950 — Die kaledonische Faltung Mitteleuropas im Bilde des gesamteuropäischen. *Z. Deutsch. Geol. Ges.*, **100**: 221–266.

STUPKA O., 1991 — O tektonicheskoi strukturie nizhnie-srednepaleozoiskikh obrazovanii otlozhenii iugo-zapadnoi okrainy Vostochnoevropeiskoi platformy i vozmozhnyi mekhanism ieie formirovania (v sviazi s problemoi nieftiegazonosnosti glubokozalegaiushchtikh gorizontow. *Geol. i Geokh. Gor. Iskop.*, **77**: 13–23.

STUPKA O., 2002 — Nasuvni i pidnasuvni strukturi – novi perspektivni obiekt poshukiv pokladiv nafti i gazu w miezhakh pivdienno-zakhidnoi okrainy Skhidno-evropeiskoi platformy. *Probl. Nieft. Kompleksu Ukrainy*, Kiev: 30–46.

STUPKA O., 2004 — Problemi tektoniki Ukraini na suchasnomu etapi rozvitku geologichnoi nauki. *Geolog*, **2***:* 48–54.

STUPKA O., MIZERSKI W., 2007 — Uwagi o wpływie struktury przedpola na formowanie się nasunięć płaszczowinowych. *Prz. Geol.*, **35**: 430–434.

ZNOSKO J., 1962 — Obecny stan znajomości budowy geologicznej podłoża pozakarpackiej Polski. *Kwart. Geol.*, **6**, 4: 485–511.

ZNOSKO J., 1964 — Poglądy na przebieg Kaledonidów w Europie. *Kwart. Geol.*, **8**, 4: 697–720.

ZNOSKO J., 1986 — Polish Caledonides and their relation to the European Caledonides. *Z. Deutsch. Geol. Ges*., **135**: 585–511.

ZWERGER R., 1948 — Der tiefere Untergrund des westlichen Peribaltikums. *Abh. Geol. Landesanst.* N.F., **210**.

ŻABA J., POPRAWA P., 2006 — Historia deformacji strefy Koszalin-Chojnice (pomorski segment szwu transeuropejskiego) na podstawie analizy strukturalnej utworów paleozoicznych i mezozoicznych w otworach Polskie Łąki PIG 1 i Toruń 1. *Pr. Państw. Inst. Geol*., **186**: 225–252.

ŻELAŹNIEWICZ A., BUŁA Z., FANNING M., SEGHEDI A., ŻABA J., 2009 — More evidence on Neoproterozoic terranes in southern Poland and southeastern Romania. *Geol. Quart.*, **53**, 1: 93–124.