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Triassic-Jurassic evolution of the Pomeranian segment of the Mid-Polish Trough — basement tectonics and subsidence patterns (discussion)

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Krzywiec (2006*a*) has proposed a new pattern of deep faults in the pre-Zechstein basement of the Polish Basin controlling the subsidence in the Permian and Mesozoic. The position of these faults is shown in his maps (figs. 5–11). He reproduced these maps in two other simultaneous papers in Polish (Krzywiec, 2006*b*, Krzywiec *et al*., 2006). In the first mentioned paper he paid a good deal of attention (Krzywiec, 2006*a*, p.144–147) to my earlier scientific ideas on the topic. My comments are as follows:

1. One of his key illustrations (Krzywiec, 2006*a*, fig. 4) is of small scale and devoid of seismic data. Thus, discussion of details is difficult. At this scale one cannot precisely check either the thickness gradients in the Mesozoic — an important target of the research — or distinguish regional from local (predominantly salt-induced) changes in thickness. The illustrations in his next paper in the same volume (Krzywiec, 2006*c*) are better in this respect. However, one question emerges. In the text Krzywiec (2006*a*, p. 141) wrote that: "*...In the entire Mid-Polish Trough (MPT) ... there is a virtual lack of reliable seismic information on its structural configuration at sub-Zechstein levels...* ". In spite of this, he puts on the cited figure the sub-Zechstein faults, moreover with their inclination and kinematic arrows suggesting ubiquitous compressional stresses. On what basis?

2. I doubt in the usefulness of the magnetic and gravity anomalies (Krzywiec, 2006*a*, figs. 7 and 8) as evidence for faults only in the Zechstein substratum. The magnetic anomalies are helpful for defining boundaries in the crystalline crust only. Beyond the area of shallow position of crystalline rocks in the Precambrian craton the anomalies are subdued. Gravity Bouguer anomalies are a joint effect of all the structural stages from the crystalline crust to the Cenozoic. Moreover, the supposed faults (e.g. F, G and partly E and D, Krzywiec, 2006*a*, fig. 7) run not along the gravity gradients but along the gravity minima.

3. Figure 5 in Krzywiec (2006*a*) portrays the present configuration of the Zechstein salt base (after inversion). Therefore it should not be used as evidence for Triassic-Jurassic evolution. The faults which modelled the sub-Zechstein relief after the inversion were not necessarily the same as those that earlier modelled the Mesozoic subsidence. Moreover, Krzywiec used a map of the Zechstein base by Papiernik *et al*. (2000). He has not noticed that this map is a smoothed, computer-made version of an earlier map (Dadlez,1998). The advantage of the latter map is that the contours of the Zechstein base are here differentiated into controlled, inferred and conjectural. One result from this map, among others, is that the contours for the area north of Poznań — decisive for the course of fault G — are conjectural (see below).

4. Under these circumstances the most important evidence for the activity of sub-Zechstein faults are the thickness gradients in the Mesozoic portrayed by Krzywiec (2006*a*) in his other key illustration (fig. 9). The isopachs were redrawn here from my paper (Dadlez, 2003) at a smaller scale. Figure 6 by Krzywiec (2006*a*) is reproduced here and compared with some of my earlier proposals (Fig. 1).

5. Faults A and B are a long-known peri-Baltic system of faults (Kamień-Adler Fault and Trzebiatów Fault, respec-

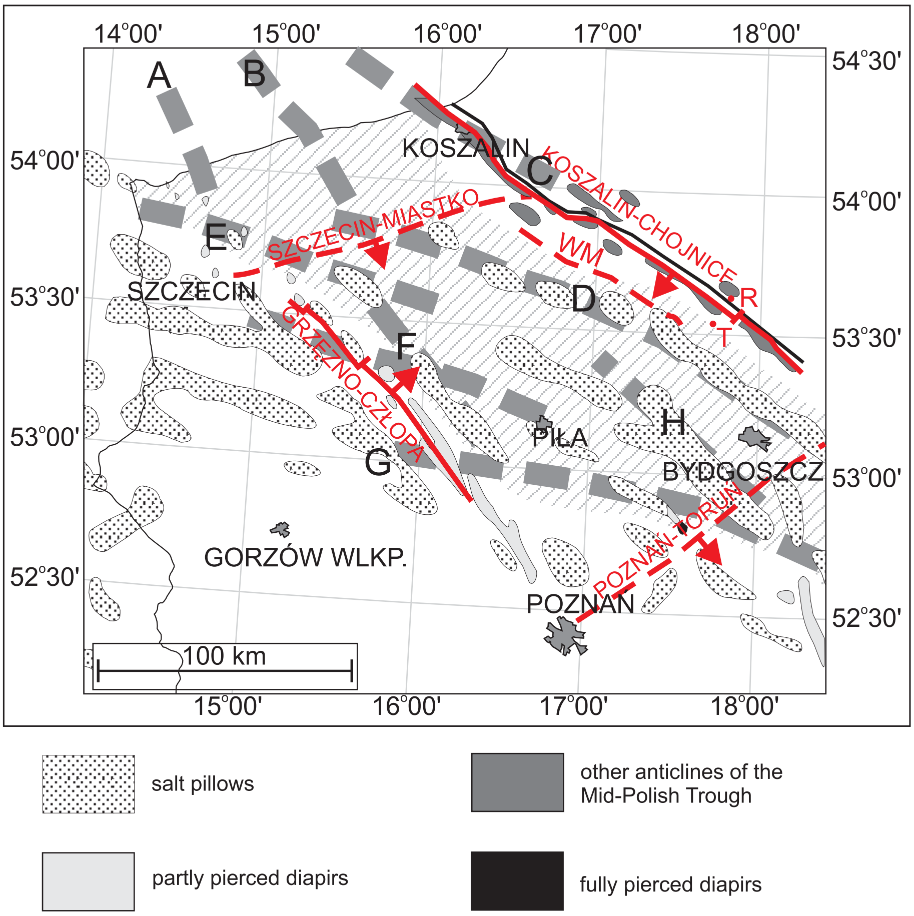

Fig. 1 Comparison of the localities of deep faults after Krzywiec (grey and black) and Dadlez (red)

R — Raciąż borehole, T — Tuchola borehole, WM — Wielimie High

tively), with a NNW–ESE trend. These faults are probably separated from the areas farther to the south by a WSW–ENE trending sub-Zechstein fault which is equivalent to the fault A in Dadlez (1994, fig. 3) or to the Szczecin-Miastko Fault in Dadlez (1997, fig. 122). The faults A and B were first mentioned thirty years ago by Dadlez (1965, 1967) and more precisely characterized later (Dadlez, 1974, 1993). Krzywiec has not taken account of these earlier papers and has not discussed their consequences for sub-Zechstein geology and tectonics despite this being the area of the best records in this respect.

6. Fault C has also long been known (see papers by Dadlez quoted above). It runs precisely along the Koszalin-Chojnice Fault Zone and extends much farther to the SE than shown by Krzywiec on all his figures. In the Mesozoic the southeastern segment of the fault is deduced from e.g. thickness contrasts of Jurassic and Late Cretaceous strata between the Tuchola and Raciąż boreholes (1036 m *versus* 408 m; Fig. 1). Krzywiec (2006*a*) marks fault C as active during pre-Zechstein times in its NW segment only. However, I do not see any reason for assuming that this fault was not active during that time along all its length. The contrasts in sub-Zechstein strata are significant across this fault in its southeastern segment just as in the northwestern segment. The Upper Devonian occurs here SW of it while differentiated Palaeozoic strata lie NE of it.

7. Fault E in the Muschelkalk-Keuper stage is not the boundary of the MPT (Krzywiec, 2006*a*, p. 146) because it is the southern limit of an intrabasinal high. I do not agree with the remark (Krzywiec 2006*a*, p. 146) that the map of this interval "*...was not corrected...*" and "*...could not be used as a basin-scale indicator of subsidence pattern...*". The thickness pattern on the Muschelkalk-Keuper map (Krzywiec, 2006*a*, fig. 9B) is specific. It refers to a time of intensified tectonic activity and — first of all — of the first salt displacements. Consequently, the regional trends should be separated from the local ones. The map presents the post-Keuper situation and the occurrence of intrabasinal highs at that time are real.

8. Fault F runs beneath the SW slope of the MPS. It is an example of a mistake location of fault in figures 9C and 9D by Krzywiec (2006*a*). It should not run along the centre of a strong gradient zone but at its western edge where a strong gradient zone begins (respectively isopach 500 m in 9C and isopach 200 m in 9D). This is the location of the supposed Grzęzno-Człopa Fault Zone (Dadlez, 2005). This zone forms a hinge at which the extensive plateau, 100 km wide, where Jurassic to Lower Cretaceous strata some 500–600 m thick pass northeastwards (over a distance of about 40 km) into thicknesses increasing rapidly to 1800 m below the MPS slope and (reconstructed) to 2400 m below its centre. So, it is not true (Krzywiec, 2006*a*, p. 144) that this is a minor fault which "*...played ... a subordinate role during basin subsidence...*" (for more comprehensive discussion see Dadlez, 2005).

9. Faults D and G are poorly evidenced in their western parts (no thickness gradients) on any map by Krzywiec (2006*a*; fig. 9). In their eastern parts they are not well defined in the Muschelkalk and Keuper. The same concerns fault E in figure 9A and 9D where it runs obliquely and not parallel to the isopachs. Fault G in the Jurassic coincides with the presumed gradients. However, as noted earlier (see item 3), this is an area of the poorest seismic data.

10. Krzywiec wrote (2006*a*, p. 146) that: "*... the map of Upper Jurassic series ... was not analyzed...*" because it is "*...very poorly constrained as inversion-induced erosional truncation and total removal of these deposits is rather widespread ...*". However, this removal was similar to that in the Middle Jurassic (which nevertheless was presented by Krywiec 2006*a*, fig. 9D). Besides, the extrapolation into the eroded areas on Upper Jurassic (and also Lower Cretaceous) maps is not "*...poorly constrained...*" but is very probable be-

cause of data from the slopes of the MPS (see Dadlez, 2003, figs. 6 and 7). I think the reason for omitting these maps should be that there are no strong thickness gradients and no evidence for fault activity during these periods.

11. Krzywiec wrote: (Krzywiec, 2006*a*, p. 146): "*...the regional analysis of the sub-Zechstein fault pattern does not support the concept that the MPT is segmented by a system of SW–NE striking transverse strike-slip faults that were active during the Triassic-Jurassic subsidence as proposed by Dadlez (1994, 1997)...*". In fact, I never wrote about transverse strike-slip faults active during the Triassic-Jurassic subsidence. In the first cited paper I employed the idea of Arthaud and Matte (1977) of a late Variscan system of shears in the forefield of the Variscan orogen and I stated that: "*The ... late Variscan system of conjugate longitudinal (right-lateral) and transversal (left-lateral) strike-slip faults became later a structural frame of the Zechstein basin. The faults ... reactivated in a oblique-slip or dip-slip sense and divided the basin into blocks...*" (Dadlez, 1997, p. 315). They formed then kinds of ramps which are clearly visible on figure 7 in the same paper. Farther I wrote that during the Permian and Mesozoic sedimentation and late Mesozoic inversion the dip-slip deformations were dominant and the strike-slip displacements, if any, were of much lesser scale (hundreds of metres to a few kilometres).

12. Concluding, I accept the idea, suggested by Krzywiec (2002), of the decoupled evolution of the Zechstein-Mesozoic basin caused by Zechstein salts and of the influence exerted by sub-Zechstein faults on this evolution. Differences between us concern the location and course of these faults. I do not see that the proposals of Krzywiec (2006*a*) are better than my earlier versions (see references). In the model by Krzywiec (2006*a*) fault C is too short; fault F is not evidenced at all. Faults E, D, G (particularly their western segments) and fault H are not sufficiently substantiated.

My idea is that the deep faults Koszalin-Chojnice and Grzężno-Człopa are fundamental features of NW–SE trend, being fault-induced boundaries of the northwestern segment of the MPT (Fig. 1). They may be accompanied by subordinate faults modelling the interior of the trough as e.g. the fault of the same trend (Fig. 1) which limits the Wielimie High from the SW (Dadlez, 1983). I maintain the concept of transverse syn-Variscan, stike-slip faults of WSW–ENE or SW–NE trends (these are the Szczecin-Miastko and Poznań-Toruń faults in Dadlez, 1997, fig. 122, shown by Krzywiec 2006*a*, as the faults 1 and 3 in his fig. 10) There are significant differences on both sides of these faults in the thicknesses and tectonics of the Mesozoic. All these faults were reactivated in a dip-slip regime after the late Variscan strike-slip system. Lastly, Krzywiec (p.146) wrote "*...the absence of faulting in the supra-salt cover cannot be regarded as a proof that the evolution ... was not related to ongoing crustal extension (rifting)...*" However, I maintain that the MPT was not a rift in the Mesozoic times since it was not bounded by regional active faults at that time. This does not preclude a rifting origin of its foundation in earlier times, most probably during Rotliegend times.

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