Annales Societatis Geologorum Poloniae (2004), vol. 74: 311–318.

CENOZOIC DYNAMICS OF THE DĘBINA SALT DOME, KLESZCZÓW GRABEN, INFERRED FROM STRUCTURAL FEATURES OF THE TERTIARY–QUATERNARY COVER

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Hałuszczak, A., 2004. Cenozoic dynamics of the Dębina Salt Dome, Kleszczów Graben, inferred from structural features of the Tertiary–Quaternary cover. *Annales Societatis Geologorum Poloniae*, 74: 311–318.

Abstract: The Dębina Salt Dome (DSD) is located in the central part of the Tertiary Kleszczów Graben, between the open-cast brown coal mines: "Bełchatów" and "Szczerców". Complicated geological features of the DSD are related to the polyphase tectonic activity in the Kleszczów Graben, and the salt structure dynamics which is believed to be coupled with that activity. The distinctive anticlinal elevation of the sedimentary cover of the DSD points to Cenozoic uplift of the salt. The timing of these salt pulses can be considered as related to main phases of tectonic activity in the Tertiary and Quaternary, well-documented during field studies in the brown coal open mine "Bełchatów". Due to the Middle/Late Tertiary salt uplift, a vast asymmetric anticline of up to 400 m amplitude was formed in the Early Miocene sandy and coaly sediments, including the so-called main coal seam. Renewed salt movements of the DSD occurred in the Quaternary. Considering the magnitude of the top-Tertiary surface elevation versus preliminary dating of this activity, it is concluded that the rate of the salt uplift was about 0.3 mm/year, with the strain rate estimated at 4 x 10^{-14} s^{-1}. Both parameters show relatively fast Quaternary salt movements of the DSD, being representative for the diapir rise active phase (from 10^{-14} s^{-1} to 10^{-16} s^{-1}).

Key words: salt diapirs, neotectonics, Kleszczów Graben, Poland.

Manuscrip received 5 March 2004, accepted 20 July 2004

INTRODUCTION

The Dębina Salt Dome (DSD) is one of eleven diapirs piercing the base-Cenozoic surface which are known from the Polish Zechstein basin area (Tarka, 1992). It is the southernmost salt dome, marginally situated at the contour of 200 m of the cyclothem PZ2 salt thickness, which is considered as the border of the most intensive salt deformations of the Polish Zechstein basin, as seen on Fig. 1a. The DSD is particularly important as compared to the other salt extrusions known from the Polish Lowlands, as a result from its readable structural record of the Cenozoic activity. As evidenced by wellbore data, the Tertiary–Quaternary DSD cover, originally more than 400 m thick, has been strongly uplifted and partly pierced by the salt core.

The DSD has been discovered and preliminary described in the 1960–1970's, during documentation of drilling works for brown coal deposits. The DSD location close to active exloitation zones causes substantial mining hazard which is an important reason for intensive investigations recently carried out in this area.

The paper is based on a number of boreholes drilled in studied area, as well as on the results of author's field investigations obtained from the open cast mine "Bełchatów". An analysis of the subsurface data from the DSD, including its broad surroundings, was completed using wellbore data from some of 1,000 wells. The majority of the wells end up in the Cenozoic strata and only some of them pierce through the Permian–Mesozoic complex.

GENERAL SETTING AND RELATIONS TO THE KLESZCZÓW GRABEN

The Dębina Salt Dome (DSD) is situated in the central part of the Tertiary Kleszczów Graben, between the open-cast brown coal mines: "Bełchatów" and "Szczerców". Complicated geological features of the DSD area are related to the polyphase tectonic activity in the Kleszczów Graben, and the dynamics of the salt structures appears to be coupled with that activity.

At the present state of its recognition, the Kleszczów Graben can be characterized as a multi-segmented, subsided structure which extends over a distance of some 80 km, between the Pilica River in the east and the Warta River in the west (Fig. 1b). The graben is located within the boundary

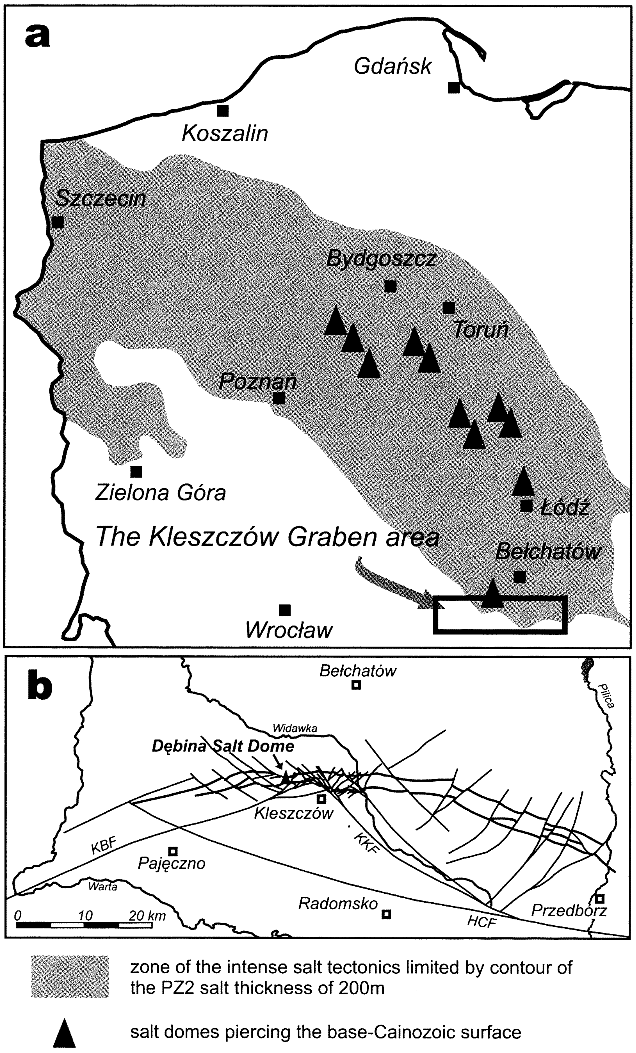

Fig. 1. General setting of the Dębina Salt Dome: a – schematic location against other salt diapirs of the Polish Lowlands (after Tarka, 1992), b – location in the Kleszczów Graben area (after Gotowała & Hałuszczak, 2002); (KBF) Kluczbork-Bełchatów Fault; (KKF) Kodrąb-Kleszczów Fault; (HCF) Holy Cross Mts. Fault

zone that occurs between the Łódź Depression to the north and the Radomsko Elevation to the south. Due to its W–E extent, the Kleszczów Graben apears to link the Holy Cross Mountains with tectonic elements of the Fore-Sudetic Monocline. The basement of the 250 to 600 m thick Tertiary–Quaternary sequence is represented by Jurassic and Cretaceous beds. Permian rocks occur only in a small area of the DSD. The Mesozoic strata were folded and faulted during the Laramide phase (early Palaeogene) of the Alpine orogeny. It is accepted that the structural development of the Kleszczów Graben was significantly influenced by the Tertiary–Quaternary reactivation of the pre-existing regional dislocation within the sub-Cenozoic basement (Gotowała & Hałuszczak, 2002).

OUTLINE OF THE DSD GEOLOGY

Basing on wellbore data, one can consider the uppermost part of the salt dome as relatively well-known. The sub-Cenozoic surface map (Fig. 2) shows that the DSD is elevated 60–100 m above the top-Mesozoic surface in the southern and nothern flanks of the graben. The DSD is elevated along the graben axis 350–450 m above the adjacent, eastern and western subsided areas. At shallow intersection levels (+150 to +125 m), the top of the salt dome has a shape of a meridionally elongated, irregular ellipse with its longer axis of 600 m, and the shortest axis of 400 m. At deeper levels, the diapir extends to the east, parallel to the graben elongation, showing the relatively gently dipping eastern slope.

The salt dome cap was formed by sulphate rocks (anhydrites, gypsum) which are overlain or interbedded by breccias of claystones, mudstones, and carbonate rocks of either Jurassic or Cretaceous age (Szewczyk, 1999). The thickness of the cap varies significantly: from several metres to 120 m close to southern bordering fault of the Kleszczów Graben, where typical cap rocks are replaced by a fault gouge. Salt mirror was found by drillings at depths of some 170–200 m under the groundsurface, i.e. the top of the mirror occurs, on the average, at a depth of +30 m to +10 m above the sea level. Over a short distance towards the outer parts of the salt core, its top falls abruptly at a depth of about 0 m, what points to the presence of steep slopes of the salt structure. Some 700 m eastwards of the dome centre, the salt rocks were encountered at a depth of –35 m what may suggest an eastward continuation of the salt structure at the deeper levels. As observed in drill cores, the salt deposits are represented by laminated halite, mixed, medium and coarse-grained, white, rarely light-grey salt inserts, and anhydrite intercalations. It was concluded that these salts are correlative with the first Zechstein salt cycle – PZ1 (Dąbrowska, 1978).

Due to insufficient recognition of the Mesozoic bedrock stratigraphy all around the DSD, its development in Mesozoic time can be considered, at present, only per analogy with other areas. The Polish Lowlands salt structures were, as a rule, subjected to the earliest mobilisation in the axial part of the Mid-Polish Trough, and, the farther from that area, the uplifting movements occurred later. Within close range, salt mobilisation is referred to the following time-spans: Early Cretaceous to Late Tertiary (Rogoźno and Łanięta Salt Domes in the Łódź Depression; Dadlez & Marek, 1977), Keuper (Kłodawa Dome; Burliga, 1996, 1997), and Late Oxfordian (Wieluń area; Głazek, 1999). Judging from geological setting of the neighbourhood of the Wieluń area and its suggested macrostructural relations with the Kleszczów Graben zone (Głazek, 1999), one may presume that the initial mobilisation of the DSD salt masses started in the similar period of time.

It is generally accepted that the ascending salt masses utilized a tectonic zone of weakness which was created at the intersection of deep, pre-existing faults (Figs. 1b, 2). The analysis of numerous wellbore data, including petroleum exploration drillings located in a broad vicinity of the Kleszczów Graben, helped to reconstruct the pattern of regional dislocations in deeper stratigraphic horizons, from the Lower Carboniferous up to the Mesozoic (Gotowała, 1999; Gotowała & Hałuszczak, 2002). The DSD location coincides with a broad zone of intersection of such dislocations, as: the Kluczbork-Bełchatów Fault, and the Klesz-

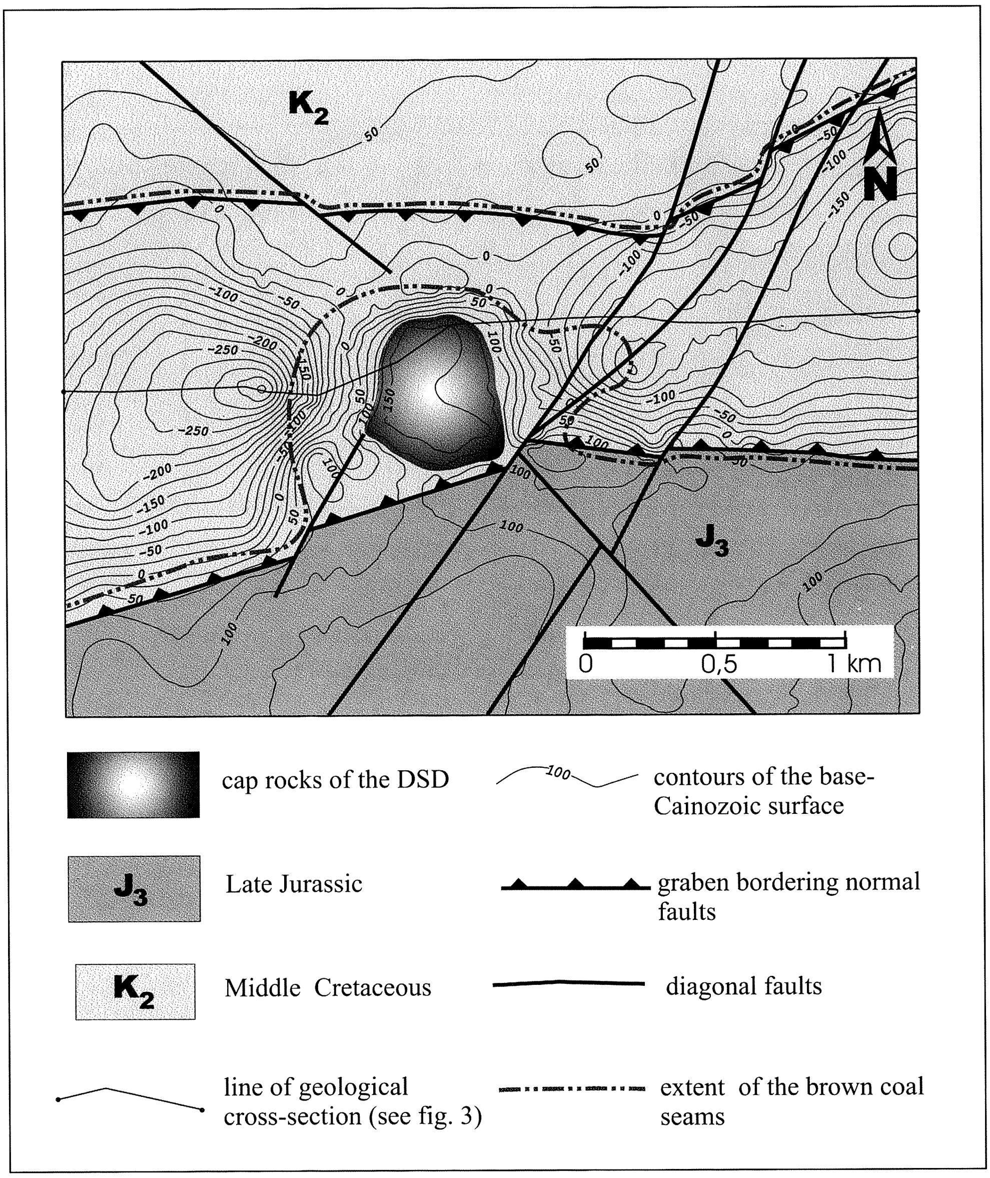

Fig. 2. Structural contour map of the base-Cenozoic surface in the Dębina Salt Dome area

czów-Kodrąb Fault which is considered as a branch of the Holy Cross Mts. Fault (Fig. 1b). The exact relationship between salt structures and the basement fault pattern has been pointed out, i.a., by Kockel (2003) who provided excellent examples from Northern Germany.

STRUCTURAL EVIDENCE FOR CENOZOIC ACTIVITY OF THE DSD

The Cenozoic lithostratigraphic succession close to the DSD is similar to that of the other parts of the Kleszczów Graben. It is a continuation of the graben sedimentary infill, which was examined in detail in the brown coal open-cast mine "Bełchatów". Further, detailed results of lithofacies and stratigraphic studies of the Cenozoic sediments are reported in papers by Krzyszkowski (1990, 1992), Stuchlik *et al.* (1990), and Szynkiewicz (2000).

According to mesostructural field observations supporting current stratigraphic dating, the Cenozoic infill of the graben can be subdivided into three main structural levels which are bounded by angular unconformities (Gotowała & Hałuszczak, 2002).

The lower structural unit of the Early and, partly, Middle Miocene (up to the Badenian) age, is composed of subcoal sandy deposits, the main coal seam, as well as secondary coal beds, together with the accompanying coalified clays. The top of the lower unit is formed by the erosional surface GTPN, dated to the late Middle/Late Miocene. This surface cuts folds and faults in the coal and coal-bearing sediments. The overlying clayey-sandy sediments which represent the Late Miocene (and/or Pliocene?), and the lower part of the Quaternary (up to the Saalian=Odranian Glaciation) belong to the middle structural unit. The well-developed deformational structures in this sequence are cut by the erosional surface GCPN, which is believed to be cor-

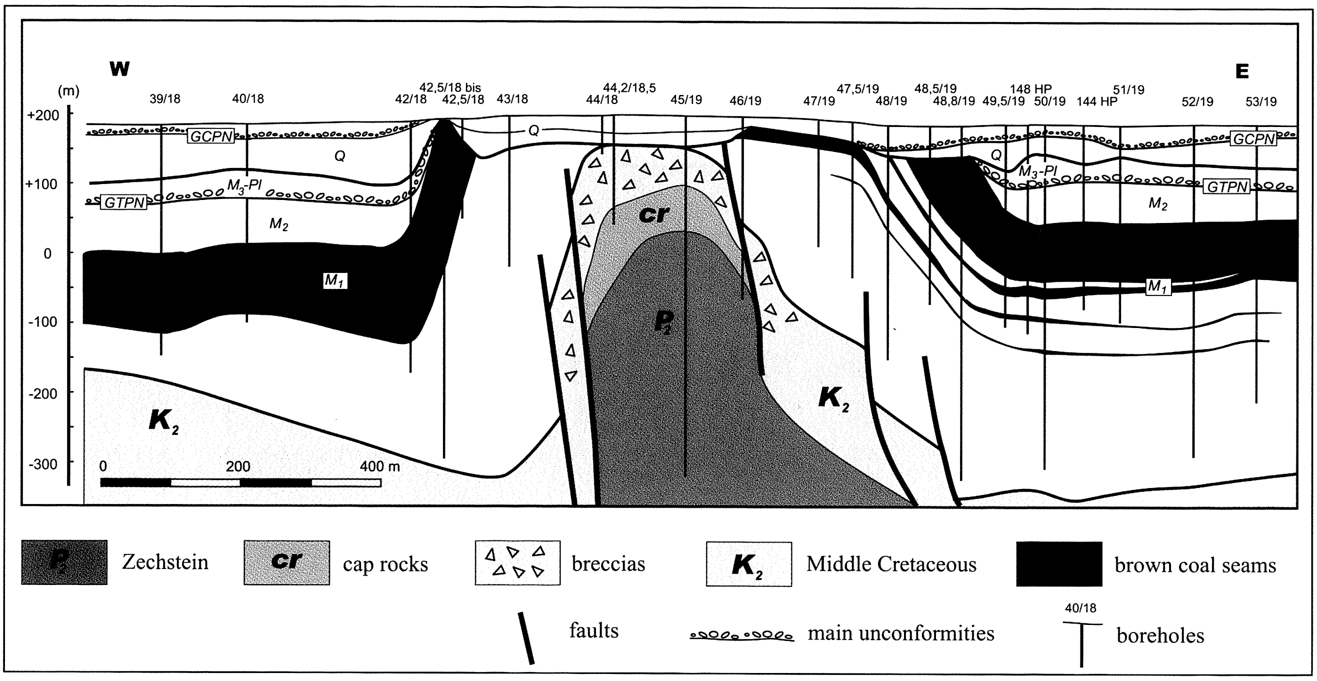

Fig. 3. Geological section across the Dębina Salt Dome area, two times exaggerated. Q – Quaternary; M_3-Pl – Late Miocene to Pliocene; M_2 – Middle Miocene; M_1 – Early Miocene; GCPN – main Quaternary unconformity; GTPN – main Tertiary unconformity

relative with the Inter-Saalian (Pilica) Interstadial. The overlying, relatively undisturbed Quaternary (Inter-Saalian to the Holocene) strata form the upper structural unit.

The total thickness of Cenozoic sediments around the diapir is variable, and changes from 400 m inside the graben depression, to 100–150 m outside the graben. Towards the DSD centre, these sediments were successivelly reduced by erosion, on the average to 20–35 m over the salt plug.

The Tertiary strata, including brown coal seams, formed an outstanding brachy-anticlinal structure, ellipse-shaped in map-view, which displays strong westward asymmetry (Figs. 2, 3). Following graben extension, the structure presents an inclined fold, whose longer limb dips to the east at 25°, and its shorter limb is inclined at least 50° to 60° towards the west. The inclination of coal layers in the western limb locally increases up to vertical position, and the layers becomes even overturned, dipping at 80° to 85° to the east.

As shown on the cross-section (Fig. 3), the strongly folded Tertiary strata represent sandy sub-coal deposits and the so-called main brown coal seam, dated to the Early Miocene. On the western side of the DSD, coal deposits constitute one massive coal bed, about 100 m thick. On the eastern side, the lower part of main seam is interbedded with sand, mud and clay. Locally, in outer areas of the anticline, the youngest Tertiary clayey-sandy sediments (Late Miocene and /or Pliocene?) are preserved, resting discordantly on the coal-rich deposits.

Highly elevated and folded Tertiary sediments were deeply cut by erosion in a later period. In the centre of the DSD, the Quaternary series overlies directly the dome cap rocks. However, the internal structural features of the overlying Quaternary sediments have not been recognised in detail. In general, their thickness over the DSD is 20 to 30 m, and beyond the dome zone it grows steadily even up to 100 m. The upper part of Quaternary succesion is believed to be correlative with the Wartanian glacial stage.

Structural features of the Cenozoic overburden, including its thickness and lithofacies relations, have enabled for reconstruction of the main stages of the DSD development in the Tertiary–Quternary. The analysis of wellbore data reveals that the thickness of the sub-coal deposits increases on the western and eastern sides of the DSD. It could have displayed the development of rim synclines in the earliest Miocene, as a result of moderate salt activity. Typical features of the coal series and occurrence of numerous, relatively thick coal layers close to the salt core suggest that there were no significant salt uplift movements in the upper part of the Early Miocene. On the contrary, it might be the evidence of similar sedimentary conditions, which, in the same period, occurred in other parts of the Kleszczów Graben. Strong Tertiary movements which caused folding of the supra-dome sediments occurred after the Early Miocene, and before the Quaternary. Considering the actual position of correlative coal layers, we can notice that the Tertiary series are elevated up to 180 m, viewing from the west, and about 200 m when viewed from the east. However, when we reconstruct the position of Tertiary layers over the DSD which were destroyed by erosion, we can assess the fold amplitude at about 400 m, that is, generally, two times bigger. Conclusive measurement of the magnitude of Tertiary uplift requires subtracting the influence of later Quaternary DSD activity.

The Quaternary salt movements are testified to by an elevation of the top-Tertiary/base-Quaternary surface, as shown on the map (Fig. 4). The above-mentioned surface is situated at heights varying, on the average, from +170 m to +180 m over a broad area that encircles the salt dome centre. It is noteworthy, that several wells encountered the coaly

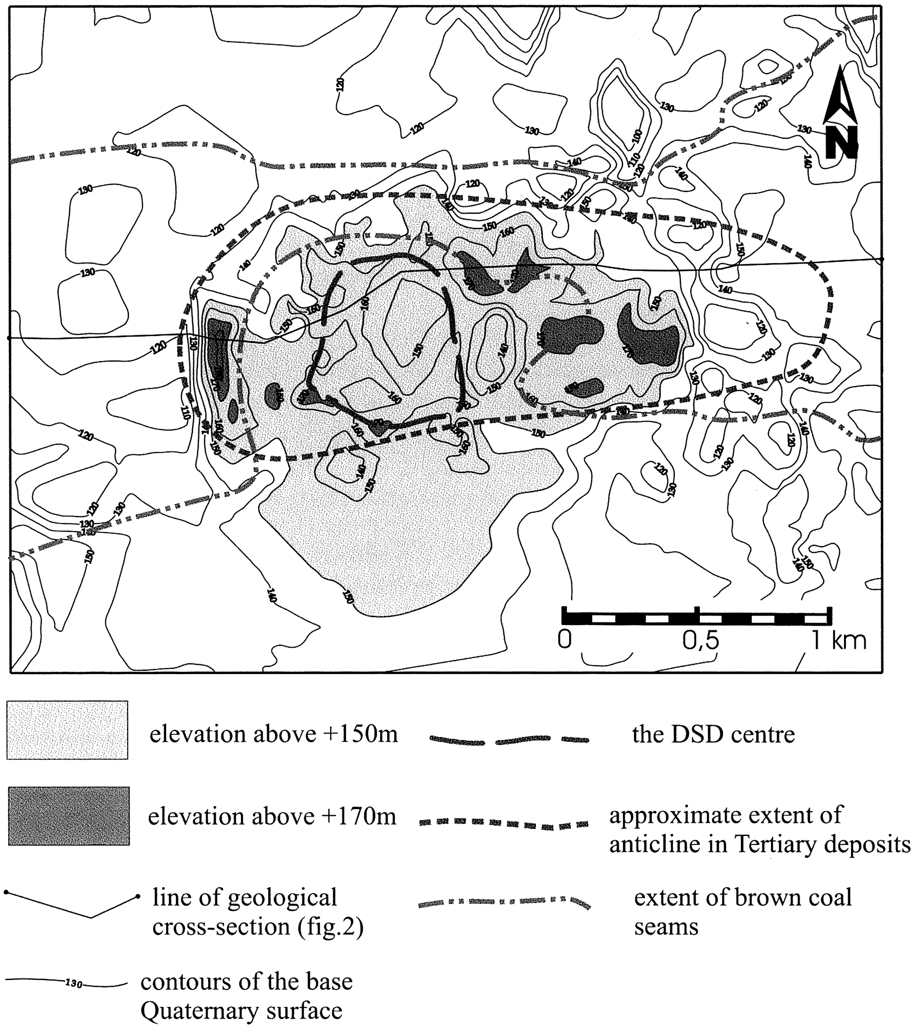

Fig. 4. Structural contour map of the base-Quaternary surface in the Dębina Salt Dome area

Tertiary sediments just a few metres under the ground level at heights of +185 m to +195 m. Outside the DSD, the top-Tertiary surface lowers to heights that range from +140 m to +120 m. Further analysis of that surface displays an irregular pattern of secondary highs and hollows which, in part, appear to be a result of wrong identification of the top-Tertiary sediments in drill core materials. Some secondary hills of a circular arrangement are controlled by steeply dipping coal beds which subcrop at the base-Quternary surface. Thus, assuming that the examinated surface was primarily of horizontal, generally flat topography, it must have been uplifted up to 70 m. The groundsurface topography does not show any more visible, present-day expression of the DSD.

ASSESSMENT OF THE DSD TERTIARY–QATERNARY DYNAMICS

The step-wise Cenozoic development of the DSD, including two distinctive pulses in the Tertiary and Quaternary, may be readily inferred from structural features of the covering sediments. Discontinous dynamics of the DSD clearly displays complete development of the coal-bearing Early Miocene deposits which followed moderate salt mobilisation in the earliest Early Miocene. One may infer that principal episodes of the diapir rise coincided with those Tertiary and Quaternary tectonic phases which were well documented during field investigation in the nearby open-cast mine in Bełchatów (Gotowała & Hałuszczak, 2002). The Tertiary tectonic phase in the Kleszczów Graben does not have any precise stratigraphic dating, yet. When we consider the age of those layers which overlie and underlie angular unconformities GCPN, we find out that the activity can be generally referred to the upper part of the Middle Miocene (late Badenian or later), or to the turn of the Middle/Late Miocene. Favourable conditions for the salt uplift were provided as a result of extensional regime, which occurred at least in the initial period of this tectonic phase. The state of the tensile stress was well recorded by predominantly normal mode of numerous Tertiary faults which were examined in the open-cast mine (Gotowała & Hałuszczak, 2002). In reference to the previously mentioned structural data, the magnitude of salt movement can be estimated at up to even 400 m.

Renewed salt movements of the DSD occurred in the Quaternary. As a result of uplift, there occurs an irregular elevation of the top-Tertiary surface which is 60–70 m high. It is suggested that this pulse is related to the Quaternary tectonic activity in the Kleszczów Graben, being coeval with the time interval from the Ferdynandów Interglacial up to the Saalian = Odranian Glaciation. The most recent field investigations in the Bełchatów open-cast mine show non-penetrative, zonal occurrence of the Quaternary deformations which have been aligned and apparently controlled by the main pre-existing dislocations in the sub-Cenozoic basement. The origin of the Quaternary salt reactivation is believed to be related to tensile stresses, which were produced by postglacial unloading. The dominant role of glacial rebound coupled with the mobility of the deep-rooted fault zone has already been noticed (Hałuszczak, 1995; Gotowała & Hałuszczak, 2002).

Taking into account that the time interval lasted ca. 24,000 years, and that the magnitude of Quaternary uplift was ca. 70 m, the rate of that process can be estimated as about 0.3 mm/year. The resulting value is considerably smaller than the rate of 1mm/per year that has been calculated for 15,000 year-lasting, post-glacial uplift in the Inowrocław and Góra areas, on the basis of geomorphological studies (Niewiarowski, 1983). Comparable with the DSD rate, the maximum uplift rate of 0.5 mm/year has been estimated, e.g., in the East Texas diapir province (Seni & Jackson, 1983). Diapiric rates and comparative rates for other types of active geologic flow are listed, e.g., by Jackson and Talbot (1994).

The strain rate can be considered as a more conclusive measurement of the Quaternary uplift. It is expressed as percentage proportion of the strain that occurs in a time unit, i.e., $e = e_d/t$, where e_d is the Quaternary change of vertical elongation of the DSD divided by its total vertical elongation, and t is the time (in seconds) of the movement activity. If the total elevation of the DSD above the top surface of the Zechstein source beds, basing on regional data of Mrozek (1975) is, on the average, 2.5 kilometres, the strain rate amounts to $4 \times 10^{-14}\ s^{-1}$.

Both the disccused parameters show relatively fast salt Quternary movements in the DSD, being representative for the active phase of diapir rise (from $10^{-14}\ s^{-1}$ to $10^{-16}\ s^{-1}$; Seni & Jackson, 1983). According to the discontinous mode of salt pulses, one can suggest that effective salt uplift rate calculated for short-lasting intervals would be considerably greater than that given above.

CONCLUSIONS

The discontinous, step-wise Cenozoic development of the DSD, including two distinctive pulses in Tertiary and Quaternary times, may be readily inferred from structural features of the covering sediments which are being discussed in this paper. The timing of these salt pulses is considered to be related to the Cenozoic tectonic activity of the Kleszczów Graben, well documented during field studies in the brown coal open-cast mine "Bełchatów". The first pulse of the Cenozoic salt uplift occurred at the beginning of the Early Miocene, although its intensity is assessed as distinctly minor than that of later episodes. Strong movements which caused folding of the supra-dome sediments occurred after the Early Miocene and before the Quaternary, probably in the upper part of the Middle Miocene (late Badenian or later) or at the turn of the Middle/Late Miocene. Basing on the amplitude of the Tertiary asymmetric supra-dome anticline, the magnitude of salt uplift was estimated at 400 m.

Irregular elevation of the top-Tertiary surface, 60–70 metres high on the average, documents the renewed Quaternary movements of the DSD. Taking into account the duration of the Quaternary tectonic activity in the Kleszczów Graben (Inter Saalian-Ferdynandów Interglacial up to the Saalian=Odranian Glaciation), lasting ca. 24,000 years, the rate of the salt uplift can be estimated at 0.3 mm/year. Another important parameter, the strain rate, amounts to $4 \times 10^{-14}\ s^{-1}$. It points to relatively fast Quternary salt movements which are representative for the active phase of the diapir rise (from $10^{-14}\ s^{-1}$ to $10^{-16}\ s^{-1}$). The groundsurface topography over the DSD does not show any more visible present-day expression.

Acknowledgements

The paper has been presented at the 5th National Conference "Neotectonics of Poland", organized in Kraków, 26-27 Sept. 2003, by the Commission for Neotectonics of the Committee for Quaternary Studies of the Polish Academy of Sciences, Institute of Geological Studies of the Jagiellonian University, and the Galicia Tectonic Group.

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Streszczenie

KENOZOICZNA DYNAMIKA WYSADU SOLNEGO DĘBINY (RÓW KLESZCZOWA) NA PODSTAWIE BUDOWY STRUKTURALNEJ JEGO TRZECIO- I CZWARTORZĘDOWEJ POKRYWY

Andrzej Hałuszczak

Położony w centralnej części trzeciorzędowego rowu tektonicznego Kleszczowa wysad solny Dębiny stanowi najdalej ku południowi wysuniętą strukturę tego typu w obrębie polskiej części basenu cechsztyńskiego (Fig. 1a). Na tle pozostałych 11 diapirów przebijających powierzchnię podkenozoiczną, znanych z obszaru Niżu, wysad Dębiny wyróżnia się dobrze udokumentowaną aktywnością w kenozoiku, o czym świadczy jednoznacznie silne wypiętrzenie utworów trzecio- i czwartorzędowych w osłonie wysadu.

Wysad solny Dębiny położony jest w strefie wyraźnego załamania się przebiegu rowu Kleszczowa, co – jak powszechnie się przyjmuje – związane jest z przecinaniem się południowego uskoku brzeżnego rowu i poprzecznych dyslokacji zorientowanych NW–SE i NE–SW, o przypuszczalnie regionalnym zasięgu (Fig. 1b, 2).

Analiza blisko 1000 wierceń z szerokiego otoczenia wysadu Dębiny i opracowane na tej podstawie mapy strukturalne, a także dotychczasowe wyniki badań terenowych autora w sąsiadującej z wysadem odkrywce kopalni "Bełchatów", rzucają nowe światło na dynamikę końcowych etapów jego rozwoju w kenozoiku. Wysad jest wypiętrzony o około 350–450 m względem dna rowu Kleszczowa i około 60–100 m w stosunku do skrzydeł rowu (Fig. 2, 3). W górnej części, najlepiej rozpoznanej dzięki licznym wierceniom, wysad stanowi stromy pień solny, o poziomym zarysie elipsy (600 m x 400 m) wydłużonej wzdłuż rozciągłości rowu. Czapę wysadu reprezentują gipsy i anhydryty, przykryte lub przewarstwiające się z brekcjami utworów jurajskich i kredowych, o łącznej miąższości do ok. 120 m. Utwory solne korelowane z cyklotemem PZ1 zostały nawiercone na głębokości 170–200 m poniżej powierzchni terenu, tzn. na głębokości od ok. +30 m do +10 m.

Profil utworów kenozoicznych w strefie wysadu solnego Dębiny jest bardzo zbliżony do szczegółowo rozpoznanego profilu tych utworów w odsłonięciach odkrywki "Bełchatów". Wyraźne analogie dotyczą również układu głównych erozyjnych powierzchni niezgodności kątowych w utworach kenozoiku, dokumentujących kolejne etapy deformacji. Na podstawie obserwacji terenowych przyjęto podział utworów kenozoicznych rowu na trzy zasadnicze jednostki strukturalne. Jako dolne piętro wydzielono piaszczyste i ilaste utwory podwęglowe, wraz z tzw. pokładem głównym węgla brunatnego i występującymi wyżej podrzędnymi warstwami węgla, reprezentującymi łącznie wczesny i częściowo środkowy miocen. Strop jednostki wyznacza erozyjna powierzchnia niezgodności kątowej GTPN, ścinająca deformacje fałdowe i uskoki występujące w wymienionych utworach. Środkowe piętro strukturalne stanowią występujące powyżej bezwęglowe, piaszczyste i ilaste utwory późnego miocenu (i pliocenu?) oraz dolna część osadów czwartorzędowych, obejmujących utwory od zlodowacenia południowopolskiego po zlodowacenie Odry. Silne, strefowe zaburzenia występujące w tych utworach są ścięte powierzchnią GCPN. Najmłodsze piętro strukturalne tworzą na ogół poziomo zalegające utwory związane z interwałem czasowym: interstadiał Pilicy – holocen.

Warstwy trzeciorzędowe w okrywie wysadu Dębiny formują złożoną, antyklinalną kopułę o wyraźnej asymetrii zachodniej (Fig. 3, 4). W przekroju równoleżnikowym obraz tej kopuły zbliżony jest do fałdu pochylonego z długim skrzydłem wschodnim, nachylonym wzdłuż osi rowu do ok. 25° i krótkim, stromym skrzydłem zachodnim, nachylonym co najmniej 50°–60°. Lokalnie, na skrzydle zachodnim kopuły, nachylenie warstw węglowych wzrasta do pionu lub też przeginają się one w drugą stronę przyjmując położenie odwrócone z upadami rzędu 80°–85° ku wschodowi. Wysoko wypiętrzone i zafałdowane utwory wczesnego, częściowo środkowego miocenu zostały w toku późniejszej erozji (późny miocen, czwartorzęd) silnie zniszczone, a w centralnej strefie wysadu całkowicie usunięte. Szczegółowa korelacja litostratygraficzna wyżejległych warstw czwartorzędowych nie jest jednoznaczna. Ich miąższość ponad wysadem nie przekracza najczęściej 20–30 m. Pojedyncze otwory rejestrują występowanie zawęglonych utworów trzeciorzędowych bezpośrednio pod powierzchnią terenu.

Analiza profilu utworów ponad wysadem wraz z występującymi w tych osadach niezgodnościami i lukami erozyjnymi ujawnia skokowy charakter ruchów soli w kenozoiku, z wyraźnie zaznaczającymi się dwoma etapami: trzeciorzędowym i czwartorzędowym. Przyjęto, że oba wymienione etapy ruchów soli odpowiadają wiekowo fazom aktywności tektonicznej, jakie zostały udokumentowane w nieodległych względem wysadu odsłonię- ciach utworów kenozoicznych w odkrywce kopalni Bełchatów. Starsza z tych faz jest datowana na środkowy miocen (młodszy

baden lub po badenie), młodsza – na okres od interglacjału ferdynandowskiego po zlodowacenie Odry włącznie. Pierwsze, umiarkowane ruchy soli mogły wystąpić już w najniższym wczesnym miocenie, o czym świadczy pewien wzrost miąższości podwęglowych utworów piaszczystych w rowie, po obu stronach wysadu. Nieciągły charakter dynamiki wysadu najlepiej odzwierciedla obecność na skrzydłach kopuły blisko 250 m sekwencji warstw węglowych, piaszczystych i ilastych, odpowiadających utworom dolnego piętra strukturalnego (wczesny, częściowo środkowy miocen). Oznacza to, że w wymienionym okresie warunki sedymentacji w strefie wysadu Dębiny zdominowane były przez subsydencję i nie odbiegały w istotny sposób od pozostałych części rowu. Wielkość późniejszego wypiętrzenia diapiru można ocenić na podstawie położenia korelatywnych warstw węglowych. Wynosi ona co najmniej 200 m, a po zrekonstruowaniu warstw zniszczonych przez erozję blisko 400 m.

Ponowne dźwignięcie wysadu nastąpiło w czwartorzędzie, co dokumentuje poddarcie powierzchni podczwartorzędowej ok. 60–70 m powyżej jej średniego położenia w szerokim otoczeniu wysadu (Fig. 4). Przyjęcie podobnego przedziału czasowego dla tych ruchów, jak w przypadku czwartorzędowej aktywności tektonicznej rejestrowanej w odsłonięciach odkrywki Bełchatów, tj. interwału liczącego ok. 24 000 lat, pozwala oszacować prędkość tego procesu na ok. 0,3 mm/rok. Uwzględniając pulsacyjny charakter ruchów soli należy oczekiwać, że rzeczywiste, krótkookresowe prędkości były znacząco większe. Innym często stosowanym miernikiem dynamiki procesu deformacyjnego jest prędkość odkształcenia (*strain rate*) $e = e_d/t$, gdzie e_d jest ilorazem przyrostu wysokości wysadu i jego wysokości pierwotnej, a t jest czasem trwania ruchów. Przyjmując podobne jak poprzednio ramy czasowe aktywności wysadu, prędkość jego odkształcenia wynosi 4×10^{-14} s^{-1}. Oba obliczone parametry wskazują na stosunkowo szybkie ruchy soli z prędkością typową dla faz aktywnego wzrostu wysadów. Ukształtowanie powierzchni topograficznej ponad wysadem solnym Dębiny nie dostarcza argumentów na rzecz jego współczesnej aktywności.