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The Polish Basin — relationship between the crystalline, consolidated and sedimentary crust

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In the area of the Polish Basin five deep seismic sounding profiles, recorded during 1991–1997, were used to compare the structure of the crystalline and consolidated crusts with that of the sedimentary cover. Repeated reactivation of deep crustal fractures controlled the thickness distribution and development of faults in Palaeozoic and Mesozoic sequences. NW–SE to WNW–ESE basin-parallel and transverse N–S to NE–SW striking fracture systems are evident. The former includes the Teisseyre–Tornquist Zone that marks the profound crustal boundary between the East European Craton and the typical Trans-European Suture Zone (TESZ) crust that is characterized by a variably thick consolidated upper crustal layer, composed of Caledonian-deformed Early Palaeozoic and possibly Vendian sediments, and defines the NE boundary of the Permian and Mesozoic Mid-Polish Trough (MPT). Its northwestern TTZ segment was intermittently active throughout the whole geological history of the area. The SW boundary of the TESZ, marked by the Dolsk Fault across which the consolidated crustal layer is replaced by a crystalline Variscan upper crust, is only evident on profiles LT-7 and P4. The deformation front of the Variscan Externides is located some 100 km to the NE of the Dolsk Fault within the confines of the TESZ crust. On profiles TTZ-PL and P2, significant lateral changes in the thickness of the consolidated and crystalline crust of the Pomeranian, Kuiavian and Holy Cross Mts. segments of the MPT are noted that coincide with the transverse Bydgoszcz-Poznań-Toruń and Grójec fault zones. These crustal changes are associated with substantial changes in the composition and thickness of supracrustal sedimentary sequences and the degree of inversion of the MPT.

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Key words: Mid-Polish Trough, Polish Basin, sedimentary crust, consolidated crust, crystalline crust.

INTRODUCTION

The Polish Lowlands area (Fig. 1) was a subject of intensive seismic investigations (DSS — seismic refraction and wide-angle reflection) starting in 70' and continuing to the recent years (see Guterch and Grad, 2006, for a summary). Guterch *et al*. (1994) and Grad *et al*. (1999) interpreted the results of these studies for the LT-7 and TTZ-PL profiles. Subsequently, Dadlez (1997*a*) and Berthelsen (1998) presented geological interpretations of the LT-7 profile, arriving at significantly different conclusions. In 1997, additional five profiles, labeled P1 to P5, were recorded in the framework of the POLONAISE '97 program. Geophysical results of profiles P1, P2 and P4, accompanied by preliminary geological interpretations, were published by Jensen *et al*. (1999), Janik *et al*. (2002) and Grad *et al*. (2003), respectively. More detailed geological interpretations of the entire area covered by the LT-7, TTZ-PL and POLONAISE '97 profiles are contained in the papers by Grad *et al*. (2002) and Dadlez *et al*. (2005). Particularly the latter paper presents details of the crustal structure at deeper levels. The TTZ-PL profile was recently reinterpreted together with the CEL 03 profile which forms part of the new CELEBRATION 2000 program (Janik *et al*., 2005). First comparison of profiles from the POLONAISE and CELEBRATION programs contains the paper by Guterch and Grad (2006).

These investigations were preceded by a series of DSS profiles that yielded a less complete record of crustal velocities (Guterch *et al*., 1986). Królikowski *et al*. (1996) and Dadlez (1997*b*) presented geological interpretations of these profiles that are partly no longer valid. However, some of these profiles were recently reprocessed (Grad *et al*., 2005) and these results are included in this paper as supporting information.

All of these reports focused on the structure of crystalline and consolidated crusts. Crystalline crust is here considered as consisting of highly deformed metamorphic and igneous rocks, characteristic of Precambrian platforms. By contrast, the consolidated crust is composed of highly deformed but not

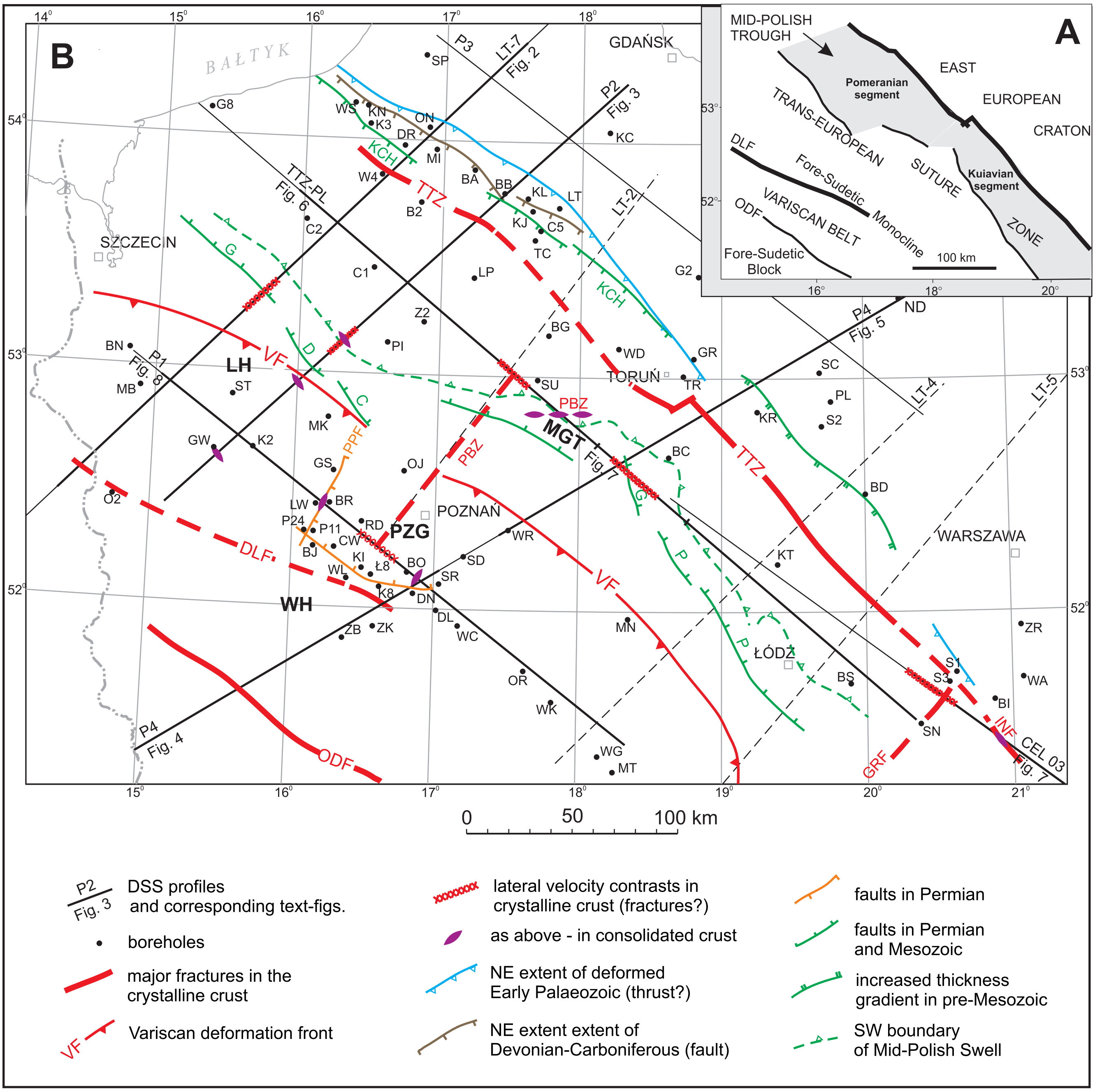

Fig. 1. A — geological sketch showing main tectonic features of the study area in NW Poland, B — location of studied deep seismic sounding profiles and analysed boreholes against tectonic features

Full names of boreholes are listed in Appendices A–E; other abbreviations: DLF — Dolsk Fault, G-D-C — Grzęzno-Drawno-Człopa faults, G-P-P — Gopło-Ponętów-Poddębice faults, GRF — Grójec Fault, INF — Iłża-Nowe Miasto Fault, KCH — Koszalin-Chojnice Zone, LH — Lubusza High, MGT — Mogilno Trough, ODF — Odra Fault, PBZ — Poznań-Bydgoszcz-Toruń Zone, PPF — Paproć-Pniewy Fault, PZG — Poznań Graben, TTZ — Teisseyre-Tornquist Zone, WH — Wolsztyn High, VF — Variscan Deformation Front

necessarily metamorphosed sedimentary and subordinate igneous rocks, characteristic of Palaeozoic platforms. Both crustal types are unconformably covered by sedimentary sequences, representing the sedimentary part of the crust (sedimentary crust). As the reports cited above did not address the relationship between the structures of sedimentary, consolidated and crystalline parts of the crust, it is the objective of this paper to fill in this gap.

TECTONIC SETTING

The Polish Basin is essentially defined by its Permian to Mesozoic sedimentary fill that is covered by a relatively thin veneer of Cenozoic deposits. This basin straddles the Teisseyre-Tornquist Zone (TTZ) that marks the boundary between the Precambrian East European Craton (EEC) to the NE and the Palaeozoic Platform of Western and Central Europe to the SW. During Phanerozoic times, the area covered by the Polish Basin has undergone a complex evolution during which its megatectonic setting changed, with each evolutionary step having repercussions on the crustal configuration of this area (e.g. Ziegler, 1990; Dadlez, 1997*b*). Basically, four stages can be recognized in the geological evolution of the Polish Basin, the representative rock complexes of which are separated by fundamental unconformities that mark the end of the Early Palaeozoic Caledonian, the Devonian-Carboniferous Variscan and the Permian-end Mesozoic Early Alpine tectonic cycles. Although the Permian and younger evolution of the Polish Basin is well constrained by geological and geophysical data, constraints on the evolution of this area become increasingly weaker the further one goes back in time, leaving much open to increasingly controversial interpretations (see e.g. Winchester *et al*., 2002).

During the latest Mesozoic and Cenozoic times the evolving Carpathian Orogen flanked the Polish Basin to the south. During the Paleogene and Neogene its southernmost parts were incorporated into the rapidly subsiding flexural Carpathian foreland basin (Oszczypko, 2006) that graded to the north into a weakly subsiding platform on which relatively thin, predominantly clastic deposits accumulated extending far onto the EEC.

During the Permian and Mesozoic, the Polish Basin subsided between the front of the by now inactive Variscan Orogen to the south and south-west and the stable EEC in the north and north-east under a mildly tensional setting but mainly in response to thermal contraction of the lithosphere. As such, it formed the easternmost part of the large intracontinental Central European Basin (Ziegler, 1990). In the course if its subsidence, the margins of the Polish Basin were progressively overstepped with sediments encroaching onto the marginal parts of the EEC, as well as on the external zones of the Variscan belt in the area of the relatively wide Fore-Sudetic Monocline (Fig. 1A). The axial zone of Polish Basin, which is characterized by maximum subsidence and an almost complete sedimentary succession, is located close to the TTZ and is referred to as the Mid-Polish Trough (MPT, Fig. 1A). This trough was inverted during the Late Cretaceous and Paleocene.

Stepping back in time, the area of the future Polish Basin was occupied during Devonian and Early Carboniferous times by an extensive, clastic-carbonate platform that extended far onto the EEC and that was flanked to the SW by a passive margin facing the partly oceanic Rheno-Hercynian-Silesian Basin (Ziegler, 1990). Following latest Devonian–Early Carboniferous closure of this basin during the early phases of the Variscan orogeny, the Polish shelf basin was transformed near the Variscan deformation front into a foreland basin, probably filled with Namurian and Westphalian paralic and continental coal measures, as seen in the Upper Silesian Basin. The area of the Fore-Sudetic Monocline is underlain by the external parts of the Variscan fold belt, dominated by Late Carboniferous flysch (Wierzchowska-Kicułowa, 1984; Mazur *et al*., 2006) and isolated cores of older, weakly metamorphosed rocks (Krawczyńska-Grocholska and Grocholski, 1976). Following the end-Westphalian termination of crustal shortening in the Variscan Orogen, it was reactivated by dextral shear (Mazur *et al*., 2006). These shear movements resulted in the disruption of the Carboniferous basin underlying the Polish Basin and the extrusion of voluminous volcanics, particularly in Western Poland and adjacent Germany. Related thermal disturbance of the asthenosphere-lithosphere system provided the driving mechanism for the subsequent subsidence of the Central European Basin, including its Polish part (Ziegler, 1990; Van Wees *et al*., 2000).

The Early Palaeozoic history of the Polish Basin area is most enigmatic. It is commonly thought that it was occupied by parts of the North German-Polish Caledonian mobile belt (Ziegler, 1990; Pharaoh, 1999). However, the details of its evolution are interpreted in different ways. According to some authors there was an uninterrupted Caledonian orogenic belt that extended from Northern Germany into Southern Poland, paralleling the margin of the EEC (e.g. Znosko, 1971, 1986). Others suggest that this belt consists of an assemblage of tectonostratigraphic terranes that were accreted to the Baltica palaeocontinent, thus forming the Trans-European Suture Zone (TESZ) (Berthelsen, 1992; Pharaoh, 1999). For instance, Meissner *et al*. (1994) and Hoffmann and Franke (1997) claim that the TESZ marks the suture between the Gondwana-derived East Avalonia Terrane and the EEC, whereas Pożaryski (1991), Franke (1994) and Cocks *et al*. (1997) suggest that other terranes of Gondwanan provenance are involved in this zone. On the other hand, Dadlez (2000) and Dadlez *et al*. (1994, 2005) propose the involvement of proximal terranes that were detached from Baltica and that were re-accreted to it during Early Paleozoic times (see also Narkiewicz, 2002). Berthelsen (1998) postulated that the EEC extends at lower and middle crustal levels as far south as the Trans-European Fault Zone, corresponding to the suture of the Thor Ocean that had separated the East Avalonia Terrane from the EEC during Cambro-Ordovician times. Accordingly, the TESZ is regarded as an “intraplate pseudosuture”.

Whereas outcrop and well data permit to define with some confidence the accretionary history of the South Polish terranes and also of the East Avalonia Terrane in the North German-Danish borderlands, only geophysical data are available on the substrate of the Mid-Polish Trough, apart from few wells documenting in Pomerania the presence of folded Silurian and Ordovician sediments that are unconformably covered by Devonian deposits. Correspondingly, only geophysical data can be used to assess whether the MPT is underlain either by East Avalonia or potential Baltica-derived terranes. In any case, during the Early Palaeozoic the NE part of the present Polish Basin was occupied by the passive margin of the EEC (Baltica) whilst a mobile, probably allochthonous belt occupied its remaining parts.

According to geophysical data three crustal types (Fig. 1A) underlay the Polish Basin, namely the EEC crust in the NE, the TESZ crust in its central parts and Variscan Belt crust in the SW (Dadlez *et al*., 2005; Guterch and Grad, 2006). The EEC crust, which is covered by flat-lying Palaeozoic and younger sediments, is three-layered and consists of an upper (Vp = 6.2–6.3 km/s), middle (Vp = 6.6–6.7 km/s) and lower (Vp = 7.1–7.2 km/s) layer having average thicknesses of 9–10 km, 10–13 km and 12–17 km, respectively. The Variscan crust that is covered by Permian to Cenozoic sediments is also three-layered with the consolidated crust being rather thin, whilst the middle crust is thicker (>20 km) and the lower crust is thinner (4–10 km), both revealing lower velocities (*Vp* about 6.2 km/s and 6.5 km/s, respectively) as compared to the EEC. By contrast, specific features characterize the intervening TESZ crust that is again three-layered. In the western parts of the TESZ the lower and middle crystalline crustal layers are as thin as 5 km each whilst the consolidated crust (velocity 5.8–5.9 km/s) is very thick, attaining as much as 10 km (Fig. 2). In its eastern parts, however, the thickness of the lower and middle crustal layers increases to 10 km each whereas the thickness of the consolidated crust decreases to 8 km and less. In the some 100–150 km wide SW belt of the TESZ crustal domain, thin Variscan thrust sheets (Variscan consolidated crust — *Vp* 4.0–4.5 km/sec) override the TESZ consolidated crust.

SEISMIC DATA

This paper is essentially based on seismic data that were presented in the fundamental papers quoted in the introduction and on complementary velocity data for sedimentary sequences that were derived from archival sources (Figs. 2–8). Some velocity miss-ties were encountered at the intersections of profiles that were recorded in different years. Such miss-ties are for instance evident along the TTZ-PL profile, for the NW part of which the version of Janik *et al*. (2005) was used, while its SE part is based on the earlier interpretation of Grad *et al*. (1999) that provides a good correlation with the Studzianna borehole. These miss-ties should be eliminated during the forthcoming 3-D modelling study.

This paper pays special attention to the correlation of deep fractures in the crystalline/consolidated crust and shallower faults in the sedimentary crust, and not so much to the correlation between stratigraphic successions and velocity layers since these depend essentially on burial depths. Moreover, the velocities of specific layers can only be compared in areas of horizontal layering. Therefore, the correlation of velocity layers with stratigraphic units is rather rough. Shallow parts of the sedimetary cover are generally well corelated (Figs. 2–8) with velocity layers of <3.0 km/s (Cretaceous), 3–4 km/s (Jurassic), 4–5 km/s (Triassic) and >5.0 km/s (Permian). However, there are exceptions to this rule. For example, the two adjacent C1 and C2 boreholes (Fig. 6) show for the Permian an interval velocity of 4.7 km/s (C1) and velocities of 3.6 km/s for its upper part and 4.7 km/s for its lower part (C2). In this respect, the deeper in the sequence the poorer the correlation between given velocities and stratigraphic intervals becomes. Some cases will be discussed in the following text. For comparison, the base Zechstein is shown in Figures 2 to 8 as it corresponds to the deepest regionally correlative reflection-seismic marker.

The Cenozoic is not included in the profile interpretations owing to its small thickness that usually does not exceed

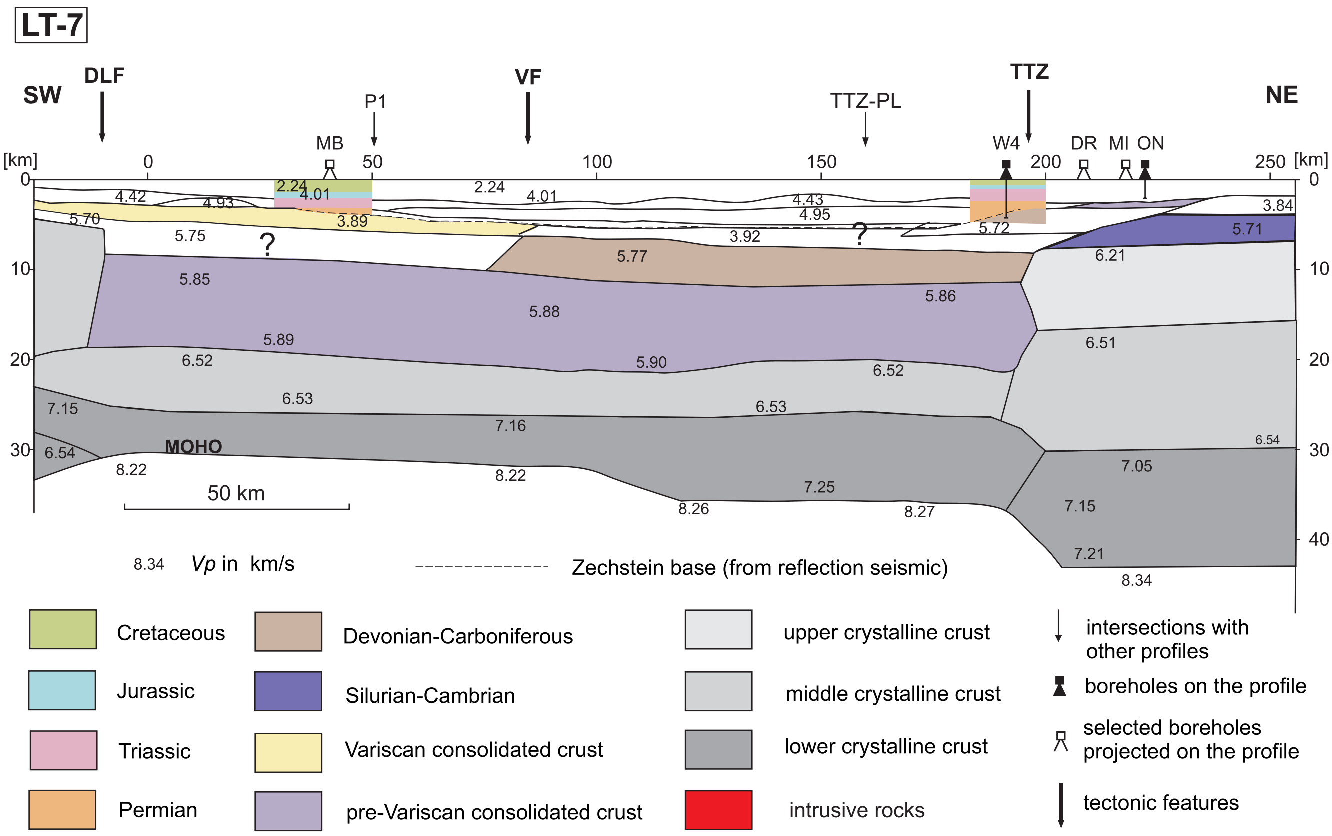

Fig. 2. Geological interpretation of the LT-7 deep seismic sounding profile

Velocity model after Guterch *et al*. (1994, supplemented); for abbreviations of tectonic features see Figure 1; for abbreviations of borehole names see Appendix A

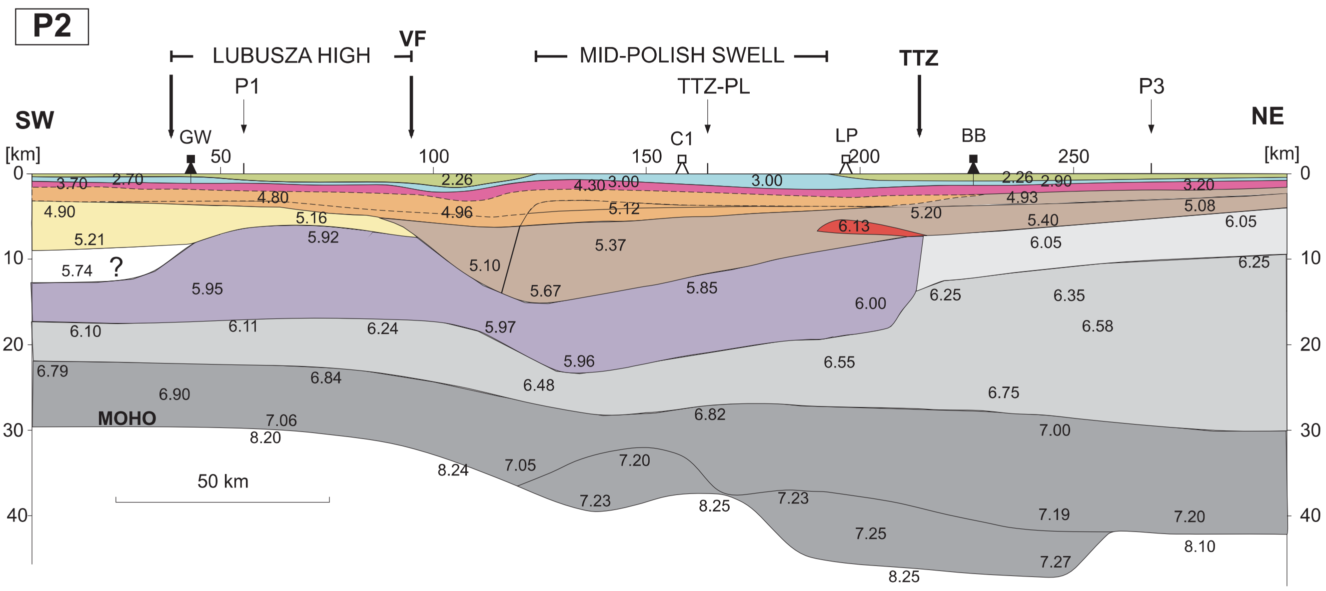

Fig. 3. Geological interpretation of the P2 profile

Velocity model after Janik *et al*. (2002, supplemented); for other abbreviations see Figure 1 and Appendix A

200 metres. Profiles P3 and P5 are not addressed in this paper as they lie entirely on the EEC that has a relatively simple structure. Finally, the area SE of the Grójec Fault Zone (Holy Cross Mountains area) is not considered here because the results of the CELEBRATION program are still preliminary.

POMERANIAN SEGMENT OF THE TTZ

In the Pomeranian segment of the Mid-Polish Trough, the TTZ coincides with a very distinct, vertical boundary (deep fracture) that marks the contact between the crystalline crust of the EEC and the TESZ crust. This is particularly evident on the profile LT-7 (Fig. 2) whilst on the profile P2 (Fig. 3) this boundary is more subdued. The EEC crust stands out as a typical cratonic, Svecofennian three-layered crystalline crust, the upper, middle and lower layers of which are characterized by Vp = 6.00–6.35, 6.55–6.75 and 7.0–7.2 km/s, respectively, and occur at average depths of 6–16, 16–30 and 30–42 km, respectively. By contrast, the three-layered TESZ crust consists of an upper layer (consolidated crust) with Vp = 5.8–5.9 km/s that occurs in the depth range of 11–20 km, a middle layer with Vp = ±6.5 km/s at depths of 20–26 km, and a lower layer with Vp = 6.8–7.2 km/s at depths of 26–36 km.

The deep TTZ crustal fracture that marks the boundary between the EEC and TESZ crust (Figs. 1 and 2) coincides at sedimentary levels with the Koszalin-Chojnice Fault Zone *sensu lato* that has been repeatedly reactivated during the evolution of the Polish Basin. This boundary zone coincides (Fig. 1) with (a) the contact between the undeformed Lower Palaeozoic sediments of the EEC and the Ordovician to Silurian series that were folded during the Caledonian Orogeny (Teller and Korejwo, 1968; Modliński, 1968; Dadlez, 1978; see also Fig. 1 and compare the SP and KC boreholes with ON+KL+LT boreholes in Appendix A), (b) the NE limit of Devonian and Carboniferous platform deposits (Fig. 1 and boreholes from WS to TC in Appendix A), and (c) at Mesozoic levels the Koszalin-Chojnice Zone that played an important role during the deposition of the Permian-Mesozoic sediments and the Late Cretaceous-Paleocene inversion of the Mid-Polish Trough.

Near their present-day northeastern erosional edge, Devonian/Carboniferous strata display considerable thicknesses (e.g. boreholes from WS to MI, Appendix A). Detailed analyses of Late Devonian (Matyja, 1993) and Early Carboniferous facies patterns (Lipiec and Matyja, 1998) show that these series had originally extended far onto the EEC. The present-day boundary of Devonian and Carboniferous series appears to be controlled by a fault or a set of faults along which they are downthrown to the SW, as evidenced by some boreholes that intercepted faults of this system (C5, BA boreholes, Appendix A).

In the Permian and Mesozoic series a distinct fault-controlled zone of thickness changes borders the Koszalin-Chojnice Zone from NE (Fig. 1) that in places is associated with narrow transtensional grabens (Krzywiec, 2000). Boreholes located on opposite sides of this fault zone exemplify contrasting thicknesses of Zechstein and Mesozoic series (compare wells WS to KJ, G2 to BB and TC, and GR to WD, Appendix A). Extremely large Permian and Triassic thicknesses are observed farther to the SW along the axis of the MPT (LP boreholes, Appendix A and C2 to SU, Appendix D). For reconstructed pre-erosional thickness of Jurassic and Lower Cretaceous in this area see also Dadlez (2003). The Koszalin-Chojnice Zone formed the NE boundary of the Mid-Polish Trough.

Each of the three boundaries discussed above is shifted to the NE with respect to the deep crustal fracture (TTZ), namely the Caledonian deformation front by about 30 km, the fault-controlled Devonian-Carboniferous erosional edge by some 20–25 km and the NE margin of the MPT by 10–20 km. Considering the general megatectonic setting of these boundaries, the Caledonian deformation front was of a compressional or transpressional nature, whereas the Devonian-Carboniferous erosional edge and the margin of the Mid-Polish Trough were controlled by extensional to transtensional faults. As the amount of shortening in the thin-skinned Caledonian fold belt of Pomerania is smaller than in the adjacent German-Baltic sector where it is estimated to reach 100 km (Schlüter *et al.*, 1997; Hoffmann and Franke, 1997), it is likely that strike-slip movements played a greater role in its Polish area.

The velocity distribution in the sedimentary cover of the EEC up-dip from the deep crustal fracture is not clear enough. In the case of LT-7 (Fig. 2), it is suggestive of an onlap pattern that is not compatible with the available stratigraphic data. On the P2 profile (Fig. 3), the sedimentary series of the EEC lie parallel and nearly horizontally, representing from top to bottom: Cretaceous (*Vp* = 2.26 km/s), Jurassic (*Vp = 2.9 km/s), Triassic (Vp* = 3.2 km/s) and Permian to Devonian series (*Vp* = 4.9 km/s).

KUIAVIAN SEGMENT OF THE TTZ

On profile P4 (Fig. 4), the geometry of the deep vertical fracture bounding the EEC crust to the SW is very similar to profile LT-7 (Fig. 2). The same applies also for the velocity distribution in the crystalline crust of the EEC. However, there are significant differences between the Pomeranian and Kuiavian segments of the TTZ in terms of the sedimentary cover, despite a much poorer borehole control in the Kuiavian area (Fig. 1) where there is no evidence for the occurrence of the folded Early Palaeozoic strata along the margin of the EEC. Boreholes penetrating Permian strata are located on the craton only and show the gradual thickness increase of Mesozoic series to the SW (ND to KR boreholes, Appendix B). There are also substantial differences in the pre-Permian platform cover in so far as Devonian deposits are missing and Silurian series are directly overlain by Permian strata in the NE part of the profile (as in the NW segment), and closer to the TTZ by Upper Carboniferous sediments (S2 and BD boreholes, Appendix B).

A SW-ward increasing thickness gradient of Permian and Mesozoic series, though not as rapid as in Koszalin-Chojnice Zone, is evident on reflection seismic profiles (Dadlez, 2001), appearing some 20–30 km to the NE of the indicated margin of the EEC (Fig. 1). If this has the same meaning as in the case of Koszalin-Chojnice Zone, then it may define the NE boundary of the MPT.

The SE-most part of the area discussed (Figs. 1 and 7) belongs to the Holy Cross Mts. segment of the MPT, the characteristics of which are beyond the scope of this paper. It should be noted, however, that in this area the presumed course of the TTZ, as well as of the folded Early Palaeozoic sediments (S1 borehole, Appendix B) and fault-bounded Devonian series (S3 borehole, Appendix B), run very close to each other (Fig. 1). With the pinch-out of Permian deposits, the Palaeozoic sedimentary crust consists of Carboniferous to Silurian strata. Earlier Palaeozoic series are not known in this area (ZR to BI boreholes, Appendix B).

SW BOUNDARY OF THE MID-POLISH TROUGH

The identification of the SW boundary of the MPT is essentially based on the NE-ward thickness increase of Permian and Mesozoic series (particularly Bunter and Jurassic; see

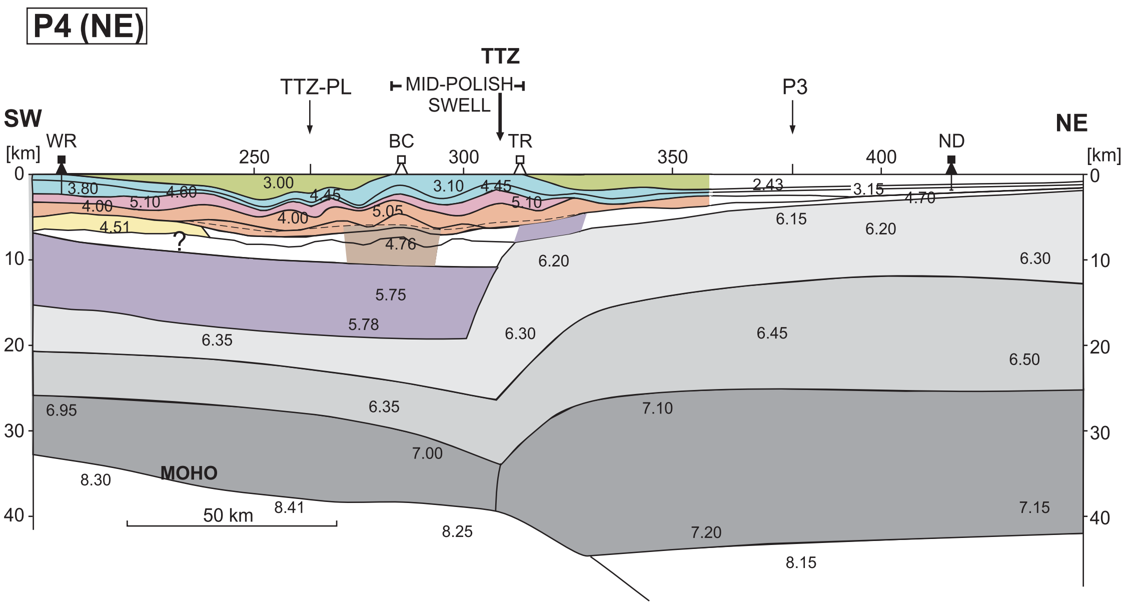

Fig. 4. Geological interpretation of the P4 profile (NE part)

Velocity model after Grad *et al*. (2003, supplemented); for abbreviatis see Figures 1 and 3, and Appendices B and C

Dadlez, 2001, 2003) and is marked by the Grzęzno–Drawno–Człopa and Gopło–Ponętów–Poddębice fault systems (Fig. 1). On the LT-7 profile only the Grzęzno Fault coincides with a step in the Moho depth (at km 100–120), increasing from 31 km in the SW to 36 km below the Mid-Polish Trough, that is associated with a 5 km thickness increase of the lower crust (Fig. 2). On the P4 profile (Figs. 4 and 5) that crosses the Gopło Fault, such a phenomenon is not evident and the Moho deepens gradually NE-ward from 30 km at the Dolsk Fault to 38 km at the TTZ, although its inclination increases near the TTZ. Interestingly, the Moho offsets delimiting the MPT that were recorded in the earlier profiles LT-4 and LT-5 (Guterch *et al*., 1986) are no longer evident in their recent re-interpretation (Grad *et al*., 2005). Moreover, throughout the northern part of profile P4 (Fig. 4) the velocities of undeformed Devonian and Carboniferous series (*cf*. BC borehole, Appendix D) are in the range of *Vp* = 4.5–4.7 km/s, similar to that in its southern part where they are characteristic of consolidated sub-Permian crust, composed here of the deformed Late Carboniferous sediments (*cf*. WR borehole, Appendix C). This fact makes the identification of the Variscan Front impossible. Recently only the higher resolution GRUNDY 2003 reflection/refraction profile (Śliwiński *et al*., 2006) indicates for this interval a rapid velocity increase to *Vp* = 5.25 km/s that is interpreted as being associated with the Variscan deformation front in place indicated in Figure 1.

On the other hand, the P2 profile (Fig. 3) shows some enigmatic and for Poland unique structures in the pre-Permian part of the sedimentary crust, namely a half-graben-like structure between 90–120 km and a large, wedge-type feature between 120–200 km. The graben is filled with rocks having velocities in the range of *Vp* = 4.9–5.1 km/s that extend to depths of 12 km. The wedge-shaped feature is characterized by velocities that increase from *Vp* = 5.12 in its shallower parts to *Vp* = 5.67 km/s in its basal parts that extend to depths of 15 km. Taking these data at face value, it is tempting to explain these features as the remnant of a Variscan foredeep basin that adjoins the margin of a Devonian-Early Carboniferous carbonate-dominated shelf, as indicated by C1 borehole (Appendix D). Whilst the 8 km thickness of rocks filling this potential foredeep may be acceptable, the 12 km thickness of the shelf-wedge is surprisingly large. Beneath the presumed foredeep/shelf contact, the velocities of the middle crystalline crust increase NE-ward from about *Vp* = 6.2 km/s to *Vp* = 6.5 km/s, its base drops down from 22 to 27 km and the Moho depth increases from 30 to 37–39 km. The problem with such an interpretation is that on the northward adjacent profile LT-7 (Fig. 2) neither of the above two structures, nor the changes in the crystalline crust and the Moho depth is evident.

Regarding the shallower parts of the crust, the contact between the shelf and the graben on profile P2 (Fig. 3) coincides with the SW boundary of the Mid-Polish Swell whilst the SW graben margin marks the presumed Variscan deformation front. The latter probably coincides with the SW margin of the main Rotliegend sedimentary basin that extends to the NE (compare thicknesses in ST and MK boreholes, Appendix C with C2 to PI boreholes, Appendix D).

Profiles LT-7 and P2 show that a continuous layer of TESZ-type consolidated crust with *Vp* = 5.8–5.9 km/sec underlies the Mid-Polish Trough and its flanking areas to the SW. South-west of the graben-type feature on profile P2, the top of the consolidated crust is uplifted to a depth of some 6 km, thus forming the Lubusza High, a plateau that is covered by Rotliegend volcanics (*Vp* = 5.16 km/s) and Zechstein (*Vp* = 4.8 km/s), Triassic (*Vp* = 3.7 km/s), Jurassic (*Vp* = 2.7 km/s) and Cretaceous sediments (*Vp* = 2.2 km/s).

DOLSK AND ODRA FAULTS, WOLSZTYN AND LUBUSZA HIGHS

The Dolsk Fault (DLF) forms the SW boundary of the typical TESZ consolidated crust (*Vp* = 5.7–5.9 km/s) to the NE and the crystalline Variscan middle crust with *Vp* = 6.15–6.20 km/s to the SW (Fig. 5). The transition between these two crustal types is marked by a steep slope with the top of the crystalline crust being located on the Wolsztyn High (WH) to the SW of the DLF at a depth of 3 km and to the NE of it as deep as nearly 14 km. On the WH, the boreholes ZB and ZK bottomed in folded Carboniferous and older (?) strata (Appendix C).

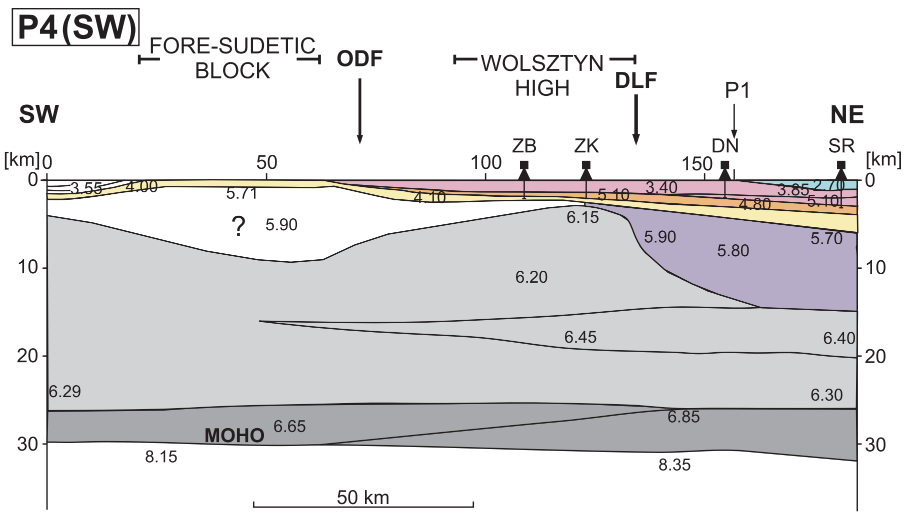

Fig. 5. Geological interpretation of the P4 profile (SW part)

Velocity model after Grad *et al*. (2003, supplemented); for abbreviations see Figure 1 and Appendices B and C

The effect of the Dolsk Fault is clearly expressed in the sedimentary cover at the contact between the Wolsztyn High the and Poznań Graben (PZG; Fig. 1) by the lack of the Rotliegend sediments on the former and their full development in the latter where they attain a thickness exceeding 500 m (compare BJ and K8 boreholes with CW–Ł8, and DW?, DL and SR with SD and WR; Fig. 1, Appendix C).

To the west of the Poznań Graben the effects of the DLF disappear as it runs there within a homogenous plateau that is built-up by Rotliegend volcanics. It is, however, recognized again at the SW end of the LT-7 profile (Fig. 2), beyond the German-Polish border, as a sharp vertical contact between the consolidated TESZ crust (*Vp* = 5.75–5.90 km/s) and the crystalline Variscan middle crust (*Vp* = ±6.2 km/s) that is covered by thin-skinned Variscan thrust sheets (Variscan consolidated crust).

On profile P4 (SW) (Fig. 5), the top of crystalline crust descends on the SW flank of the Wolsztyn High and is overlain by a layer with *Vp* = 5.7–5.9 km/s that is presumably composed of a Variscan nappe stack, the base of which reaches a depth of 9 km below the Fore-Sudetic Block (FSB, Fig. 1) that forms part of the Variscan Internides.

DLF does not form the northern limit of the Variscan external thrust belt that reaches as far as 100 km beyond it (Figs. 1, 4 and 5) in the form of flat-lying thin-skinned thrust sheets (*Vp* = 4.5 km/s) that overly the TESZ crust with *Vp* = 5.7–5.9 km/s (see MB, OJ, WR and MN boreholes, Appendix C). Correspondingly, in this zone two generations of the consolidated crust occur, namely a thin Variscan one overlying a thick Caledonian one.

The Odra Fault (ODF, Fig. 1) is a feature that is known since long and is thought to mark the boundary between the Variscan Externides, forming basement of the Fore-Sudetic Monocline, and Internides (Sudety and the Fore-Sudetic-Block). The ODF is seen only in the sedimentary platform cover that thins to about 500 m on the Fore-Sudetic Block where it is confined to Cenozoic strata, whereas to the NE it thickens and is composed of the Zechstein and Triassic deposits. Surprisingly enough, this fault is not marked in the crystalline crust in which only a lateral transition from a thinner to a thicker middle crystalline crust is recorded.

The ODF and probably also the DLF form together with the Intra-Sudetic and Sudetic boundary faults a part of the Late Variscan Sudetic fault system that has a dextral strike-slip component (Alexandrowski and Mazur, 2002; Mazur *et al*., 2006) and extends into German territories, mainly in the form of the Elbe fault system (Scheck *et al*., 2002).

AXIAL ZONE OF THE MID-POLISH TROUGH

The profile TTZ-PL that was recorded along the axis of the MPT and that was subsequently partly duplicated and extended further to the SE by the CELEBRATION 03, shows significant differences in the crystalline and consolidated crusts between the Pomeranian (0–180 km) and Kuiavian (180–480 km) segments (Figs. 6 and 7).

In the Pomeranian segment (Fig. 6) the crystalline lower (*Vp* = 7.00–7.20 km/s) and middle crust (*Vp* = 6.50–6.60 km/s) are both about 9 km thick with their tops occurring at average depths of 26 and 17 km, respectively. The thickness of the lowermost sedimentary crust (*Vp* = 5.7–5.8 km/s) decreases slightly SE-wards from 13 to 10 km and contains around 150 km a possible intrusive body with *Vp* = 6.38 km/s. Between 160 and 180 km the crystalline crust thins rapidly, mainly at the expense of its lower part, to as little as 12 km, whereas the thickness of the consolidated upper crust increases commensurately to as much as 15 km, whilst the Moho shows only a minor step from 36 to about 38 km. To the SE of this disturbance zone, which obviously marks a major crustal boundary between the Pomeranian and Kuiavian segments of the MPT and is equivalent to the Poznań-Bydgoszcz-Toruń Zone, the thickness of the crystalline crust increases progressively to as much as 25 km while the consolidated upper crust thins to as little as 5 km (Figs. 6 and 7).

In the Kuiavian segment, the tops of the crystalline lower and middle crust gradually rise SE-ward from 35 to 27 km and 25 to 13 km, respectively, while the Moho remains almost flat at a depth of about 38–39 km. Compared with the crust of the Pomeranian segment, significantly lower velocities characterize the lower and middle crystalline crust of the Kuiavian segment (*Vp* = 6.8–6.9 and *Vp* = 6.2–6.3, respectively). TESZ-type upper consolidated crust with *Vp* of 5.95–6.0 km/s underlies the entire axial zone of the MPT. The base of the consolidated crust rises gradually from 19 km in the Pomeranian segment to 13 km in the SE part of the Kuiavian segment. At 220 km, a probably fault-controlled 2 km vertical offset juxtaposes the top of the lowermost sedimentary crust with *Vp* = 5.8 km/s against Late Palaeozoic sediments with *Vp* = 4.8 km/s. This suspected fault is interpreted as the shallow expression of the deep crustal boundary between the Pomeranian and Kuiavian segments that indeed coincides with the boundary between the strongly inverted Pomeranian part of the Mid-Polish Swell and the marginal Mogilno Trough of the Kuiavian segment (Fig. 6).

As profile TTZ-PL follows between 0–230 km the axis of the Pomeranian Swell but between 230–310 km the axis of the Mogilno marginal trough and enters the Kuiavian Swell at 310 km, its shallow sedimentary configuration is subject to major lateral changes (Figs. 6 and 7). On the Pomeranian Swell the youngest members of the sequence have been eroded and the remaining succession (G8 to SU boreholes, Appendix D) consists mainly of the Permian (*Vp* = 4.7 km/s), Triassic (average *Vp* = 3.5 km/s) and incomplete Jurassic series (*Vp* = 2.8–3.2 km/s). In the Mogilno Trough, which is located outside the Mid-Polish Swell but still within the Mid-Polish Trough, a thick Upper Cretaceous succession with *Vp* = 3.2 km/s is preserved above older Mesozoic and Permian deposits. On the Kuiavian Swell, the Jurassic (*Vp* = 3.8 km/s), the Triassic (*Vp* = 4.4–4.7 km/s) and the Zechstein (*Vp* = 5.15 km/s) are the main components of the sedimentary cover (BC and KT boreholes, Appendix D) and their base is more depressed than on the Pomeranian Swell. This change is compatible with the Cenozoic subcrop map that shows a characteristic bend of erosional edges to the west and south of Toruń (Fig. 1). Below the Zechstein occurs a layer with *Vp* = 4.7–4.8 km/s that probably represents Rotliegend, Carboniferous and Devonian sediments. This layer is 1–4 km thick in the Kuiavian segment and attains thicknesses even of 7–8 km (and much increased velocities) in the Pomeranian segment. Thus, it is much thinner in the Kuiavian than in the Pomera-

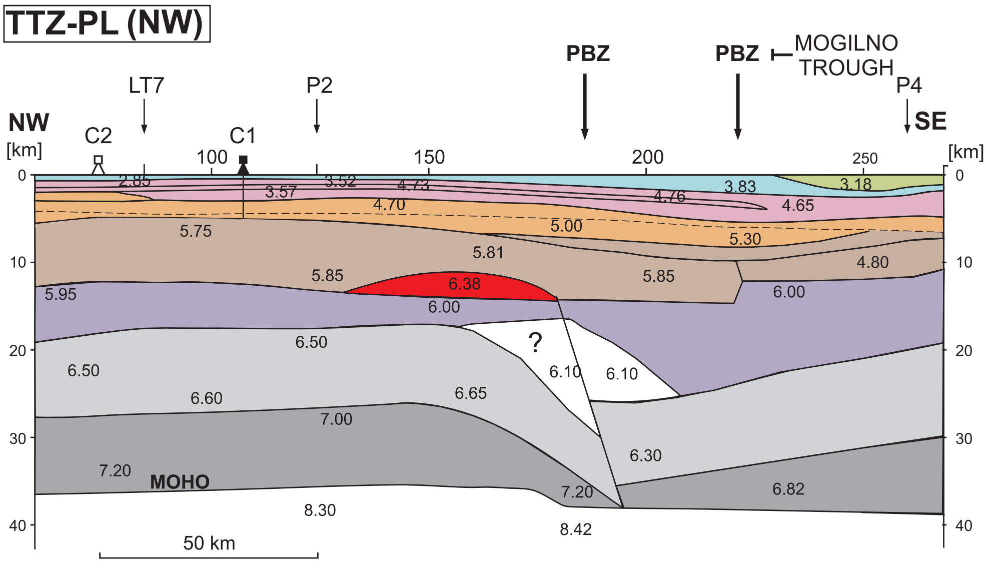

Fig. 6. Geological interpretation of the TTZ-PL profile (NW part)

Velocity model after Grad *et al.* (1999), supplemented; for abbreviations see Figure 1 and Appendix D

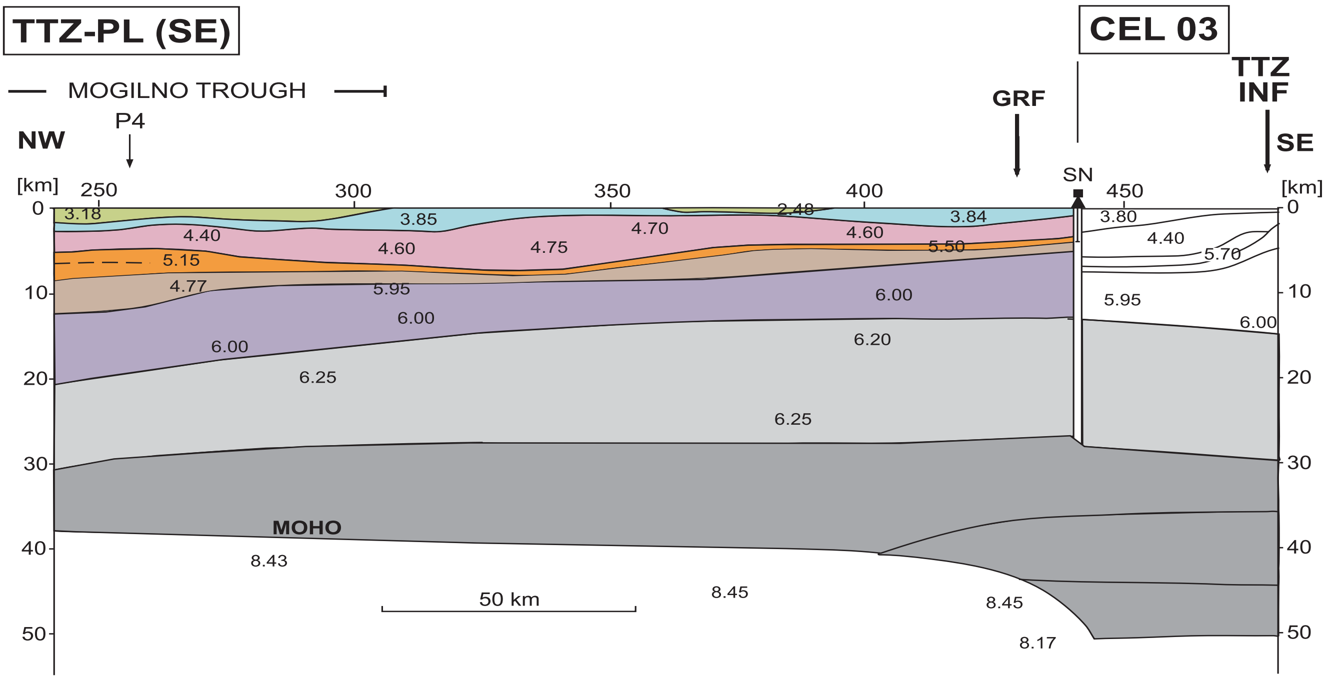

Fig. 7. Geological interpretation of the TTZ-PL profile partly combined with the CEL 03 profile

Velocity model after Grad *et al*. (1999) and Janik *et al*. (2005), supplemented; for abbreviations see Figure 1 and Appendix D

nian part, as is also the Rotliegend that is composed exclusively of sedimentary rocks (BC, BS and SN boreholes, Appendix D).

The boundary between the Pomeranian and Kuiavian segments is also expressed in the configuration of the EEC margin, corresponding to the TTZ, that is offset immediately to the NW of profile P4 by a transverse fault (Młynarski, 2002, see Fig. 1). This fault, combined with the fracture mentioned above in the consolidated crust, defines the course of the tectonic Poznań-Bydgoszcz-Toruń Zone (PBZ in Fig. 1) that separates the Pomeranian and the Kuiavian segments.

The deep-seated Grójec Fault separates the Kuiavian segment from the SE-ward adjacent Holy Cross Mts. segment (Figs. 1 and 7; Janik *et al*., 2005). At sedimentary levels, the Grójec Fault marks the boundary between the depressed Kuiavian segment of the MPT and the intensely inverted and uplifted block of the Holy Cross Mountains and their Mesozoic apron.

FORE-SUDETIC MONOCLINE

On the P1 profile that runs along the SW flank of the Polish Basin (Figs. 1 and 8), major thickness changes of the crystalline crust can be observed between its NW and SE parts

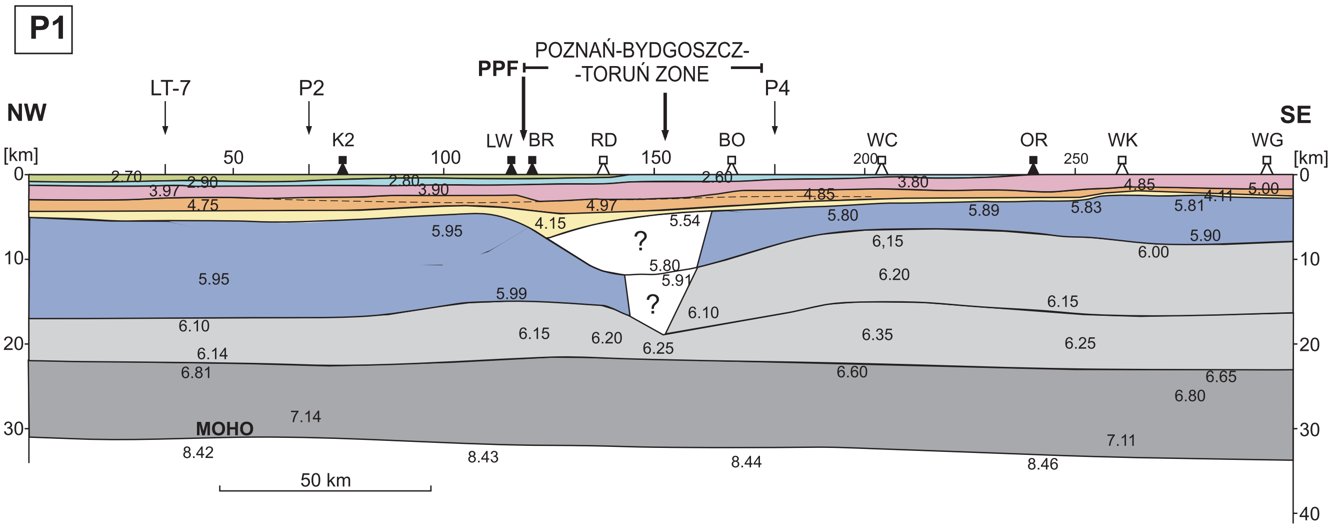

Fig. 8. Geological interpretation of the P1 profile

Velocity model after Jensen *et al*. (2001, supplemented); for abbreviations see Figure 1 and Appendix E

across an apparent discontinuity that occurs around 120–160 km. The Moho, however, forms a gentle monocline that dips from 31 km at the NW end of the profile to 33 km at its SE end. The NW part of profile P1 is characterized by a typical TESZ crust. An up to 12 km thick consolidated crust (Vp = 5.9–6.0 km/s) extends to depths of 15–17 km and probably consists of folded Early Palaeozoic sediments. It overlies a relatively thin crystalline middle (Vp = 6.1–6.2 km/s) and lower crust (Vp = 6.8–7.2 km/s) corresponding to the depth intervals of 17–22 km and 22–31 km, respectively. In the SE part of profile P1 four crustal layers can be distinguished, namely the TESZ-type consolidated upper crust (Vp = 5.8–5.9 km/s) that reaches down to less than 10 km, the crystalline middle crust that extends to depths of 23 km and is characterized by Vp = 6.0–6.2 in its upper part and by Vp = 6.25–6.35 km/s in its lower part, and the lower crust with Vp = 6.6–7.1 km/s that at depths of 32–33 km is underlain by the Moho discontinuity. Thus, the lower crystalline crust has a rather uniform thickness of 8–10 km along the whole profile and occurs at similar depths in both parts of it, whereas the thin (5–6 km) middle crystalline crust in the NW is replaced in the SE by an up to 15 km thick layer with velocities Vp = 6.0–6.35 km/s, and the consolidated crust thins from 12 km in the NE to as little as 5 km in the SE.

In the transition zone between the two crustal types, which is not sharp but rather gradual (Fig. 8), velocities of Vp = 5.4–5.8 km/s reach down to nearly 12 km, probably reflecting the occurrence of a thick pile of stacked thrusts. As the fundamental change in middle crustal thickness on profile P2 at about 150 km (Fig. 8) correlates with a similar change on profile TTZ-PL at about 180 km (Fig. 6), this is taken as marking the trace of the tectonic Poznań-Bydgoszcz-Toruń Zone (PBZ, Fig. 1).

A characteristic layer with Vp = 4.1–4.15 km/s that is overlain by a higher velocity layer (Vp = 4.75–5.0 km/s) occurs along the whole profile in the highest part of the consolidated crust. This layer, which was penetrated by boreholes only in the SE part of the profile, is interpreted as consisting of the deformed Carboniferous rocks. They are involved in Variscan thrust sheets that were erosionally truncated during latest Carboniferous-Early Permian times. This is an expression of the extremely thin-skinned nature of the Variscan Externides (maximum thickness 1.5 km in the NW and about 500 m in the SE of the profile, increasing to 3 km around 125 km). Consequently, the profile runs along a belt where the Caledonian consolidated crust, presumably involving Early Palaeozoic sediments, is overlain by Variscan consolidated crust.

The contrasting basement configuration of the NW and SE parts of profile P2 finds also their expression in the sedimentary cover. In the NW its basal part is composed of lower Rotliegend volcanic and subordinate sedimentary rocks (Vp = 4.75 km/s), representing a separate igneous centre that is not connected with the eruptive centres in Germany (Katzung and Obst, 2004). In Poland, Early Permian volcanics attain thicknesses of more than 1500 m (O2 borehole, Appendix C) decreasing to the east. The sedimentary Rotliegend is here absent or very thin. These beds are overlain by the Zechstein and Triassic (Vp = ~3.9 km/s), and Jurassic (Vp = 2.9 km/s) series. The latter contain significant gaps and thickness reductions in the western part, particularly in the Upper and Middle Jurassic. Cretaceous strata (Vp = 2.7 km/s) are thick in the west and thin eastwards. This thickness reduction is compensated by an increased thickness of the Jurassic (compare stratigraphic logs of the BN to RD boreholes, Appendix E). The Triassic has a relatively constant thickness of 1400–1500 m, whilst the Zechstein thickness decreases eastward from *ca*. 900 to *ca*. 500 m.

Differences in the sedimentary cover of the SE part of the profile, as compared to its NW part (WC to MT boreholes, Appendix E), include the absence of Cretaceous deposits, thicker Triassic (1500–1700 m, Vp = 3.8 km/s) and thinner Zechstein (200–500 m, Vp = 4.85 km/s).

The western margin of the Poznań Graben is marked by the faulted contact (Paproć-Pniewy Fault — PPF, Fig. 1) between the plateau to the west that is devoid of Rotliegend sediments, and the graben to the east that contains thick Rotliegend (compare borehole profiles GS, Appendix C, and LW and P24 with that of BR, RD, BO and P11, Appendix E). This graben is superimposed on the presumably fault-controlled, locally thick Vp = 4.15 interval (125 km) that is thought to contain folded Carboniferous sediments. Thus, the Poznań Graben probably developed by reactivation of an earlier extensional basement structure.

CONCLUSIONS

1. Deep fractures (faults or fault zones) interpreted in the basement of the Polish Basin at the levels of the crystalline and consolidated crust influenced the development of shallower faults in the sedimentary crust, as well as the composition of sedimentary cover on individual crustal blocks. Two systems of these fractures are noted, namely longitudinal W–E to NW–SE trending ones and transversal N–S to NE–SW trending ones.

2. The margin of the EEC, corresponding to the TTZ, appears as a sharp, presumably sheared crustal boundary that extends almost vertically through the entire crust, as evident on profiles LT-7, P2 and P4. Spectacular impact, though intermittent, on the sedimentary crust was exerted by the northwestern segment of the TTZ. Data from its southeastern segment are not fully satisfying.

3. The southwestern boundary of the MPT is visible on the LT-7 profile (thickening of the lower crust) and on the P2 profile as expressed by the rejuvenation of a conjectural Variscan shelf — foredeep couple.

4. The southwestern margin of TESZ-type crust is only seen at the SW ends of profiles LT-7 and P4 where the consolidated crust of the TESZ-type is juxtaposed against a more cratonic looking crust. This boundary corresponds to the Dolsk Fault that was active at the close of the Variscan epoch and, in its central part, during the Permian. The Odra Fault is not recorded in the crystalline crust; it is visible in the sedimentary cover only.

5. The MPT is underlain by a typical TESZ-type crust that is characterized by a variably thick consolidated crust consisting presumably of Caledonian (and older?) deformed sediments that is underlain by a crystalline crust of laterally variable thickness. Major changes in the crustal configuration of the Pomeranian, Kuiavian and Holy Cross Mts. segments of the MPT appear to be controlled by deep- reaching crustal fractures, such as the Poznań-Bydgoszcz-Toruń Zone and Grójec Fault. Whether these faults separated individual terranes or simply delimited individual blocks of one and the same terrane is unknown.

6. The subdivision of the MPT into a Pomeranian and a Kuiavian parts is not fully clear. However, significant changes are noted in the structure of the crystalline crust accompanied by substantial differences in the composition of sedimentary cover. The Grójec Fault marks the southeastern crustal boundary of the most depressed part of the MPT.

7. Further comparative studies on the crustal configuration of the different terranes involved in the TESZ are required to arrive at a defendable conclusion.

The following important questions, which should be elucidated during the expected 3D reprocessing of seismic data, still remain open:

— the differences in a simple picture in the LT-7 profile and a complicated picture in the P2 profile

— the structure in the quadrangle TTZ-PL–P4–P1–P2 profiles with special reference to the location of the tectonic Poznań-Bydgoszcz Zone.

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APPENDIX A

Thickness of stratigraphic units (metres) in boreholes located in northwestern part of the TTZ (LT-7 and P2 profiles)

Borehole (abbreviation)	Creta-ceous	Juras-sic	Trias-sic	Zech-stein	Rotlie-gendes	Carboni-ferous	Devonian	Silurian	Ordo-vician	Cambrian
Słupsk IG 1 (SP)	401	–	502	29	56	–	–	3340	28	560
Kościerzyna IG 1 (KC)	614	249	611	397	2	–	–	2300	31	597
Okunino 1 (ON)	669	166	550	208	–	–	–	137np.f.	–	–
Klosnowo IG 1 (KL)	825	306	668	355	–	–	–	>70np.f.	–	–
Lutom 1 (LT)	916	287	606	425	21	–	–	>546np.f.	–	–
Wyszebórz 1 (WS)	654	353	688	–	32	–	778	–	>324np.f.	–
Kościernica 1 (KN)	694	248	573	–	25	–	1015	–	>35np.f.	–
Kłanino 3 (K3)	571	360	990	159	38	973	624	–	>204np.f.	–
Miastko 1 (MI)	415	286	781	150	15	–	797	–	>9np.f.	–
Drzewiany 1 (DR)	487	304	1021	411	–	493	>275np.	–	–	–
Brda 2 (BA)	569	498	693	74	24	375	76tc.	–	>424np.f.	–
Babilon 1 (BB)	774	309	763	512	2	247	>445np.	–	–	–
Krojanty 1 (KJ)	925	298	757	310	–	–	>545np.	–	–	–
Wierzchowo 4 (W4)	816	662	1557	578	79	661	>333np.	–	–	–
Bielica 2 (B2)	828	638	1332	666	34	–	>362np.	–	–	–
Chojnice 5 (C5)	1056	698	584tr.	292tr.	–	–	1851tc.	–	>352np.f.	–
Tuchola IG 1 (TC)	799	909	923	325	–	–	>1007np.	–	–	–
Lipka 1 (LP)	–	1106e.	1587	833	319	>678np.	–	–	–	–
Grudziądz 2 (G2)	961	632	708	526	–	–	–	>101	–	–
Gronowo 1 (GR)	1314	1255	800	518	–	–	–	>387	–	–
Toruń 1 (TR)	844	1559	1580	261st.	–	–	–	891f.	664np.f.	–
Wałdowo 1 (WD)	585	1501	1201	1531st.	165	155	>153np.	–	–	–

Boreholes (abbreviated names) are located in Figure 1; other abbreviations: np. — not pierced, f. — folded, e. — partly eroded, tr. — tectonic reduction, tc. — tectonic contact, st. — salt tectonics

APPENDIX B

Thickness of stratigraphic units (metres) in boreholes located in southeastern part of the TTZ (P4 profile)

Borehole	Cretaceous	Juras-sic	Trias-sic	Zech-stein	Rotlie-gendes	Carboni-ferous	Devonian	Silurian	Ordovi-cian	Cambrian
Nidzica IG 1 (ND)	666	441	–	–	–	–	–	–	–	150
Szczawno 1 (SC)	1090	919	821	519	–	–	–	813	38	>89np.
Polik IG 1 (PL)	1177	1011	835	524	6	–	–	672	68	>78np.
Sierpc 2 (S2)	1069	1242	1309	386	–	129	–	–	–	>44np.
Bodzanów IG 1 (BD)	1426	1284	1104	421	18	427	–	763	62	>99np.
Karnkowo IG 1 (KR)	1578	924tr.	1017	728	–	–	–	>233np.	–	–
Szwejki IG 1 (S1)	587	1918	597tr	373	–	–	–	>378np.f.	–	–
Szwejki IG 3 (S3)	449	2102	1307	266	–	–	>1275np.	–	–	–
Żyrów 1 (ZR)	1020	653	615	294	–	>332np.	–	–	–	–
Warka IG 1 (WA)	1023	603	462	176	–	312	–	>414np.	–	–
Białobrzegi IG 1 (BI)	966	806	590	–	–	–	>502np.	–	–	–

For abbreviations see Appendix A

APPENDIX C

Thickness of stratigraphic units (metres) in boreholes located in Dolsk Fault area (P4 profile)

Boreholes	Cretaceous	Jurassic	Triassic	Zechstein	Rotliegendes sediments	Rotliegendes volcanics	Carbo-niferous	?Devonian
Myślibórz 1 (MB)	698	412	1407	1014	–	–	>129np.f.	–
Strzelce Kraj. 1 (ST)	751	521	1455	1070	14	>654	–	–
Mężyk 1 (MK)	1010	583	1440	1042	17	>118	–	–
Gnuszyn 1 (GS)	365	609	1532	947	–	>87	–	–
Objezierze IG 1 (OJ)	131	808tr.	2361st.	587st.	216	235	>500 np.f.	–
Ośno IG 2 (O2)	290	227	1481	1004	66	>1553np.	–	–
Boruja 3 (BJ)	29	313	1486	474	–	–	>38np.f.	–
Wielichowo 1 (WL)	–	106e.	1631	419	5	–	>44np.f.	–
Kościan 8 (K8)	–	173e.	1610	406	26	–	>191np.	–
Czarna Wieś 1 (CW)	–	471e.	1586	419	>43np.	–	–	–
Kamieniec 1 (KI)	–	355e.	1691	419	370	22	>28np.f.	–
Łagiewniki 8 (Ł8)	–	250e.	1678	431	418	–	>89np.f.	–
Zbarzewo 1 (ZB)	–	–	1367e.	406	183	30	>53np.f.	–
Donatowo 1 (DN)	–	–	1767e.	490	–	269	>313np.f.	–
Żakowo 1 (ZK)	–	–	1412e.	506	33	–	–	147np.f.
Dolsk 1 (DL)	–	63e.	1789	443	1	31	>157np.f.	–
Śrem 1 (SR)	–	424e.	1735	531	14	–	>281np.f.	–
Środa IG 3 (SD)	–	1038e.	1676	647	>460	–	–	–
Września IG 1 (WR)	92	1129	1811	887	813	50	>1014np.f.	–
Malanów 1 (MN)	1196	997	1814	831	320	–	>56np.f.	–

For abbreviations see Appendix A

APPENDIX D

Thickness of stratigraphic units (metres) in boreholes located in axial zone of the Mid-Polish Trough (TTZ-PL profile)

Borehole	Creta-ceous	Juras-sic	Triassic	Zech-stein	Rotliegendes sediments	Rotliegendes volcanics	Carboni-ferous	Devonian	Silurian
Gorzysław 8 (G8)	–	575e.	1719	367	12	107	381	>1069	–
Ślepce 1 (Sl)	–	768e.	2197	714	382	181	>90np.	–	–
Czaplinek IG 2 (C2)	–	34e.	1900	1320	1284	246	>29np.	–	–
Czaplinek IG 1 (C1)	–	513e.	1910	1471	939	–	>961np.	–	–
Piła IG 1 (PI)	–	938e.	2005	1252	1088	–	>14np.	–	–
Złotów 2 (Z2)	–	573e.	1754	1734st.	>614np.	–	–	–	–
Bydgoszcz IG 1 (BG)	–	1769e.	1668	661st.	540	–	–	778	>43np.f.
Szubin IG 1 (SU)	–	503e.	1557	2169st.	806	–	>31np.	–	–
Byczyna 1 (BC)	236	2177	2034	498st.	481	–	>193np.	–	–
Kutno 1 (KT)	–	2886e.	2502	>509 np.	–	–	–	–	–
Budziszewice IG 1 (BS)	–	1293e	2317	886	490	–	>551np.	–	–
Studzianna IG 2 (SN)	–	955e	2331	578	80	–	>85np.	–	–

For abbreviations see Appendix A

APPENDIX E

Thickness of stratigraphic units (metres) in boreholes located in the Fore-Sudetic Monocline (P1 profile)

Borehole	Creta-ceous	Jurassic	Triassic	Zech-stein	Rotliegendes sediments	Rotliegendes volcanics	Carboni-ferous
Banie 1 (BN)	854	337	1411	982	25	>159np.	–
Buszewo 1 (BU)	653	458	1472	790	17	>21np.	–
Gorzów 2 (GW)	462	401	1413	885	1	>93np.	–
Krobielewko 2 (K2)	560	490	1401	717	2	>41np.	–
Lwówek 1 (LW)	325	479	1390	583	–	>16np.	–
Brody 1 (BR)	288	569	1431	654	>49np.	–	–
Rudniki 1 (RD)	142	619	1463	593	425	>288np.	–
Paproć 11 (P11)	118	389	1440	478	252	>100np.	–
Paproć 24 (P24)	144	368	1417	417	–	406	>190np.f.
Borowo 1 (BO)	–	485e.	1663	529	264	–	>5np.f.
Wycisłowo 1 (WC)	–	27e.	1739	449	6	–	>613np.f.
Orpiszew 1 (OR)	–	120e.	1524	303	57	–	>70np.f.
Wysocko Mł. 1 (WK)	–	–	1302e	275	123	–	>45np.f.
Węglewice 1 (WG)	–	55e.	1646	264	65	–	>23np.f.
Mł. Tyble 1 (MT)	–	95e.	1642	226	–	–	>463np.f.

For abbreviations see Appendix A