

FRAGMENTS OF OCEANIC CRUST IN THE VARISCAN BASEMENT OF SOUTH-WESTERN POLAND

UKD 551.733.13/.735.1.02:551.242.1(438-14)

In 1979 Majerowicz (10) expressed the opinion that the ultrabasites and basites of the Ślęza Mountain Group, situated within the Fore-Sudetic Block to the south of Wrocław, represent an ophiolitic suite consisting of the following complexes:

1. Ultrabasic rocks – serpentinites (former Iherzolites, dunites, harzburgites and others).
2. Gabbro complex with cumulative structures.
3. Mafic rocks occurring as sheeted dikes. According to the cited author no pillow lavas have been found, however.
4. Pelagic siliceous deposits accompanying the ultramafites and mafites.

One year later Narębski (11) basing on geochemical evidence recognized in the spilitic complexes of the Góry Kaczawskie Region equivalents of oceanic island basalts, and in the eastern part of the Lusatia – Karkonosze Massif – tholeiites of island arcs. In the same year, Znosko (15) presented the view that basites and ultrabasites adjoining the gneissic Góry Sowie Block (tectonic unit 1 on Fig.) represent a fragment of oceanic crust over which the Block has been thrust. The above basites and ultrabasites belong, together with the Góry Kaczawskie spilites (unit 4 on Fig.), to the complex of ophiolitic association. They form, according to the cited author, strongly disrupted fragments of oceanic crust of the Mediterranean type, or products of its secondary melting.

In 1985, Borkowska (1), after summarizing petrology and geochemistry of gabbroids from the southwestern rim of the Góry Sowie Block, came to the following conclusion: "Although chemistry of gabbroid rocks of the Nowa Ruda Massif differs from the typical ophiolites of Coleman, existing similarities suggest their probable derivation from the oceanic crust". The cited author tends thus to assume that the gabbros originated due to secondary melting of an oceanic crust.

The views on the contribution of an oceanic crust in the geological structure of the Sudetes and Fore-Sudetic Block, formulated primarily basing on the results of petrographical and geochemical investigations of igneous rocks, received a recent support in the results of comparative studies of the Paleozoic sedimentary sequences in the Sudetes and their neighbourhood. This analysis is presented by the author (7) in a separate paper.

In the geology of the Sudetes, a problem of rocks derived from a supposed oceanic crust is temporally and spatially related to the question of allochthonous origin of some tectonic elements due to large-scale mass-movements, i.e. due to exotectonics. One of the first authors to suggest a possibility of such an interpretation was Teisseyre (12). He was inclined to explain thrusting of the Góry Kaczawskie spilites over the Upper Devonian to Lower Carboniferous conglomerates of the Świebodzice Depression as an effect of gravitational gliding of rock masses from the rising Pre-Kaczawskie Chain. Also Haydukiewicz (9) proposed in 1978 that "some of the Góry Kaczawskie nappe-like units may have originated due to delapsion as so-called sedimentary nappes (,olisthonappes",

"Gleitdecken")". In 1978 Wajsprych expressed the view that the geological structure of the Góry Bardzkie is an effect of large-scale gravitational displacements of rock masses. The cited author expanded his concept of the allochthonism of the Góry Bardzkie Paleozoic in the Excursion Guidebook of the IAS 7th European Regional Meeting (14).

Very valuable supplementary data related both to the lithostratigraphy and tectonics are provided by the recent results of the Zdanów IG 1 borehole (3). The borehole section is situated to the south of intersection boundary of the gneissic Sowie Góry Block (Fig.).

DEVELOPMENT OF PALEOZOIC DEPOSITS

A comparative study of the Paleozoic sequences of the Barrandian Basin (Bohemian Massif), Lusatia-Karkonosze Block, Kłodzko Metamorphic Region, Góry Bardzkie Region and Góry Kaczawskie Region is presented in a separate paper (7); following considerations will be restricted only to presentation of the most important results.

The Paleozoic sections display many differences in facies development and sediment thicknesses as well as in a degree and character of secondary alterations. Don (4) wrote about the Kłodzko – Góry Kaczawskie – Lusatia segment consolidated during the Caledonian movements (Sardinian – Sairian Phases), and about the early Hercynian Góry Bardzkie – Góry Kaczawskie – Zgorzelec segment. Grocholski (7) noted essential differences between geological structures of both these areas, and distinguished the southern region (Karkonosze – Kłodzko) from the northern one (Góry Kaczawskie – Góry Bardzkie). Quite distinct, differing in many aspects, is the Paleozoic sequence of the Barrandian in the Bohemian Massif. Differences between the three above named sedimentary areas appear as follows:

In the Bohemian Massif, the Paleozoic sequence is represented by an almost complete succession of the Cambrian through Middle Devonian deposits. They reach an overall thickness on the order of 7000 meters, and contain considerable amounts of volcanics and abundant marine fossils. The deposits accumulated in a gradually subsiding sedimentary basin developed on a continental crust. When compared to the other accumulation areas this basin may be interpreted as a marginal sea.

The Paleozoic sections of the Karkonosze – Lusatia Block are incomplete, with numerous stratigraphic gaps, intercalations of shallow-water sediments and thick volcanic complexes. The general paleotectonic setting has been interpreted as characteristic for an island arc separating the above mentioned marginal sea from an open ocean. In addition to lithological and facies evidence the above hypothesis is substantiated by a distinctive chemistry of volcanics in the eastern part of the Karkonosze – Lusatia Block (11), typical for an island arc setting.

The Paleozoic sequences of the Góry Kaczawskie and Góry Bardzkie have been restored basing on a number

of fragmentary outcrops. They contain a complete or nearly complete succession of the Upper Ordovician through Lower Carboniferous, represented in their lower part (Silurian – Lower Devonian) by pelagic, deeper-water, in places abyssal radiolarian oozes. On the other hand, the Middle Devonian to Lower Carboniferous deposits display the attributes of a distal flysch facies. The whole sequence is strongly tectonised and was shown to be locally included into melange and sedimentary nappes. The most characteristic, however, is its co-occurrence with spilite-keratophyre complexes of considerable but only roughly defined thickness. The volcanics are thought to be of Cambrian age; the occurrence of younger complexes is, however, probable. Geochemically, these rocks correspond to basalts of oceanic islands (11) while the accompanying

sediments were interpreted as characteristic for open-oceanic bottoms. Don (5) considered that during the Paleozoic the region ("rift") of Góry Kaczawskie was the site of, as he put it, "facies-structural regime approximating or typical for areas with oceanic basement". The hypothesis of oceanic basement is also supported by the earlier cited opinions of Majerowicz (10), Znosko (15) and Haydukiewicz (9).

The above named complexes of igneous rocks and accompanying pelagic deep-water sediments, which were interpreted as characteristic for oceanic bottoms, are exotic elements allochthonous relative to the Karkonosze – Lusatia segment (Kłodzko – Góry Izerskie – Lusatia) representing a continental crust. The boundary between these allochthonous elements and the above segment runs, as noticed by Don (4), along the Main Sudetic Fault (Fig.).

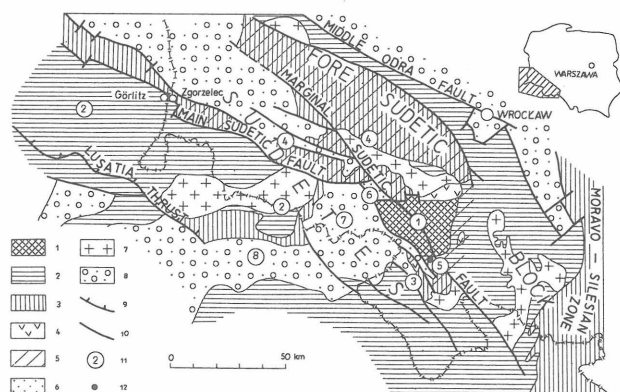
The gneissic Góry Sowie Block – in the earlier literature referred to as the "gneissic plate of the Góry Sowie" – shows structural and petrogenetic relationships to the Moldanubian rocks forming a core of the Bohemian Massif. As indicated by gravimetric and magnetic measurements, the Góry Sowie Block rests upon the serpentinites and gabbroids found in immediate vicinity of its edge both on the surface and in boreholes.

The sections of Paleozoic sediments (Upper Devonian to Lower Carboniferous) occurring in the neighbourhood of the Góry Sowie Block provide information on tectonic events responsible for an origin of the present structural framework of the Central Sudetes. Metamorphosed volcanic-sedimentary rocks of the Kłodzko Metamorphic Region (documented Ludlow – probable Devonian) are overlain by unaltered limestones and detrital deposits of the Famennian age. The first occurrences of pebbles formed of the Góry Sowie gneisses and gabbroids have been stated in the Upper Devonian sedimentary sequence of the Świebodzice Depression. One may therefore assume that paleogeographic pattern in the Central Sudetes changed rapidly after the Middle Devonian. As a working hypothesis it may be proposed that the fragment of oceanic crust (serpentinites, gabbros) with overlying microcontinent, the gneissic plate of the Góry Sowie, docked at the crystalline core of the Bohemian Massif, probably across an oblique strike-slip zone. (According to the above explanation, the old term "Góry Sowie Plate" regains its relevance). From this time on, the gneissic Góry Sowie Block became involved in further structural development of the Central Sudetes. This Block supplied material for conglomerates in the autochthonous and para-autochthonous deposits of the Upper Devonian and Tournaisian.

SEQUENCE OF TECTONIC EVENTS

Further history of tectonic events in the Central Sudetes may be reconstructed as follows. After docking of the oceanic crust and overlying gneissic Góry Sowie Block, an active fault zone developed in the northern part of the Block, supplying detrital material to the Świebodzice Depression during the Late Devonian and Early Dinantian. The zone in question was bordering from the north a hypothetical southern massif which, however, has been intermittently inundated with shallow marine incursions (embayments?). Their occurrence is evidenced by para-autochthonous neritic Famennian and Tournaisian deposits found in the northern part of the Góry Bardzkie region in the borehole Zdanów IG 1.

During the Tournaisian, folding of the Nassau Phase



Solid geological map (without Cenozoic and Mesozoic) of south-western Poland and adjoining areas

- 1 – Upper Proterozoic: gneissic complex of the Góry Sowie,
- 2 – Upper Proterozoic–Cambrian complex of sedimentary and igneous rocks metamorphosed in amphibolite facies,
- 3 – Upper Proterozoic–Middle Cambrian and Upper Ordovician–Lower Carboniferous complex of sedimentary and igneous rocks metamorphosed in greenschist facies or very weakly altered,
- 4 – Early Paleozoic serpentinites and gabbros,
- 5 – occurrence limit of fragments of Paleozoic oceanic crust,
- 6 – Upper Devonian and lowermost Carboniferous coarse-grained deposits of the Świebodzice sequence,
- 7 – late Variscan granitoid intrusions,
- 8 – Carboniferous and Permian developed as molasse,
- 9 – overthrusts,
- 10 – faults,
- 11 – most important tectonic units (listed below),
- 12 – location of Zdanów IG 1 borehole

Most important tectonic units (numbers on the map refer to respective units): 1 – Góry Sowie Block, 2 – Lusatia–Karkonosze Block, 3 – Kłodzko Metamorphic Region, 4 – Góry Kaczawskie Region, 5 – Góry Bardzkie Region, 6 – Świebodzice Depression, 7 – Intra-Sudetic Basin, 8 – Karkonosze Piedmont Basin

Szkic geologiczny odkryty (bez utworów kenozoicznych i mezozoicznych) Polski południowo-zachodniej i obszarów przyległych

- 1 – górny proterozoik – kompleks gnejsowy Gór Sowych,
- 2 – górny proterozoik–kambry – kompleks skał osadowych i magmowych przeobrażonych w facji amfibolitowej,
- 3 – górny proterozoik–kambry środkowy oraz ordowik górny–karbon dolny – kompleks skał osadowych i magmowych przeobrażonych w facji zieleńcowej lub bardzo słabo zmienionych,
- 4 – wczesnopaleozoiczne serpentyny i gabra,
- 5 – zasięg występowania fragmentów paleozoicznej skorupy oceanicznej,
- 6 – górny dewon i najniższy karbon – osady gruboklastyczne sekwencji Świebodzic,
- 7 – młodowarwscyjskie intruzje granitoidów,
- 8 – utwory karbonu i permu w wykształceniu molasowym,
- 9 – nasunięcia,
- 10 – uskoki,
- 11 – ważniejsze jednostki tectoniczne (por. wykaz),
- 12 – lokalizacja otworu Zdanów IG 1

Wykaz ważniejszych jednostek tectonicznych, numerom w kółkach na mapie odpowiadają następujące jednostki: 1 – blok Gór Sowych, 2 – blok Łużyce–Karkonosze, 3 – region metamorfiku kłodzkiego, 4 – region Gór Kaczawskich, 5 – region Gór Bardzkich, 6 – depresja Świebodzic, 7 – basen śródsudectki, 8 – basen przedgórz Karkonoszy

occurred, which, according to Teisseyre (12) "was accompanied by gravitational tectonics resulting in gliding of the outer Góry Kaczawskie structures towards the Świebodzice Depression that was just being folded". Probably in the same time the spilite-keratophyre series and accompanying deep-marine sediments of the Góry Kaczawskie were docking at, or, in any case, connected to the Bohemian Massif.

As a result of the above movements, the Intrasudetic Basin developed during the Viséan, and has been filled by thick (about 4000 meters) complexes of terrigenous sediments. In the late Viséan, the sea encroached again over the Central Sudetes area. Facies differentiation of the Upper Viséan in the northern Góry Bardzkie (2) evidences dynamic patterns of nearshore accumulation processes in this area.

Major displacements of rock masses took place during the Namurian A, probably in the early Namurian A (Erzgebirgen Phase), when the allochthonous deposits of the Silurian to Dinantian (Viséan included) were thrust over the para-autochthonous part of the northern Góry Bardzkie Region. One of results of these movements is a superposition of the Devonian on the Dinantian deposits, found in the Zdanów IG 1 borehole. It remains an open question whether this displacement has been due directly to endotectonics or, as suggested by Chorowska (3), to mass movements.

FINAL REMARKS

The above presented working hypothesis on docking of oceanic crust of the Góry Kaczawskie – Góry Bardzkie segment at the sialic crust of the Bohemian Massif sheds light on many unresolved or difficult to resolve questions touched upon in the Gunia's paper (8), and concerning a geological position of the Góry Sowie Block. At the same time, the concept presented herein poses many new problems which need solution or verification. First of all, it is not clear from where came the fragment of oceanic crust with the microcontinent i.e. the Góry Sowie Plate. The present writer tends to exclude a drift from the south. The further question is: when did docking of the Góry Kaczawskie segment occur and due to what kind of displacement? What was the character of tectonic movements of the Erzgebirgen Phase? What is a spatial and temporal relationship of the movements described from the Central Sudetes to the nappe tectonics and successive stages of metamorphism recognized in Hruby Jeseník in the Eastern Sudetes, and, finally, what is the tectonic position of the so-called Metamorphic Region of the Middle Oder or, in more general terms, of the Wrocław Formation as described by Grocholski (6). The latter is represented by sedimentary and volcanic series metamorphosed in amphibolite facies.

Solution of the above different problems requires developing new research projects involving integrated modern methodology usually applied to verification of hypotheses regarding "suspect terranes", first of all including paleomagnetic studies, isotope dating as well as a microfacies analysis of the deposits occurring in a broadly understood Sudetic foreland.

Translated by M. Narkiewicz

REFERENCES

1. Borkowska M. – Gabroic rocks and their minerals from the Nowa Ruda massif. *Geol. Sudetica* 1985 nr 20, 1.

2. Chorowska M., Radlicz K. – Carboniferous limestones and conglomerates in western part of the Bardo structure. *Kwart. Geol.* 1984 nr 2.
3. Chorowska M., Maciejewska S. et al. – Badania głębokiej budowy geologicznej Sudetów – struktura bardzka. Dokumentacja wynikowa otworu Zdanów IG 1. 1985. In Polish only. Arch. Dok. Źródł. Wrocław.
4. Don J. – The Caledonides and Variscides in the Western Sudetes. *Prz. Geol.* 1984 nr 8–9.
5. Don J. – Model of expansional development of the Western Sudetes Mts. in the Paleozoic (a proposal). *Ibidem* 1985 nr 3.
6. Grocholski A. – Crystalline series of the Fore-Sudetic Block and the connected prospects for mineral resources. *Biul. Inst. Geol.* 1982 nr 341.
7. Grocholski A. – Paleozoic of south-western Poland. 1986 (in press).
8. Gunia T. – Geological position of the Sowie Góry block and its influence on the paleogeography of the Paleozoic Central Sudetes. *Geol. Sudetica*. 1985 nr 20, 2.
9. Haydukiewicz A. – Zagadnienie budowy płaszczowinowej Gór Kaczawskich [In:] Wybrane zagadnienia stratygrafii, sedymentacji i tektoniki metamorfizmu kaczawskiego 1977. In Polish only; Wrocław.
10. Majerowicz A. – The Ślęza Mountain Group Versus recent petrological problems of ophiolites. Engl. sum. [in] The Selected stratigraphic, petrographic and tectonic problems of the region east of the Sowie Góry Gneissic Block and the Kłodzko Metamorphic Units. 1979. Wrocław.
11. Narębski W. – Paleotectonic setting of the Circum-Karkonosze Lower Paleozoic spilite – keratophyre suites based on geochemistry of iron group elements. *Rocz. Pol. Tow. Geol.* 1980, nr 50, 1.
12. Teisseyre H. – Stratigraphy and tectonics of the Świebodzice Depression. *Biul. Inst. Geol.* 1968 nr 222.
13. Wajsprych B. – Allochthonous Paleozoic rocks in the Viséan of the Bardzkie Mts. (Sudetes). *Rocz. Pol. Tow. Geol.* 1978 nr 48, 1.
14. Wajsprych B. – Sedimentary record of tectonic activity on a Devonian-Carboniferous continental margin, Sudetes. [In:] IAS 7th European Regional Meeting Excursion Guidebook. 1986. Kraków. Poland. Ossolineum.
15. Znosko J. – The problem of oceanic crust and of ophiolites in the Sudetes. [In:] Ophiolites and Initio-lites of Northern Bowler of the Bohemian Massif Guide book of excursions. 1981 vol. II Potsdam – Freiberg.

STRESZCZENIE

Utwory paleozoiczne od górnego ordowiku po dolny karbon włącznie, występujące w Górach Kaczawskich i Górach Bardzkich oraz w obrębie zachodniej części bloku przedsudeckiego wykształcone są w facji głębokomorskiej, pelagicznej. Współwystępują z nimi magmowe skały zasadowe i ultrazasadowe. Wysunięto tezę, że zarówno serie osadowe jak i magmowe stanowią fragment skorupy oceanicznej, który przyłgnął („was docked”), być może w strefie ukośnego przesuwu, do Masywu Czeskiego reprezentującego skorupę kontynentalną. Czas tego wydarzenia określono na przełom dewonu środkowego i gór-

nego. Utwory barrandienu w Masywie Czeskim zinterpretowano jako osady morza marginalnego oddzielonego od otwartego oceanu łukiem wysp, którego fragment ciągnie się od metamorfiku kłodzkiego po blok karkonosko-lużycki. W turneju i namurze A miały miejsce kolejne przemieszczenia mas skalnych, zachodzące przynajmniej częściowo w wyniku wielkoskalowych ruchów grawitacyjnych.

РЕЗЮМЕ

Палеозойские отложения с верхнего ордовика до нижнего карбона (включительно), распространенные в Качавских и Бардзких горах, а также в пределах западной части предсудетского блока, представлены в

глубокоморской, пелагической фации. Вместе с ними находятся там тоже магматические основные и ультраосновные породы. Поставлен тезис, что как осадочные, так и магматические породы являются фрагментом океанической коры, который пристал, может быть в зоне диагонального перемещения, к Чешскому массиву представляющему континентальную кору. Возраст этого события определен на перелом среднего и верхнего девона. Отложения Баррандиена в Чешском массиве интерпретируются как осадки побочного моря, отделенного от открытого океана дугой островов, которой фрагмент тянется от кłodзкого метаморфика до кarkonosko-лужицкого блока. В турнейском и намюрском ярусах происходит очередное перемещение скальных масс, вызванное хотябы частично крупномасштабными движениями.