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Hypothetical structure of the Earth crust of the Variscides of south-western Poland — alternative models for the EU-3 transect

New interpretation of existed geophysical and geological data for the. EU-3 transect (earlier the VII international profile), based on results of new studies on structure of the Earth crust of the Variscides from Middle Europe, allowed to construct 3 hypothetical models of the crust for Polish part of Variscides. One of them based on tectonic-plate interpretation of the tectogene but two others — on the subfluence conception.

INTRODUCTION

Last years were the period of intensive development of complex programs of studying the continental lithosphere, carried along so called "geotransects", crossing the most important, visible on surface, geological structures (D. J. Blundell, 1990; G. Dohr, 1989). Such transects were done — among others — on area of the European Variscides in England, Ireland, France, Spain and Germany. Geological interpretation of results of geophysical studies allowed to compare structures, discerned on surface, with internal structure of the Earth crust and to create new structural-genetic models (among them: C. B. Bois et al., 1987; H. J. Behr, T. Heinrichs, 1987; *BIRPS AND ECORS*, 1986; *DEKORP RESEARCH GROUP*, 1988; W. Franke et al., 1990; T. H. Wever et al., 1990).

Hitherto only one profile of the deep seismic sounding, passing across the Polish part of the Variscan tectogene, was realized in first half of seventies, along so called VII international profile (A. Guterch et al., 1975 — Fig. 1). Geological interpretation

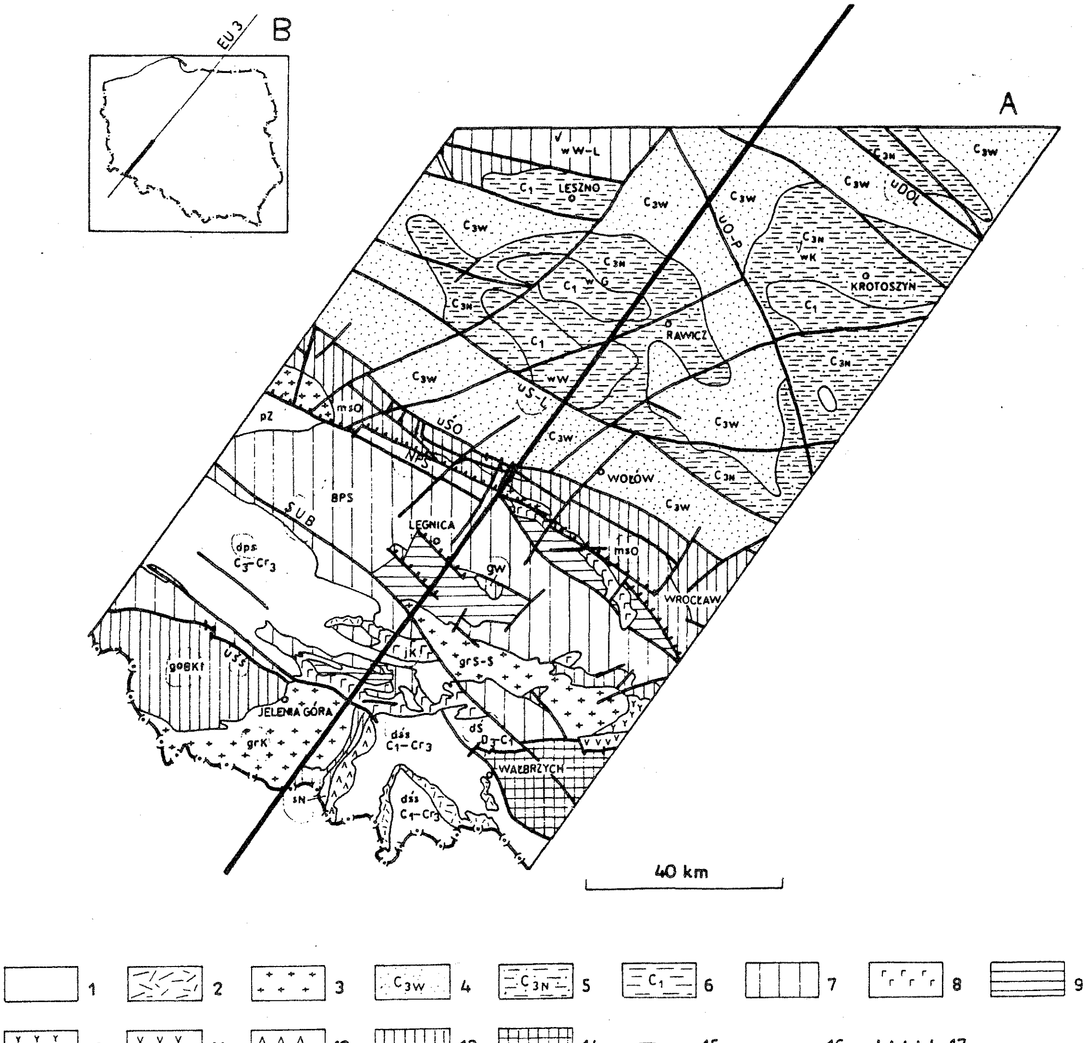


Fig. 1. The geological strip-map without Quaternary of the Variscan part of the EU-3 transect (A) with location of the EU-3 transect in Poland (B); elaborated part of transect was marked

1 — Upper Devonian, Carboniferous, Permian, Triassic and Lower Cretaceous deposits of the internal depressions of the Sudetes; 2 — volcanites and volcanoclastics; 3 — granitoids late and posttectonic (Upper Carboniferous–Lower Permian); 4 — Westfalian deposits in the basement of the Fore-Sudetic Monocline; 5 — Namurian deposits in the basement of the Fore-Sudetic Monocline; 6 — Lower Carboniferous deposits (flysch) of the Fore-Sudetic Monocline; 7 — epimetamorphic slaty series (Cambrian–Upper Devonian, Lower Carboniferous?); 8 — epimetamorphic volcanogenic series (spilitic-keratophyric series, Cambrian–Devonian); 9 — epimetamorphic slaty-greywacke series (Devonian?); 10 — gabbros; 11 — serpentinites; 12 — volcano-plutonic series of Leszczyniec (Lower Paleozoicum); 13 — gneiss-amphibolitic mesozonal

of geophysical data was done by W. Pożaryski (1975). The geological section, presented by him, was based on the model of block structure of the Earth crust along all studied part of this profile.

This paper aims at new interpretation of existed seismic, gravimetric and magnetic data from the Variscan part of this profile (after new nomenclature it was signed as EU-3). Lack of new seismic image, particulary — results of seismic-reflection data — caused that proposed conceptual models have a hypothetical character and are rather suggestions, stimulating the scientific discussion on the internal structure of the Polish Variscides. They are based mainly on results of the seismic-reflection profiling in various parts of the European Variscides and their geological interpretations published during last years (H. J. Behr, T. Heinrichs, 1987; P. Matte, 1986, 1988; W. Franke et al., 1990; P. Giese et al., 1983). Geological surficial data, among them — results of deep drillings, results of two various version of gravimetric modelling (A. Pepel et al., 1989; T. Grabowska, M. Raczyńska, 1991) and magnetic one (A. Koblańs-ki, 1990) as well as gravimetric data for the sub-Permian besement, estimated with the stripping method by C. Królikowski, A. Grobelny (1991) were used for construction of three different models of the crust presented in the paper.

series (Upper Proterozoicum?–Lower Paleozoicum); 14 — gneisses, migmatites, amphibolites of the Góry Sowie Block; 15 — geological boundaries; 16 — faults; 17 — overthrusts boundaries; geological units: wW–L — Wolsztyn — Leszno Elevation, wK — Krotoszyn Elevation, wG — Góra Elevation, mśO — Middle Odra metamorphicum, BPS — Fore-Sudetic Block, gW — gneisses of Wądroże Wielkie, jK — Kaczawa Unit, grS–S — Strzegom — Sobótka granitoid massif, dps — North-Sudetic Depression, dśs — Intra-Sudetic Depression, dŚ — Świebodzice Depression, goBKI — Karkonosze-Izera gneiss block, grK — Karkonosze granitoid massif, sN — Niedamirów series; main faults: uDOL — Dolsk faults system, uO–P — Poznań — Oleśnica Fault, uS–L — Śląsk — Lubusza Fault, uŚO — Middle Odra Fault (northward from it — the Fore-Sudetic Monocline area — were not drawn the platform deposits of Permian–Mesozoic), NPS — Fore-Sudetic Overthrust, SUB — Marginal Sudetic Fault, uśs — Intra-Sudetic Fault

Odkryta mapa geologiczna pasa transektu EU-3 o szerokości 100 km (A) wraz z lokalizacją transektu w Polsce (B); zaznaczono fragment transektu

1 — osady dewonu górnego, karbonu, permu, triasu i kredy górnej wewnętrznych depresji Sudetów; 2 — wulkanity i wulkanoklastyki; 3 — granitoidy późno- i posttektoniczne (karbon górny–perm dolny); 4 — osady westfalu podłoża monokliny przedsudeckiej; 5 — osady namuru podłoża monokliny przedsudeckiej; 6 — osady karbonu dolnego (flisz) monokliny przedsudeckiej; 7 — epimetamorficzne serie łupkowe (kambr–dewon górny, karbon dolny?); 8 — epimetamorficzne serie wulkanogeniczne (seria spilitowo-keratofirowa, kambr–dewon); 9 — epimetamorficzne serie łupkowo-szarogłazowe (dewon?); 10 — gabra; 11 — serpentynity; 12 — wulkaniczno-plutoniczna seria Leszczyńca (starszy paleozoik); 13 — gnejsowo-amfibolitowe serie mezozonalne (górny proterozoik? -starszy paleozoik); 14 — gnejsy, migmatyty, amfibolity bloku Gór Sowich; 15 — granice geologiczne; 16 — uskoki; 17 — granice nasunięć; jednostki geologiczne: wW–L — wyniesienie Wolsztyna — Leszna, wK — wyniesienie Krotoszyna, wG — wyniesienie Góry, mśO — metamorfik środkowej Odry, BPS — blok przedsudecki, gW — gnejsy Wądroża Wielkiego, jK — jednostka kaczawska, grS–S — masyw granitoidowy Strzegomia — Sobótki, dps — depresja północnosudecka, dśs — depresja śródsudecka, dŚ — depresja Świebodzic, goBKI — gnejsowy blok karkonosko-izerski, grK — masyw granitoidowy Karkonoszy, sN — seria Niedamirowa; główne uskoki: uDOL — system uskoków Dolska, uO–P — uskok Poznania — Oleśnicy, uS–L — uskok śląsko-lubuski, uŚO — uskok środkowej Odry (na N od uskoku środkowej Odry — monoklina przedsudecka — nie przedstawiono utworów platformowych permo-mezozoiku), NPS — nasunięcie przedsudeckie, SUB — uskok sudecki brzeżny, uśs — uskok śródsudecki

Presented here crustal sections are the models, indicating — according to author — such features of the Earth crust along studied geotransect, which reflect the Variscan tectogenesis and partly — the older deformations. Reactivation of the Variscan structures have mostly influenced on orientation of the Mesozoic, and Cainozoic deformations.

Author is very indebted to Dr A. Pepel for offering his unpublished materials about gravimetric modelling of the EU-3 profile and Prof. R. Dadlez from Państwowy Instytut Geologiczny for kindful acceptation of this idea and fruitful discussion.

THE EU-3 TRANSECT AND GEOLOGY OF SW POLAND

The EU-3 transect crosses the zone of Variscan deformation in SW Poland, extending along SW–NE direction from the state boundary on eastern slopes of Śnieżka in the Karkonosze Mts up to the Dolsk faults system near Gostynin, which marks — after W. Pożaryski (1975) — the external border of the Variscan externides (Fig. 1). It crosses successively, starting from state boundary, the Sudetes with the Karkonosze-Izera and Kaczawa Mts segments, separated by the Intra-Sudetic Fault, later the Fore-Sudetic Block nearby Legnica, the faults system of Middle Odra near Prochowice and the Fore-Sudetic Monocline nearby Rawicz and Gostyń. This transect crosses — regarding the crust structure — several tectonic blocks with significant differences of the crust thickness and — probably — of its internal structure (A. Guterch et al., 1975). The south-western part of profile belongs to the Sudetian Structure, constituting the eastern prolongation of the Saxothuringian Zone in sense of F. Kossmat (1927). The Sudetian Structure (Sudeticum), divided by the Marginal Sudetic Fault into horst of the Sudetes and downfaulted Fore-Sudetic Block, forms an internal part of the Polish Variscides ("internides" after W. Pożaryski, 1975). An external part of tectogene is represented by the Wielkopolska Block, located within Rhenohercynian Zone (W. Grocholski, 1975). The pre-Variscan and Variscan basement is known here only from boreholes and it underlies the sedimentary cover of the Fore-Sudetic Monocline, consisted of the Permian–Mesozoic deposits (K. Wierzchowska-Kicułowa, 1984).

THE SUDETIAN STRUCTURE (THE SAXOTHURINGIAN ZONE)

The Sudetian segment of the section divides distinctly into 2 parts: the Sudetic Block with average crust thickness about 35 km and the Fore-Sudetic Block with thinned crust and relatively distinct seismic boundary between its upper and lower parts (Conrad boundary). Both blocks are separated by the Marginal Sudetic Fault, the late Variscan structure reactivated in the Cainozoic time. The second important tectonic boundary of this area is the Intra-Sudetic Fault, dividing it into two, different in facies development, domaines of the Sudetes. The south-western domain consists of medium grade metasediments originated in period of Riphean–Lower Devonian, and of granitogneisses with radiometric datings for 480–500 mln years, metamorphosed and deformed before Upper Devonian. The north-eastern domain (the Kaczawa Unit and others) is composed of low-metamorphosed deposits of Wendian–Lower Carboniferous age and of metavolcanites of the spilitic-keratophyric series, deformed before Upper Carboniferous (J. Don, A. Żelaźniewicz, 1990). Deep structure of both fault zones is hitherto unclear. According to interpretation of W. Pożaryski (1975) they represent deep-seated vertical fractures reaching the Moho boundary, but other possible interpretations exist, highly hypothetical due to lack of seismic-reflection data. Both the Marginal Sudetic and Intra-Sudetic faults could be the most shallow parts of large listric overthrusts (shovel-like), which merge gradually into subhorizontal detachement planes within various levels of the Earth crust. Their vergence is unkown. Regarding a general northern vergence of intracrustal structures in better recognized areas of the Middle European Variscides it could be suggest that mentioned fault zones have similar, northern vergence. From other point of view the south-western vergence could be proposed — according some geological data — as an asymmetry of fold structures and direction of overthrusting.

THE WIELKOPOLSKA BLOCK (THE RHENOHERCYNIAN ZONE)

The profile of the Wielkopolska crust has average thickness about 28–30 km. The continental crust is underlaid here with lensoidal transitional zone between crust and upper mantle, distinguished by A. Guterch et al. (1975), which thickness varies from 3 up to 6 km. Under the platform sedimentary cover, from 1 up to several km thick, the folded and cleavaged deposits of Devonian and Carboniferous and low-grade metamorphic complexes of unknown age were found in boreholes (K. Wierzchowska--Kicułowa, 1984, 1987). The deeper basement is undetected. The gravimetric modelling of A. Pepel et al. (1989) indicates that in southern part of this zone the folded basement of the Fore-Sudetic Monocline could be underlaid with basic rocks of limited thickness. The whole basement of the Fore-Sudetic Monocline is cut by numerous fault zones, which extend up to the lower crust gradually decreasing their inclination and joining with horizontal discontinuities at various crust levels. Vergency of these structures is surely north-eastward, similar as in all Rhenohercynian Zone. They probably form a system of imbricate shear nappes, connected with underthrusting of the Wielkopolska Block in relation to the Sudetian one. The Dolsk faults system, located 180–200 km from the state boundary, marks probably the northern border of the externides zone.

THE SUTURE BETWEEN THE SUDETIAN STRUCTURE AND THE WIELKOPOLSKA BLOCK

The so called fault zone of Middle Odra forms a tectonic suture between these two fragments of the Polish Variscides. It could not be recognized from surface due to Tertiary sedimentary cover. Lack of seismic-reflection data unables a detail reconstruction of the internal crust structure but gravimetric and magnetic informations indicate an existence of large ultrabasic-basic complexes along both (SW and NE) borders of the gneiss block of Middle Odra. After some surface data this gneiss block is overthrusted on less metamorphosed rock complex of the Kaczawa Unit in the Fore-Sudetic Block (J. Oberc, 1972). Also the magnetic and gravimetric anomalies indicate that north-eastern ultrabasic-basic body is SW inclined and — due to it — the suture zone has probably fan-shape structure, with the Moho surface involved.

The continental crust of the zone of Middle Odra is wedged up between the crustal blocks of the Sudetian and Wielkopolska structures. Along the contact planes occur probably large masses of the basic-ultrabasic rocks.

THE ALTERNATIVE SECTIONS OF THE EARTH CRUST ALONG THE EU-3 TRANSECT

Three alternative versions of geological sections through the Earth crust along the EU-3 transect were prepared using the mentioned geophysical and geological data. These versions are based on different genetical models of continental crust structure, proposed for the Middle European Variscides and adapted to geological features of the Polish part of this transect.

THE COLLISION (PLATE-TECTONIC) MODEL — FIG. 2

The collision model is based on foundation, that in Middle Europa a small Variscan oceanic basins, separating several continental blocks of microplate character have existed in Lower Paleozoic time (see — P. A. Ziegler, 1986; P. Matte, 1986; and others). Such blocks have collided with each other from Upper Devonian to Upper Carboniferous within the compression field, caused by contact of the East-European Platform and Bohemian Massif (S. Cwojdziński, 1980). The belts of oceanic or suboceanic crust, separating them, have been subducted, probably southward, being partly obducted on the edges of continental blocks. Fragments of tectonically segmented ophiolitic complexes occur recently along the collision sutures.

It seems that the metamorphic block of Middle Odra is of great importance in discussed part of the EU-3 section (No 5 on Fig. 2). It is surrounded from south and north by basic and ultrabasic rocks (Nos 4 and 6 on Fig. 2). Their location is documented with results of magnetic studies (curve *Z*), gravimetric modelling (A. Pepel et al., 1989) as well as occurrence of greenstones and diabases along the southern edge of the Middle Odra gneiss block between Środa Śląska and Prochowice (J. Jerzmański et al., 1986). The results of gravimetric modelling, done by A. Pepel (density inversion), and gravimetric data (C. Królikowski, A. Grobelny, 1991) indicate also an existence of heavy basic rocks in the basement of folded Lower and Upper Carboniferous deposits of the Fore-Sudetic Monocline. The collision suture of Middle Odra has a fan shape and consists of ultrabasic (supposed) and basic (partly documented) bodies, surrounding the wedged massif of metamorphic rocks (amphibolitic facies of medium pressure series) with small granitoid bodies. Poor recognition of the metamorphic complexes unables detection of possible occurrence of magmatic complexes of island arc type or signs of high-pressure metamorphism. The collision of the Sudetic and Wielkopolska blocks has caused an uplift of the Middle Odra gneiss block which formed a nucleus of the orogene, from which a orogenic wave has migrated outwards.

An importance of the Middle Odra metamorphic block as a orogenic nucleus is confirmed by vergence of folds and overthrusts in the Sudetian Zone and sub-Permian basement of the Fore-Sudetic Monocline. The Sudetic Block existed in that model in over subduction position that predisposed an intensive plutonic and volcanic activity during Upper Carboniferous and Lower Permian. The back-arc diapir of the mantle, connected with subducted southward oceanic plate, could cause an origin of tensional deep-seated fractures, grainitoid plutons, tensional sedimentary basins and others on the Sudetes area. Relative displacements of the crustal blocks, separated by deep fractures, could be related with phenomena of mantle diapir — for instance: the Fore-Sudetic Block (No 3 on Fig. 2) has been uplifted in relation to Sudetes (Nos 1 and 2 on Fig. 2) just from Lower Carboniferous.

High frequency of deep dislocations inclined southwards nearaby Dolsk in the Variscan externides area, limiting an occurrence of epimetamorphic rocks in the sub-Permian basement of the Fore-Sudetic Monocline (Leszno — Krotoszyn Elevation), could suggest an existence of second, later collision suture in this region (Wolsztyn — Leszno suture), located between the Wielkopolska Block and neighbouring from NW the Września one. But such structure is highly hypothetical (S. Speczik, 1985).

THE SUBFLUENCE MODELS

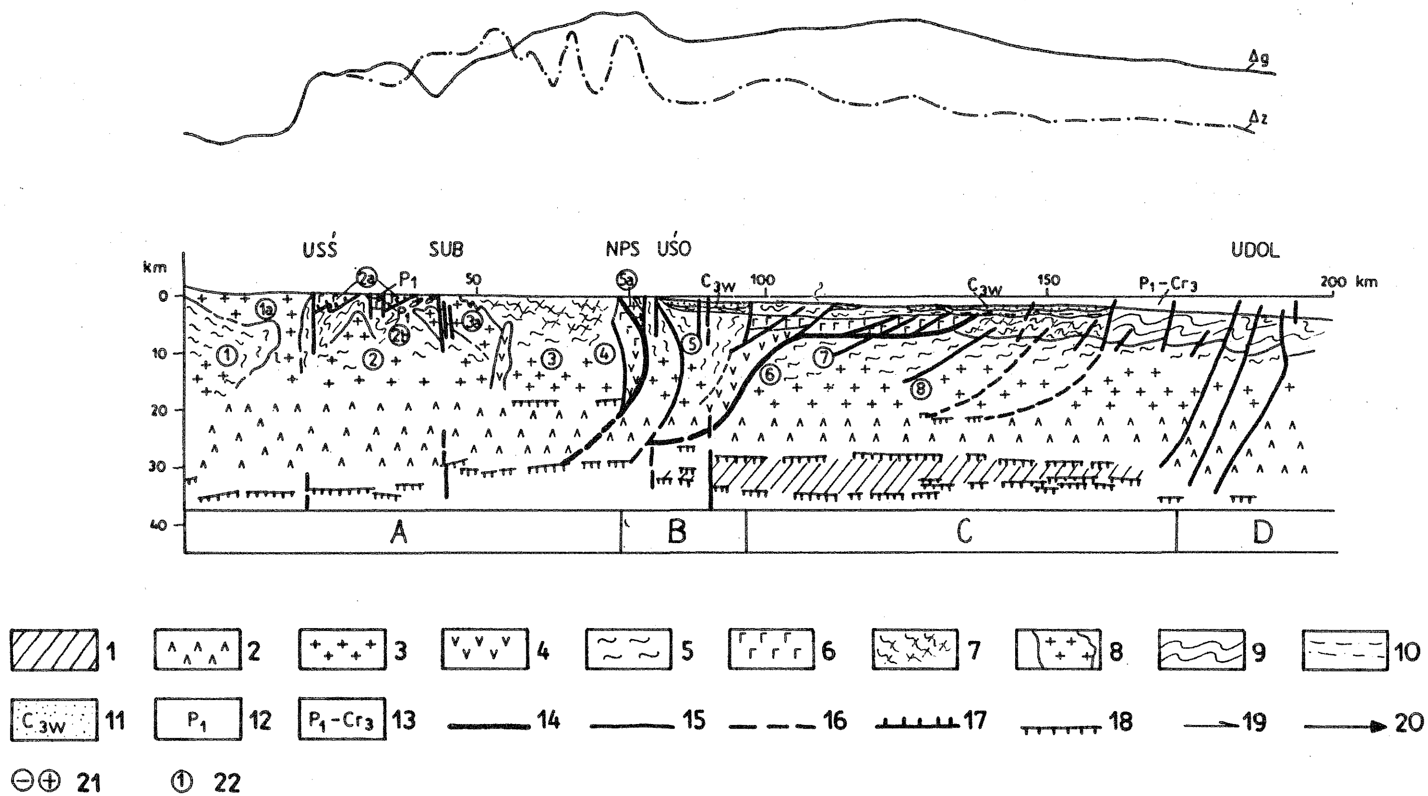
The subfluence models were elaborated on basis of widely known, particulary in German geological literature, conception of an occurrence in the Earth crust of the Middle European Variscides the large listric dislocations, along which the stresses of Variscan tectogenesis were relieved (H. J. Behr, 1978; K. Weber, 1978). These dislocations dissect the Earth crust on the blocks, displaced vertically and horizontally.

The seismic studies of last years, carried within the Saxothuringian and Rhenohercynian zones (H. J. Behr et al., 1984; W. Franke et al., 1990; T. H. Wever et al., 1990) documented several deep discontinuities, inclined at low angles and underlaid with narrow zones of lowered velocity of seismic waves. Some of this discontinuities cross the whole Earth crust, disturbing the Moho surface, other ones flatten in the central part of the crust, passing into horizontal reflection levels.

The displacement of the infracrustal and — probably also upper mantle material — into upper crust levels could take place along listric planes.

Two models of subfluence tectonics for the Variscan part of the EU-3 transect in Poland were elaborated: one-stage version of the subfluence model, refering to whole Earth crust and two-stage one.

It was assumed in both models that the mechanism responsible for the crust deformation was horizontal displacement of the crust substratum outside from uplifted areas of the Earth upper mantle (diapir top). Reaction of overlaying crust consisted in origin of system of listric dislocations, subhorizontal in deeper crust parts but transforming into overthrusts and reverse or normal faults in shallow ones. The course and vergence of listric dislocations, their vertical range and magnitude of mutual displacements of crustal blocks, separated by these dislocations, depend on direction and intensity of the substratum displacements. Later, post-Variscan reactivation of the crust structures could cause an origin of large, vertical deep seated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fractures, cutting whole Earth crust and Moho surface, visible on the section drawn by W. Pożaryski (1975).

THE SUBFLUENCE MODEL — ONE-STAGE VERSION

It was assumed for this model creation (Fig. 3), that the subfluence deformation of the Variscan tectogene has involved the whole thickness of the Earth crust. Central geological position of the Middle Odra metamorphic zone in relation to the internides and externides of the tectogene should reflect in its deep crust structure. Planes of major listric dislocations separate the Middle Odra metamorphic block (No 5 on Fig. 3) from other parts of tectogene. Along some of these planes occur the ultrabasic and basic rocks (Nos 4 and 6 on Fig. 3) of the upper mantle genesis, uplifted into upper parts of the crust from deep levels of tectogene. The major listric dislocations in this model disturb the continuity of the Moho surface, particulary under internal, Sudetian part of the Variscides. Regarding the southward vergence of tectonic structures of the Sudetes (Nos 1 and 2 on Fig. 3) and the Fore-Sudetic Block (No 3 on Fig. 3), recently

Fig. 2. The interpretational-conceptual section along the EU-3 transect, the collision model. Above section — a diagram of the Bouguer gravimetric (Δg) and magnetic (Δz) anomalies

1 — transitional zone between mantle and crust; 2 — lower part of the crust ("basaltic" layer); 3 — upper part of the crust (granitic-gneiss layer); 4 — ultrabasic-basic complexes (gabbros, serpentinites); 5 — complexes of gneisses and granitogneisses; 6 — spilitic-keratophyric volcanogenic complexes; 7 — epimetamorphic slaty complexes (phyllitic); 8 — granitoids; 9 — Carboniferous and Devonian deposits — undivided; 10 — Lower Carboniferous and Namurian deposits; 11 — Westfalian deposits; 12 — Lower Permian deposits from the depressed basins of the Sudetes; 13 — Permian–Mesozoic platform cover of the Fore-Sudetic Monocline; 14 — main, deep crustal discontinuities; 15 — deep crustal discontinuities of second order; 16 — hypothetical courses of discontinuities; 17 — overthrusts boundaries; 18 — seismic boundaries within the crust (after A. Guterch et al., 1975); 19 — directions of displacements along dislocations; 20 — directions of supposed displacements of the undercrust substratum; 21 — directions of displacements related to section plane: + — toward the observer, - — from the observer; 22 — numbers of the tectonic structures described in text; USŚ — Intra-Sudetic Fault; SUB — Marginal Sudetic Fault; NPS — Fore-Sudetic Overthrust; UŚO — Middle Odra Fault; UŚL — Śląsk–Lubusza Fault; UDOL — Dolsk fault system; A — Sudetic Block; B — collision suture of Middle Odra; C — Wielkopolska Block; D — Wolsztyn — Leszno collision suture

Przekrój interpretacyjno-koncepcyjny wzdłuż transektu EU-3, model kolizyjny. Ponad przekrojem wykres anomalii grawimetrycznych Bouguera (Δg) i anomalii magnetycznych (Δ z)

1 — strefa przejściowa płaszcz — skorupa; 2 — dolna część skorupy (warstwa „bazaltowa"); 3 — górna część skorupy (warstwa granitowo-gnejsowa); 4 — kompleksy ultrazasadowo-zasadowe (gabra, serpentynity); 5 — kompleksy gnejsowe i granitognejsowe; 6 — wulkanogeniczne kompleksy spilitowo-keratofirowe; 7 — epimetamorficzne kompleksy łupkowe (fyllitowe); 8 — granitoidy; 9 — osady karbonu i dewonu — nierozdzielone; 10 — osady karbonu dolnego i namuru; 11 — osady westfalu; 12 — utwory czerwonego spągowca basenów zapadliskowych Sudetów; 13 — permo-mezozoiczna pokrywa platformowa monokliny przedsudeckiej; 14 — główne, głębokie nieciągłości skorupowe; 15 — głębokie nieciągłości skorupowe drugiego rzędu; 16 — hipotetyczny przebieg nieciągłości; 17 — granice nasunięć; 18 — granice sejsmiczne w obrębie skorupy (wg A. Gutercha i in., 1975); 19 — kierunki przemieszczeń wzdłuż dyslokacji; 20 — kierunki hipotetycznych przemieszczeń substratu podskorupowego; 21 — kierunki przemieszczeń w stosunku do powierzchni przekroju: + — w stronę obserwatora, - — od obserwatora; 22 — numeracja struktur tektonicznych opisanych w tekście; USŚ — uskok śródsudecki; SUB — uskok sudecki brzeżny; NPS — nasunięcieprzedsudeckie; UŚO — uskok środkowej Odry; UŚL — uskok śląsko-lubuski; UDOL — system uskoków Dolska; A — blok sudecki; B — szew kolizycyjny środkowej Odry; C — blok wielkopolski; D — szew kolizycyjny wolsztyńsko-leszczyński

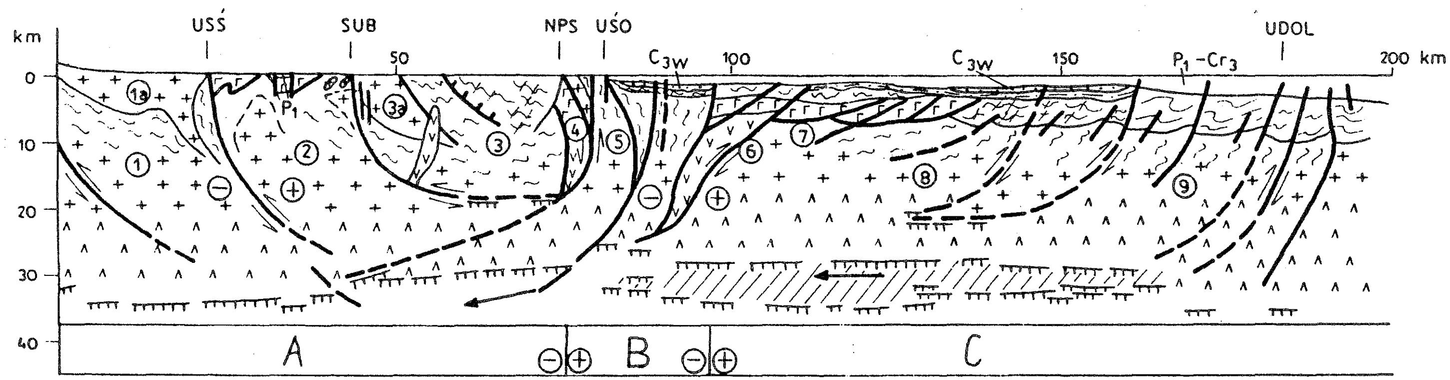

Fig. 3. The interpretational-conceptual section along the EU-3 transect — the subfluence model, one-stage version
A — Sudetian Zone; B — Middle Odra metamorphicum; C — Wielkopolska Block; other explanations as in Fig. 2
Przekrój interpretacyjno-koncepcyjny wzdłuż transektu EU-3 — model subfluencyjny, jednopiętrowy
A — strefa sudecka, B — metamorfik środkowej Odry; C — blok wielkopolski; pozostałe objaśnienia jak na fig. 2

documented on surface, it was decided that it correspond to similar vergence of large intracrustal listric structures. These dislocations — following nearly vertically in the upper part of the crust, where they correspond to the faults, separating the Karkonosze-Izera Block (1), Kaczawa Unit (2) and Fore-Sudetic Block (3) — flatten successively downward. Some of them could disturb a course of the Moho surface, although many of them reach horizontal position in middle or lower levels of the crust. Strong shear deformations have taken place along the listric dislocations — such zones could be probably roots of granitoid intrusions, penetrating the upper parts of the crust in form of post-tectonic stiching plutons (the Karkonosze granites — 1a — and granites of the Strzegom — Sobótka Massif — 3a — numbers on the transect line).

During the Variscan movements the horizontal displacements of individual crustal blocks, separated by listric dislocations, have taken place. Regional Variscan stress field in Europe suggests that a dextral strike-slip (wrenching) movements have acted along NW–SE directed dislocations. The transect line crosses no less than two zones of such dextral regional displacements — the Intra-Sudetic Fault and dislocation zone of Middle Odra.

The listric dislocations of northward vergence and varied deep range are probably developed also within the Variscan externides, northwards from the Middle Odra metamorphic zone in the basement of the Fore-Sudetic Monocline (Nos 8 and 9 on Fig. 3). In this interpretation is unclear the position of the basic rocks complex between Odra and Rawicz, which occurrence at the base of the Carboniferous deposits of the monocline was documented with results of gravimetric modelling (A. Pepel et al., 1989). The gravimetric model of T. Grabowska and M. Raczyńska (1991), based on other assumptions, do not regard an occurrence here the masses of heavy rocks. Number of listric dislocations in the externides zone (Rhenohercynian one) is difficult to define according actual data. In the upper part of the crust the reverse and normal faults, cutting partly also the platform cover of the monocline, could correspond to them. Relatively shallow position of the epimetamorphic complexes within the Leszno — Krotoszyn Elevation in the sub-Permian basement of the monocline is probably connected with their uplift along some major listric dislocation.

THE SUBFLUENCE MODEL — TWO-STAGE VERSION

This model assumes that most of the listric dislocations disapear within upper part of the crust, at the depth about 20 km, in so called supracrustal level of the crust (Fig. 4). The horizontal discontinuites dominate in its lower, infracrustal level. In discussed model the crustal deformation has two-stage character and it follows in other way within every level. Occurrence of horizontal discontinuities in lower parts of the Earth crust was documented with seismic investigations in many regions of the German Variscides (H. Murawski, 1981). Concentration of such discontinuities is noticed just above the Moho discontinuity, forming so called layered zone. Probably this zone accumulates horizontal intracrustal displacements. In upper, supracrustal level of the crust these displacements had equivalents in zones of shear deformations, located along planes of listric faults, and in the nearsurface zone (up to depth of 5 km) — in form of overthrusts and folds.

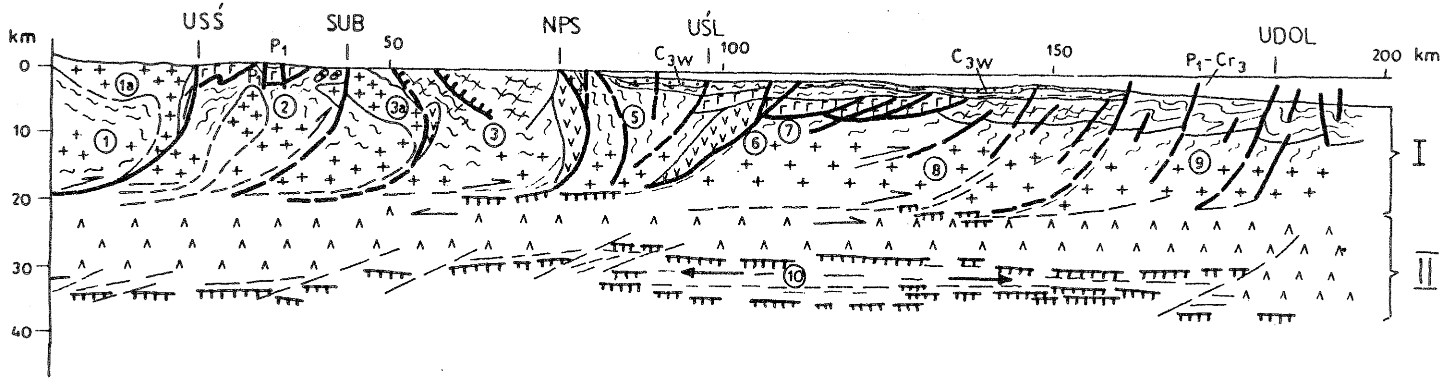

Fig. 4. The interpretational-conceptual section along the EU-3 transect — the subfluence model, two-stage version
I — supracrustal level; II — infracrustal level; others explanations as in Fig. 2
Przekrój interpretacyjno-koncepcyjny wzdłuż transektu EU-3 — model subfluencyjny, dwupiętrowy
I — piętro suprakrustalne; II — piętro infrakrustalne; pozostałe objaśnienia jak na fig. 2

The described model assumes, according to idea of H. J. Behr (1978) generally southward movement of the substratum, under the Bohemian Massif. Regional structure of whole tectogene indicates such direction. All main subfluence zones within the supracrustal level have northern vergency — they are inclined to south. Only in the Sudetian Zone, in upper parts of the crust, geological data can prove an inversion of inclination of these dislocations. In presented model the sure Variscan deformation has taken place in upper part of the crust (up to the depth of 20 km) and it was a reaction of its more rigid parts for quasi-plastic deformation of the lower crust. Along surfaces of the listric faults the rock complexes of deep origin have been uplifted (Nos 4 and 6 on Fig. 4) as well as some mesozonal and epizonal metamorphic complexes (for instance: the Middle Odra metamorphic block — 5 — and metamorphicum of the Leszno — Krotoszyn Elevation — 8).

The lensoidal transitional zone (No 10 on Fig. 4) of densities and seismic wave velocities medial between values typical for lower crust and for upper mantle, is probably the well developed "layered complex", along which the horizontal movements have acted. Its existence under the Rhenohercynian segment of tectogene and its lack under the Sudetian Zone could indicate the different arrangement of the Variscan deformation. In the Rhenohercynian segment are more horizontal discontinuities on various levels and the listric deformations are more frequent. In the Sudetian Zone the main plane of the horizontal displacement comes deeper, probably under the Moho surface. Deformations within the crust are more rigid, the intracrustal shear plane are no so frequent but probably more expressed. They could be marked by the root parts of the granitoid stiching plutons.

FINAL REMARKS (CONCLUSIONS)

All three presented here interpretational-conceptual sections are hypothetical models. Particulary lack of seismic data about structure of the deep parts of the crust, few informations about the discontinuity planes and unsure character of gravimetric modelling make all such interpretations very difficult. Also data, *sensu stricto* geological, coming from the uppermost parts of the crust, are highly unsure and based on indirect informations.

It is undoubtful that the Variscan tectogene consists of individual crust blocks, divided by the tectonical sutures, along which the mutual block displacements acted in vertical (listric faults) and horizontal (strike-slip faults) planes. These blocks, being recently in contact with each other on the same intersection level, have different lithostratigraphic profiles, grade of metamorphism and often different type of internal tectonics. Examples of such blocks with various geological evolution are the Karkonosze-Izera Block (1), the Kaczawa Block (2) and the Middle Odra metamorphic block (5). Also the Fore-Sudetic Block (3) showed, beginning from Upper Devonian–Lower Carboniferous, different geological evolution in relation to areas surrounding it from S and N. Regarding the mutual relations of the blocks, belonging to the Variscan tectogene of south-western Poland and their evolution the subfluence models explain better observed features than the plate-collision one.

Recognition of the deep tectonic relations within the Earth crust of the Polish Variscides requires extensive geological and geophysical studies, among which also modern seismic (seismic tomography) and magnetotelluric investigations as well as surficial structural analysis (kinematic) of Variscan complexes.

The elaborated alternative sections could give an assumption for discussion, directing further investigations.

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HIPOTETYCZNA STRUKTURA SKORUPY ZIEMSKIEJ WARYSCYDÓW POLSKI POŁUDNIOWO-ZACHODNIEJ — MODELE ALTERNATYWNE DLA TRANSEKTU EU-3

Streszczenie

Przekroje koncepcyjne przez skorupę ziemską wzdłuż transektu Eu-3 (dawniej VII profil międzynarodowy) dla waryscyjskiego odcinka profilu zostały skonstruowane na podstawie powierzchniowych danych geologicznych (dla Sudetów i bloku przedsudeckiego), danych z otworów wiertniczych (dla monokliny przedsudeckiej) oraz rezultatów badań geofizycznych, w tym rzadkich danych sejsmicznych. Wykorzystane

zostały także różne wersje modelowań grawimetrycznych wzdłuż linii transektu opracowane przez A. Pepela i in. (1989), T. Grabowską, M. Raczyńską (1991) oraz C. Królikowskiego, A. Grobelnego (1991). Modelem wyjściowym dla nowej intepretacji geologicznej był przekrój geologiczny dla VII profilu międzynarodowego opracowany w 1975 r. przez W. Pożaryskiego.

Geotransekt EU-3 w ramach polskiego fragmentu Waryscydów przecina kilka bloków tektonicznych o różnej miąższości skorupy i prawdopodobnie różnej strukturze wewnętrznej (fig. 1). SW część przekroju należy do struktury sudeckiej stanowiącej wschodnie przedłużenie strefy saksońsko-turyngskiej w znaczeniu F. Kossmata (1927). Struktura sudecka podzielona na horst Sudetów i obniżony uskokowo blok przedsudecki tworzy wewnętrzną część tektogenu waryscyjskiego (internidy wg W. Pożaryskiego, 1975). Zewnętrzna część tektogenu jest reprezentowana przez blok wielkopolski leżący w obrębie strefy reńsko-hercyńskiej. Prewaryscyjskie i waryscyjskie podłoże jest tu znane jedynie z wierceń i podściela pokrywę platformową monokliny przedsudeckiej zbudowaną z utworów permo-mezozoicznych.

Ważną rolę na opracowanym odcinku transektu EU-3 wydaje się odgrywać blok metamorfiku środkowej Odry (mezozonalny) otulony od południa i północy przez masy skał zasadowych i ultrazasadowych stromo zapadające pod blok gnejsowy. O takiej ich pozycji świadczą wyniki badań geologicznych i geofizycznych. Na możliwość występowania mas ciężkich skał zasadowych (metabazalty?) w podłożu sfałdowanych utworów karbonu monokliny przedsudeckiej wskazują niektóre wyniki modelowań grawimetrycznych.

Reasumując, strefa środkowej Odry ma charakter szwu tektonicznego o wachlarzowatej strukturze wewnętrznej z mezozonalnym blokiem gnejsowym pośrodku. Stąd rozchodziła się fala deformacji waryscyjskich z wergencją północną ku N (externidy) i wergencją południową ku S, w kierunku masywu czeskiego (internidy). W zależności od przyjętego modelu budowy skorupy ziemskiej zanurzające się w głąb szwy tektoniczne mogą być interpretowane bądź to jako szwy kolizyjne (w modelu tektoniczno-płytowym — fig. 2), bądź też jako granice subfluencyjne (modele subfluencyjne, fig. 3 i 4). W tym ostatnim wypadku uznano, że dyslokacje subfluencyjne mogą przecinać całą skorupę naruszając miejscami powierzchnię Moho (model subfluencyjny — jednopiętrowy, fig. 3) lub też wygasać na granicy dolnej i górnej skorupy (model subfluencyjny — dwupiętrowy, fig. 4). W obu wypadkach są to dyslokacje listryczne, odpowiadające znanym z powierzchni dyslokacjom, takim jak sudecki uskok brzeżny, uskok śródsudecki, nasunięcie przedsudeckie, uskok śląsko-lubuski itd., wypłaszczające się stopniowo w głąb skorupy. Modele subfluencyjne oparte zostały na koncepcji K. Webera (1978) i H. J. Behra (1978) opracowanej dla Waryscydów Niemiec.

Wszystkie trzy przedstawione przekroje interpretacyjno-koncepcyjne są modelami hipotetycznymi. Wszelkie interpretacje wgłębne są bardzo trudne z uwagi na brak danych sejsmicznych, zwłaszcza refleksyjnych, oraz niepewny charakter modelowania grawimetrycznego. Także informacje *sensu stricto* geologiczne pochodzące z najwyższych partii skorupy są w znacznym stopniu niepewne i oparte na pośrednich danych. Nie ulega natomiast wątpliwości, że tektogen waryscyjski składa się z różnych bloków skorupowych rozdzielanych przez szwy tektoniczne, wzdłuż których zachodziły wzajemne przemieszczenia bloków zarówno pionowe, jak i poziome. Bloki te kontaktujące dziś ze sobą w tym samym poziomie intersekcyjnym reprezentują odmienne profile litostratygraficzne, różny stopień metamorfizmu i styl tektoniki wewnętrznej. Odpowiedź na pytanie, jaka jest rzeczywista struktura skorupy w pasie polskich Waryscydów i który z modeli jest jej najbliższy, mogą dać jedynie nowe programy badawcze oparte na nowoczesnej metodyce sejsmicznych badań refleksyjnych, badań pól potencjalnych oraz tektoniczno-strukturalnych. Z tego punktu widzenia niezbędny jest udział Polski w programie badawczym *Europrobe*.