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ON THE POLISH TROUGH

W. POŻARYSKI[1] & W. BROCHWICZ-LEWIŃSKI[1]

ABSTRACT

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The Polish trough represents the main part of a huge synsedimentary structure stretching from the Carpathians to the North Sea, mainly in a zone of weakness at the contact of the East-European Precambrian and Palaeozoic platforms. It was active from the Early Permian to the Early Cretaceous as a graben, and in the Late Cretaceous as a downwarp. A SW corner of the Baltic Shield acted as the threshold responsible for the division of the structure into Danish and Polish parts and limiting the zone of inversion. A connection with the Carpathian geosyncline is traced.

INTRODUCTION

The Polish trough has been of interest to geologists for a long time on account of its great length (almost 800 km), rectilinear course and huge (up to 10,000 km) thickness of Mesozoic and Upper Permian deposits. It stretches throughout Poland, extending to SE beneath the Carpathian Foredeep. Its western limb plunges beneath flysch overthrusts between the Vistula and San rivers, and the eastern limb does so in the vicinity of Stryj in the western Ukraine. Towards the northeast, in Scania and Denmark, it passes into the Danish Embayment of about 500 km long. The total length of this structure, from the Carpathians to the North Sea, is estimated at 1350 km.

The Polish part is best known thanks to exposures, very numerous drillings to the depth of 6000 m, and a dense network of geophysical profiles and especially reflection and refraction seismic profiles and 6 profiles of deep seismic sounding which recorded the Moho surface. The knowledge of the basement of the trough is still fragmentary, in comparison with a fairly complete knowledge of the structure and stratigraphy of deposits infilling the trough. In the Holy Cross Mountains, where the Laramie inversion was especially strong, a full Palaeozoic profile is known and even a large part of Eocambrian. The results of studies (POŻARYSKI, 1957, 1975-a, b, 1977; DADLEZ, 1974, 1976; DADLEZ & MAREK, 1974; MAREK, 1977; ZNOSKO ET AL., 1977) make it possible to reconstruct the morphological form, history and origin of the trough and suggest connections with the system of North Sea troughs (P. A. ZIEGLER, 1975; POŻARYSKI, 1975-a).

BASEMENT OF THE TROUGH

The trough originated in the marginal part of the East European Platform. The course of the margin of the Platform has been widely discussed in the literature and differently interpreted, especially in the case of its section adjoining the Baltic Sea and the NW extension. The line of the margin is most clearly marked in the image of the magnetic field of Poland and the Ukraine (SKORUPA, 1959; KRUTIKOVSKAYA ET AL., 1971; POŻARYSKI, 1973). The Old Platform basement displays a mosaic of fossil magnetic anomalies with amplitudes of 500-1500 γ, usually normal to the margin, whereas the SW

[1] Instytut Geologiczny, Rakowiecka 4, 00-975 WARSZAWA, Poland.

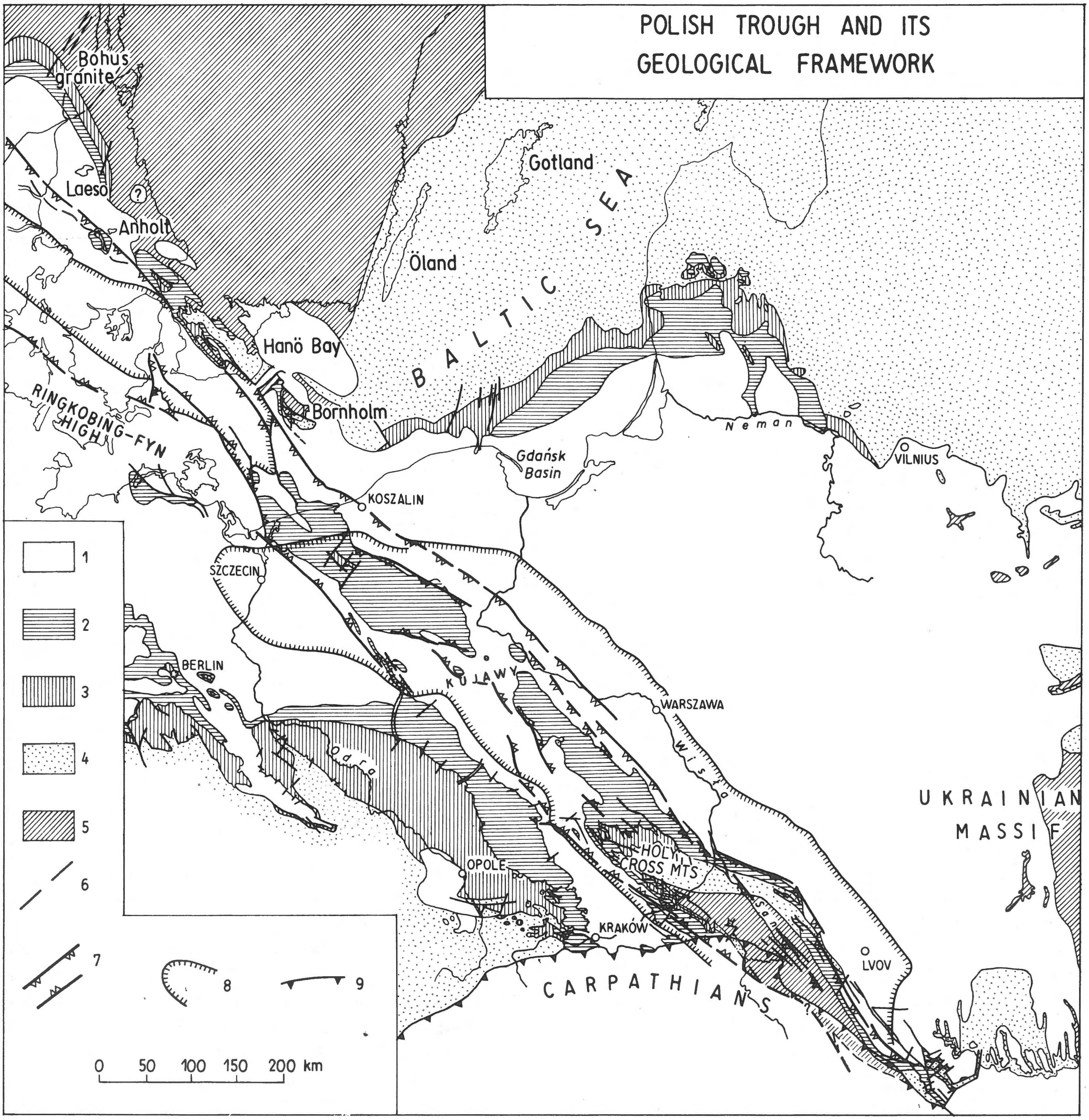

Fig. 1
Polish-Danish aulagocen versus geology of central Europe (map of Cenozoic subcrops drawn from various sources).

1: Cretaceous; 2: Jurassic; 3: Triassic; 4: Palaeozoic; 5: Precambrian; 6: faults; 7: synsedimentary Cimmerian faults and flexures delineating graben; 8: boundary of Late Cretaceous downwarp infilled with Upper Cretaceous deposits 750-2500 m thick; 9: boundary of Carpathian overthrust.

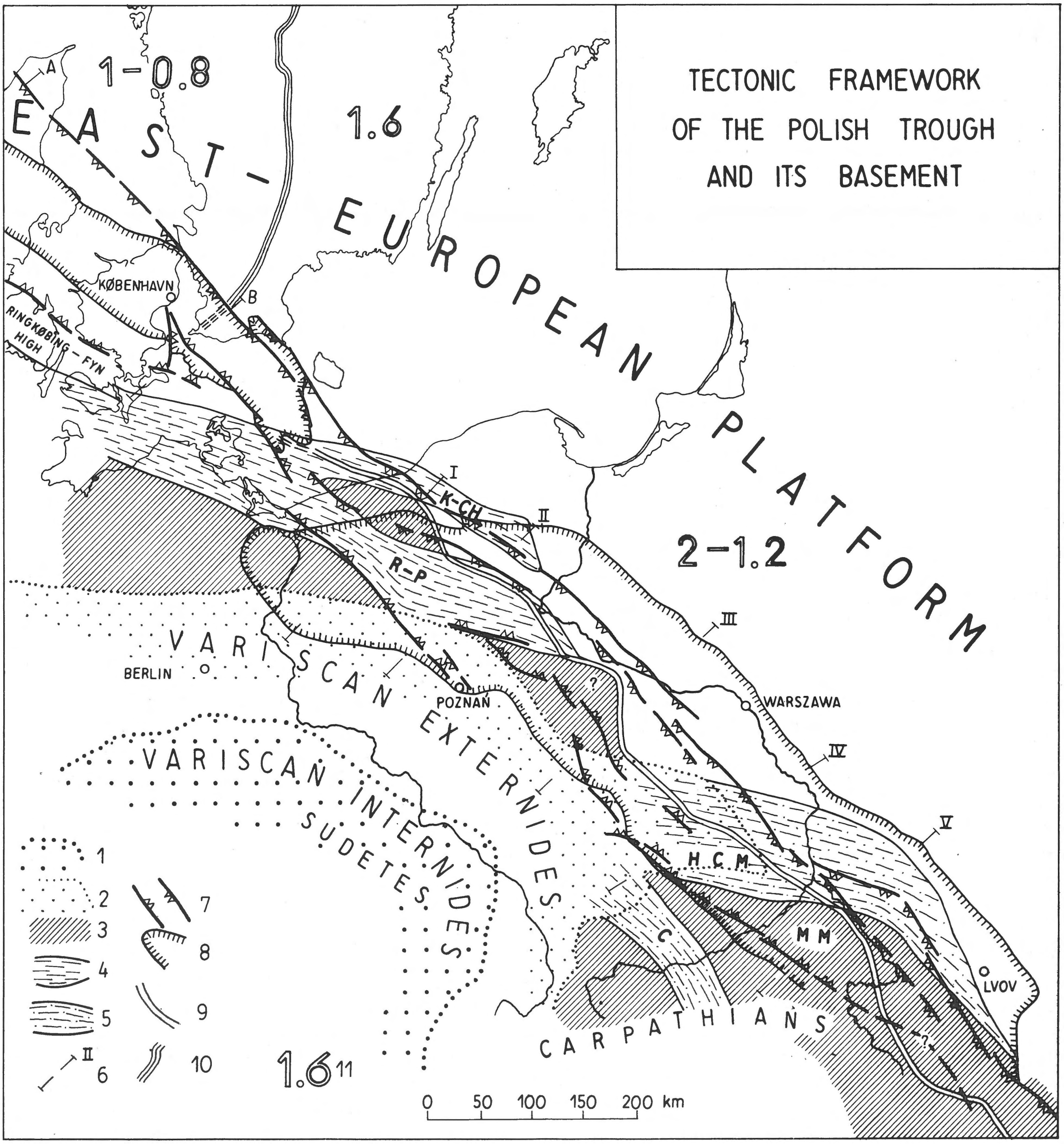

Fig. 2

Tectonic framework of the Polish trough and the basement of the Permo-Mesozoic cover (after Dadlez & Marek, 1974; Klingspor, 1976; Strömberg, 1976; Shakshin, 1977; Pożaryski & Kotański, in press; and other sources).

1: Variscan internides; 2: Variscan externides; 3: older Baikalides (MM: Małopolski massif); 4: Early Palaeozoic aulacogens (K-Ch: Koszalin-Chojnice; R-P: Rügen-Piła); 5: Late Baikalian – Variscan aulacogens (HCM: Holy Cross Mountains; C: Cracow); 6: Palaeotectonic cross-sections (I-V) through Mid-Polish aulacogen, and geological corss-sections (A-B) through the Danish Embayment; 7: synsedimentary Cimmerian faults and flexures delineating pre-Late Cretaceous graben; 8: boundary of Late Cretaceous downwarp infilled with Upper Cretaceous deposits 750-2500 m thick; 9: SW boundary of the basement with Gothian consolidation (2,000-1,200 Ma) determined on the basis of magnetic data; 10: schistosity zone marking eastern boundary of Dalslandian reactivation; 11: age of the end of consolidation (in Ma).

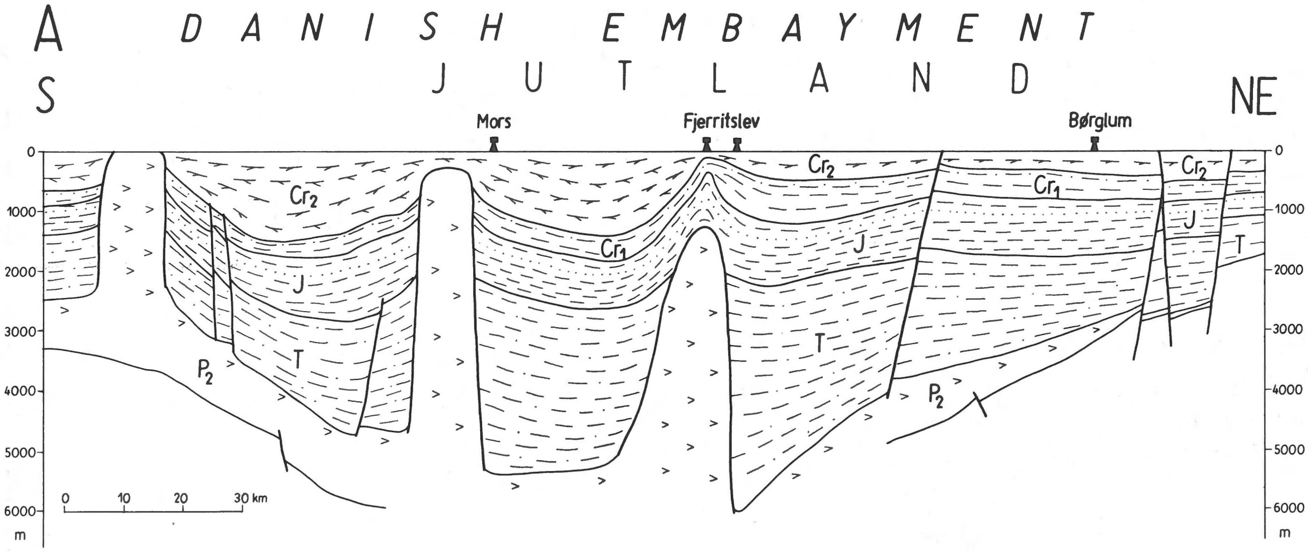

Fig. 3
Hypothetical geological cross-section through the Danish Embayment in Jutland, without Cenozoic formations (after Baartman & Christensen, 1975).

1: Upper Cretaceous marly deposits; 2: Upper Jurassic, Middle Triassic and Zechstein limestones; 3: Lower Cretaceous, Lower Jurassic and Lower Triassic sands and sandstones with siltstone and claystone intercalations; 4: Middle Jurassic, Lower and Upper Triassic claystones with siltstone and sandstone intercalations; 5: Zechstein salts and anhydrites; 6: main boreholes used in constructing the cross-sections. Broken lines: boundaries of strata which underwent Laramie erosion.

foreland of the platform is characterized by anomalies with amplitudes of about 100 γ, parallel to the margin. The mean value of magnetization is markedly smaller on the foreland than on the basement, which results in a strong regional gradient. Dating of the Polish part of the Old Platform basement (DEPCIUCH ET AL., 1975) indicate Karelian consolidation (2000-1600 Ma) and strong Gothian regeneration (1560-1190 Ma). This is an old, epi-Gothian platform which formed the East European subcontinent at the end of the Proterozoic.

The basement of the Young Platform adjoining the former from the south-west, underwent consolidation in the Late Proterozoic (Dalslandian, Grenvillian) or Early Baikalian (Celtic) tectonic epoch (1200-850 Ma and 850-650 Ma, respectively) as shown by POŻARYSKI (1975-a, 1977), KHAIN (1976) and ZNOSKO ET AL. (1977). Metamorphic events of the latter age were shown in Poland (POŻARYSKI & TOMCZYK, 1968). The Baltic and Danish extension of the trough is characterized by different basement. The image of magnetic anomalies (STRÖMBERG, 1976) shows that the boundary between the western and eastern magnetic provinces is no longer sharp. The eastern part of southern Sweden is characterized by strong gradients of magnetic anomalies typical of the epi-Gothian Platform whereas the western part, separated from the former by the schistosity zone, represents an area of Dalslandian activity. This Dalslandian part of the pre-Baikalian East-European Platform presumably also comprises the whole Kattegat, Zealand and middle and northern Jutland. It represents the NW extension of the Polish trough, that is the Danish Embayment.

South of it, in SW Scania and SW of Bornholm, the Polish trough cuts the most south-western part of the Baltic Shield with the Gothian basement. This is the most stable part of the trough, responsible for the division of the whole structure into Danish and Polish parts.

The evolution of the trough was significantly influenced by the southern boundary of this block with Gothian basement which passes close to Rügen and Koszalin on the Polish coast. This was also the northern boundary of the area of subsidence and, partly, orogenic movements in the Baikalian-?Caledonian-Variscan geosyncline. The geosynclinal area stretched SW of the epi-Gothian Platform, plunging beneath the Carpathians and reappeared in North Dobrogea and North Crimea (DEMJANCHUK ET AL., 1977). Caledonian folding is not developed here on a great scale whereas the Baikalian and Variscan folding is fairly strong. The Early Baikalian orogen, dated at 850-650 Ma, is known from southern Poland (POŻARYSKI & TOMCZYK, 1968). The external zone of this orogen is of the miogeosynclinal type and enters the epi-Gothian basement area in the Lower San region. At the end of the Eocambrian, the Malopolski massif originated in this region. The massif was stable throughout the Phanerozoic. The Variscan orogen of the Sudety Mountains originated in central and south-western Poland. Variscide ranges which are latitudinally oriented in western and central Europe turn southwards when they approach the Old Platform.

Palaeozoic deposits occurring in the boundary zone of the platforms between the Carpathians and the Baltic are known

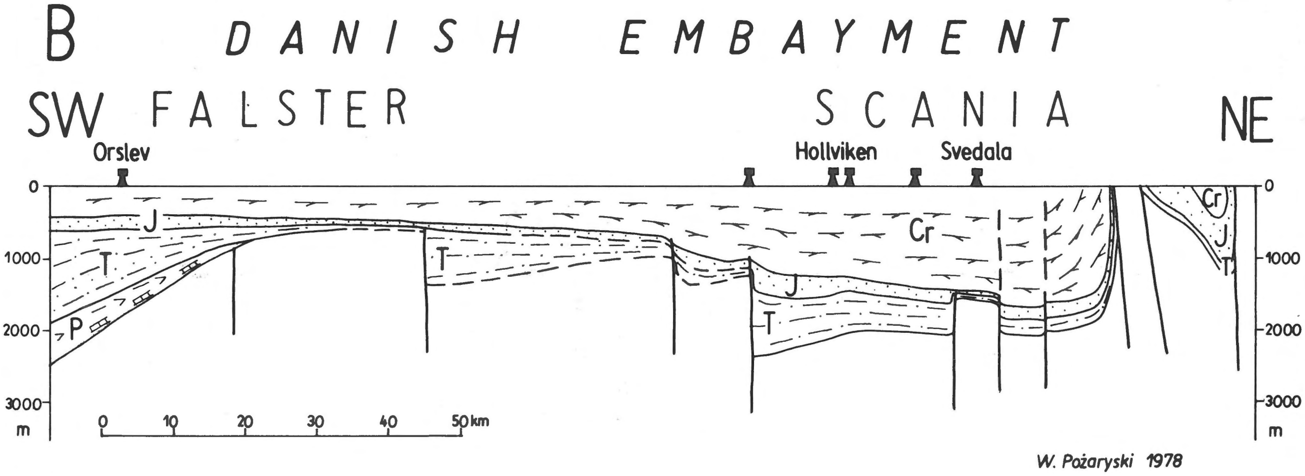

Fig. 4
Geological cross-section through the southern end of the Danish Embayment from Mön to Scania, without Cenozoic formations (after Baartman & Christensen, 1971; Rasmussen, 1971). For legend: see Fig. 3.

from numerous boreholes. It may be stated that they do not form any continuous circum-platform orogenic belt but rather at least two synsedimentary troughs of the aulacogen type and with compressional folding. (POZARYSKI & KOTAŃSKI, in press). The troughs are WNW-ESE oriented, i.e. transverse to the margin of the epi-Gothian Platform (NW-SE). They come from the Palaeozoic geosyncline and deeply incise the Old Platform. In central Poland we have the Holy Cross Mountains aulacogen, and on the north the Kołobrzeg – Koszalin – Chojnice aulacogen with a hypothetical Rügen – Piła branch. They were previously described as the Lublin basin and the Kołobrzeg – Chojnice range respectively (POŻARYSKI, 1977, pp. 178-194 and 200-203). The Holy Cross Mountains aulacogen was active from the Cambrian to the Early Carboniferous, ending with Carboniferous folding. In turn, the latest folded deposits in the Kołobrzeg – Koszalin – Chojnice aulacogen are of Early Silurian age while the Middle and Upper Devonian strata are flat lying. Between the aulacogens, Permian basement is built of almost flat lying Silurian deposits penetrated by several boreholes in the marginal part of the epi-Gothian Platform (CZERMIŃSKI & PAJCHLOWA, 1975). The typical foredeep of the Variscan orogen is missing in Poland (ŻELICHOWSKI, 1972). Upper Carboniferous and Lower Permian deposits ranging from 0 to 1000 m or more in thickness occur in areas separating these aulacogens or cover them (as e.g. in Rügen and near the mouth of Odra river).

TECTONIC EVOLUTION AND SEDIMENTATION

The Polish trough is a rectilinear, two-stage structure. The lower, graben stage is dated as Early Permian – Early Cretaceous and represents graben delineated by synsedimentary flexures and faults with amplitudes generally greater from the side of the Old Platform. These marginal dislocations are usually arranged *en echelon* and figures 1-2 show them in a simplified way. The graben is from less than 80 to 140 km wide. The peaks in activity of the dislocations coincided with periods of clastic sedimentation and the activity was clearly decreasing in times of marine carbonate sedimentation as e.g. in the Middle Triassic and Upper Jurassic.

Graben stage

The Permian basin essentially inherited the form of the molasse post-Variscan basin and represented the most eastern part of the North Sea Basin (ZIEGLER, 1978). The distribution of facies and subsidence zones depended on the basement. The nucleus of the trough originated in the Early Permian in the area between the Palaeozoic aulacogens, that is in the Kujawy. Initially it just entered the area of the Holy Cross Mountains aulacogen and hardly touched the Małopolska Massif on the south (CZERMIŃSKI & PAJCHLOWA, 1975; KUTEK & GŁAZEK, 1972) and connections with the Carpathian geosyncline were weak if they ever existed. The northern, Koszalin – Chojnice aulacogen also acted as a barrier and the trough changed its direction westwards, passing along the northern boundary of the Variscan orogen. The Zechstein sea did not enter deeply into the area of the aulacogen and perhaps not the Ringkobing Fyn High, entering the Danish Embayment from NE.

The Triassic was characterized by increased differentiation in the rate of subsidence, reflected by the formation of tectonic troughs in the North Sea. The Horn graben (active in the Triassic only) and Viking Central Graben are the best examples here (P. A. ZIEGLER, 1975). Deposits originating in the grabens are three times thicker than elsewhere (RASMUSSEN, 1974). The graben originating in Poland broke through the Palaeozoic aulacogens. The zone of maximum thickness of the Lower Triassic (over 900 m, up to about 1390 m in a borehole NE of Poznań) stretched from Kujawy furth-

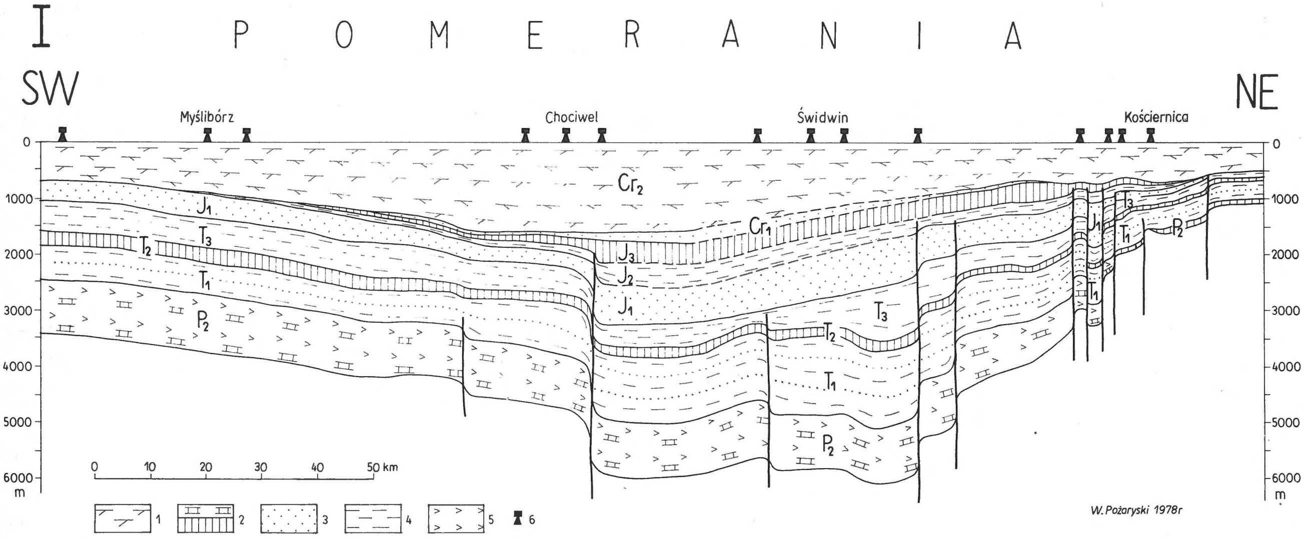

Fig. 5
Palaeotectonic cross-section I through the Polish trough in western Pomerania before the Laramie inversion; halokinesis subtracted (after data from Czermiński & Pajchlowa, 1975; Dadlez, 1976; and other collective works including 'Geology of Poland' vol 4, 1977). For legend: see Fig. 3.

er to the NW to Scania through the Baltic and not westwards, south of Rügen. On the south, the extent of the Triassic is much wider than that of the Permian, indicating a wide connection with the Carpathian geosyncline. The influence of the basement presumably decreased and the connections with the structural framework of the Variscan foredeep disappeared. Moreover, a certain unification of facies occurs in the Early Triassic. Claystones and siltstones which are sometimes marly and with intercalations of marly and oolitic limestones with anhydrite predominate in the more central parts of the basin including the graben area and more sandy facies occur closer to the margins of the basin.

In the Middle Triassic marine carbonate facies predominated, so the graben is markedly less readable on isopach maps except for the Kujawy part. The outline of the trough can again be seen clearly on isopach maps with the return of clastic sedimentation in the Late Triassic and Lias (CZERMIŃSKI & PAJCHLOWA, 1975). The influence of the basement was essentially the same as in the Early Triassic. The subsidence axis commonly passed close to the SW margin of the trough, which is related to a higher mobility of the Young Platform and, therefore, the part of the trough situated SW of the margin of the Gothian basement. In the Malopolski massif the trough was oriented NNW-SSE in the Triassic and Lias. The marginal Wielkopolska High, delineating the trough from the west in Kujawy, was marked in the Lias and Late Triassic which is seen by the thickness of deposits 10 and 4 times lower, respectively, than in the trough (MAREK, 1977). Such marginal highs of the elongated elevation type and with gaps and reduction in thickness of deposits are well known from the North Sea (W. H. ZIEGLER, 1975; P. A. ZIEGLER, 1975). Halokinetic movements began in the Polish trough in the Late Triassic. They were especially intense along dislocations inside the graben where salt domes originated.

The form of the graben and the influence of the basement remained essentially the same in the Middle Jurassic. The axis of sedimentation in the areas of the Palaeozoic aulacogen of the Holy Cross Mountains and the Małopolski massif shifted to the NE with some change in direction. The graben still existed in the Late Jurassic and Early Cretaceous but its margins became somewhat flattened. In the Early Cretaceous the sedimentation was once more limited mainly to the graben.

The division of the trough structure into Polish and Danish parts was marked throughout the graben stage. The above mentioned southern Scania and SW Baltic block, rigid on account of its Gothian basement, acted as the threshold here. New stratigraphic work carried out in these areas showed that this division was not so sharp as had been assumed by SORGENFREI (1963). It appears that during the graben stage (Permian – Early Cretaceous) the sedimentation in this threshold zone was markedly more continuous (see NORLING, 1972; NORLING & SKOGLUND, 1977). Deposits originating here were, however, a few times thinner than in the part of the Danish Embayment adjoining the North Sea not to mention those in Poland.

Downwarp stage

The conditions of subsidence and sedimentation greatly changed at the beginning of the Late Cretaceous. In the North Sea grabens marls and claystones were deposited up to 1200 m (P.A. ZIEGLER, 1975) or even 1700 m (DUNN ET AL., 1973) in thickness and outside the troughs carbonate deposits

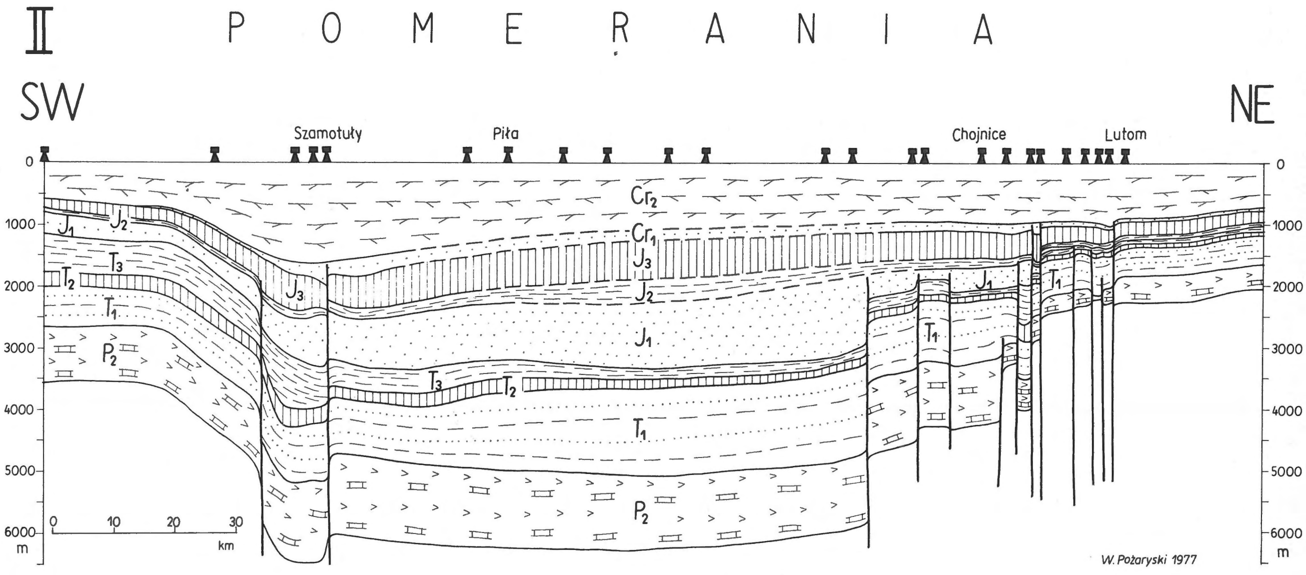

Fig. 6
Palaeotectonic cross-section II through the Polish trough in southern Pomerania before the Laramie inversion; halokinesis subtracted. For sources: see Fig. 4. For legend: see Fig. 3.

almost two times thinner were laid down. At this time in Poland the zone of strong subsidence widened turning into a wide downwarp filled with a thick (over 2000 m thick E of Poznań) series of the Upper Cretaceous. Deposits originating here were marly and marly-siliceous and sometimes with large admixtures of quartz-glauconite sand, whereas in the adjoining areas calcareous-marly deposits of the chalk facies predominated up to 750 m in thickness (when the effect of erosion and gaps in sedimentation is removed). The conditions may be considered as typical of the whole widely interpreted North Sea Basin. In the case of the Mid-Polish aulacogen, the Late Cretaceous downwarp corresponds to the downwarp stage and is not delineated by steep faults or flexures. The latter is also the case for the Central Viking Graben (P.A. ZIEGLER, 1975).

As shown by M. Jaskowiak-Schoeneichowa (in DADLEZ, 1976), the Cretaceous furrow did not reach the northern end of the Polish trough, ending in Pomerania (see also POŻARYSKI ET AL., 1978) and not breaking through the Kolobrzeg – Koszalin – Chojnice aulacogen. North-west of the aulacogen, the Late Cretaceous furrow reappears near Bornholm but it is almost three times narrower there than in Poland and is rather narrower than the Triassic graben. From Bornholm to the Kattegat it is controlled by giant fault zones or flexures and the Upper Cretaceous is up to 1900 m thick.

To the south, the Upper Cretaceous furrow plunges beneath the Carpathian overthrust. Sandy facies predominate in its axis.

The Laramie inversional movement began at the end of the Late Cretaceous. In several places the marginal faults were re-activated by inversional movements oriented in opposite directions. At the same time the area of the Variscan orogen was uplifted, where Cretaceous deposits are preserved usually in patches. Inversional movements were also marked in the whole area influenced by the Caledonian-Variscan orogeny, stretching up to the North Sea and Ringkobing Fyn High to the west and north-west. The Upper Maastrichtian is only preserved in some places as a result of these movements and the whole Lower Palaeocene (Dano-Montian) is missing west of the Mid-Polish Placanticlinorium. East of the axis of inversion several stratigraphic gaps are found in the Maastrichtian; the Danian is completely missing and the Montian is thin (less than 100 m thick, see POŻARYSKI & POŻARYSKA, 1960). In the whole of central and northern Poland, outside the area influenced by the Carpathian geosyncline, Tertiary deposits younger than the Palaeocene are represented by erosional patches or thin brown-coal (Miocene), except for some throughs.

DIASTROPHISM

The influences of Variscan and early Alpine diastrophism finally ceased in the Palaeocene. A new, meridional trend which appeared at that time was related to sea-floor spreading in the North Atlantic. This process took place 81-53 Ma ago (NAIRN & STEHLI, 1974; and others) when meridional tectonic troughs such as Rockall-Hutton, Roscall and West Shetland originated or were rejuvenated. The whole area east of Jutland including Poland was situated outside the extent of these movements and the Tertiary North Sea Basin did not comprise much of Poland.

As far as the nature of the movements is concerned it should be stated that tension predominated in the graben

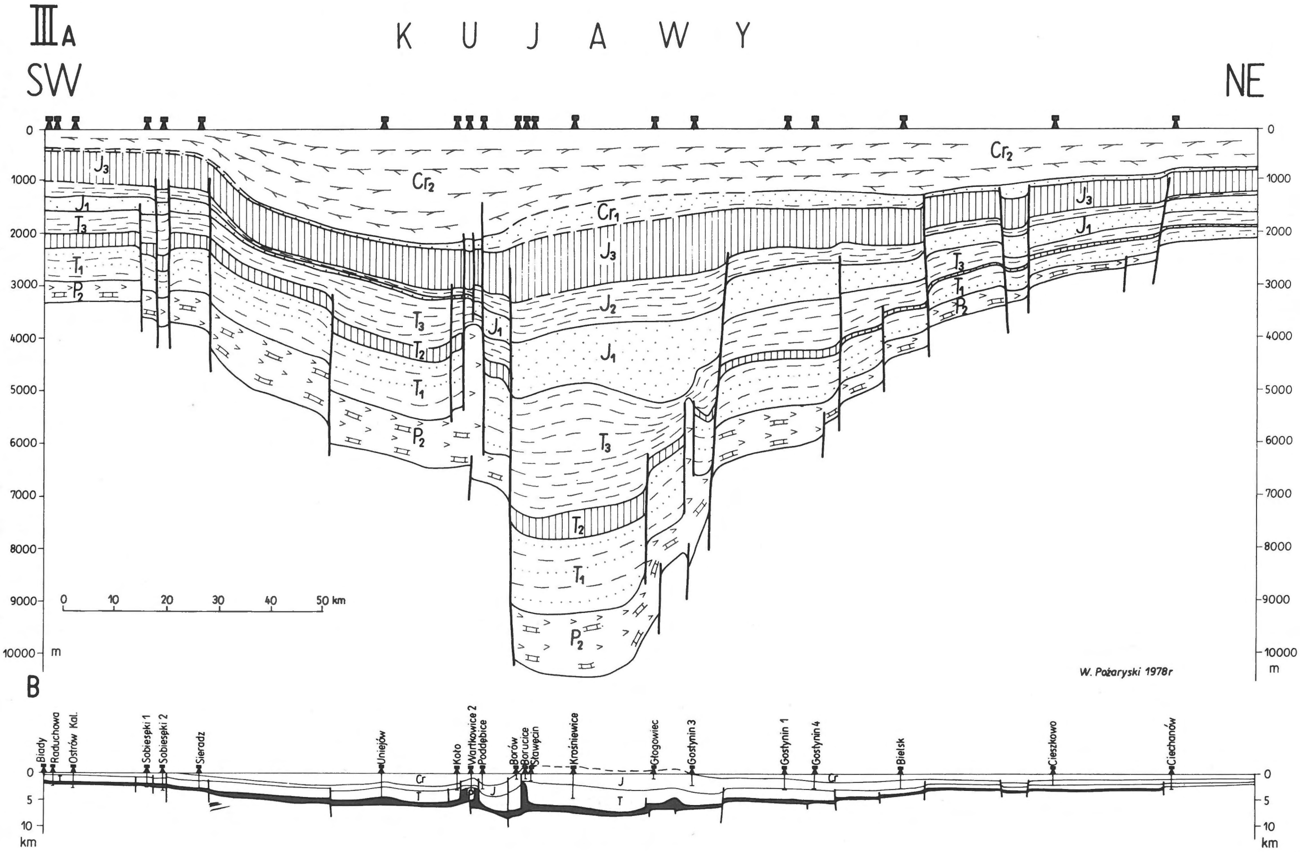

Fig. 7

A: Palaeotectonic cross-section III through the Polish trough in the Kujawy before the Laramie inversion; post-Triassic halokinesis subtracted (based on data from 'Geology of Poland' vol. 4, 1977; and Marek, 1977). For legend: see Fig. 3.

B: Same section as in Fig. 6, but without vertical exaggeration and showing present-day structure of the aulacogen in the Kujawy region. Black: Zechstein. For sources: see Fig. 7A.

stage and the beginning of the downwarp stage, and compression in the inversion stage. P.A. ZIEGLER (1975) showed connections between these phenomena from the North Sea and movements taking place in the Tethys (TRÜMPY, 1960; TOLLMANN, 1966). Inversional structures originating in the North Sea were characterized by reversed faults. Overturned flexures and reversed faults passing into small-scale overthrusts are omnipresent here (BOIGK, 1968; POŻARYSKI, 1948), indicating horizontal translocations (W. H. ZIEGLER, 1975). The evidence for such translocations is fairly good in Poland (POŻARYSKI, 1948, 1977) and the Ukraine (SHAKSHYN, 1977). Two components of horizontal movements should be differentiated in the Polish trough. One is connected with compression of the trough and oriented from NE and SW towards its axis. These stresses usually gave rise to some folding of the sedimentary cover shown on the Tectonic Map of Poland (POŻARYSKI, 1977). In the surroundings of the Holy Cross Mountains the folds are connected with faults and represent the result of compression of the basement (STUPNICKA, 1971). In the Kujawy and Pomerania areas with thick series of Zechstein rock salt, the Mesozoic cover was disharmonically folded, undergoing decollement from the Palaeozoic basement along salt layers. The folding and resulting formation of salt domes took place in the Late Cretaceous as recently shown by MAREK (1977). The movements were most intense at the turn of the Cretaceous and Tertiary. Compression, although not favourable for the formation of faults, gave rise to salt domes in some places only. The second component of horizontal movements was parallel to the axis of the trough, resulting in a shift of the whole western block to the NW and NNW along the trough. In the Pomeranian region on the north, this movement was impeded by a rigid Baltic Shield and an overthrust is recorded on the Koszalin – Chojnice line, west of the Lower Vistula river. The overthrust entered the Baltic Sea. The movement came from the Carpathian geosyncline where the Inner Carpathians were thrust over the foreland to the north.

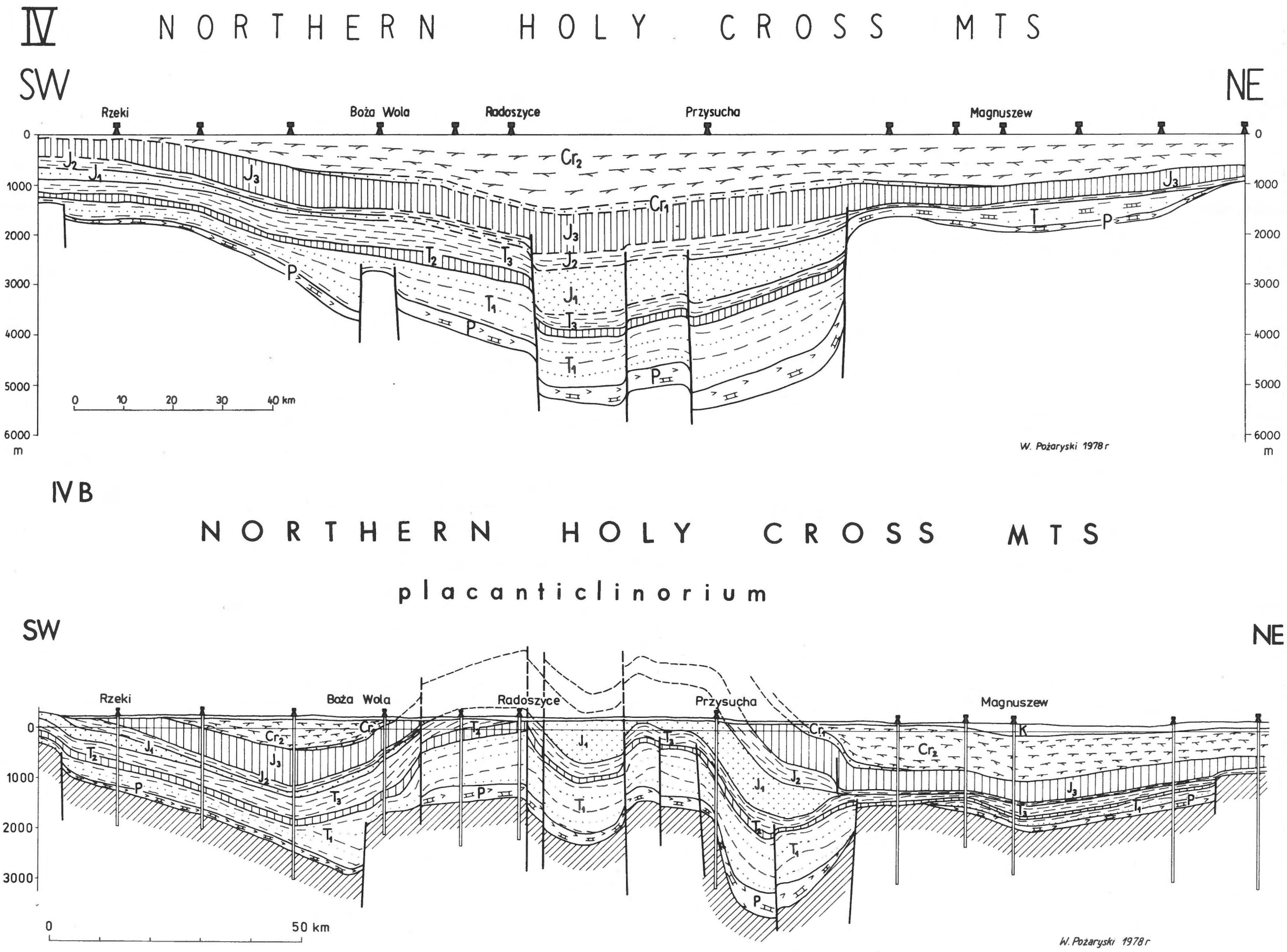

Fig. 8

A: Palaeotectonic cross-section IV through the Polish trough along the northern slopes of the Holy Cross Mountains before the Laramie inversion (based on seismic and borehole data, mainly from: 'Geology of Poland' vol. 4, 1974, 1977; Guidebook of 48th Meeting of the Polish Geol.. Soc., 1976; and Kutek & Głazek, 1972). For legend: see Fig. 3.

B: Cross-section IV-IV through the northern slope of the Holy Cross Mountains after the Laramie inversion (strata subsequently eroded are marked with a broken line). O-line corresponds to mean sea-level; K: Cenozoic. For other symbols: see Fig. 3.

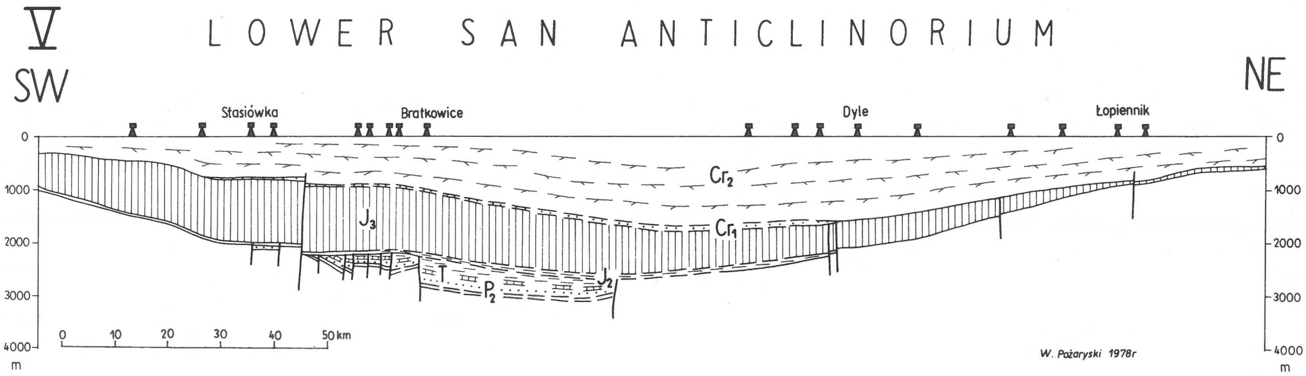

Fig. 9

Palaeotectonic cross-section V through the Polish trough, south of the Holy Cross Mountains in the Lower San River anticlinorium area, before the Laramie inversion (based on data from Moryc & Waśniewska, 1965; Głowacki & Senkowiczowa, 1969; Moryc, 1971; Konarski, 1974; Niemczycka, 1976; Geroch et al., 1972; and others). For legend: see Fig. 3.

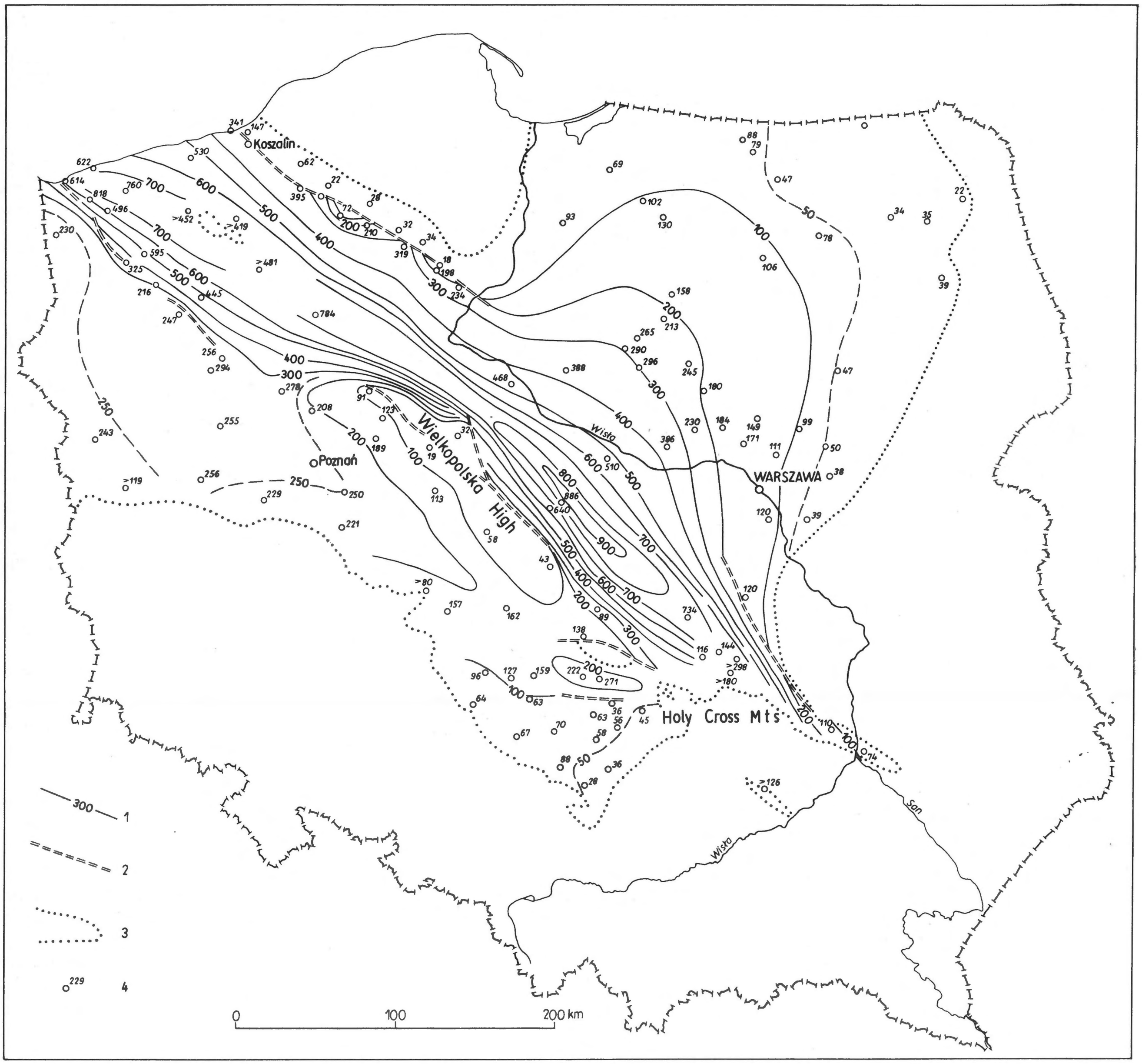

Fig. 10
Isopach map of Hettangian, Sinemurian and Pliensbachian (Lower Jurassic) deposits in extra-Carpathian Poland (after Dadlez in Czermiński & Pajchlowa, 1975, Pt. II, table 4).

1: isopachs in 100 m intervals (in 50 m intervals where broken); 2: synsedimentary faults and flexures; 3: extent of Hettangian, Sinemurian and Pliensbachian; 4: boreholes penetrating Lower Jurrassic (Numbers represent thickness in m).

CONNECTIONS BETWEEN THE POLISH TROUGH AND CARPATHIAN GEOSYNCLINE

The south-western limb and axial part of the aulacogen plunge beneath the overthrusts of flysch nappes of the Carpathians between the Vistula and San rivers. Some boreholes and geophysical data (KONARSKI, 1974) show that they retain a NW-SE direction beneath the flysch cover. The north-eastern limb of the aulacogen passes in the basement of molasse infilling the Miocene foredeep in Poland into the western Ukraine where it plunges beneath the Carpathians south of Lvov (SHAKSHYN, 1977). The studies on the Jurassic and Cretaceous, carried out by the Ukrainian geologists, confirmed a marked increase in their thickness in the aulacogen with relation to the foreland.

Up to the present there is no evidence for the nature of

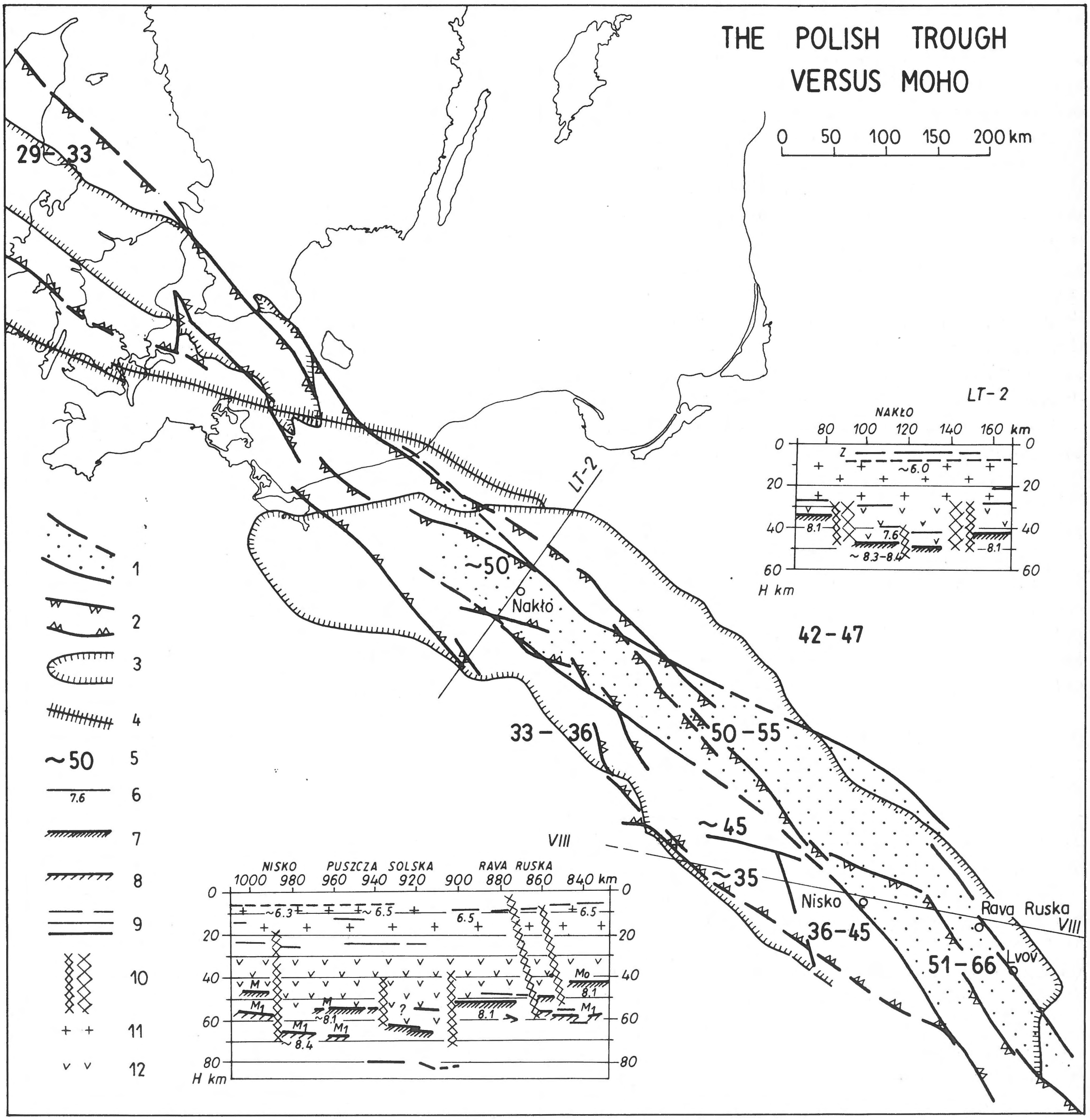

Fig. 11
The Polish-Danish trough versus depth of occurrence of the Moho surface (after Guterch et al., 1975; Guterch, 1977; Caston & Hirschleber, 1971).

1: zone of anomalously thick Earth's crust (50-60 km thick or more); 2: synsedimentary Cimmerian faults and flexures delineating graben; 3: boundary of Late Cretaceous downwarp infilled with Upper Cretaceous deposits 750-2500 m thick; 4: northern boundary of the Baikalian-Variscan geosyncline; 5: depth of the Moho in km; 6: boundary velocity in km/s; 7: Moho boundary; 8: M_1 boundary; 9: other discontinuities in the crust and upper mantle; 10: deep fractures; 11: upper part of the crust; 12: lower part of the crust.

contact of the aulacogen and flysch exogeosyncline as deposits of the latter are thrust far on to the foreland. GABINET ET AL., (1976) described a thick series of conglomerates at the extension of the aulacogen margin in the geosynclinal area. The latest Cretaceous – Early Palaeocene age of these deposits seems to show a Laramie inversion in this area.

POLISH TROUGH VERSUS MOHO SURFACE

The deep seismic soundings showed that the Old epi-Gothian Platform is characterized by a more uniform and greater depth of occurrence of Moho surface than in the case of the Young Platform from the south-west (42-47 km and 30-35 km, respectively). A zone of anomalously large depths of occurrence of Moho surface, 50-60 km or more, was discovered at the boundary of these platforms about 10 years ago by GUTERCH (1968, 1977). This zone, 65 to 100 km wide, is separated from both platforms by deep crustal fractures. Its course agrees well with a markedly wider area corresponding to the Mid-Polish aulacogen from the syneclize stage but their axes do not coincide. In some places, as e.g. in south-eastern Poland, the trough in the Moho almost completely diverges from the Triassic-Jurassic graben. The zone of anomalously large depths of Moho is also not consistent with the placanticlinorium area. It should be stated, therefore, that the suprastructural trough has no direct equivalent in the infrastructure, i.e. in Moho, but the two phenomena are presumably genetically related.

A more detailed analysis of interrelationships between infra- and suprastructural tectonic elements occurring at the contact of the two platforms, carried out by POŻARYSKI (1976), showed that the zone of anomalous depths of the Moho coincides with the Carboniferous trough differentiated in SW Poland by ZELICHOWSKI (1972) and by CHIŻNIAKOW & ŻELICHOWSKI (1974). The origin of the former is related to disjunctive diastrophism from the end of the Variscan epoch and is confined to the close foreland of the area effected by the Late Variscan orogeny. This is further supported by the coincidence of the NE boundaries of the trough in the Moho and the Carboniferous cover or, at least as in the case of the areas SE of Warsaw, the thick Carboniferous cover. In turn in the Danish Embayment, where the Devonian and Carboniferous are missing, the zone of anomalous depths of the Moho may not occur. Preliminary point soundings show that the Moho surface occurs there at depths ranging from 29 to 32 km (CASTON & HIRSCHLEBER, 1971; see also BALLING, 1976, p. 240). There are also other data indicating convergence of fault-type structures in the Moho and evidently Late Variscan tectonic elements marked in the suprastructure. The Dolsko fault marked in the Moho and consistent in location and orientation with directions of Variscan fractures (GUTERCH ET AL., 1975; POŻARYSKI, 1976) and the fault in the Moho found north of Kielce and consistent with the Holy Cross Mountains deep fracture (GUTERCH, 1977) are the best examples here.

From this it follows that the Polish-Danish trough as a whole does not represent the suprastructural equivalent of an infrastructural form connected with the zone of anomalous thickness of the Earth's crust which originated at the end of the Variscan tectonic epoch. The location of these structures is the same because of the influence of the margin of the Old East-European subcontinent on the tectonic phenomena developing on its contact with the Young Platform. A final compression connected with igneous activity of the Palaeozoic geosynclinal cycle had a decisive influence on the increase in thickness of the crust here. A weak tension marked throughout the western forefield of the Old Platform initiated the formation of the Danish-Polish-Ukrainian aulacogen.

REFERENCES

Baartman, J. C. & O. B. Christensen 1975 Contributions to the interpretation of the Fennoscandian Border Zone – Dansk geol. Unders. (II Raekke) 102: 47 pp.

Balling, N. P. 1976 Geothermal models of the crust and uppermost mantle of the Fennoscandian Shield in South Norway and the Danish Embayment – J. Geophys. 42: 237-256.

Boigk, H. 1968 Gedenke zur Entwicklung des niedersächsischen Tektogens – Geol. Jb. 85: 861-900.

Caston, U. & H. Hirschleber 1971 Seismic measurements in Jutland, 1969 – Z. Geophys. 37: 47-69.

Chiżniakow, A. W. & A. M. Żelichowski 1974 Outline of the tectonics of the Lublin-Lvov area, SW Poland and Ukraine – Kwart. Geol. 18: 707-719.

Czermiński, J. & M. Pajchlowa (eds.) 1975 Lithological-paleogeographic atlas of platform part of Poland, 1:2 000 000 – Wydawnictwa Geologiczne (Warsaw).

Dadlez, R. 1974 Types of local tectonic structures in the Zechstein-Mesozoic complex in North-western Poland – Biul. Inst. Geol. Warsaw 274: 149-177.

—— (ed.) 1976 Permian and Mesozoic of the Pomerania Trough (in Polish, with English summ.) – Prace Inst. Geol. 79: 1-173.

Dadlez, R. & S. Marek 1974 General outline of the tectonics of the Zechstein-Mesozoic complex in Central and North-western Poland – Biul. Inst. Geol. Warsaw 274: 111-148.

Depciuch, T., J. Lis & H. Sylwestrzak 1975 K-Ar age of the rocks of the crystalline basement of North-East Poland – Kwart. Geol. 19: 759-779.

Demjanchuk, V. G., A. T. Bogaets, G. V. Bojchuk, V. F. Indutnyj, V. P. Klochko, G. N. Ladyzhenskij, P. K. Markov & R. V. Palinskij 1977 First evidence for the age of the folded basement rocks in the north-western part of the Black Sea – Dopovidy Akad. Nauk Ukrainskoj SSR, Ser. B 12: 1071-1073.

Dunn, W. W., S. Eha & A. H. Heikkila 1973 North Sea is a tough theater for the oil-hungry industry to explore – Oil Gas J. 8.

Gabinet, M. P., J. O. Kulczickij & O. I. Matkovskij 1976 Geology and mineral resources of Ukrainian Carpathians, Pt. I, Stratigraphic and lithological-geochemical sketch – Izd. Vyzsha szkola (Lvov): 200 pp.

Geroch, S., A. Jednorowska & W. Moryc 1972 The Lower Cretaceous sediments in the southern part of the Carpathian Foreland – Rocz. Pol. Tow. Geol. 42: 409-421.

Glowacki, E. & H. Senkowiczowa 1969 Remarks on the development of Triassic deposits in SE Poland – Kwart. Geol. 13: 338-356.

Guidebook of 48th Meeting of the Polish Geological Society (Starachowice, 24-26 wrzesnia 1976) – Wydawnictwa Geologiczne (Warsaw): 268 pp.

Guterch, A. 1968 Geophysical characteristics of deep structure of the Earth Crust in Poland – Bull. Acad. Polon. Sci., Sèr. Sci. géol. géogr. 16: 147-152.

—— 1977 Structure and physical properties of the Earth's crust in Poland in the light of new data of DSS – Publ. Inst. Geophys. Pol. Acad. Sci. A-4 115: 347-357.

Guterch, A., R. Materzok, J. Pajchel & E. Perchuć 1975 Seismic structure of the Earth crust along VII international profiles of deep seismics soundings – Przeglad geol. 23 (4).

Hoffman, P., J. F. Dewey & K. Burke 1974 Aulacogens and their genetic relation to geosynclines, with a Proterozoic example from Great Slave Lake, Canada – Soc. Econ. Paleont. Mineral. Special Publ. 19: 38-55.

Khain, V. E. 1976 The new international tectonic map of Europe and some problems of structure and tectonic history of the continent. In: D. V. Ager & M. Brooks (eds.): Europe from crust to core – Wiley. (London): 19-40.

Klingspor, I. 1976 Radiometric age-determination of basalts, dolerites and related syenite in Skåne, southern Sweden – Geol. Fören. Stockholm Förh. 98 (566): 195-216.

Konarski, E. 1974 Oxfordian and Kimmeridgian in the foreland of the Polish Carpathians – Kwart. geol. 18: 116-131.

Krutikovskaya, Z. A., O. M. Rusakov, I. K. Pashkevich & K. Posgay 1971 The magnetic field of the Carpathian region and some problems of its geological interpretation – Acta Geol. Acad. Sc. Hungaricae 15: 377-382 (Bull. IXth Congress Carpatho-Balcan Geol. Ass. III, Budapest).

Kutek, J. & J. Głazek 1972 The Holy Cross area, Central Poland, in the Alpine cycle – Acta geol. pol. 22: 603-653.

Marek, S. (ed.) 1977 Geological structure of the eastern part of the Mogilno-Lódź trough (Gopło-Ponetów-Pabianice Zone) – Prace Inst. Geol. 80: 1-165.

Moryc, W. 1971 The Triassic of the foreland of Central Carpathians – Rocz. Pol. Tow. Geol. 41: 419-486.

Moryc, W. & J. Waśniewska 1965 Neocomian deposits at Basznia near Lubaczów, SE Poland – Rocz. Pol. Tow. Geol. 35: 55-70.

Nairn, A. E. & F. G. Stehli 1974 A model for the North Atlantic. In: The ocean basins and margins, vol. 2, The North Atlantic – Plenum Press.

Niemczycka, T. 1976 Upper Jurassic rocks of the eastern Poland area (between the Vistula and the Bug rivers) – Prace Inst. Geol. 77: 99 pp.

Norling, E. 1972 Jurassic stratigraphy and Foraminifera of western Scania, Southern Sweden – Sver. Geol. Unders., Ser. Ca. 47: 1-120.

Norling, E. & R. Skoglund 1977 The South-West margin of the Eastern European platform in the territory of Sweden – Zeitschr. angew. Geol. 23: 449-458.

Pożaryski, W. 1948 Jurassic and Cretaceous between Radom, Zawichost and Kraśnik – Biul. Państw. Inst. Geol. 46: 1-141.

—— 1957 SW margin of Fenno-Sarmatia – Kwart. geol. 1: 383-424.

—— 1973 Main pre-Alpine tectonic elements of Poland – Publs. Inst. Geophys. Pol. Acad. Sci. 60: 11-19.

—— 1975-a The tectonic setting of Poland in the light of the studies on the North Sea area – Przegląd geol. 23: 575-584.

—— 1975-b Differentiation in stability of substratum of Danish-Polish trough. In: Recent and neotectonic crustal movements in Poland, vol. I – Wydawnictwa Geologiczne (Warsaw): 33-48.

—— 1976 The western margin of the Old European Platform in Poland in the light of DSS data – Publs. Inst. Geophys. Pol. Acad. Sc. A-2 101: 3-13.

—— 1977. In: M. Książkiewicz, J. Oberc & W. Pożaryski (eds.): Geology of Poland, vol. IV, Tectonics – Publishing House Wydawnictwa Geologiczne (Warsaw): 718 pp.

Pożaryski, W., W. Brochwicz-Lewiński & M. Jaskowiak-Schoeneichowa 1978 Geological map of the Baltic Sea – Przegląd geol. 26: 1-5.

Pożaryski, W. & Z. Kotański (in press) Baikalian, Caledonian and Variscan events in the forefield of the East-European Platform – Geol. Jb. (Hannover).

Pożaryski, W. & K. Pożaryska 1960 On the Danian and Lower Paleocene sediments in Poland – Inst. Geol. Congress, Report of 21st Session Norden, 5 (Copenhagen): 170-180.

Pożaryski, W. & H. Tomczyk 1968 Assyntian orogen in South-East Poland – Bull. Inst. Geol. Warsaw 237: 13-28.

Rasmussen, L. B. 1972 Oversigt over dybdeboringernę på Dansk Landområde 1965-68 – Dansk geol. Foren. (Arsskrift 1971): 41-48.

—— 1974 Some geological results of the first five Danish exploration wells in the North Sea – Danmarks Geol. Unders. III Raekke 42: 1-46.

Shakshyn, V. A. (ed.) 1977 Geological map of Ukrainian Carpathians and adjoining depressions, 1:200 000, Ukrain. nautschno-issled. geologorazved. Inst. (Lvov).

Skorupa, J. 1959 Morphology of the magnetically active basement and of crystalline basement in north-eastern Poland – Biul. Inst. Geol. Warsaw 160:51 pp.

Sorgenfrei, T. 1963 Jura und Unterkreide in Dänemark – Z. deutsch. geol. Ges. 114: 446-451.

Strömberg, A. 1976 A pattern of tectonic zones in the western part of the East European Platform – Geol. Fören. Förh. 98: 227-243.

Stupnicka, E. 1971 Tectonics of Mesozoic rocks in the southern border of the Holy Cross Mts – Rocz. Pol. Tow. Geol. 40: 393-410.

Tollmann, A. 1966 Die alpidischen Gebirgsbildungs-Phasen in den Ostalpen und Westkarpaten – Geotekt. Forsch. 21: 156 pp.

Trümpy, R. 1960 Paleotectonic evolution of the Central and Western Alps – Bull. Geol. Soc. Amer. 71.

Zelichowski, A. 1972 Evolution of the geological structure of the area between the Góry Świętokrzyskie and the Bug River – Biul. Inst. Geol. Warsaw 263: 1-97.

Ziegler, P. A. 1975 Geologic evolution of North Sea and its tectonic framework – Amer. Ass. Petrol. Geol. Bull. 59: 1073-1097.

—— 1978 North Sea rift and basin development. In: I. B. Ramberg & E.-R. Neumann (eds.): Tectonics and geophysics of continental rifts, vol. 2 – D. Reidel Publ. Co. (Nato Series).

Ziegler, W. H. 1975 Outline of the geological history of the North Sea. In: A. W. Woodland (ed.): Petroleum and the continental shelf of North-West Europe, vol. 1, Geology – Applied Sci. Publ. Ltd. (Barking): 165-187.

Znosko, J., V. S. Petrenko & M. V. Chirvinskaya 1977 Main features of the tectonic structure of the western borderland of the Russian Plate – Vestn. Moskov. Univ., Ser. geol. 3: 21-30.

POST-PROOF ADDED NOTE:

Up to the present, there is no evidence for any igneous activity throughout the development of the Polish part of the trough.