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Epicontinental basins in Poland: Devonian to Cretaceous — relationships between the crystalline basement and sedimentary infill

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Correlation between the structure of crystalline crust and the geometry and evolution of the epicontinental basins in Poland has been attempted. Using the data of the DSS and gravity measurements, several crustal blocks and their separating fractures have been distinguished. Northern and eastern parts of the country are characterized by typical three-layered cratonic crust of the Svecofennian age (unit A) while the southwestern part — by two-layered Variscan crust (unit C). The former was a basement of northeastern slopes of the Devonian through Cretaceous epicontinental basins whereas the latter underlies the southwestern part of the Permian–Mesozoic basins. Between the both there is — in the northwestern and central parts of the country — a belt of anomalous crust, 150–200 km wide (unit B). It is characterized by a thick upper layer of extremely low velocities (5.8–5.9 km/s) and in its northeastern zone (B') — by a transitional crust-mantle layer with intermediate velocities 7.8–7.9 km/s. The latter coincides with the axial zone of the Permian–Mesozoic basin called Mid-Polish Trough (MPT) which was later inverted to form the Mid-Polish Swell (MPS). Earlier it was an external zone of the Devonian–Carboniferous epicontinental basins. The second zone of this unit (B") adjoining from the south-west is perhaps equivalent to the external belts of the Variscan orogen, including its foredeep. At the end of the Early Palaeozoic the entire unit B was probably an assemblage composed of small crustal blocks of unknown origin: either of modified cratonic crust (proximal terranes?) or newly formed pre-Variscan crust or both. Transversal fractures of the NE–SW trend subdivide the area into individual segments: Baltic, Pomeranian, Kujavian and Małopolska ones. In particular, the last of them (southeastern part of the country) shows a different pattern of crustal units. Correlation with crustal fractures in the central areas of Poland is here difficult because of very sparse data. In the whole area studied some of the presumed fractures in the crystalline basement coincide with shallower fault zones recorded by geological investigations but some others do not.

INTRODUCTION

Studies on relationships and interdependence between the structure of crystalline crust and its overlying sedimentary basins are one of crucial problems in the sedimentary basin analysis. Changes of geotectonic conditions were decisive for the evolution of every sedimentary basin. They were — in the geological sense — both relatively rapid and slow. The former were related to diastrophic processes at the margins of lithospheric plates: the extension and splitting of continental crust, and the spreading of young oceanic crust (growth of new oceans) at divergent margins as well as the compression, narrowing of oceans and collisions between continental blocks at convergent margins. Slow changes were expressed by a general rearrangement of plates at the Earth's surface and by broad plate deformations (epeirogeny) which were also possibly related to processes occurring at the plate boundaries.

Extensional diastrophism occurring at the plate margins resulted, in turn, in a eustatic rise of the ocean level, whereas compressional diastrophism caused deformations of rock complexes, changes in Earth's topography (folding of mountain belts) and eustatic regressions. Consequently, these processes influenced the shapes of basins and their sedimentary infill. The same role was played by vertical diastrophic movements within the plates, influencing the subsidence and uplift and, thereby, also the dimensions of accomodation space of the basin as well as the intensity, volume and direction of clastic material supply. A general rearrangement of plates resulted in climatic changes. The climate itself was also dependent on the increase or decrease — due to the eustasy — of the areas occupied by seas. The climate, in turn, determined the character of deposits and the development of bio-

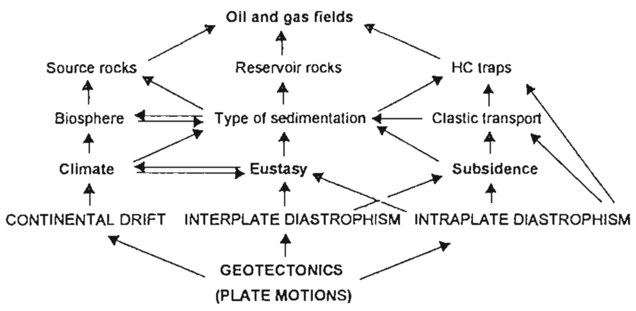

Fig. 1. Geotectonics and basin development

Geotektonika a rozwój basenów

sphere. This shows that, ultimately, geotectonic processes were largely responsible for a composition and structure of geological sequences of each basin (Fig. 1).

They played the same role in the origin of oil and gas fields. First, a source rock must be deposited under specific conditions: generally dark clays rich in organic matter, deposited in a humid climate, under restricted water circulation, in central parts of basins far from clastic material supply. This rock must be brought down by subsidence to greater depths, to convert the organic matter in higher temperatures into hydrocarbons. Porous reservoir rocks (clastic or carbonate) in which hydrocarbons — squeezed out from source rocks — are accumulated, must be formed. Thus, clastic input or climatic conditions favourable to a formation of granular limestones are again the crucial factors. Finally, a trap must come into existence as a result of favourable geometrical configuration either depositional or structural and/or diagenetic. So, a causal sequence still operates here: the subsidence, diastrophism, eustasy, clastic input and climate. All these are determined, first of all, by geotectonic processes.

This paper is an attempt to explore a question of relationships between the crystalline crust and sedimentary cover in the epicontinental basins in Poland, from the Devonian through the Mesozoic. Crystalline crust is here rather poorly investigated by seismic refraction and wide-angle reflection methods. Sparse data on the velocity pattern within this crust are the major disadvantage. Sedimentary cover is sufficiently studied by seismic reflection survey and numerous boreholes in its Zechstein–Mesozoic part only, except for northeastern cratonic part with good records down to the basement top. Elsewhere, a lack of modern seismic near-vertical reflection data and scarcity of deeper boreholes augment the difficulties with the interpretation of the Devonian–Carboniferous part of the cover.

GENERAL GEOTECTONIC SETTING

Development of the epicontinental basins in question lasted almost 350 Ma. Geotectonic conditions were changing during that time but a general subdivision into stable, cratonic areas in the north and east (East European Craton — Precambrian Platform) and more mobile areas to the south and west (Palaeozoic Platform) remained the same. Geotectonic character of the Devonian–Carboniferous basins is different than that of the succeeding ones. They were the peri-cratonic basins: they rested upon a gently sloping outer margin of the East European Craton, and farther to the south-west — as far as the boundary of the mobile Hercynian (Variscan) belt — upon the blocks fringing the craton, presumably deformed and accreted after the Early Palaeozoic. At first they were shelf basins — at times strongly activated due to a proximity of a mobile belt. Later on — when a mountain range started to form — they were partly converted (near the foldbelt) into foredeep basins. The Permian and Mesozoic basins were typical intra-cratonic basins which came into existence between the Variscan foldbelt and the uplifted inner part of the East European Craton

Late Palaeozoic and Mesozoic epicontinental sedimentary basins of Poland formed the eastern parts of the western and central European basins. Location of this area and its present main structural-tectonic units are shown in Fig. 2.

Before the here discussed time span — in the Early Palaeozoic — the East European Craton (Baltica Plate) had been surrounded by the Iapetus Ocean from the west and by the Tornquist Sea (Ocean?) from the south (L. R. M. Cocks, R. A. Fortey, 1982). At the beginning of the Devonian, the Caledonian mountain belt was formed as a result of the closure of the Iapetus Ocean. Baltica joined the North American Craton to form one continent named Laurussia (= Old Red continent — see P. A. Ziegler, 1989), widening simultaneously its area to the south by the accretion of minor crustal and lithospheric blocks, mainly of Gondwanan provenance. Laurussia extended in the Devonian from the proto-Pacific Ocean in the west to the Uralian Ocean in the east. In the south it was surrounded by the Rheic Ocean (P. A. Ziegler, 1990). At the end of the Carboniferous, after both these oceans were closed and the Hercynian mountain belts (Variscides and Uralides) formed, a period of Permian–Triassic supercontinent Pangea followed. During the Mesozoic, this supercontinent was gradually fragmented: south of the territory of Poland, the oceanic Tethys domain developed during the Triassic and Jurassic. To the west — the North Atlantic Ocean began to open in Mid-Jurassic times. The Tethys started to close during the Cretaceous while the Atlantic has been opening up to now. The interplay between the Tethyan and Atlantic provinces, dominated the whole Mesozoic history of the European peninsula of Eurasian continent, located between the both.

During the whole discussed period, the positions of main lithospheric plates were changing. The area gradually migrated from the equatorial zone in the Devonian (presumably on the Southern Hemisphere) and Carboniferous *via* the tropical zone (during the Permian–Triassic) and the subtropical zone (in the Jurassic–?Cretaceous) towards the recent position

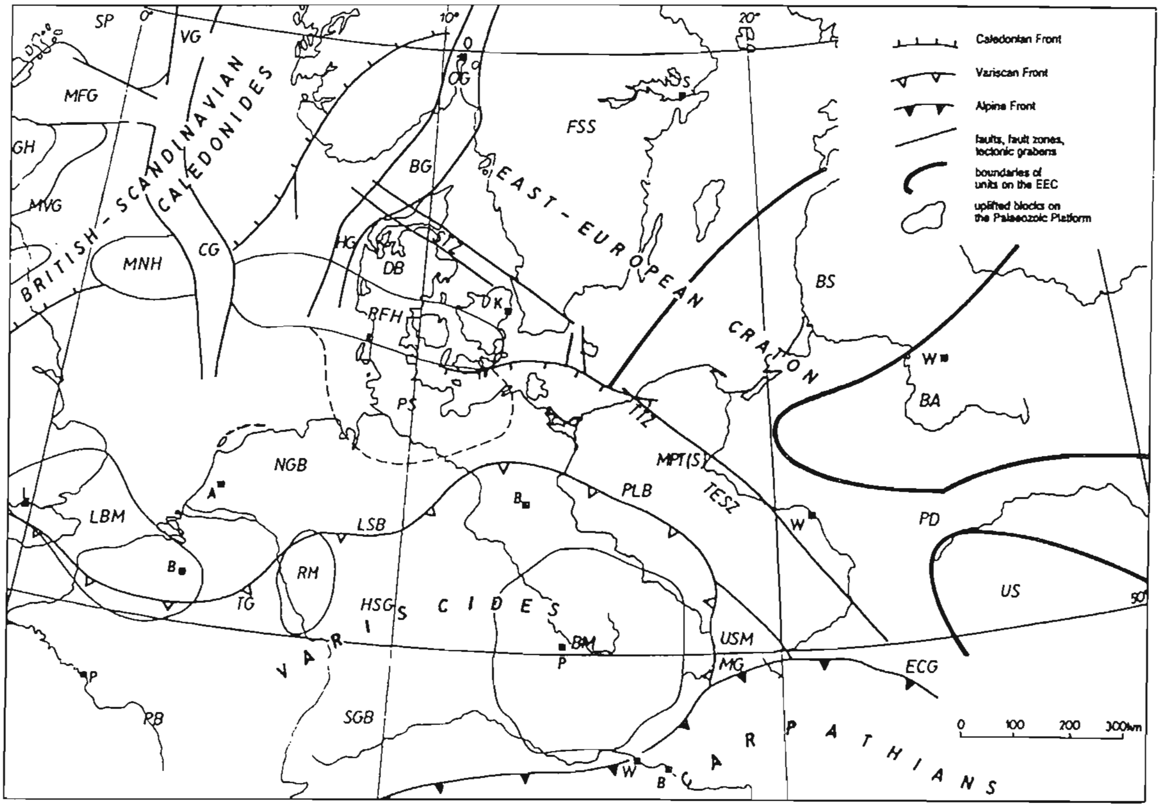

Fig. 2. Structural-geotectonic subdivision of Central and Western Europe; Western Europe after P. A. Ziegler (1990)

BA — Belorussian Anteclise, BG — Bamble Graben, BM — Bohemian Massif, BS — Baltic Syneclise, CG — Central Graben, DB — Danish Basin, ECG — East Carpathian Gate, FSS — Fennoscandian Shield, GH — Grampian High, HG — Horn Graben, HSG — Hessian Gate, LBM — London-Brabant Massif, LSB — Lower Saxony Basin, MFG — Moray Firth Graben, MG — Moravian Gate, MNH — Mid-North Sea High, MPT(S) — Mid-Polish Trough (and Swell), MVG — Midland Valley Graben, NGB — North German Basin, OG — Oslo Graben, PB — Paris Basin, PD — Podlasie Depression, PLB — Polish Basin, PS — Pompecki Swell, RFH — Ringköbing-Fyn High, RM — Rhenish Massif, SGB — South German Basin, SP — Shetland Platform, STZ — Sorgenfrei-Tornquist Zone, TESZ — Trans-European Suture Zone, TG — Trier Gate, TTZ — Teisseyre-Tornquist Zone, US — Ukrainian Shield, USM — Upper Silesian Massif, VG — Viking Graben

Podział strukturalno-geotektoniczny Europy środkowej i zachodniej; Europa zachodnia według P. A. Zieglera (1990)

BA — antekliza białoruska, BG — rów Bamble, BM — masyw czeski, BS — synekliza bałtyka, CG — rów centralny, DB — basen duński, ECG — brama wschodniokarpacka, FSS — tarcza fennoskandzka, GH — wypiętrzenie grampiańskie, HG — rów Horn, HSG — brama heska, LBM — masyw londyńsko-brabancki, LSB — basen dolnosaksoński, MFG — rów Moray Firth, MG — brama morawska, MNH — wypiętrzenie środkowe Morza Północnego, MPT(S) — bruzda i wał śródpolski, MVG — rów doliny Midland, NGB — basen północnoniemiecki, OG — rów Oslo, PB — basen paryski, PD — obniżenie podlaskie, PLB — basen polski, PS — wał Pompeckiego, RFH — wypiętrzenie Ringköbing-Fionia, RM — masyw reński, SGB — basen południowoniemiecki, SP — platforma szetlandzka, STZ — strefa Sorgenfrei'a- Tornquista, TESZ — strefa szwu transeuropejskiego, TG — brama trewirska, TTZ — strefa Teisseyre'a-Tornquista, US — tarcza ukraińska, USM — masyw górnośląski, VG — rów Viking

at higher latitudes with temperate climate. Lithospheric plates also rotated simultaneously with their displacement. The ancient border of Baltica from the Tornquist sea side, which run latitudinally during the Devonian, rotated clockwise in course of time, finally taking its present-day trend: NW–SE. These changes, in particular the translocation from the equator towards the pole, together with the opening of new oceanic domains, obviously influenced the climate (temperature, humidity, prevailing winds).

The above-described succession of events resulted in the following configuration of uplifted and depressed areas at the end of the Mesozoic (Fig. 2):

1. The uplifted and rigid Precambrian East European Craton, largely consolidated earlier than 1.1 Ga ago, with a relatively thin, sedimentary cover full of gaps and tectonically slightly deformed, extended in the north-east. Its border runs from the North Sea *via* northern Jutland, southern Baltic, across Poland from Koszalin to Zamość (Teisseyre-Tornquist Zone), and then through Western Ukraine as far as Dobrogea at the Black Sea. A crustal block of younger consolidation age (800–700 Ma) is detached in the Danish sector from uniform cratonic body by the Sorgenfrei-Tornquist Zone. This is the Ringköbing–Fyn High, separating the Danish Basin from the North German Basin. Moreover, relatively uplifted and downwarped units can be distinguished in the marginal zone of the craton. They are transverse to the strike of this zone. Along the depressed units, the embayments of succeeding basins were formed, providing intermittent communication path-

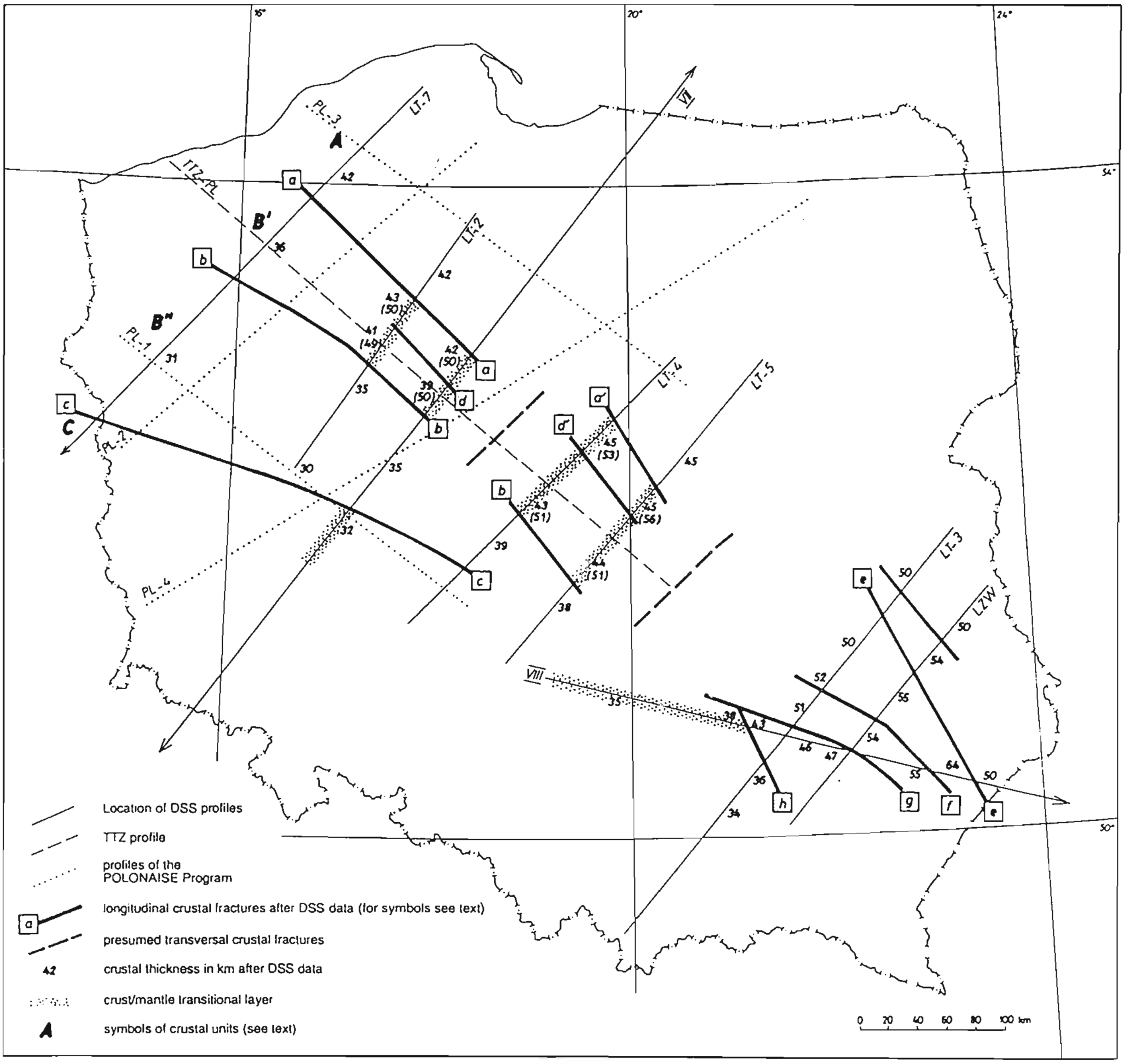

Fig. 3. Crustal fractures and blocks after DSS data

Pęknięcia i bloki skorupowe według danych GSS

ways with basins in the inner part of craton. The uplifted units are: the Fennoscandian Shield, the Mazury Elevation (a far pericline of the Belorussian Anteclise) and the Ukrainian Shield. The depressed units are: the Baltic Syneclise intermittently connected with the Moscow Syneclise and the Podlasie Depression — a periodic connection with the Pripyat Graben and Dniepr Aulacogen.

2. The uplifted relics of the British-Scandinavian Caledonides which emerged along the Iapetus suture extended in the north-west. They maintained their rigidity over the whole Late Palaeozoic and Mesozoic (e.g. Grampian High), and are now visible at the surface as the mountains of North Ireland, Wales, Scotland, North England and Norway. This structure is transected by younger grabens, first of all of the North Sea system (Central Graben and Viking Graben). Farther south there is the rigid London–Brabant Massif which belongs to the same generation of uplifts but is covered by thin platform deposits.

3. In the southern part of the discussed area the Rheic Ocean extended during initial phases of the basin evolution. A belt of epicontinental basins stretched between the ocean and the border of the craton. After the Variscides had been born, their post-erosional relics formed the southern flanks of the Permian–Mesozoic basins. These are: the Armorican, Rhenish and Bohemian Massifs. They acted as a barrier separating the Tethyan oceanic basins developing at that time,

out of which the present-day Alpine–Carpathian mountain belt emerged later. South of the barrier, the Paris and South German Basins were connected with the Tethys by a broad front, and the barrier itself was repeatedly broken to form local straits: the Trier, Hessian, Moravian and East Carpathian Gates which enabled marine connections between the Tethys and the basins of Western and Central Europe.

4. Between the three uplifted areas (East European Craton, British Caledonides and Variscan massifs) there is a triangle-shaped region of the relatively strongest Permian and Mesozoic subsidence, comprising the present-day North Sea, German Lowlands and Polish Lowlands. It is divided into separate basins (sub-basins) including the Polish Basin. Its pre-Permian history is most enigmatic. A complicated mosaic of lithospheric-crustal blocks (exotic and proximal terranes?) — an assemblage commonly called Eastern Avalonia (A. Berthelsen, 1992) — presumably adjoins the southwestern border of the East European Craton. During the Early Palaeozoic they were accreted to the craton, increasing its area towards the south and west. This region probably consists also of reactivated pieces of the Precambrian craton — particularly within the zone of the so-called Trans-European Suture Zone (TESZ) — as well as of Cadomian blocks. The entire area was presumably consolidated during the Caledonian epoch. Thickness of cratonic crust (40–45 km, locally over 50 km) is in a sharp contrast to the thickness of Palaeozoic crust (about 35 km, locally thinning to 25 km), predominant in Western Europe. The contact between them is either direct or there is an intermediate belt of anomalous crust in the border zone (e.g. TESZ, see below).

In this situation, the Variscan Front and the Alpine Front represent roughly the southern boundaries of the epicontinental Devonian and Carboniferous basins and the Permian–Mesozoic basins, respectively. However, in the latter case (and perhaps also in the former) the southernmost margins of the epicontinental basins are hidden beneath the overthrust piles of outer orogenic units.

The distribution of the above-mentioned uplifted and subsided elements influenced the rate of subsidence, directions of clastic transport and the character of sedimentary infill of the Permian–Mesozoic basins. The East European Craton, the British Caledonides and the Variscan massifs were the main source areas. In Poland, this role was played mainly by the Fennoscandian Shield and Bohemian Massif.

TYPES OF THE CRUST AND MAJOR LONGITUDINAL (NW–SE) FRACTURES

When studying the relationships between the crystalline crust and sedimentary basins it is convenient to define certain crustal areas or blocks with different properties of the crust and to identify and describe crustal fractures separating these blocks. Both these features influence regional subsidence pattern, and thus control the formation and evolution of sedimentary basins as well as their subsequent tectonic inversion.

Obviously, the structure of crystalline crust in the deeper parts of the basin can be studied solely by geophysical (seismic and gravity) methods. As to the sedimentary cover, the weakly deformed area of the East European Craton which was the northeastern slope of successive basins is satisfactorily examined by geophysical methods and verified by boreholes. Top of crystalline basement is well defined by the shallow seismic refraction data (S. Młynarski, 1982) and the internal structure of the cover — by reflection seismic survey. In the remaining areas, there are no reliable deep (near-vertical) reflection seismic records to investigate the structure between the Zechstein base and the basement top: the commercial reflection seismic data reach down to the Zechstein base only. This part of the sedimentary cover is sufficiently controlled by boreholes, contrary to the sub-Zechstein part where they are scarce.

The crystalline crust is relatively poorly studied in the basement of the Polish basins (Fig. 3). The discussed area is cut across (A. Guterch *et al.*, 1984, 1986*a*, *b*, 1994) by only eight DSS profiles (deep seismic sounding: refraction and wide-angle reflection seismic survey). Distances between five of them in northwestern and Central Poland are 50–100 km and farther to the south-east there is a gap 170 km wide. Beyond this gap — in southeastern Poland — there are three profiles including one running very obliquely in relation to the others (VIII). Only one of these eight profiles (LT-7) is of high quality with well recognized pattern of seismic velocities (V_p) within the crust.

The crystalline crust in this profile (Fig. 4) is in principle of three types (A. Guterch *et al.*, 1994; R. Dadlez, 1997). Northeastern slope of the basin: the East European Craton (unit A) is composed of a thick crust (42 km). This is a three-layer crust typical of an old craton of Svecofennian consolidation. Seismic velocities (V_p) of the upper layer, 9–11 km thick, are 6.2–6.3 km/s. The middle layer, about 14 km in thickness, is characterized by seismic velocities V_p = about 6.5 km/s. The lower layer, 12 km thick, shows seismic velocities $V_p = 7.0$–7.2 km/s.

The opposite, southwestern slope of the basin, recognized in the discussed profile in the territory of Germany (unit C), is underlain by an apparently thinner crust, predominantly 32–36 km thick, of a two-layer structure of its crystalline complex (not shown in Fig. 4; see figs. 2–4 in: A. Guterch *et al.*, 1994). The upper layer, 18 km in thickness, shows seismic velocities $V_p = 6.2$–6.3 km/s. Velocities of the lower layer, 10–12 km thick, are about 6.5 km/s. Thus, seismic velocities of both these layers are generally similar to the velocities of the two upper layers of the Precambrian crust. Geological correlations show that this crust is typical of inner zones of the Variscan orogen.

Between these two areas in profile LT-7, there is a zone of a highly differentiated crustal structure of enigmatic origin. This crustal zone (unit B) is about 200 km wide and is divided into two sectors: B' and B" (Fig. 4). Within both these sectors

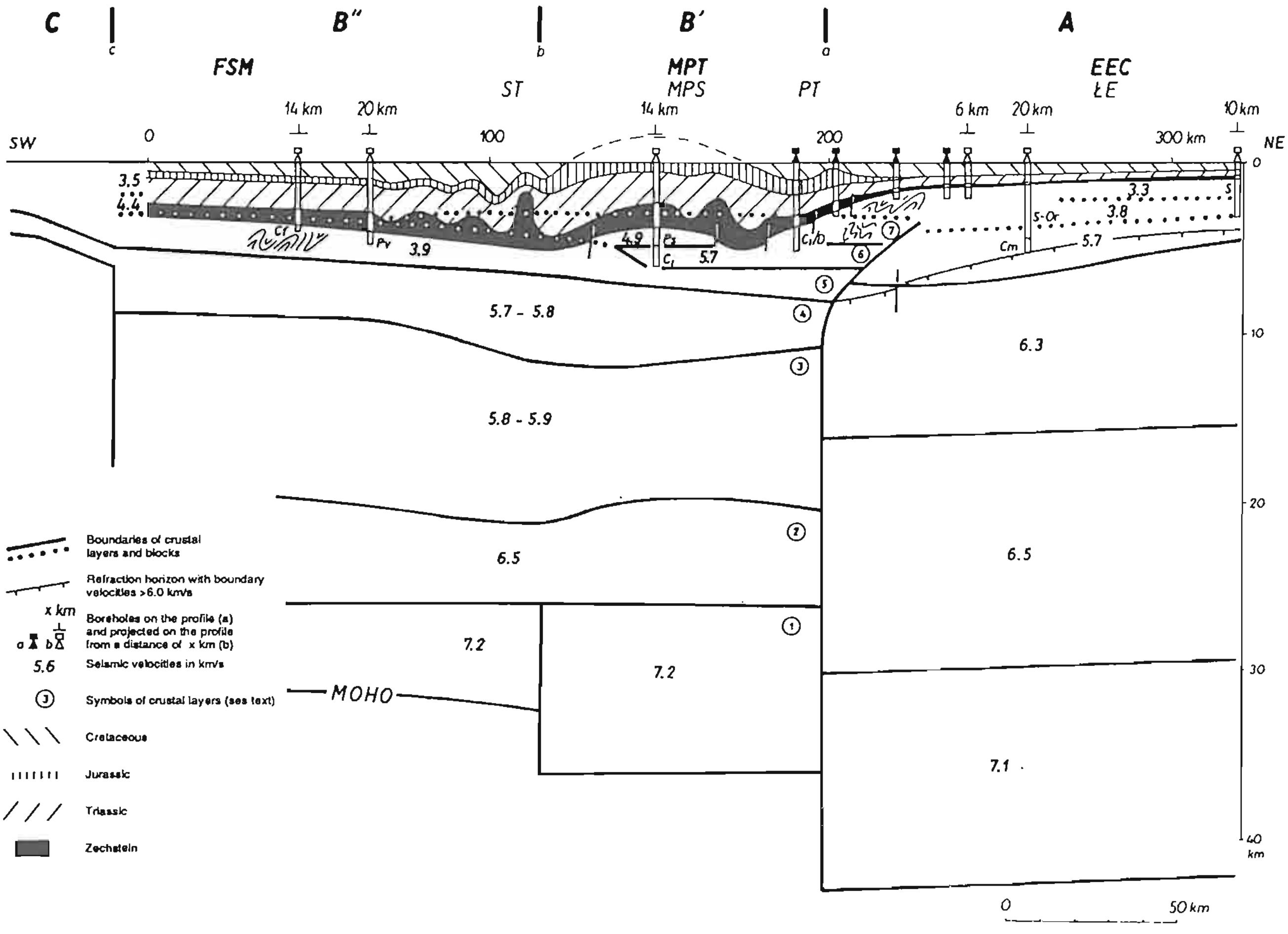

Fig. 4. DSS profile LT-7 (geophysical data after A. Guterch *et al.*, 1994)

Profil GSS LT-7 (dane geofizyczne według A. Gutercha i in., 1994)

the crustal structure is three-layer, and so the crust is similar, in this respect, to the structure of the Precambrian crust. The lower layer (1 in Fig. 4) shows seismic velocities of about 7.2 km/s, the middle (2) — about 6.5 km/s, i.e. both values are almost identical to the velocities of the lower and middle layers of the Precambrian crust. The differences are, however, essential. Thicknesses of both these layers are considerably smaller than those in the craton. The lower layer is 10 km thick in block B' and only 5–6 km in block B", compared with 12 km in the craton. The middle layer is only 6–7 km thick compared with 14 km in the craton. The greatest difference refers to the upper layer (3 + ?4) which shows exceptionally low seismic velocities of 5.8(5.7)–5.9 km/s. This probably indicates the presence of slightly metamorphosed rocks. Its great thickness is also surprising (layer 3 alone: 9–11 km, together with the layer 4: 12–14 km). Other features of this zone are as follows (A. Guterch *et al.*, 1994): relatively high position of the Moho discontinuity (36 km in block B' and 31 km in block B"), laminated structure of the middle layer of the crust in block B" and the occurrence of a lens within the mantle in block B' at a depth of 46–51 km, characterized by lower seismic velocities (down to 7.7 km/s) in relation to the underlying and overlying mantle (8.6 and 8.4 km/s, respectively).

The above-mentioned crustal units are separated from each other by vertical fractures. In the case of boundaries between units A and B (Fig. 3 and 4 — fracture **a**) as well as B and C (fracture **c**) these discontinuities are univocally determined by geophysicists; along the boundary between blocks B' and B" (fracture **b**), such a discontinuity may be presumed on the basis of contrasts in crustal characteristics (Fig. 4).

The extrapolation of the results of LT-7 profile farther towards central Poland is difficult, firstly because seismic velocities are not fully examined along other profiles and, secondly, because of peculiar feature of the LT-7 profile compared with the others: a sharp contrast between major crustal types — the one in the north-east, showing thickness of more than 40 km thick versus the other in the south-west about 30–35 km thick. In the profiles of Central Poland (Figs. 3 and 5), between these two types of the crust a third crustal type appears with a characteristic transitional crust/mantle layer. The profiles situated in the southeastern part exhibit a quite different pattern (Fig. 6). Thus, a first glance at the map

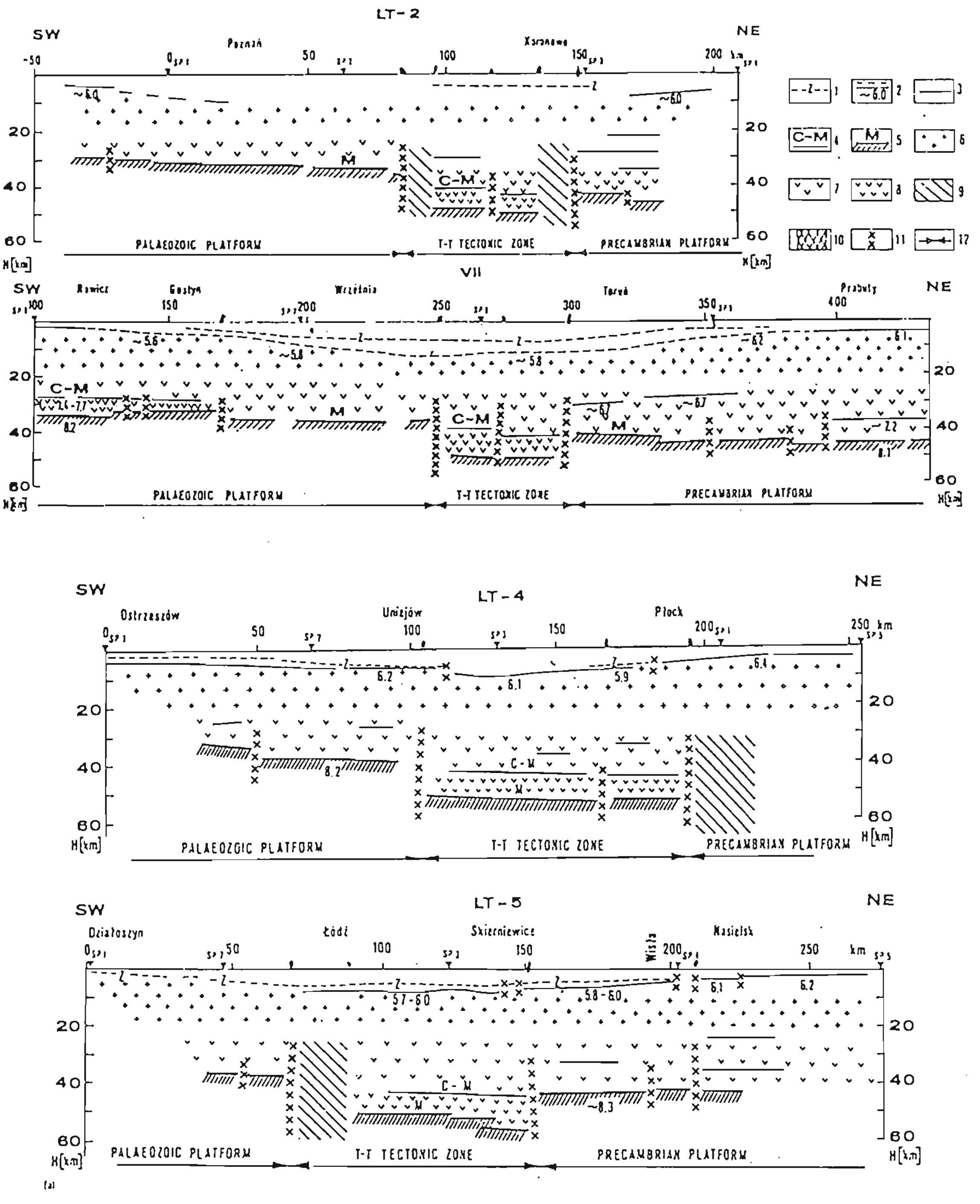

Fig. 5. DSS profiles from Central Poland (after A. Guterch *et al.*, 1986*a*, *b*)

1 — Zechstein base, 2 — refracted boundaries and velocities along the boundary in km/s, 3 — reflection boundaries, 4 — crust/mantle discontinuity in the lower part of the crust — upper boundary of transition layer between the crust and upper mantle, 5 — Moho discontinuity, 6 — upper part of the crust, 7 — lower part of the crust, 8 — layer of high velocities (7.5–7.7 km/s) in the lower part of the crust (transition layer crust/mantle), 9 — zone of strong disturbances of seismic waves, 10 — anomalous zone in the crustal structure, 11 — deep fractures, 12 — boundaries of crustal blocks

Profile GSS z Polski środkowej (według A. Gutercha i in., 1986*a*, *b*)

1 — spąg cechsztynu, 2 — granice refrakcyjne i prędkości wzdłuż granic w km/s, 3 — granice refleksyjne, 4 — nieciągłość skorupa/płaszcz w dolnej części skorupy — górna granica warstwy przejściowej między skorupą a górnym płaszczem, 5 — nieciągłość Moho, 6 — górna część skorupy, 7 — dolna część skorupy, 8 — warstwa o wysokich prędkościach (7,5–7,7 km/s) w dolnej części skorupy (warstwa przejściowa skorupa/płaszcz), 9 — strefa silnych zakłóceń fal sejsmicznych, 10 — strefa anomalnej budowy skorupy, 11 — głębokie pęknięcia, 12 — granice bloków skorupowych

(Fig. 3) reveals a transversal segmentation of the area which was also noticed by A. Guterch *et al.* (1986*a*). The following segments can be distinguished: the Baltic, Pomeranian, Kujavian and Małopolska ones. The first of them is represented by LT-7 profile, the second — by profiles LT-2 and VII, the third — by profiles LT-4 and LT-5 and the fourth — by

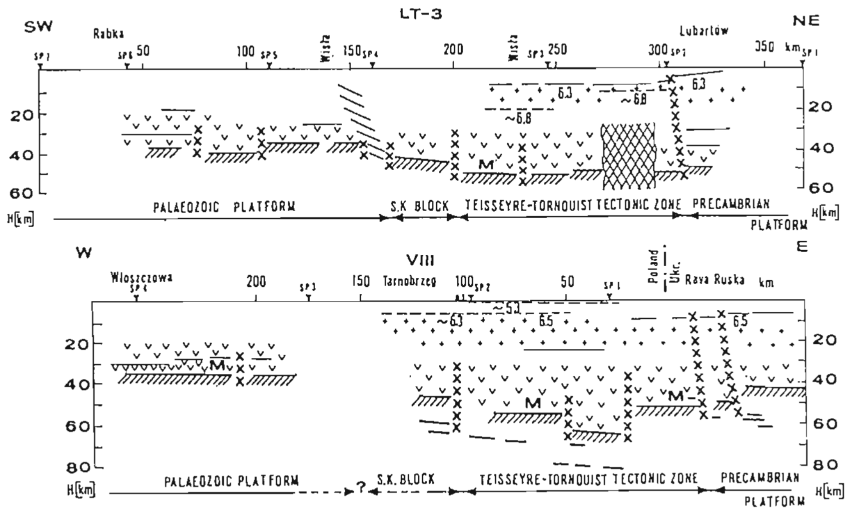

Fig. 6. DSS profiles from southeastern Poland (after A. Guterch *et al.*, 1986*a*)
For explanations see Fig. 5

Profile GSS z południowo-wschodniej Polski (według A. Gutercha i in., 1986*a*)
Objaśnienia przy fig. 5

profiles LT-3, LZW and VIII. Presumed transversal (NE–SW) fractures separating these segments are indicated in Fig. 3. Their location is suggested by gravity data (see below).

A prolongation of the crustal fracture (**c**) separating unit C from unit B can be recognized within the Pomeranian and Kujavian segments (Fig. 3). An extension of both fractures separating units B' and B" (**b**) as well as A and B (**a**) can also be observed. However, the latter is markedly shifted towards NE in the Kujavian segment in relation to Pomeranian segment. As a result, the zone of the anomalous crust is 50 km wide in the Pomeranian segment and 90 km wide in the Kujavian segment. An additional longitudinal fracture (**d**) appears between **a** and **b** in both segments. The presumed counterparts of fractures **a** and **d** in the Kujavian segment are labelled **a'** and **d'**, respectively, because their relationships remain uncertain.

Other features of the crust considerably change in both these segments as compared with the Baltic segment (Fig. 3). Along unit B", the crust successively thickens from 31 km in profile LT-7 through 35 km in profiles LT-2 and VII up to 38–39 km in profiles LT-4 and LT-5. In profile VII, in the crystalline basement of block C, a transitional layer of seismic velocities of 7.7–7.8 km/s appears between the crust and the mantle (Fig. 5). The most significant changes, however, appear in unit B': in the Pomeranian and Kujavian segments the crust is apparently thicker than in the Baltic segment and, at the mantle/crust boundary, there is a transitional layer, 8–10 km thick, with seismic velocities intermediate between the mantle and the crust: 7.7–7.8 km/s (Fig. 5). Its relationship to the intra-mantle lens of similar seismic velocities, observed in profile LT-7, is unknown. This transitional layer may be included either into the mantle or into the crust. According to the former approach, the crust would display a thickness similar to that of the Precambrian unit A (41–45 km). According to the latter, it would be considerably thicker, reaching 49–56 km. Block B' only, characterized along its whole length by this transitional layer (and not the whole block B), should be identified with the Trans-European Suture Zone (TESZ).

Crustal structure in southeastern Poland (Małopolska segment) differs markedly from that in northwestern and central parts of the country. It appears more complex but is still enigmatic (Figs. 3 and 6). The crust, more than 50 km thick (Precambrian?), extends far to the south, probably underlying the whole Łysogóry region of the Holy Cross Mountains. There is a narrow zone of anomalous structure of the crust in profile LT-3 (Fig. 6). However, the layer of intermediate seismic velocities between the crust and the mantle has nowhere been found. In the same profile, between the Precambrian and Palaeozoic crust, there is a block of intermediate crustal thickness (43–45 km), not occurring elsewhere (S. K. Block in Fig. 6). In the oblique profile VIII, in turn, just close to the border of Poland, there is a narrow zone with a depth to the Moho exceeding 60 km (Figs. 3 and 6). This zone, according to geological data, is situated right beneath the Caledonian deformation belt. Crustal fractures in this region are not aligned parallel one to another as they are within the previously discussed segments — they reveal rather a fan-like pattern. Their correlation between profiles LT-3 and LZW (A. Guterch *et al.*, 1984) is not certain. All these peculiarities of the Małopolska segment make there the identification of the TESZ considerably difficult and, moreover, speak against the identification of this zone with the Teisseyre-Tornquist Zone.[1]

OTHER CRUSTAL FRACTURES

All the DSS profiles (except for profile VIII) are aligned in SW–NE direction (recent profile TTZ-PL trending NW–SE — Fig. 3 — is now being interpreted). Thus, they do not give information about possible transversal fractures parallel to that direction. The latter fractures are suggested only by differences in the pattern of longitudinal fractures (Fig. 3). Therefore, the gravimetric methods have also been used to trace other fractures, including the transversal ones. Two methods of transformation of gravity field have been applied. One is based on fixing the horizontal gradient axes (C. Królikowski *et al.*, 1996) and the other is three-dimensional Euler's deconvolution (J. Jamrozik, 1996).[2] The comparison of fractures, suggested by the DSS and gravity data points to their moderate degree of coincidence, different in various regions (Fig. 7).

In the Pomeranian segment, there is a fairly good accordance of the main fractures recorded by the DSS with gravity gradient zones. The gradient zones: 1 (Świnoujście–Drawsko) and 2 (Szczecinek–Debrzno) are generally coincident with fractures **b** and **a**, respectively. In the Kujavian segment, the crustal fractures recorded by the DSS do not agree with the gravity gradient zones. Fracture **c** coincides with gravity gradient 7. In the Małopolska segment, discontinuity 4 is concordant with crustal fracture **g** at its northwestern end only; they diverge farther southeastwards. Subordinate fracture **f** is partly in accordance with gravity gradient 15. Strong gravity gradient 6 coincides with fracture **e**.

The most important transversal gravity gradient zones are 10+11 (Koronowo–Margonin), 12 (Włocławek–Konin) and 13 (Grójec–Opoczno). The last of them separates the Kujavian and Małopolska segments. The question of boundary between the Pomeranian and Kujavian segments is ambiguous. It runs either along the discontinuities 10+11 or 12. The fact that the former cuts obliquely the regular pattern of the DSS fractures speaks against this version. From the other side, preliminary results of the TTZ-PL profile seem to suggest that this gradient zone does play a more important role in crustal structure than the zone 12. Subordinate gravity gradients 9 and 16 may mark the lines of second-order segmentation.

CRYSTALLINE CRUST AND SEDIMENTARY COMPLEXES

The limitations of the analysis aiming at the correlation between the structure of crystalline crust below the Polish Basin and its sedimentary infill are following:

1. Apart from a poor knowledge of seismic velocities in the crystalline crust, the greatest gap in the data ranges from the base of the Zechstein–Mesozoic complex (sufficiently explored by the commercial reflection seismics and numerous boreholes) and down to the Moho discontinuity, but first of all — from this base to the top of crystalline complex of the crust. This interval is generally lacking reflection seismic data (with minor exceptions) and has been investigated partly only by rather scarce boreholes. In future, this gap may be filled by applying a modern near-vertical reflection seismic techniques, integrated with other geophysical methods, first of all with the non-processed and processed gravity data.

2. The non-transformed Bouguer gravity picture in the Mid-Polish Trough (MPT) (C. Królikowski, Z. Petecki, 1995) reveals a significant coincidence of the gravity lows and highs with the main tectonic units of the Permian–Mesozoic complex. The uplifted Mid-Polish Swell (MPS) is marked as a zone of high values bordered on both sides by the areas of low values which correspond to the neighbouring troughs filled with Cretaceous deposits. Even the details of both pictures are similar. For example, the Pomeranian Swell, more strongly uplifted in relation to the Kujavian Swell, is marked by higher gravity values; the narrowing and maximum uplifting of the Pomeranian Swell in its central part as well as its widening and plunging towards SE are mirrored in gravity image; the split of the swell in the Baltic region and the existence of the Trzebiatów Syncline filled with Cretaceous deposits between

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[1] The Teisseyre-Tornquist Zone (TZZ) along its whole length is not an equivalent to the TESZ. In accordance with long-standing tradition — it should be identified rather with a single deep fracture (northeastern border of the TESZ — *cf.* R. Dadlez, 1993). Moreover, a sigmoidal linking of the TTZ (or rather TESZ according to the present author) between the Kujawy and Małopolska segments (as in fig. 3 by A. Guterch *et al.*, 1986*a*) is not justified because in the former it is characterized by the anomalous crust and in the latter — by typical cratonic crust; it is overlain here by normal epicontinental sedimentary sequence of the Lublin Graben, beginning with Vendian.

[2] DSS profiles give us the information about the structure of the crust along the vertical planes only. Horizontal correlation between profiles is subjective. On the contrary, gravity data show the cumulative effect of gravity anomalies. Projected on horizontal plane with poor suggestions concerning the vertical distribution of the sources of anomalies.

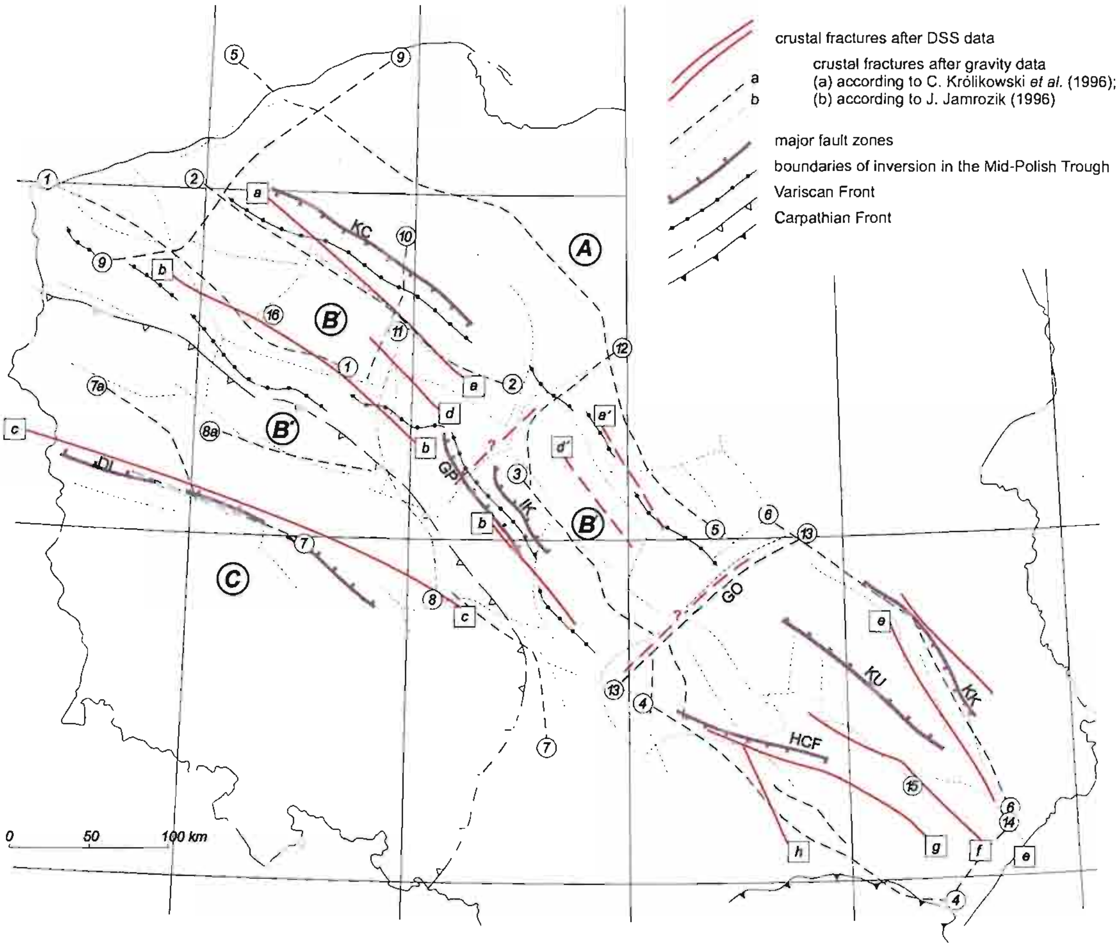

Fig. 7. Correlation of crustal fractures after DSS and gravity data with major fault zones after geological data

a–h — crustal fractures after DSS data; 1–16 — crustal fractures after gravity data (symbols explained in the text); fault zones after geological data: DL — Dolsk, GO — Grójec–Opoczno, GP — Gopło–Pabianice, HCF — Holy Cross Fault, IK — Izbica–Kłodawa, KC — Koszalin–Chełmża, KK — Kock, KU — Kazimierz–Ursynów

Korelacja pęknięć skorupowych według danych GSS i grawimetrycznych z głównymi strefami uskokowymi według danych geologicznych

a–h — pęknięcia skorupowe według danych GSS; 1–16 — pęknięcia skorupowe według danych grawimetrycznych (symbole omówione w tekście); strefy uskokowe według danych geologicznych (objaśnienia symboli — patrz podpis w języku angielskim)

both its branches is also clearly visible in the gravity map. Thus, the gravity pattern highly depends on the structure of the youngest members of the sedimentary cover. However, if the gradient zones, bounding the gravity units, have deep crustal roots (what is likely, for example, on the basis of detailed analysis of the LT-7 profile — R. Dadlez, 1997, see also Fig. 4), then it suggests that each first-order Permian–Mesozoic unit rests upon an individual crustal block and that these structures are typical posthumous units.

3. The previously described structure of the crust is the present-day one. Reconstruction of the pre-existing structure, at the beginning of the Permian–Mesozoic basin formation and even earlier, at the onset of the Devonian–Carboniferous basin development, is difficult and may only be a subject of speculations. It is obvious that both the position of the Moho surface and the inner structure of the crystalline crust (proportions between its layers) may have changed during those 350 Ma. This assumption was, among others, a reason for interpreting the base of the transitional crust/mantle layer as the pre-Permian Moho and its top — as the present Moho (R. Dadlez *et al.*, 1995).

Possible relationships between the crystalline crust and the structure of the epicontinental sedimentary cover, especially between the deep fractures and shallow fault zones, are given below. As an illustration, some major fault zones (particularly those with evidenced synsedimentary activity), recorded by commercial reflection seismics and by boreholes are introduced in Fig. 7 for comparison with geophysical data. Other geological features as orogenic fronts and the boundary of inversion of the MPS are also indicated. The latter is drawn not along the sub-Tertiary boundary between the Upper and Lower Cretaceous (as accepted so far) but along the axes of the Late Cretaceous depocentres directly flanking the MPS.

Gravity discontinuities 5 and 6 are situated within the craton although the first of them approaches its edge at the southeastern end. The geological nature of the former is unknown. The latter — being one of the most intense gravity gradients in the territory of Poland — coincides with the Kock Fault Zone (KK) which borders from the north-east the Carboniferous Lublin Graben. It corresponds to the DSS fracture **e**. However, the opposite border of the graben — the Kazimierz–Ursynów Fault Zone (KU) — which is at least of the similar importance and may have been earlier the prolongation of the Caledonian deformation front, is not recorded by any seismic or gravity data.

DSS fracture **a** and gravity discontinuity 2 is in rough accordance with the Koszalin–Chełmża Fault Zone (KC). This is a fundamental feature which runs near the northeastern limit of the Caledonian folded belt. During the Devonian (and Carboniferous?) it was a boundary between the shallower and deeper shelf. After the syn-Variscan block-fault deformations its northeastern limb was strongly uplifted. It resulted in the removal of the Devonian and Carboniferous deposits, probably of considerable thickness, which recorded marine connections between the Polish Basin and the basins of the Baltic countries and Central Russia, first of all in the Late Devonian. During the Permian and Mesozoic the KC zone was still characterized by sharp contrasts in thickness (particularly in the Permian, Early and Middle Jurassic and Early Cretaceous) and sometimes also in facies patterns. It formed northeastern boundary of the MPT with significantly higher subsidence of its southwestern flank. Southeastward divergence of this zone in relation to both geophysical features may be an expression either of southwestern inclination of deeper faults or of a step-like system of second-order faults.

The opposite edge of the Permian–Mesozoic MPT in the Pomeranian segment coincides with DSS fracture **b** and gravity discontinuity 1. No synsedimetary faults are so far recorded in the Permian–Mesozoic complex of this area but their existence cannot be excluded because of rather poor seismic resolution at greater depths. In the pre-Permian times this line may have represented the boundary between the Carboniferous outer shelf and the Variscan foredeep. A few boreholes in the area of unit B' (located between fractures **a** and **b**) penetrated thick, epicontinental Devonian and Lower Carboniferous series. Boreholes in the southern part of unit B" encountered either folded and weakly metamorphosed Carboniferous rocks of the external Variscan belt or the Rotliegend sediments and volcanic rocks (Fig. 4). The northern part of this unit is not penetrated by deep boreholes.

Discontinuities 1 and 2 and their accompanying fractures **a** and **b** roughly define in this segment also the boundaries of inversion of the MPT (Fig. 7, see also Fig. 4). Similar situation is in the Kujavian segment where the area of the MPT and of its inversion is bounded by fractures **b** and **a'**. However, these fractures are not confirmed here by gravity data. Fractures **d** and **d'** do not find their counterparts in the tectonics of the Permian–Mesozoic complex. Southwestern limit of the trough is particularly distinct: it is in agreement with a system of Gopło–Pabianice (GP) and Izbica–Kłodawa (IK) Fault Zones which are characterized by sharp thickness gradients of the Mesozoic. Only a single borehole in this deeply depressed area pierced the Permian and revealed the epicontinental Lower Carboniferous strata. Thus, this region seems to be a continuation of the unit B'. This unit, bounded by fractures **a** (**a'**) and **b** is characterized by transitional crust/mantle layer (Fig. 2).

It results from the above that the fracture **b** may represent at its whole length the outer margin of the Variscan foredeep, lying 30–40 km north-east from the presumed Variscan front. Farther to the south, within the probable external Variscan belt, gravity gradients 7a, 8 and 8a, aligned in the similar arcuate manner as the Variscan front (but not confirmed by any DSS fracture), mark another boundary of unknown origin (Fig. 7). It is reflected in the Zechstein as a northern edge of carbonate platform. The next one to the south is the fracture **c** coincident with gravity gradient 7. It is equivalent to the Dolsk Fault (DL) which probably separates the external from the internal units of the Variscan belt. During the Permian it probably governed the evolution of the Wolsztyn High (devoid of Rotliegend sediments) as well as of the Zechstein carbonate platform.

In the whole area between fractures **a** and **c** (unit B) the uppermost layer of the crystalline crust is characterized by low velocities (5.8–5.9 km/s). It may indicate the existence of low-grade metamorphic rocks. The origin and age of this layer is enigmatic taking into account also the fact that it is underlain by the lower crust of cratonic affinities but of anomalously small thicknesses. Preliminary interpretations assume that it is a collage of smaller crustal blocks either of modified cratonic crust or of pre-Variscan (Caledonian? Cadomian?) consolidation, or both.

In the Małopolska segment the fracture **g** only is concordant — at least in its western part — with the well-known Holy Cross Fault. It is a major fault zone dividing the Holy Cross Palaeozoic block into two regions: Kielce and Łysogóry units. It played a fundamental palaeogeographical role, particularly during the Devonian; later it probably formed the southern boundary of the southeastern extension of the MPT — the Nowe Miasto–Iłża Fault (M. Hakenberg, J. Świdrowska, 1997). It is, however, not visible in the gravity field while marked gravity gradient 4 (and an additional fracture **h**?) are connected with the southern edge of the uplifted Palaeozoic block of the Holy Cross Mts. Farther to the north fracture **f** and its accompanying gravity gradient 15 run along a probable system of grabens — filled with Upper Carboniferous strata — in the northeastern forefield of the Holy Cross Mts. It is partly coincident with a presumed northeastern boundary of the extension of the Mid-Polish Trough (M. Hakenberg, J. Świdrowska, 1997). The crust north of the Holy Cross Fault is a thickened cratonic crust. South of this fault the interpretation is so far impossible due to unsufficient data.

Among transversal fractures, the Grójec–Opoczno Fault Zone (GO) (13), very distinct in the gravity picture, is the boundary between the elevated Holy Cross Mts. block and the more depressed units in Central Poland. Thus, it played a significant role during the inversion which led to destruction of full sequences in the axial part of the southeastern extension of MPT what makes difficult the reconstruction of communication pathways between this trough and the Tethyan domain during the Permian and Mesozoic. This process was probably a reactivation of earlier fault system which was active during the Devonian/Carboniferous basin development. It is evidenced by different lithological-stratigraphical Devonian and

Carboniferous sections on both sides of this system, in the Lublin and Warsaw regions.

Delimitation of the Kujavian from Pomeranian segment is disputable. The difference between the both is visible on any geological map without Cenozoic deposits: in the Pomeranian Swell the Lower Jurassic subcrops dominate while in the Kujavian Swell the Upper Jurassic prevail on the sub-Cenozoic surface. This difference seems to reflect a fundamental boundary at depth. Geological data suggest that a deep fracture (Włocławek–Konin) along the line 12 (which is better recorded by the Euler's deconvolution method than by the horizontal gradient axes method) is more probable than the fracture 10+11 to play the role of this boundary. Probably, both fractures are important: the deepest depression of the MPS (with Lower Cretaceous strata appearing at the sub-Cenozoic surface) is situated between them.

Transversal segmentation of the basin was reflected in the subsidence and sedimentation history of the Permian–Mesozoic MPT and, specifically, in the differences between the Pomeranian and Kujavian segments. The former shows an asymmetry with greater thickness contrasts across the Koszalin–Chojnice zone than across the opposite flank, first in the Upper Rotliegend and then in the Early and Middle Jurassic and, to a lesser extent, in the Late Triassic, Early Cretaceous and Zechstein. In the Kujavian segment the asymmetry is conversely directed. Sharp thickness gradients, recorded largely in the Early and Middle Jurassic and Early Cretaceous, are located across the southwestern flank related to the Izbica–Kłodawa and Gopło–Pabianice Fault Zones, while on the opposite flank thickness changes are more gradual.

MPT is sometimes regarded as an asymmetrical passive rift with northeastern proximal zone which subsided stronger than the southwestern distal zone where uplifts comparable with the so-called core complexes came into existence (J. Kutek, 1996, 1997). Variable asymmetry of the MPT is indicated also here. However, the presumed border faults of the alleged rift are not continuous. Shorter segments only on both sides of the trough can be recognized as synsedimentary faults. Moreover, their activity was intermittent, separated by periods when the fault was dormant and thickness increases were gradual. Therefore the term "trough" seems to be more appropriate than the term "rift".

All described fault zones are interpreted mainly as normal, dip-slip structures. However, minor strike-slip component (tens of kilometres) may have contribute in the Variscan epoch while it was almost unnoticeable during the Late Mesozoic/Early Tertiary inversion (R. Dadlez, 1994).

An important problem is a role of the anomalous crust belt with the transitional crust/mantle layer (unit B'). A spatial relationship between the MPT with its inversion zone (MPS) and this belt, is unquestionable. However, it originated probably much earlier, perhaps at the end of the Early Palaeozoic, as a consequence of collision between the East European Craton and minor lithospheric-crustal blocks (terranes). It is assumed that at the end of the Variscan epoch — during the ultimate collision between the great continental blocks: Gondwana and Laurussia — orogenic processes caused a mobility of magmas within the uppermost mantle and lower crust. Due to stronger fracturing and higher "permeability" of the young crust within a mobile belt and its foredeep, the magma could easier force its way towards the surface: thus, the vast lava extrusions of varying composition, predominantly acid, with their central field in Eastern Germany, came into existence during the Early Permian (P. A. Ziegler, 1990). Farther to the north-east, in the Polish Basin, the older crust was more compact, particularly within zones of earlier collisions between crustal blocks and the East European Craton. Mantle injections were able to intrude the crust on a limited scale only and to impregnate its lower part. In that way a characteristic layer of intermediate seismic velocities between the crust and mantle was formed. The overheated crust was uplifted and a long period of erosion followed during the Early Permian. In the course of further Permian–Mesozoic evolution, until the Late Cretaceous, a phase of subsidence took place due to crustal cooling (for details see R. Dadlez *et al.*, 1995).

The transitional layer was earlier considered a result of phase transformations: eclogite – garnet granulite – gabbro at the mantle/crust boundary (R. Dadlez, 1980; J. Znosko, 1979). Perhaps this view is not outdated and both processes may have acted (A. Guterch *et al.*, 1986*a, b*).

The causes of inversion at the Mesozoic/Cenozoic boundary are usually related to crustal shortening in the forefield of the nearby Alpine orogenic belt (P. A. Ziegler, 1990). Since the effects of compression within the sedimentary cover and in particular within the well explored Permian–Mesozoic complex are rather scarce (lack of tight folds, limited number of reverse faults with normal faults predominating), it should be assumed that the shortening occurred rather at the level of crystalline crust, largely within its lower, laminated part. Moreover, a possibility exists that the inversion may have been a sort of self-driven process: subsidence, triggered by cooling of the crust led to accumulation of very thick sedimentary complexes which started to act as thermal blanket, and caused again the heating of lower crust and the uplift (W. B. Joyner, 1967; W. J. van de Lindt, 1967). Perhaps both processes (crustal shortening and transformations at the Moho level) may have contributed to the inversion.

CONCLUSIONS

1. Northern and eastern slopes of the epicontinental basins in Poland are underlain by typical three-layered cratonic Precambrian crystalline crust of Svecofennian age (unit A). In the southwest, a two-layered Variscan crust was a substratum of the opposite slope of the Permian–Mesozoic basins (unit C). Between the both, a 150–200 km wide belt of

anomalous crust, observed in the northwestern and central parts of the country (unit B) is probably composed of an assemblage of smaller crustal blocks of disputable origin. This belt in turn is divided into two longitudinal zones. Northeastern one (B') — with the uppermost thick layer of low velocities and a transitional crust/mantle layer — was a basement for the external parts of the Devonian–Carboniferous epicontinental basins and later — for the axial part of the Permian–Mesozoic basin (MPT). The latter was later inverted to form the MPS. Southwestern zone (B"), devoid of transitional layer, is probably overlain by external units of the Variscan orogenic belt (including its foredeep) which in turn are built over crustal collage of pre-Variscan age.

2. Southeastern part of the country (Małopolska segment) shows a different pattern of crustal units not so directionally arranged as farther to the north-east. Southwestern extent of the cratonic crust which is here thicker is disputable. Correlation with crustal fractures in the central areas of Poland is impossible. These differences most distinctly express the transversal segmentation of the basin which elsewhere is suggested by gravity data enabling its subdivision into the Baltic, Pomeranian and Kujavian segments.

3. Some of the presumed fractures in the crystalline crust coincide precisely with syn- and postsedimentary faults and fault zones recorded by geological studies in the sedimentary cover but some others do not.

4. Following open problems should be solved in the nearest future:

— the origin of the transitional crust/mantle layer in the blocks B' and C and its relation to the intra-mantle lens in the LT-7 profile, as well as its influence on geology of the upper parts of crust;

— the extent and thickness of the upper layer of the crystalline crust in the unit B with anomalously low seismic velocities;

— recognition of the pattern of seismic velocities within all the distinguished segments;

— examination — using the near-vertical reflection seismic survey — of the inner structure of the crust, particularly in the upper layer of the crystalline crust and between the base of Zechstein and the top of crystalline basement.

5. All these goals should be achieved during the integrated geophysical researches, planned for the next years. They will be carried out with the use of modern methods and techniques, and significant co-operation of western institutions. Field works of the first stage of these projects — the DSS POLONAISE Program — were carried out in spring 1997 along four profiles in the Polish Basin (Fig. 3). Similar experiment in southwestern Poland is anticipated for 2000.

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REFERENCES

BERTHELSEN A. (1992) — Mobile Europe. In: A continent revealed — the European geotraverse. Cambridge Univ. Press, p. 11–32.

COCKS L. R. M., FORTEY R. A. (1982) — Faunal evidence for oceanic separation in the Palaeozoic of Britain. J. Geol. Soc., London, **139**, p. 465–478.

DADLEZ R. (1980) — Tectonics of the Pomeranian Swell (NW Poland) (in Polish with English summary). Kwart. Geol., **24**, p. 741–767, no. 4.

DADLEZ R. (1993) — Teisseyre-Tornquist tectonic zone in Poland. Publ. Inst. Geophys. Pol. Acad. Sc., **A-20** (255), p. 49–51.

DADLEZ R. (1994) — Strike-slip movements in the Polish Lowlands. Geol. Quart., **38**, p. 307–318, no. 2.

DADLEZ R. (1997) — Seismic profile LT-7 (northwest Poland): geological implications. Geol. Mag., **134**, p. 653–659, no. 5.

DADLEZ R., NARKIEWICZ M., STEPHENSON R. A., VISSER M. T. M., VAN WEES J.-D. (1995) — Tectonic evolution of the Mid-Polish Trough: modelling implications and significance for central European geology. Tectonophysics, **252**, p. 179–195.

GUTERCH A., GRAD M., MATERZOK R., PAJCHEL J., PERCHUĆ R., TOPORKIEWICZ S. (1984) — Deep structure of the Earth's crust in the contact zone of the Palaeozoic and Precambrian Platforms and the Carpathian Mts. in Poland. Acta Geophys. Pol., **32**, p. 25–41, no. 1.

GUTERCH A., GRAD M., MATERZOK R., PERCHUĆ E. (1986*a*) — Deep structure of the Earth's crust in the contact zone of the Palaeozoic and Precambrian Platforms in Poland (Teisseyre-Tornquist Zone). Tectonophysics, **128**, p. 251–279.

GUTERCH A., GRAD M., MATERZOK R., PERCHUĆ E., TOPORKIEWICZ S. (1986*b*) — Results of seismic crustal studies in Poland (in Polish with English summary). Publ. Inst. Geophys. Pol. Acad. Sc., **A-17** (192), p. 1–84.

GUTERCH A., GRAD M., JANIK T., MATERZOK R., LUOSTO U., YLINIEMI J., LUCK E., SCHULZE A., FORSTE K. (1994) — Crustal structure of the transition zone between Precambrian and Variscan Europe from new seismic data along LT-7 profile (NW Poland and East Germany). C. R. Acad. Sc. Paris, **319**, ser. II, p. 1489–1496.

HAKENBERG M., ŚWIDROWSKA J. (1997) — Propagation of the southeastern segment of the Polish Trough connected with bounding fault zones (from the Permian to the Late Jurassic). C. R. Acad. Sc. Paris, **324**, ser. II, p. 793–803.

JAMROZIK J. (1996) — Interpretacja regionalnych anomalii grawimetrycznych przy zastosowaniu trójwymiarowej dekonwolucji Eulera. Arch. BG. Geonafta.

JOYNER W. B. (1967) — Basalt-eclogite transition as a cause for subsidence and uplift. J. Geophys. Res., **72**, p. 4977–4998.

KRÓLIKOWSKI C., PETECKI Z. (1995) — Gravimetric atlas of Poland. Państw. Inst. Geol. Warszawa.

KRÓLIKOWSKI C., PETECKI Z., DADLEZ R. (1996) — Vertical discontinuities in the Earth's crust of the TESZ in Poland — gravity data. Geol. Quart., **40**, p. 155–168, no. 2.

KUTEK J. (1996) — The Polish Permo–Mesozoic basin as an asymmetrical rift basin. Proc. Labor. Tectonics and Geological Mapping. UW, **96**, p. 1–4, no. 2.

KUTEK J. (1997) — The Polish Permo-Mesozoic rift basin. IGCP Project no. 369, 4th Annual Meeting. Barcelona.

LINDT W. J. van de (1967) — Movement of the Mohorovicic discontinuity under isostatic conditions. J. Geophys. Res., **72**, p. 1289–1297.

MŁYNARSKI S. (1982) — The structure of deep basement in Poland in the light of refraction seismic surveys (in Polish with English summary). Kwart. Geol., **26**, p. 285–296, no. 2.

ZIEGLER P. A. (1989) — Evolution of Laurussia. Kluwer Acad. Publ.

ZIEGLER P. A. (1990) — Geological atlas of Western and Central Europe. Shell Int. Petr. Maatsch. B.V.

ZNOSKO J. (1979) — Teisseyre-Tornquist tectonic zone: some interpretative implications of recent geological and geophysical investigation. Acta Geol. Pol., **29**, p. 365–382, no. 4.

BASENY POLSKIE OD DEWONU PO KREDĘ — ZWIĄZKI MIĘDZY KRYSTALICZNYM I OSADOWYM KOMPLEKSEM SKORUPY ZIEMSKIEJ

Streszczenie

Stan rozpoznania skorupy krystalicznej na Niżu Polskim jest dość słaby. Profile GSS przecinają ten teren z NE na SW co 50–70 km i tylko jeden z nich ma pełne rozpoznanie rozkładu prędkości sejsmicznych w skorupie. Największą luką w rozpoznaniu kompleksu osadowego jest brak głębokiej sejsmiki refleksyjnej. Kompleks ten jest dobrze zbadany tylko do spągu cechsztynu. Dodatkowym, choć trudnym do interpretacji źródłem informacji są nieprzetworzone i przetworzone dane grawimetryczne. Na tych podstawach dokonano próby powiązania ze sobą obydwu kompleksów skorupy, identyfikacji jej bloków i dzielących je pęknięć wraz z ich korelacją z danymi geologicznymi z najwyższej części skorupy. W środkowej i północno-zachodniej części kraju łatwe do identyfikacji pęknięcia podłużne (NW-SE) wiążą się z granicami permsko-mezozoicznej bruzdy śródpolskiej i granicami jej inwersji oraz z uskokiem Dolska wewnątrz pasma waryscyjskiego. Południowo-zachodnie pęknięcie ograniczające bruzdę określa w głębi, być może, granicę między platformą dewońsko-karbońską a zapadliskiem przedgórskim waryscydów. Układ pęknięć skorupowych w części południowo-wschodniej kraju jest mniej uporządkowany, a korelacja z płytszymi strefami uskokowymi nie tak jednoznaczna. Ta różnica akcentuje najwyraźniej poprzeczną segmentację basenu, który skądinąd podzielony jest na kilka bloków o odmiennej charakterystyce skorupy.

Duże znaczenie przypisuje się obecności w wąskiej strefie wzdłuż basenu warstwy przejściowej między skorupą i płaszczem o pośrednich prędkościach sejsmicznych 7,7–7,8 km/s, która jest zbieżna z osią bruzdy śródpolskiej i z osią jej inwersji. Ten pas anomalnej skorupy (B') wraz z przyległym do niego następnym pasem (B") położone są między typową, niezmienioną skorupą prekambryjską a skorupą waryscyjską. Strefa ta ma niejasną genezę — może być albo zbiorowiskiem wczesnopaleozoicznych bloków skorupowych (terranów?), przylegającym do kratonu, albo silnie zmodyfikowanym obrzeżem samego kratonu. Być może w skład tego pasa wchodzą bloki o jednej i drugiej genezie. W najbliższej przyszłości zasób naszych wiadomości powinien się znacznie poszerzyć po pełnej interpretacji podłużnego profilu GSS pod nazwą TTZ-PL i profilów z programu POLONAISE.