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The role of longitudinal dislocation zones and strike-slip transversal deep fracture of Silesia-Lubusza (Hamburg — Kraków) in formation of main zone of meridional folds on Silesia and Moravia areas

The East-Moldanubian Line passes from the Silesia-Lubusza deep fracture nearby Wrocław in southward direction along eastern margin of the Góry Sowie Block, middle part of the Bardo structure, the basement of the Upper Nysa Kłodzka Graben toward the Moldanubian Overthrust, forming its southern part. On Lower Silesia it separates two tectonic zones with different fold directions. On western side the folds are of Cadomian, Caledonian and Sudetic age and they have primary directions WNW-ESE. On eastern side directions of fold structures are from NNE-SSW to N-S and these folds have originated during the Cadomian, Old Variscan and Asturian phases. The zone of meridional folds is about 140 km wide and it extents up to the Orlova Overthrust of Asturian age on Upper Silesia. Exeept of western limb of the Štemberk — Horní Benešov stacking the tectonic transport within meridional folds was eastward directed. Eastward from the Orlova Overthrust the tectonics of platform-type prevails and the folds have directions nearing the parallel one. In their basement occurs the Precambrian massif, covered with the platform deposits of Cambrian and Devonian age, underlaying the Carboniferous series. The zone of meridional folds has developed due to eastward phase displacement of structure on western side of the Moldanubian Line toward the Upper Silesian Massif, being resistance mass that time. The style of structure of mentioned folds confirms an opinion that the basin width in which the rock series have been deposited was no less than twice larger than the width of fold bundle. The meridional folds are cutted from north with perpendicular to them the Silesia-Lubusza deep fracture, being part of the Hamburg — Kraków deep fracture. On its northern side the folds of Góry Kruszcowe Phase, with northern vergence, are composed of rocks of Late Precambrian, Cambrian, Devonian and Carboniferous. They prolong eastward into the bundle of Kraków folds. Mentioned folds have directions: WNW-ESE or W-E, the same as folds placed westward from the East-Moldanubian Line and eastward from Orlova Overthrust. The whole structure is covered with deposits of mainly Mesozoic and Neogene age. The Silesian-Lubusza deep fracture is of stricke-slip type. Its southern side was folded eastward. The amplitude of horizontal displacements increases toward WNW. Its northern side has been unfolded during stricke-slip movement. From the south is attached to this deep fracture the Silesia-Moravia

zone of Variscides, being the eastern part of main zone of meridional folds. Between it and the Silesia-Lubusza deep fracture locates the Upper Silesian Massif.

INTRODUCTION

Deep fractures and great faults are often difficult to distinguish in situation of insufficient seismic data. They play important role in geological structure of Lower Silesia. Part of them was known as faults from the beginning of geological studies of this area. Some great dislocations, as for instance the Middle Odra Fault, covered with younger deposits, were found due to seismic studies or drillings (F. Berger, 1932).

It was documented that sueh dislocations heve separated the higher order units of different type of structure and folding age. Along the prolongations of larger faults occur sometimes the slipped faults, playing other role and it caused they were signed with other names. The examples of them are the elements of so-called the Main Sudetic Dislocation (J. Oberc, 1964, 1991*b*). This fault is longitudinal in general. The units, crossed by such fault, also participate in structure of downthrown side but under the Earth surface.

The great diagonal or transverse faults — deep fractures — reaching down up to the Moho surfaee have so distinct amplitude of relative displacemnt of fault sides that the unit, crossed by them, is completely or nearly completely damaged by erosion on uplifted side. Such conditions characterize the Variscan component of the Marginal Sudetic Fault. On the uplifted, during this period and later, side of this fault have been eroded rock series of the Bardo and Świebodzice tectonic structures (J. Oberc, 1967). But erosion has been so shallow that on the same fault side could preserved also other Variscan units: on west — the folds of Fore-Sudetic part of the Góry Kaczawskie structure, on east — the units of Hruby Jesenik, located northward from the Belsko Fault, the equivalent of the Marginal Sudetic Fault.

The presented work discusses such deep fractures and faults, on both sides of whieh occur fold structures, most often of various age but located one to another at nearly right angle. In that situations is impossible a prolongation of units from one side of deep fracture (fault) into opposite one.

Such role play the three, active during Variscan age, deep fractures (the faults in parts):

— the Niemcza deep fracture, prolonging southward across the Bardo structure and the Upper Nysa Kłodzka Graben into the zone of large overthrusts and dislocations on the margin of the Moravian Moldanubicum; its intersection is here discussed as the East-Moldanubian Line;

— the Orlova Overthrust on Upper Silesia, which from the depth of about 6 km (see lower) under the Upper Carboniferous aets as typical deep fracture;

— the Silesia-Lubusza fragment (J. Oberc, 1972) of the Hamburg — Kraków deep fracture (W. Brochwicz-Lewiński et al., 1983).

The first two mentioned dislocations, of meridional orientations in general, limit from west and east the 140 km wide zone of meridional folds. This zone is closed from north (J. Oberc, 1980*b*) with the fragment of the Silesia-Lubusza Dislocation. This

zone is not bounded from south by Variscan dislocation but it disappears under units of the Carpathian tectogene.

Here will be omitted the problems of magmatism and intrusions because despite of their occurrence on studied area they are not significant for main discussed ideas.

MAIN FOLD DIRECTIONS IN THE WEST AND MIDDLE SUDETES

According to author's proposals (J. Oberc, 1991*a*) along the eastern margin of the Góry Sowie Moldanubicum and far to south, across the Bardo structure and along the Upper Nysa Kłodzka Graben continues an important tectonic boundary. It separates two blocks of lithosphere — western Kłodzko-Góry Sowie Block and eastern — East-Sudetic Block (J. Oberc, 1987*b*). This boundary prolongs onto the Moravia area along eastern margin of local Moldanubicum, corresponding to the Moldanubian Overthrust. For such boundary, beginning near Wrocław, author proposes the name East-Moldanubian Line. Its southern part forms the Moldanubian Overthrust. Eastward from this line, except of finer detached blocks in the Niemcza Zone, are no remains of Moldanubicum. The discussed line is discontinuous on these parts, where intrusions and perpendicular tectonic transport displaced its fragments. Such situation occurs for instance on the prolongation of end of the Góry Orlickie metamorphicum (Bušin Fault) and within zone of the Cretaceous and metamorphicum of Letovice.

The East-Moldanubian Line divides the Middle Sudetes and their foreland part, regared in similar way as have described them E. Bederke (1929) and H. Teisseyre (H. Teisseyre et al., 1957), into two parts, differing with fold directions (and with directions of recrystallization lineation); in western part dominate WNW-ESE directions, in eastern one — SW-NE to meridional directions. Basing on these data J. Oberc (1991*a*) has divided the Middle Sudetes into two parts: western part — Middle Sudetes *sensu stricto*, eastern one — Middle-Eastern Sudetes.

The characteristic fold directions for Western and Middle Sudetes (*sensu stricto*) are from parallel up to NW-SE directions; the last ones are more common in eastern part of studied area. In the Góry Bystrzyckie Mts. the recrystallization lineation changes its orientation on meridional one. Distinct differences from that pattern occur in the Cadomian epimetamorphic tectonic structure of Imbramowice, located northward from the Góry Sowie Block (J. Oberc, 1972), where this lineation characterizes with SW-NE orientation.

Typical for discussed area primary (non reoriented) fold directions have been preserved in units of various age during several following one after another tectogeneses:

— Moldanubian one (the Góry Sowie Block); later transformation has caused, particulary in northern part, the reorientation of recrystallization lineation and related folds;

— Cadomian one: the Karkonosze-Góry Izerskie Block, Góry Bystrzyckie Mts. and mentioned earlier structure of Imbramowice;

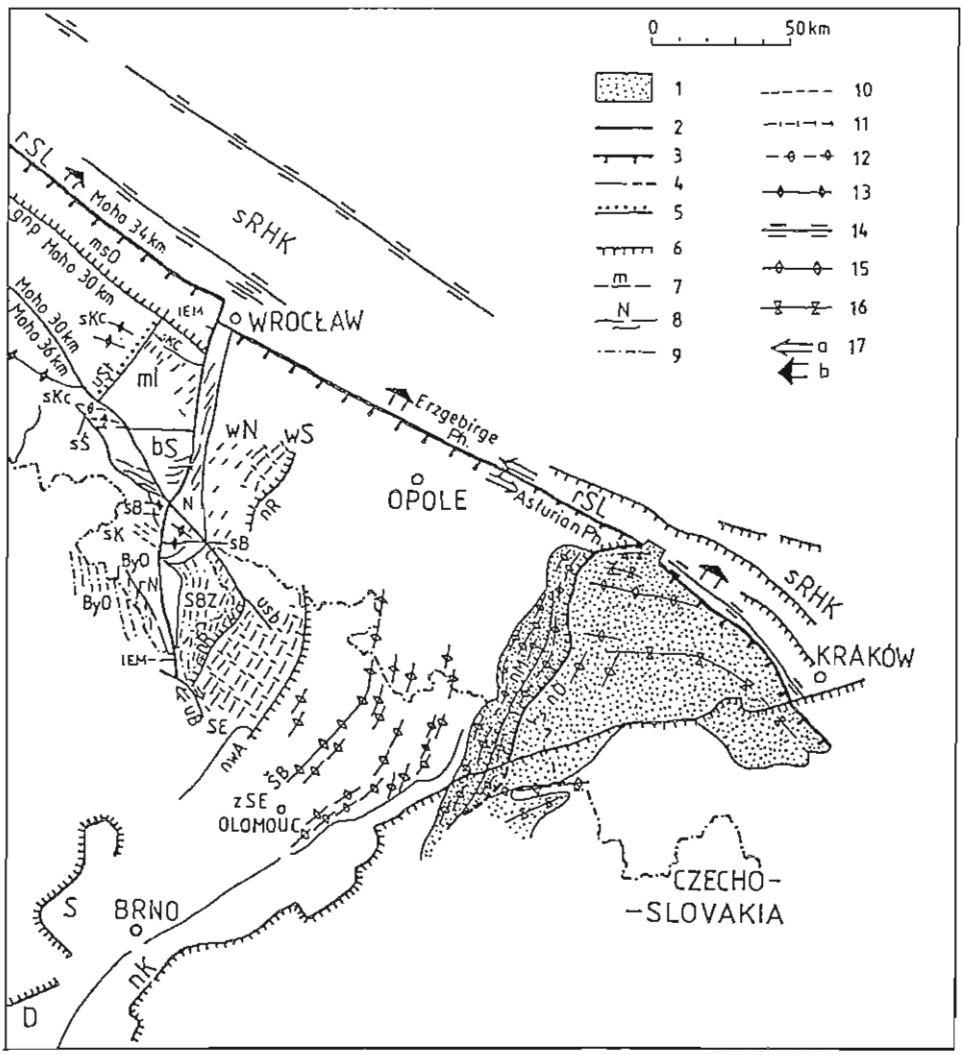

Fig. 1. Position of the main zone of meridional folds on Silesia and Moravia areas

1 — Upper Silesian Coal Basin; 2 — the East-Moldanubian Line; 3 — Silesia-Lubusza fracture (Hamburg — Kraków); 4 — main faults; 5 — pre-granitoid fault of Strzegom; 6 — overthrusts; 7 — the Moldanubian recrystallization lineation; 8 — lineation in the Niemcza Zone; 9 — Caledonian recrystallization lineation; 10 — recrystallization lineation within the Imbramowice metamorphic massif; 11 — Cadomian and Early Variscan (coaxial) lineation; 12 — axes of Variscan folds (a scheme); 13 — fold axes of Sudetic Phase; 14 — fold axes of the Góry Kruszcowe Phase; 15 — anticline axes of Asturian age; 16 — main syncline axes of Asturian age; 17 — strike-slip transport: a — of Early Variscan and Asturian phases, b — of the Góry Kruszcowe Phase; bS — the Góry Sowie Block; ByO — Góry Bystrzyckie and Góry Orlickie metamorphic massifs; D — tectonic window of Dyje; lEM — East-Moldanubian Line; N — Niemcza Zone; nR — Ramzova Overthrust; sŚ — Świebodzice structure; nK — overthrust of Carpathian Flysch; nM — Michałkowice Overthrust; nO — Orlova Overthrust; rSL — Silesia-Lubusza deep fracture; S — tectonic window of Svratka; SBZ — Śnieżnik, Góry Bialskie and Góry Złote metamorphic massifs; SE — internal zone of

— Caledonian one: structure of Paleozoic series of Karkonosze (O-S, D_1?), the Kłodzko structure (O-D_1?);

— Nassau one: the Świebodzice structure D_3-C_1 Gatt. (H. Teisseyre, 1968);

— Sudetic one — the Bardo structure (O-C_1, in its middle part strongly transformed during the Asturian Phase), the Góry Kaczawskie structure (Cm-C_1).

MAIN FEATURES OF THE STRUCTURE OF EASTERN PART OF UPPER SILESIA

The meridional (NNE-SSW) Orlova Overthrust with eastern vergency separates two types of structure of the Upper Carboniferous formation. The eastern part of Upper Silesia has platform-type structure, with frequent faults. In western part occur numerous folds of medium-type, parallel to the Orlova Overthrust. The influences of this part are visible also in eastern one; short folds with NNE-SSW orientation are rarely noticed there, especially in central part of it. Considerable area of Upper Silesia is covered with marine deposits of Miocene age (from the Carpathian Foredeep). The southern part of Upper Silesia together with this cover hides under the overthrust of the Carpathian Flysch. Lately the most valuable synthese of tectonics of Upper Silesia was presented by A. Kotas (1985).

The boundaries of Upper Silesia, except of south-western part, have a fossil character. The Upper Silesian Coal Basin has — in general — a shape of trapezium,

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Eastern Sudetes; sB — Bardo structure; sK — Kłodzko structure; mI — Imbramowice metamorphic massif; sRHK — Rhenohercynian-Kraków Zone; usb — Marginal Sudetic Fault; uB — Bušin Fault; sKc — Góry Kaczawskie structure; uSt — Strzegom Fault; wN — Wzgórza Niemczańskie metamorphic massif; wS — Wzgórza Strzelińskie metamorphic massif; msO — Middle Odra metamorphic massif; zSE — external zone of Eastern Sudetes; gnp — Main Fore-Sudetic Overthrust; rN — Upper Nysa Kłodzka Graben; ŠB — axis of the Šterberk — Horní Benešov Elevation; nwA — overthrust of beds from the Andelska Hora

Pozycja głównej strefy fałdów południkowych na Śląsku i Morawach

1 — Górnośląskie Zagłębie Węglowe; 2 — linia wschodniomoldanubska; 3 — rozłam śląsko-lubuski (Hamburg — Kraków); 4 — główne uskoki; 5 — uskok przedgranitowy Strzegomia; 6 — nasunięcia; 7 — lineacja rekrystalizacyjna moldanubska; 8 — lineacja w strefie Niemczy; 9 — lineacja rekrystalizacyjna kaledońska; 10 — lineacja rekrystalizacyjna w metamorfiku Imbramowic; 11 — lineacja kadomska i starowaryscyjska (koaksjalna); 12 — osie fałdów waryscyjskich (schemat); 13 — osie fałdów fazy sudeckiej; 14 — osie fałdów fazy Gór Kruszcowych; 15 — osie antyklin asturyjskich; 16 — osie głównych synklin asturyjskich; 17 — transport przesuwczy: a — fazy starowaryscyjskiej i asturyjskiej, b — fazy Gór Kruszcowych; bS — blok sowiogórski; ByO — metamorfik Gór Bystrzyckich i Gór Orlickich; D — okno dyjskie; lEM — linia wschodniomoldanubska; N — strefa Niemczy; nR — nasunięcie ramzowskie; sŚ — struktura Świebodzic; nK — nasunięcie fliszu karpackiego; nM — nasunięcie michalkowickie; nO — nasunięcie orłowskie; rSL — rozłam śląsko-lubuski; S — okno svrateckie; SBZ — metamorfik Śnieżnika, Gór Bialskich, Gór Złotych; SE — wewnętrzna strefa Sudetów Wschodnich; sB — struktura bardzka; sK — struktura kłodzka; mI — metamorfik Imbramowic; sRHK — strefa reno-hercyńsko-krakowska; usb — uskok sudecki brzeżny; uB — uskok buszyński; sKc — struktura Gór Kaczawskich; uSt — uskok Strzegomia; wN — metamorfik Wzgórz Niemczańskich; wS — metamorfik Wzgórz Strzelińskich; msO — metamorfik Środkowej Odry; zSE — zewnętrzna strefa Sudetów Wschodnich; gnp — główne nasunięcie przedsudeckie; rN — rów Górnej Nysy Kłodzkiej; ŠB — oś spiętrzenia Šterberk — Horní Benešov; nwA — nasunięcie warstw z Andelskiej Hory

narrowing northward. Both ends of its base (eastern and western) are bend southward (more detaily — to SE and SW). Between them, along southern boundary of Upper Silesia, the both stages of the platform build the broad arc, convex northward, which closes there an anticline, inclined in this direction. Such situation indicates that the synclinorium of Upper Silesia divides southward for two synclinal zones, receding one from another in this direction and separated there by mentioned broad anticline.

The tectonics of platform-type of eastern part of Upper Silesia results from an occurrence of rigid Precambrian basement. It is covered with horizontally lying deposits of the Lower Cambrian (A. Kotas, 1973) and Devonian. According to many authors (see — A. Kotas, 1985; A. Dudek, 1980) it could be a fragment of described by K. Zapletal (1933) Brunnia structure. Its Upper Silesian part is distinguished as the Upper Silesian Massif. This massif is divided by parallel dislocations for smaller blocks (A. Kotas, 1985). In deposits of the Carboniferous of eastern part of Upper Silesia several anticlines with nearly parallel orientation have developed. Their axes are obliquely cutted by north-eastern margin of Upper Silesia (the Silesia-Lubusza Fault).

FOLD DIRECTIONS IN NORTHERN PART OF LOWER SILESIA, OPOLIAN SILESIA AND UPPER SILESIA

Between Gubin and Wrocław occurs narrow, known from numerous borcholes, fossil belt of the Cadomian, mesozonal metamorphicum, intruded with the Variscan granitoids. It is the Middle Odra crystalline massif, being the eastern prolongation of the Middle German crystalline zone. This massif is covered in SW part with the Tertiary deposits, under cover of which it is overthrusted on the Góry Kaczawskie structure along Main Fore-Sudetic Overthrust (J. Oberc, 1972). In north-eastern part lay on it the Permian deposits of the Fore-Sudetic Monocline. The Middle Odra crystalline massif seems to end on the prolongation of the Niemcza Zone, it means — eastward from the East-Moldanubian Line. On east of this line hitherto are undefinited the dislocations, framing from both sides described massif; they probably join together within system of the Silesia-Lubusza deep fracture. This area has unsufficient borehole data, the wells are located there more sparsely than on the area of copper ores. Farther eastward the tectonic role of the Middle Odra metamorphicum in relation to occcuring on north-east of it the Variscan folds (of the Rhenohercynian-Kraków Zone) seems to play the northern prolongation of the metamorphicum of eastern part of the Fore-Sudetic Block. Northern part of Variscides was studied earlier by J. Dvořak and E. Paproth (1979).

According to author's opinions (J. Oberc, 1984, 1987*b*) the Middle Odra crystalline massif is a intramountain massif, separating two branches of Variscides: internal-arc one (inside convex northward arc of Middle German and Middle Odra crystalline massifs). Inside of this arc occurs also the Fore-Sudetic part of the Góry Kaczawskie structure with southern vergence. The northern part of Variscides consists of folds with vergency directed outside the arc of the Middle German and Middle Odra crystalline massifs (external-arc zone). Such vergency have the folds of Harz (H.

Wachendorf, 1986) and folds of Kraków fold bundle (S. Bukowy, 1984). Toward south-east the external-arc zone prolongs into the bundle of Kraków folds. From the south contacts with described area the zone of Silesia-Moravia folds of Variscan age. For whole external-arc Variscides the author proposed (J. Oberc, 1977) name: the Rhenohercynian-Moravian-Kraków Zone. This zone has origined during several Upper Carboniferous phases. Between the Kraków and Silesia-Moravia fold bundles locates the Upper Silesian Massif.

The southern part of Polish section of external-arc zone of Variscides, known from numerous boreholes for copper ores, oil and gas, was described by J. Oberc (1977, 1990) and K. Wierzchowska-Kiculowa (1984, 1990).

The external-arc zone of Variscides consists of folded two structural stages, separated by discordance surface, obliterated during the Carboniferous foldings. Stresses have been directed from south-west, from the Middle Odra metamorphicum and from mentioned above crystalline massifs of eastern part of the Fore-Sudetic Block, particulary of its northern prolongation.

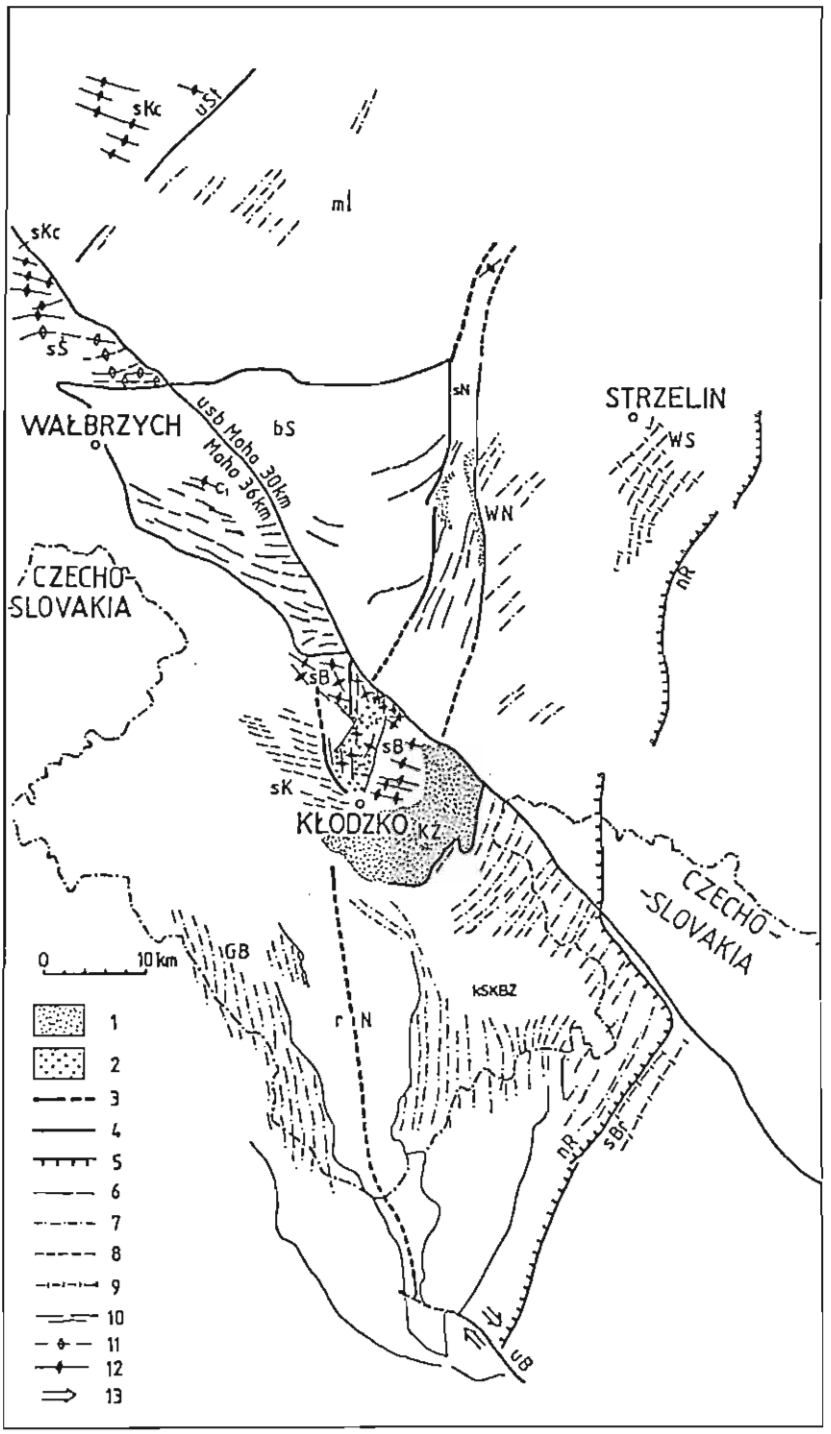
Within cores of mostly eroded anticlines occur the lower structural stages of discussed structure. They are fyllites with quartzites intercalations. After H. Krawczyńska-Grocholska and W. Grocholski (1977) this formation is younger than the Proterozoic but older than the Devonian deposits. Author named it as the beds from Święciechowa and regarded it as an equivalent of similary developed beds on Małopolska area (J. Oberc, 1972).

The upper structural stage of Variscides of northern part of Silesia consists of known for a long time deposits from Dębnik and Siewierz and of deep-marine sediments of Upper Devonian, documented by M. Chorowska in 1979 on the area, located close to western state boundary. It seems the older Devonian units occur there also. Upper stratigraphic units of discussed structural stage are represented by the Lower Carboniferous-Namurian flysch and on the Wielkopolska area are known the units of Upper Carboniferous.

The most important elevated anticlinal zones of described areas, studied by S. Bukowy (1984), J. Trzepierczyński (1987) and J. Oberc (1990), occur in vicinity of Dębnik and Siewierz, within anticline passing through Cieszów and Bielawy but mainly within the Krotoszyn — Wolsztyn zone, continuing toward NW.

ZONE OF MERIDIONAL FOLDS BETWEEN NORTHERN SECTION OF THE EAST-MOLDANUBIAN LINE AND THE ORLOVA OVERTHRUST

Between the northern section of the East-Moldanubian Line and the Orlova Overthrust occurs 140 km wide zone of folds of meridional or similar orientation. It length on the Earth surface, along the East-Moldanubian Line, is about 700 km but along the Orlova Overthrust — about 120 km. This difference is resulted from extension toward NE of the Carpathian teetogene, under which declines the zone of meridional folds. Details of its structure under the tectogene are unknown. The structure of southern Moravian section of this zone (Moravikum) will not be discussed here.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The crystalline massif of zone of meridional folds has been studied by A. Dudek (1980), who named it as Bruno-Vistulicum. Both terms have been already used by other authors in various way. A. Dudek (*l. c.*) has investigated crystalline rock series. Because the significant part of zone of meridional folds is composed of sedimentary rocks, only locally slightly metamorphosed, the term proposed by A. Dudek will not be applied and here will be discussed only the features and development of tectonics on this area.

The most complete cross-section of zone of meridional folds is placed between the Upper Nysa Kłodzka Graben and the Upper Silesian Coal Basin. It crosses southern part of the Śnieżnik metamorphicum and both domes of Cadomian gneisses of Hruby Jesenik, separated from themselves and from east by zones of less metamorphosed deposits of Older Devonian, accumulated discordantly on the gneiss basement. During the Old Variscan Phase the rocks of these stages have been refolded and the foldings in discussed zone was intensive. One of overthrusts on that area (the Ramzova Overthrust) has the amplitude of horizontal displacement of about 20 km (J. Oberc, 1967, 1968). There were overthrusted amphibolites, gneisses and mica schists of series of Stare Mešto over the Devonian beds from Branna.

Eastward from the last one in this direction the zone of the Devonian from Vrbno occur the early Variscan flysch deposits, in western part slightly transformed. These are the beds from Andelska Hora. The core of structure is anticlinal stacking named the Šterberk — Horni Benešov Zone. Complications of core part of this unit involved that R. Kettner (1956) has appreciated it as a Klippen Zone but this opinion has not

Fig. 2. Position of the East-Moldanubian Line on the Fore-Sudetic Block and in the Sudetes

1 — granitoids of Kłodzko-Złoty Stok (KZ) and of Niemcza Zone (sN); 2 — zone of intense transverse rebuilding of Bardo structure (sB); 3 — the East-Moldanubian Line; 4 — major dislocations; 5 — Ramzova Overthrust (nR); 6 — course scheme of metamorphic lineation and of axes of Moldanubian folds within the Góry Sowie gneisses (not rebuilded); 7 — metamorphic lineation within Cadomian series; 8 — lineation of Caledonian age; 9 — lineation of Cadomian and Early Variscan (coaxial) age; 10 — lineation within Niemcza Zone; 11 — fold axes of Nassau Phase; 12 — axes of folds and lineations of Sudetic Phase (a scheme); 13 — tectonic transport; bS — Góry Sowie Block, GB — Góry Bystrzyckie Mts., C_1 — Carboniferous of Góry Sowie (Lower Carboniferous); kSKBZ — crystalline massifs of Śnieżnik, Krowiarki, Góry Bialskie and Góry Złote; mI — Imbramowice metamorphic massif; rN — Upper Nysa Kłodzka Graben; sBr — Branna Zone; sK — Kłodzko structure; sKc — Góry Kaczawskie structure; sŚ — Świebodzice structure; usb — Marginal Sudetic Fault; uSt — Strzegom Fault; WN — Wzgórza Niemczańskie metamorphic massif; WS — Wzgórza Strzelińskie metamorphic massif; uB — Bušin Fault

Przebieg linii wschodniomoldanubskiej na bloku przedsudeckim i w Sudetach

1 — granitoidy kłodzko-złotostockie (KZ) i strefy Niemczy (sN); 2 — strefa silnej przebudowy poprzecznej struktury bardzkiej (sB); 3 — linia wschodniomoldanubska; 4 — ważniejsze dyslokacje; 5 — nasunięcie ramzowskie (nR); 6 — schemat przebiegu lineacji metamorficznej i osi fałdów moldanubskich w gnejsach sowiogórskich nieprzebudowanych; 7 — lineacja metamorficzna w seriach kadomskich; 8 — lineacja wieku kaledońskiego; 9 — lineacja kadomska i starowaryscyjska (koaksjalna); 10 — lineacja w strefie Niemczy; 11 — osie fałdów fazy nassauskiej; 12 — osie fałdów i lineacji fazy sudeckiej (schemat); 13 — transport tektoniczny; bS — blok sowiogórski; GB — Góry Bystrzyckie; C_1 — karbon Gór Sowich (karbon dolny); kSKBZ — krystalinik Śnieżnika, Krowiarek, Gór Bialskich, Gór Złotych; mI — metamorfik Imbramowic; rN — rów Górnej Nysy Kłodzkiej; sBr — strefa Branny; sK — struktura kłodzka; sKc — struktura kaczawska; sŚ — struktura Świebodzic; usb — uskok sudecki brzeżny; uSt — uskok Strzegomia; WN — metamorfik Wzgórz Niemczańskich; WS — metamorfik Wzgórz Strzelińskich; uB — uskok buszyński

been confirmed by next scientists. The western limb of the Šterberk — Horni Benešov stacking is inversely overthrown in this direction. Other units, located between the Upper Nysa Kłodzka Graben and Upper Silesia, were transported eastward. In this direction, eastward from the Šterberk — Horni Benešov Zone, occur in succession the younger but internally steeply folded units of the Lower Carboniferous flysch and the Upper Carboniferous deposits, thickness of which decreases eastward from 7000 to 2500 m. The best recognized, due to mining, is tectonics of Upper Carboniferous deposits up to Westphalian and several tens of steep fold were found there.

The discussed earlier assemblage of tectonic structures forms a dense mass in Sudetes. On the Fore-Sudetic Block (and further to east), where folding structure appears from under the Neogene deposits in form of „islands" of varied size, it is impossible to document an occurrence of equivalents of tectonic structures of Sudetes. It results from deeper, of about 2.5 km[1] the intersection level (J. Oberc, 1968), originad due to erosion, mainly during Mesozoic (H. Cloos, 1922).

The section through these areas starts from west. The Góry Sowie Block borders with narrow Niemcza Zone, framed with meridional dislocations, being many times the planes of strike-slip (parallel) and transversal (overthrusts and faults) movements. Within the lower structural stage of this unit occur fragments of neighbouring ones, rocks of which are strongly mylonitized. There are fragments of the Góry Sowie gneisses, of surrounding ophiolitic formation and intrusions of the Late Variscan granitoids. The upper stage consists of the Carboniferous deposits, noticed by H. Dziedzic and T. Góreeka (1965), primary sedimantary rocks nearby Brodziszów (H. Dziedzicowa, 1975) and, on northern part, of slightly metamorphosed Silurian deposits (L. Jamrozik, 1979) nearby Pustków Wilczkowicki. Deposits of upper stage of the Niemcza Zone seem to correspond to rock series of the Bardo structure, partly metamorphosed due to deeper intersection level (J. Oberc, 1987*a*).

The Wzgórza Niemczańskie are composed mainly of Cadomian two-micas schists, amphibolites and quartz-feldspar schists. In the Wzgórza Strzelińskie is visible the nappe structure (Older Devonian is refolded with gneisses and other mesozonal rocks). Both in western part of southern profile and in northern section far to east are noticed the equivalents of belt of two-micas schists, gneisses and amphibolites of Stare Mešto, which form the Fore-Sudetic prolongation of the Ramzova Nappe. Its base is the Ramzova Overthrust (J. Oberc, 1966*a*, 1968). Fragments of this nappe are amphibolites from Chałupki, from Osina Mała and from boreholes Niedźwiedź IG 1, Niedźwiedź IG 2 (J. Jerzmański red., 1992) and amphibolites from old borehole in Łojowice.

On area located far to east the folding structure is covered. There are known only several small exposures of the Lower Carboniferous nearby Toszek and from rare there deep boreholes. On east occurs the Upper Carboniferous of western, folded zone of Upper Silesian Coal Basin.

[1] This value is calculated from geological data. Slip difference of the Moho surface in Sudetes and on the Fore-Sudetic Block is estimated for 6 km (A. Guterch et al., 1975).

Correlation of southern (Sudetic) and northern (Fore-Sudetie) profiles is difficult. Flat overthrusts in Sudetes and deep erosion of the Fore-Sudetie Block could cause that part of Fore-Sudetic units are other (deeper) than ones, exposuring in Sudetes on surface. In Sudetes they are up till now not incised by erosion (nappe structure of Wzgórza Strzelińskie). Both domes of Hruby Jesenik, lying under the Ramzova Overthrust, hitherto have not their equivalents on the Fore-Sudetic Block.

In general characteristics of structure of area between the East-Moldanubian Line and the Orlova Overthrust such features should be indicated:

— meridional strikes of folds, slices and nappe overthrusts;

— their eastern vergency except of western limb of the Šterberk — Horni Benešov stacking;

— from course and features of structure of crystalline massifs of Wzgórza Niemczańskie, Wzgórza Strzelińskie and of folds of western part of the Upper Silesian Coal Basin results an opinion that the meridional folds under Neogene cover but possibly under deposits of the Fore-Sudetic Monocline, could prolong up to the Silesia-Lubusza (Hamburg — Kraków) Dislocation;

— large difficulties of correlation of cross-sections (Sudetic and Fore-Sudetic ones) results from differences of intersection level of both regions and from flat overthrusts, particulary in western zone;

— structure of zone of meridional folds has developed in several phases, beginning earlier rather on west than on east (displacement of basin axes to east);

— occurrence of flat large-scale overthrusts on west, steep and numerous folds (so well visible in Upper Silesia) and of distinct reversed displacements (western limb of the Šterberk — Horni Benešov stacking) indicates that actual width of main zone of meridional folds of Silesia, estimated for 140 km, is probably small part of primary width of sedimentary basins, from which have origined folds, slices and nappes; the palinspastic shortening, although now could be difficult to more precise, is very apperciable. If coefficient of palinspastic shortening was estimated only for 50% (J. Oberc, 1980*a*) then this width have been calculated for about 300 km.

LONGITUDINAL BOUNDARIES OF ZONE OF MERIDIONAL FOLDS

THE EAST-MOLDANUBIAN LINE (FORE-SUDETIC AND SUDETIC SECTIONS)

W r o c ł a w — Ł a g i e w n i k i S e g m e n t (northern prolongation of the Niemcza Zone). Necessity of distinguishing this prolongation results from distinctness of the East-Moldanubian Line on the Góry Sowie section and from regional situation of tectonic structures of higher order, described in this work. According to author (J. Oberc, 1987*a*, 1991*a*) the Silurian deposits from Pustków Wilczkowicki occur in the Niemcza Zone. On western side of this exposure the East-Moldanubian Line should be located.

G ó r y S o w i e S e g m e n t . Just on the first map of scale 1:100 000 (E. Beyrich et al., 1867) the eastern margin of the Góry Sowie gneisses has been distinctly

indicated. It is the Przystronie Dislocation (J. Oberc, 1972). Its faulted character was documented on detail maps of E. Meister (1932) and L. Finckh (1928). E. Bederke (1931) has noticed nearby the Niemcza Zone a bending toward NE of nearly parallel strikes of foliations within the Góry Sowie gneisses that indicates the sinistral that time movement of the Góry Sowie Block to the south (Caledonian movements and Sudetic Phase — J. Oberc, 1991*c*). During formation of Cadomian, Early Variscan and Asturian folds, the pressure of the Góry Sowie Block has been directed perpendicularly to dislocations, it means to the east (see above). In the Niemcza Zone has taken place strong mylonitization (K. H. Scheumann, 1937). As it was mentioned above the East-Moldanubian Dislocation on the area of the Góry Sowie Block has been a way for Caledonian (C. Pin et al., 1988) basites and Asturian granodiorites („syenites" of Niemcza and of Złoty Stok — see above).

B a r d o S e g m e n t . The equivalent of the East-Moldanubian Line on area of the Bardo structure could be the western boundary of zone of meridional folds (Asturian ones), crossing perpendicularly the folds of Sudetic Phase, with directions from WNW-ESE to W-E (J. Oberc, 1972). The East-Moldanubian Line passes along two, slipped one from another, sections: Mikołajów — Wilcza and Wojbórze — Kłodzko. On the second section has formed the Kłodzko Overthrust, firstly described by E. Bederke (1929)[2]. The equivalent of the Niemcza Zone contains in Sudetes, beginning from the west, following units:

— meridional folds of middle part of the Bardo structure,
— folds of WNW-ESE orientation of eastern part of the Bardo structure,
— the Kłodzko-Złoty Stok granitoid massif.

Variabilities of occurrences of granitoids of the Niemcza Zone and of Kłodzko — Złoty Stok resulted from deeper erosion of the Fore-Sudetic Block. This erosion has destroyed upper, broad parts of the Niemcza intrusions, remaining only rooted forms of vein-type (J. Oberc, 1987*a*, p. 175, Fig. D3).

S e g m e n t o f t h e U p p e r N y s a K ł o d z k a G r a b e n . It is still not well known regarding the course of the East-Moldanubian Line. Structure style of the Śnieżnik and Bystrzyca units is so different that despite of small width of the graben, separating both units, still was impossible to join them structurally in satisfactory way. It suggests a version of dislocation within the Cretaceous basement. Here the Moldanubian Line seems to be moved eastward along the under-Cretaceous strike-slip prolongation of the Bušin Fault (J. Oberc, 1980*a*), which ends the tectonic structures of internal zone of Eastern Sudetes. Significance of the Bušin Dislocation seems to increase toward the Góry Bystrzyckie and the East-Moldanubian Line is moved along this dislocation.

[2] In the manuscript of work on tectonic styles of the Bardo structure author has presented the first version. It documented the common lithological features of the Bardo structure and of upper stage of structure of the Niemcza Zone. The mentioned second version was supplemented with the problem of granitoids. Because granitoids of Złoty Stok due their petrographic similarities have been joined by E. Bederke (1927) with ones of the Niemcza Zone, J. Oberc (1987*a*) has found that they were connected with one tectonic surface.

In northern part of the Upper Nysa Kłodzka Graben the folds of Krowiarki are cutted by meridional dislocation of Krowiarki (J. Grocholska, A. Grocholski, 1958), which generation was finished after deposition of the Rotliegendes on the East-Moldanubian Line.

Concluding that the units of located westward from the East-Moldanubian Line the heterogenic Kłodzko-Góry Sowie Bloek (on which except of the Imbramowice Unit dominate directions WNW-ESE of non-transformed folds, perpendicular to fold directions in the Niemcza Zone and farther to east) have been during Cadomian, Early Variscan (K. Patteisky, 1929) and Asturian phases the folding mass for rock series, placed on eastern side of the East-Moldanubian Line, it means in East-Sudetic lithosphere bloek (J. Oberc, 1987*b*). During Asturian Phase the movements in the Kłodzko-Góry Sowie Block have not changed directions of folds of eastern part of the Bardo structure, belonging just (the Niemcza Zone) to the East-Sudetic Block.

THE ORLOVA OVERTHRUST

The Orlova Overthrust has character of reverse fault (A. Kotas, 1985), inclined westward at middle angle. On its both sides changes only the style of structure within the same Upper Carboniferous formations. The overthrust plane at the depth of about 6 km seems to join with western boundary of the Upper Silesian Massif, which acting as rigid basement has protected before folding the rock series of eastern part of the Upper Silesian Coal Basin. It indicates that barely the surface limiting the Upper Silesian Massif from west, has features of deep fracture but the surface of the Orlova Overthrust is upward prolongation of this polyphase deep fracture. The intensive and steep folding of the rock series, mainly of Upper Carboniferous age, westward from the Orlova Overthrust (see upper) indicates that their basement, from which they are probably detached, has different character than one on the east.

SIGNIFICANCE AND CHARACTER OF THE SILESIA-LUBUSZA DEEP FRACTURE

Phase advance of lithosphere blocks one to another: the Kłodzko-Góry Sowie Block (with its western subsidiaries), including Middle Sudetes *sensu stricto* (J. Oberc, 1991*a*) to the Upper Silesian Block during Asturian and Early Variscan deformations, has caused deformations of Paleozoic series on west and their Cadomian basement (Hruby Jesenik, Strzelin). Folding intensity of the whole, 140 km wide, zone of meridional folds — that was erlier documented by author — indieates the significant shortening of palinspastic spaee.

This shortening has reflected in movements along the Silesia-Lubusza deep fracture. The space northward from fracture was not shortened because the Rhenohercynian-Kraków folds, origined mainly during the Góry Kruszcowe Phase parallel to fracture, are perpendicular to direetion of strike-slip movement of southern side. The folds, located northward from fraeture, have NW-SE direction. It means that here

exists strike-slip fault (deep fracture), whose only one side has been folded (J. Oberc, 1980*b*). These movements are of sinistral character. Total amplitude of horizontal displacement has enlarged from the surroundings of Tarnowskie Góry toward Wrocław (and farther to NW), from where advanced the folding mass.

The Silesia-Moravia Zone, being the eastern part of zone of meridional folds, is not a branch of virgation as author supposed earlier (J. Oberc, 1966*b*) but it ends, along its whole width, with transversal to it, northern side of the Silesia-Lubusza Dislocation. The Moravia-Kraków folds zone could not be joined in any way with the Góry Świętokrzyskie (Holy Cross Mts.), as supposed S. v. Bubnoff (1930) because the Asturian folding phase of this zone is younger than folding phases of Góry Świętokrzyskie.

Two main directions of compression, alternating in geological time in south-western Poland, result from position of zone of meridional folds and their relation to adjoining units. This idea has been proposed and developed by author for a long time (J. Oberc, 1957). In one of earlier works (1987*b*) author has accepted the reason of folding within zone of northern margin of the Bohemian Massif was gravitational movement of lithosphere blocks along the asthenosphere surface due to expansion of the Earth. This theory author (J. Oberc, 1987*b*, p. 297) named subductionless version of plate tectonics or expansive-gravitational geotectonics.

Concluding all facts it was stated that pattern of three deep fractures, placed in the shape of Greek letter π, forms the evolution frames (boundaries) of northern end of main zone of meridional folds of Silesia. The East-Moldanubian deep fracture has the longest and most complicated history and it involved generation of folds zone, described here as meridional. In literature various elements of this unit, both vertical and horizontal, have other names: Moravik, Silesik, Silesia-Moravia Zone, eastern part of Western Sudetes, Middle-Eastern Sudetes, Brunnia, Bruno-Vistulicum, internal zone of Eastern Sudetes, East-Sudetic Culm, East-Sudetic Block and others. The name „main zone of meridional folds" (of Silesia and Moravia) is not contradictory to mentioned terms but is for them the superior description.

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ROLA WIELKICH PODŁUŻNYCH STREF DYSLOKACYJNYCH I PRZESUWCZEGO ROZŁAMU POPRZECZNEGO ŚLĄSKO-LUBUSKIEGO (HAMBURG — KRAKÓW) W FORMOWANIU SIĘ GŁÓWNEJ STREFY FAŁDÓW O KIERUNKACH POŁUDNIKOWYCH NA ŚLĄSKU I MORAWACH

Streszczenie

Między nasunięciem orłowskim na Górnym Śląsku a linią wschodniomoldanubską — od okolic Wrocławia przez wschodni brzeg bloku sowiogórskiego, wzdłuż środkowej przebudowanej części struktury bardzkiej, rów Górnej Nysy Kłodzkiej do dyslokacji buszyńskiej i dalej wzdłuż brzegu wschodniego moldanubiku morawskiego — przebiega strefa fałdów o kierunkach południkowych. Linia wschodniomoldanubska oddziela na rozważanym odcinku dwa bloki litosfery: zachodni kłodzko-sowiogórski (kierunki fałdów głównie NW–SE) i wschodniosudecki (kierunki fałdów NNE–SSW), które będziemy nazywali południkowymi. W części zachodniej strefa fałdów południkowych zbudowana jest z mezozonalnych serii kadomskich (Wzgórza Niemczańskie, metamorfik Śnieżnika, Gór Bialskich i Gór Złotych z pasmem Starego Mešta). Dalej ku wschodowi przebiega pas skał mezozonalnych późnego prekambru, przefałdowanych z utworami dewonu. Płaszczowina ramzowska, zbudowana z gnejsów, amfibolitów i łupków dwumikowych, nasunięta jest na dewon epimetamorficzny. Jednakże we Wzgórzach Strzelińskich dewon wschodniosudecki występuje powyżej amfibolitów jądra płaszczowiny ramzowskiej, a podłoże płaszczowiny ramzowskiej nie jest znane z powodu przykrycia terenu.

Na tym odcinku paralelizacja jednostek sudeckich i przedsudeckich jest trudna z powodu znacznej różnicy poziomu intersekcyjnego obu obszarów. Różnicę tę w oparciu o kryteria geologiczne autor określił na 2,5 km (J. Oberc, 1968). Na podstawie głębokiego sondowania sejsmicznego (A. Guterch et al., 1985) na obu blokach wynosi ona 6 km. Oprócz tych różnic ważnymi czynnikami są płaskie nasunięcia. Odpowiedniki znanych kopuł wschodniosudeckich Pradziada i Kępnika nie zostały jeszcze odkryte na bloku przedsudeckim.

Na wschód od tych jednostek występuje spiętrzenie antyklinalne Štemberka — Horní Benešova, którego skrzydło zachodnie w formie dewońsko-karbońskich warstw z Andelskiej Hory nasunięte jest wsteeznie ku zachodowi. Dalej ku wschodowi występują kolejne ogniwa dolnego karbonu, z których każde wykazuje obecność licznych stromych fałdów. Ta sytuacja utrzymuje się po nasunięcie orłowskie na Górnym Śląsku.

Dzięki przemieszczaniu się zbiorników osadowych ku wschodowi strefa fałdów południkowych rozwijała się bardziej od silniej elewowanej części zachodniej i poprzez ruchy starowaryscyjskie zakończyła rozwój strukturalny w czasie fazy asturyjskiej. Fałdy, łuski i płaszczowiny utrzymywały wergencję wschodnią z wyjątkiem wspomnianego wstecznego obalenia warstw z Andelskiej Hory ku zachodowi.

Przemieszczane ku wschodowi fałdy zakończyły swój ruch na masywie górnośląskim przykrytym utworami kambru, dewonu i karbonu. Tutaj rozwinęły się tylko platformowe fałdy o kierunkach WNW–ESE, jak na zachód od linii wschodniomoldanubskiej.

Obraz ten powstał dzięki przesuwaniu się wzdłuż linii wschodniomoldanubskiej fałdów Sudetów Środkowych *sensu stricto* i Zachodnich, których fałdy ustawione są prostopadle do linii wschodniomoldanubskiej. Powtarzanie nasunięć było fazowe (por. wyżej), w bloku zachodnim kłodzko-sowiogórskim przeplatane naciskami, które dostarczały fałdów o kierunkach WNW–ESE.

Szerokość strefy fałdów południkowych wynosi dziś 140 km. Autor przyjmuje, że skrócenie wynosi przynajmniej 50% szerokości zbiorników, których szerokość pierwotna była rzędu 300 km.

Strefa fałdów południkowych sięga na północy do rozłamu śląsko-lubuskiego; na jego odcinku między Wrocławiem a Tarnowskimi Górami w fazach starowaryscyjskiej i asturyjskiej rozłam ten miał charakter przesuwczy. Na północ od niego fałdy fazy Gór Kruszcowych strefy reno-hercyńsko-krakowskiej mają regularny przebieg NW–SE, wergencję północną i nie wykazują skrócenia na linii NW–SE. Tektonikę Sudetów i obszarów przyległych autor wyjaśnia (J. Oberc, 1987*b*) ruchami bloków litosfery po powierzchni astenosfery (bezsubdukcyjna wersja tektoniki płyt — geotektonika ekspansyjno-grawitacyjna).