MARCIN PIWOCKI

Geological Institute, Rakowiecka 4, 00-975 Warsaw

BROWN COALS IN POLAND; CHARACTERISTIC OF OCCURRENCES

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The distribution of deposits and other occurrences brown coals in individual structural units in various parts of the country have been discussed by several authors (e.g. 2, 3, 10, 16), mainly in papers dealing with more general stratigraphic, tectonic and deposit problems. In Poland, brown coals are known to occur in the Lower and Upper Jurassic, Upper Cretaceous and Tertiary. Economic value of Mesozoic brown coals is nowadays rather limited. The major, currently mined brown coal deposits are connected with the Miocene (Figs. 1–2) but the coals

are also known from other stages of the Tertiary: Paleocene, Eocene, Oligocene. Moreover, small accumulations were also found in the Pliocene.

MESOZOIC COALS

In Poland, Lower Jurassic brown coals occur in area from the vicinities of Przysucha to Ostrowiec Świętokrzyski at northern and north-eastern Mesozoic margin of the Holy Cross Mts, and between Częstochowa, Zawiercie and Siewierz in the Silesian-Cracow Monocline (Fig. 1). In these areas the coals were exploited from time to time and on limited scale. Brown coal layers are up to 0.9 m thick in the Holy Cross Mts and up to 1.2 m in the vicinities of Zawiercie. Thin layers and laminae of brown coals of the Lower Jurassic age were also found in drillings in the Polish Lowlands and thicker ones (up to 3 m thick) but seated at large depths – in the borehole Bieżuń 2 in the vicinities of Sierpc, north-west of Warsaw.

Distribution of brown coal layers in the Lower Jurassic appears controlled by paleogeographic factors and facies development of its individual stages. The coals are mainly related to continental packets present in lithostratigraphic units varying in age from the Hettangian to Toarcian. In the foreland of the Holy Cross Mts, they are known from the Zagajsk Series (Hettangian), in the Zawiercie area – the Blanowice Beds (Domerian), and in the Polish Lowlands they have been found in the Lower Mechów, Radów, Komorów, and Kamieńsko Beds, upper Sławęcin Series, and Olsztyn and Ciechocinek Beds (Hettangian – Toarcian, except for Carixian).

Lower Jurassic coals belong to the group of hard brown coals, highly coalified, luster and matt, similar in some features to low-coalified black ones. For example, coals from the Sierpc area resemble high volatile coals of the type 31 (6).

Lower Jurassic sequences with brown coals belong to sedimentary cover developed on the Young, Paleozoic Platform and, partly, Old East-European Precambrian Platform. The origin of these coals is related to transgressive stage in development of Mesozoic sedimentary complex of the platform cover.

Upper Jurassic (Oxfordian) swampy sediments with coalified flora and detritus of hard brown coals are known from the vicinities of Tomaszów Lubelski in southern part of the Lublin Basin (9). They represent the beginning of sedimentation of epiplatform Mesozoic complex in that area and they display features of incipient coal-bearing formation.

Thin lenses and intercalations of brown coals are also known from the Upper Cretaceous between Węgliniec and Lwówek Śląski in the North-Sudetic Basin (Fig. 1). The coals were exploited in second half of the XIX c. Individual layers are up to 0.6 m thick and built of coals of the group of hard, mat and luster brown coals. They are genetically related to continental facies of the Santonian-Campanian which was gradually shifting to north-west, following the retreating marine ingression (7). In that area, Santonian and probably in part Campanian sandy-clay complex of brackish-continental strata with coals marks the beginning of a regressive phase in development of epi-Variscan sedimentary cover in the North-Sudetic Basin.

TERTIARY COALS

In Poland, major resources of brown coals of economic value are connected with Tertiary strata in the Polish Lowlands. The coal-bearing strata are present in areas of three geological units: epiplatform North-West European Tertiary Basin (connected with the East-European in the Paleogene), Alpine Carpathian Foredeep and Alpine Carpathian range. Tertiary sediments of the Nort-West European Basin are distributed throughout the major part of the Polish Lowlands whilst those of the two remaining units appear limited to southern Poland (Fig. 1).

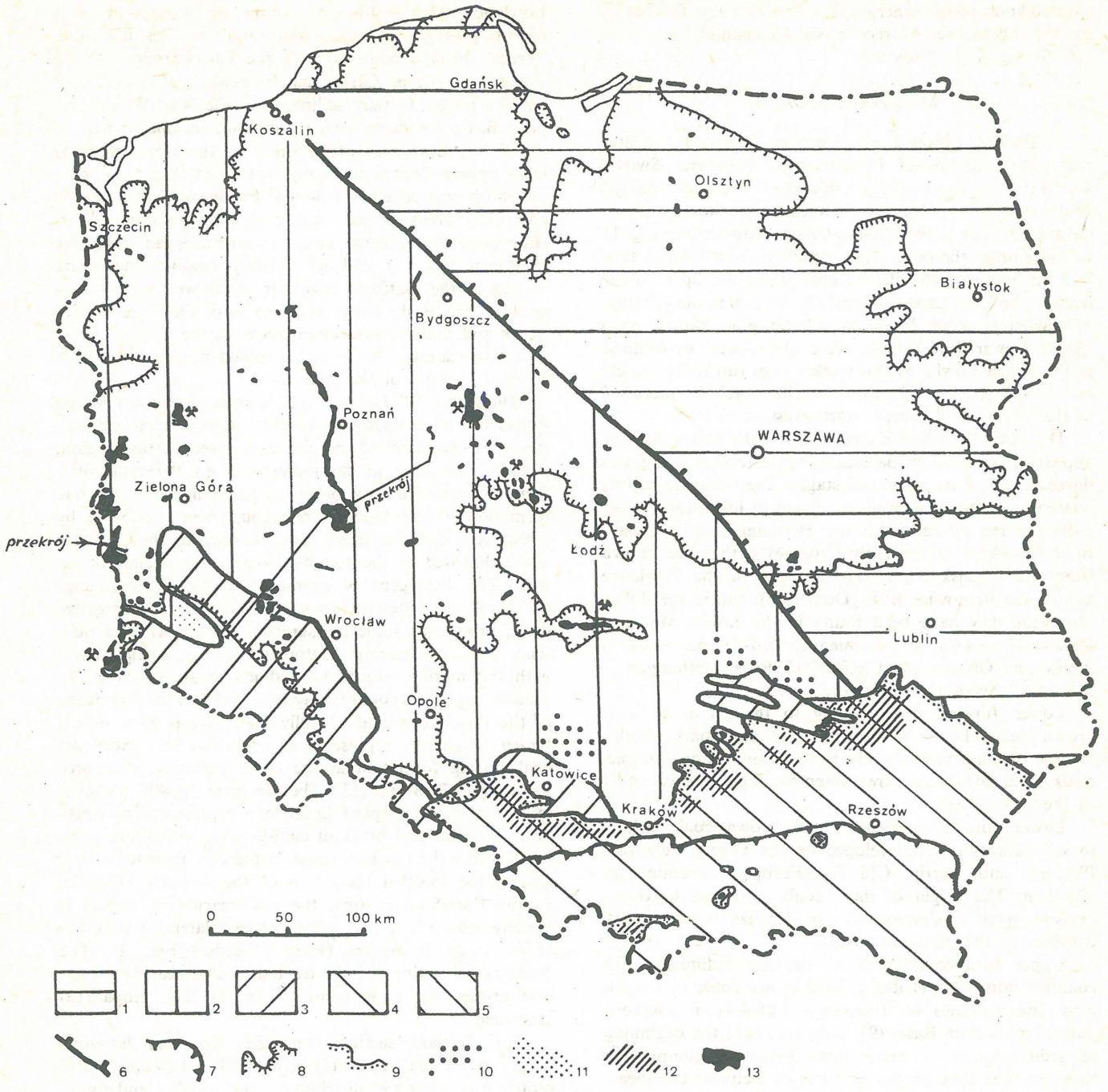
Polish part of the North-West European Tertiary Basin comprises areas of two major geotectonic units: East-European Precambrian and Central-European Paleozoic Platforms (Fig. 1) and its Tertiary coal-bearing strata belong to the platform cover. In south-west part of the country, the Basin enters some parts of the Fore-Sudetic Block and Sudety Mts, where rocks of the Tertiary complex discordantly rest on either folded basement or older structural stages of the cover.

The origin of Tertiary coal-bearing formation in the Polish Lowlands appears related to some general regularities in development of the platform cover. In that region, inundational stage in development of epi-Paleozoic platform cover ended with origin of marly-limestone marine formation of the Upper Cretaceous, being followed by a regressive and emersional stage, comprising the Cenozoic and delineated at the top by Quaternary glacial formation. The Paleogene is characterized by predominance of clastic epicontinental marine sequences of regressive cycle, broken by some transgressive events, whilst sandy-clay and coal-bearing continental strata, partly coeval with the marine, are of subordinate character (Fig. 2). Taking this into account it may be stated that the Paleogene of the Polish Lowlands, locally without top parts of the Upper Oligocene, represents an incipient, i.e. embryonic coal-bearing formation in the classification scheme proposed by S.Z. Stopa (13). The Neogene, locally comprising a part of the Upper Oligocene, is represented by strata of continental and brackish coal-bearing formation, passing towards the top into those of the clay formation and, finally, the mottled formation of the Pliocene (Fig. 2). In the Fore-Sudetic area, the coal-bearing formation is passing upwards or, in some places, laterally into the kaolin-sandy formation (Kaława Beds – Fig. 2). The Neogene formation may be treated as coal-bearing formation proper, i.e. anthracoauxetic in the S.Z. Stopa (13) classification.

The Tertiary section comprises ten coal horizons or groups of coal seams (2) in the Polish Lowlands. The groups are varying in distribution and number and thickness of coal layers (Fig. 2). The coals belong to the group of soft, mainly earthy and xylith coals.

In sedimentary cover of the East-European Platform, brown coals form moderately thick lenses and layers in the Upper Miocene and, sporadically, Pliocene, Middle Miocene and Lower Oligocene (Fig. 2). The known brown coal deposits are small and they often display secondary glacitectonic disturbances. They are mainly known from the Upper Miocene in the vicinities of Koszalin, Tuchola, Olsztyn and Kozienice. Coal layers are rarely over 3 m thick there.

In area of the Central-European Paleozoic Platform, brown coals are present in the whole section of the Tertiary, being known from the Paleocene, Eocene, Oligocene, Miocene and Pliocene (Fig. 2). Of these, Miocene, especially Middle and Upper Miocene coals (coal seam groups II and I) are of the highest economic value and they are mined at Turoszów, Sieniawa, Konin, Turek and Bełchatów (Fig. 1).



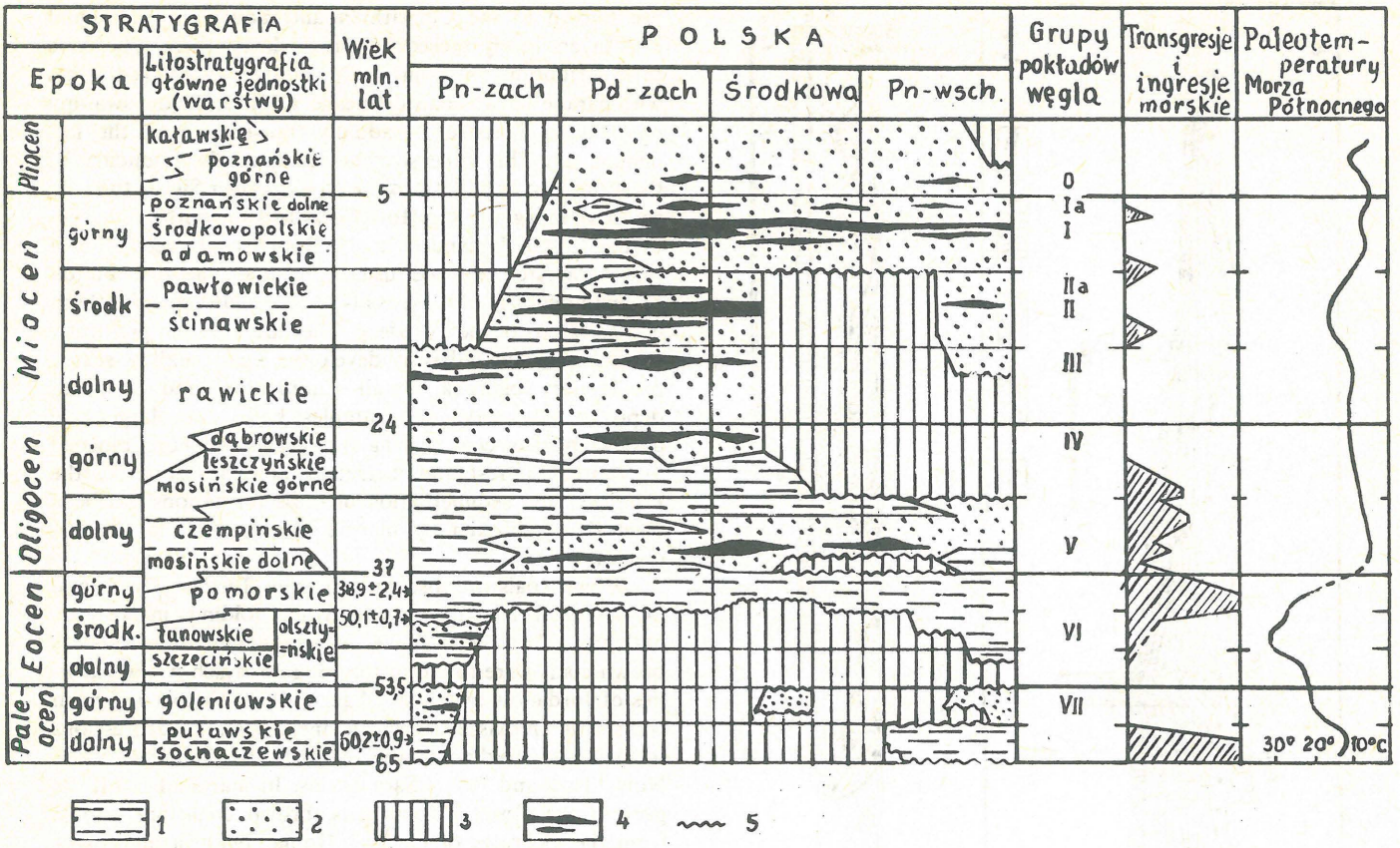
Ryc. 1. Rozmieszczenie złóż i wystąpień węgli brunatnych w Polsce na tle głównych jednostek strukturalnych.

1 – platforma wschodnioeuropejska, 2 – platforma paleozoiczna, 3 – paleozoidy, 4 – alpidy, 5 – zapadlisko przedkarpackie, 6 – granica platformy wschodnioeuropejskiej, 7 – nasunięcie karpackie, 8 – zasięg trzeciorzędowej formacji węglonośnej na Niżu Polskim, 9 – zasięg osadów miocenu w Karpatach i zapadlisku przedkarpackim, 10 – wystąpienia węgli brunatnych w osadach jury dolnej, 11 – wystąpienia węgli brunatnych w osadach kredy górnej, 12 – wystąpienia węgli brunatnych w osadach miocenu Karpat i zapadliska przedkarpackiego, 13 – złoża trzeciorzędowych węgli brunatnych.

Fig. 1. Distribution of brown coal deposits and occurrences in Poland at the background of major structural units.

1 – East-European Platform, 2 – Paleozoic Platform, 3 – Paleozoides, 4 – Alpides, 5 – Carpathian Foredeep, 6 – boundary of East-European Platform, 7 – Carpathian overthrust, 8 – extent of Tertiary coal-bearing formation in Polish Lowlands, 9 – extent of Miocene rocks in Carpathians and Carpathian Foredeep, 10 – occurrences of brown coals in Lower Jurassic, 11 – occurrences of brown coals in Upper Cretaceous, 12 – occurrences of brown coals in Miocene in Carpathians and Carpathian Foredeep, 13 – deposits of brown coals of Tertiary age.

Some Tertiary coal-bearing horizons are paralic in character in the Polish Lowlands. This is the case of local occurrences of coals of the seam group VII, related to regression of the Lower Paleocene sea in the vicinities of Szczecin and Goleniów. Coals of the seam group VI originated in result of transgressive oscillations of the Middle Eocene sea, in coastal swamps developing in the same region. In the Early Oligocene, a new marine transgression came from the west, gradually comprising the area of Poland. That transgressive episode began with deposition of continental and brackish sediments, locally with paralic brown coals of the seam group V. The shallow



Ryc. 2. Schematyczny profil facjalny i podział stratygraficzny trzeciorzędu Niżu Polskiego.

1 – osady morskie i brakiczne, 2 – osady lądowe, 3 – brak osadów, 4 – węgle brunatne, 5 – niezgodności lub przerwy. Paleotemperatury Morza Północnego za B. Buchardtem (1).

Fig. 2. Summative facies profile and stratigraphic subdivision of the Tertiary in the Polish Lowlands.

1 – marine and brackish rocks, 2 – continental rocks, 3 – lack of rocks, 4 – brown coals, 5 – unconformities or gaps. Paleotemperatures in the North Sea after B. Burchardt (1).

sea left glauconitic sands and clays and it retreated in the Late Oligocene. In south-western Poland, a zone of coastal coal-forming swamps began to migrate following the retreating sea. Coals of the seam group IV were forming in that zone (12).

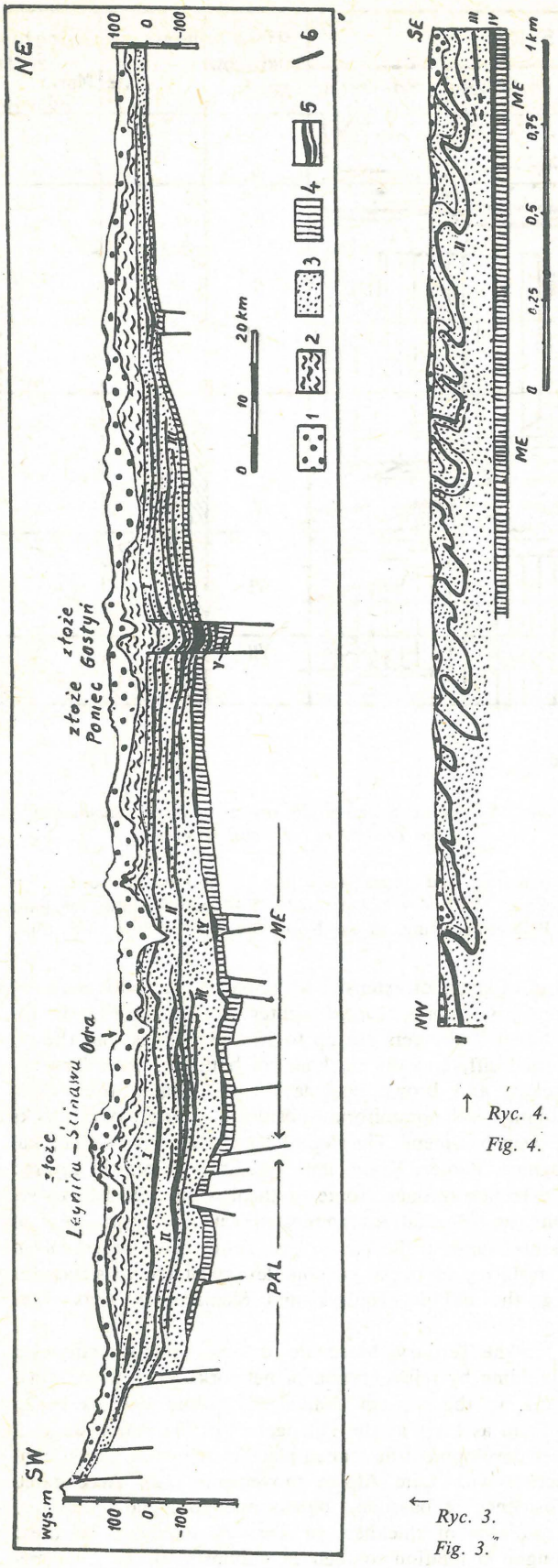
The major resources of brown coals are connected with the Miocene. The Miocene section comprises three groups of coal seams which represent an extension of paralic brown coal layers of Lusatia in the German Democratic Republic (8). Intense development of swamps in vast areas in Poland and GDR in the Miocene may be explained in terms of eustatic rise of sea level and influences of marine transgressions in the Hemmoor and Reinbek times, reaching the area of Poland through the North German Depression. Taking this into account it may be assumed that Miocene brown coal layers of western Poland are paralic in character and related to deposition in vast coastal swamps (12). Brown coal deposits occurring in central Poland and in separate, isolated basins or troughs (e.g. Turów or Bełchatów) represent the limnic type.

Paleogene occurrences of brown coals (except for the Upper Oligocene ones) are usually lenticular in shape and limited in extent and thickness, usually less than 1 m thick. They may also occur in depressions of either tectonic or karst origin but then their thickness is much greater (e.g. coals from the vicinities of Goleniów and in the Rogóźno deposit).

Upper Oligocene and Miocene coals are widely distributed in central and western Poland. They have the form of layers or extensive lenticular bodies, subhorizontal or gently dipping towards center of a basin (Fig. 3). Individual coal layers are up to 12–18 m thick and the recorded differences in thickness of both the whole Tertiary packets and brown coal layers are related to varying mobility and nonuniform subsidence of individual blocks of deep basement. The deposits such as Gubin, Cybinka, Legnica, Poniec, Konin and Trzcianka belong to layered and lenticular ones. Some of them were subjected to secondary deformations connected with dynamic stress of icesheet mass in the Pleistocene, being nowadays involved in resulting in origin of complex glacitectonic structures (e.g. the Babina, Henryk and Sieniawa deposits – see Fig. 4).

In the Tertiary, Mesozoic tectonic troughs underwent rebuilding by rejuventation of networks of their marginal faults, in the western Poland (4). Some troughs began to form as early as the Paleogene but the major stage in their development has taken place in the Miocene, in connection with Late Alpine movements (12). Accelerated subsidence of basement blocks and compaction resulted in increase of thickness of Tertiary sediments in these troughs in relation to their neighbourhood. This is especially the case of brown coal layers, attaining large thickness (often over 100 m thick) in the troughs (Fig. 3). The deposits from Bełchatów, Czempin, Krzywin, Gostyń, Nakło and other localities are related to tectonic troughs and depression in area of the Paleozoic Platform.

In northern, peripheral zone of the Alpine Carpathian Foredeep, small brown coal deposits and occurrences



Ryc. 3.
Fig. 3.

Ryc. 4.
Fig. 4.

Ryc. 3. Schematyczny przekrój geologiczny trzeciorzędowej formacji węglonośnej w południowo-zachodniej Polsce.

1 – czwartorzęd, 2 – pliocen, 3 – miocen, 4 – oligocen i lokalnie eocen górny, 5 – węgle brunatne, 6 – dyslokacje, I–V – grupy pokładów węglowych, PAL – paleozoik, ME – mezozoik.

are known in the Carpathian and Badenian. Individual coal layers rarely exceed 3 m in thickness there. The zone of distribution of continental and brackish sediments with paralic brown coals delineates a depressed and swampy part of the Foredeep, gradually transgressed by the Badenian sea. This zone stretches close to the boundary of the Foredeep and Platform, from the Upper Silesia through southern margin of the Holy Cross Mts to southern margin of the Lublin Upland (Fig. 1). Brown coals occurring in that zone are soft and usually earthy. The distribution of small deposits of these coals appears limited to northern marginal part of the Foredeep. They are found in proximity of faults, in small basins developed upon shallow-seated pre-Tertiary bedrock. Small Chomentów and Trzydnik deposits may serve as examples here. Any large-scale development of coal-bearing formations was here impeded by tectonic unrest and migration of facies zones in the Foredeep and sedimentation of these formations has been soon finally broken by marine transgression in the Badenian.

Brown coals are also known from Tertiary flysch and molasse sequences in areas of Alpine foldings in the Carpathians. Thin laminae of allochtoneous, hard humus brown coals were found in the Magura flysch in the vicinities of Jordanów and Nowy Sącz (14) and Neogene brown coals – in molasse rocks in intramontane depressions formed after folding of the flysch range, in the Orava – Nowy Targ and Nowy Sącz basins. In marginal, northern part of the Outer Carpathians, brown coals are known from the vicinities of Grudna Dolna, Iwkowa and Brzozowa (Fig. 1), i.e. the proximity of the margin of Carpathian overthrust.

Tertiary sediments of the Orava – Nowy Targ basin were described in detail by L. Watycha (15). They rest on deeply eroded rocks of the Podhale Flysch, Pieniny Klippen Belt and Magura Flysch. The basin is infilled with continental sediments of alluvial cones with intercalations of swampy packets with brown coals, dated at the Upper Oligocene, Miocene and Pliocene and up to 1,300 m thick. Limnic brown coals, both hard and soft, are present throughout the section in the form of discontinuous layers and lenses 0.2 – 0.5 m thick (up to 2 m thick at the most). The character of sedimentation in that intramontane depression with highly mobile floor was, however, rather unfavourable for formation of thick and extensive brown coal layers.

The conditions of sedimentation of molasse Miocene rocks in the Nowy Sącz basin were similar to the above mentioned (11). The basin, developed on flysch series of the Magura nappe, is filled with Miocene continental sediments over 500 m thick and comprising numerous brown coal intercalations and layers up to 2 m in thickness. Fresh-water Miocene sediments are overlain here by a thin complex of brackish and marine Lower Badenian ones.

Fig. 3. Sketch geological cross section through Tertiary coal-bearing formation in south-western Poland.

1 – Quaternary, 2 – Pliocene, 3 – Miocene, 4 – Oligocene and locally, Upper Eocene, 5 – brown coals, 6 – dislocations, I–V – groups of coal layers, PAL – Paleozoic, ME – Mesozoic.

Ryc. 4. Przekrój geologiczny przez zaburzoną glacitektonicznie trzeciorzędową formację węglonośną w zachodniej Polsce – złoże Babina (wg 5, nieco zmieniony). Objaśnienia jak na ryc. 3.

Fig. 4. Geological cross section through glacitectonically disturbed Tertiary coal-bearing formation in western Poland – Babina deposit (after 5, somewhat modified). Explanations as given in Fig. 3.

In the Grudna Dolna basin, marginal part of the Outer Carpathians, folded rocks of the Krosno flysch are overlain by marine molasse sediments of the Lower Badenian, with fresh-water ones at the base. The latter comprise a brown coal layer up to 3 m thick. The Grudna Dolna Miocene is thrusted over the Miocene of the Carpathian Foredeep, along with the flysch.

CONCLUSIONS

It follows from the above review that deposits and occurrences of brown coals in Poland are related to sedimentary platform cover and molasse sediments in the Carpathian Foredeep and intramontane depressions. Brown coal deposits characterized by the highest thickness of coals, extent and resources are related to the Tertiary brown coal formation, developed in area of the Central-European Paleozoic Platform (Figs. 1–2). Characteristic features of this coal-bearing formation include:

– the presence of continental and brackish sediments markedly varying in lithofacies;

– thickness varying from about a dozen meters to some hundred (400–450 m);

– small number (up to 10) of coal layers;

– coals confined to middle and upper parts of section of the formation (Middle and Upper Miocene);

– coal layers are markedly varying in thickness, attaining some dozens or over somewhat over 100 m in thickness at the most;

– the layers are almost horizontally arranged, with low angle dip towards center of a basin and disturbances due to faulting are relatively rare;

– layered brown coal deposits are fairly extensive, up to several hundred kilometers in area and the mode of development of coal layers appears highly uniform;

– lenticular brown coal deposits are developed in local basins and they may display high variability of coal layers;

– brown coals are represented by the group of soft coals, usually earthy and xylith ones; coal metamorphism (diagenesis) is not advanced and its differentiation is reflected by changes in humidity;

– the whole formation or its part is often scoured or glacitectonically disturbed.

In the area of the Central-European Paleozoic Platform, especially in south-western Poland, conditions were generally favourable for accumulation of phytogenic matter in the Tertiary. Areas situated in the foreland of block-uplifting Sudety Mts were characterized by increased rate of subsidence in the Late Paleogene and Neogene. The rate of subsidence was, however, varying laterally, depending on differences in mobility of individual basement blocks. It seems that the bulk of brown coal deposits are concentrated at the contact of blocks subjected to movements differing in signs. When sedimentary conditions were favourable and the subsidence compensated by sedimentation, thick layers of coal-forming matter were originating. Accumulation of phytogenic matter was facilitated by paleogeographic-facies and climatic conditions, making possible intense development of vegetational cover.

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STRESZCZENIE

Złoża i wystąpienia węgli brunatnych w Polsce są znane w osadach jury dolnej i górnej, kredy górnej i trzeciorzędu. Przemysłowo wykorzystywane złoża węgli brunatnych wiążą się z miocenem rozprzestrzenionym na Niżu Polskim (ryc. 1).

Dolnojurajskie węgle brunatne są związane głównie z osadami śródlądowymi, występującymi w obrębie kompleksów litostratygraficznych różnego wieku – od hettangu po toark. Powstały one podczas transgresywnego stadium rozwoju mezozoicznego kompleksu osadowego pokrywy platformowej. Podobny charakter mają górnojurajskie utwory bagienne z okruchami węgli brunatnych, z południowej części niecki lubelskiej. Górnokredowe węgle brunatne występują w niecce północnosudeckiej, w obrębie zespołu warstw, który rozpoczyna regresywną fazę rozwoju epiwaryscyjskiej pokrywy osadowej w tej części Polski.

Węglonośne utwory trzeciorzędowe rozciągają się w Polsce na obszarze trzech jednostek geologicznych: epiplatformowego trzeciorzędowego basenu północno-zachodnioeuropejskiego obejmującego Niż Polski, alpejskiego zapadliska przedkarpackiego oraz alpejskiego pasma karpackiego (ryc. 1). Powstanie trzeciorzędowej formacji węglonośnej Niżu Polskiego wiąże się z ogólnymi prawidłowościami rozwoju osadowej pokrywy platformowej. W paleogenie dominują epikontynentalne osady morskie cyklu regresywnego przerwanego kilkoma epizodami transgresywnymi (ryc. 2). Paleogeńskie węglonośne osady kontynentalne synchroniczne z formacją morską mają charakter podrzędny. Neogen, miejscami z górnym oligocenem, jest reprezentowany przez śródlądową i brakiczną formację węglonośną, która ku stropowi przechodzi w formację ilastą (ryc. 2).

W profilu trzeciorzędu na Niżu Polskim występuje 10 poziomów węglonośnych zwanych grupami pokładów. Różnią się one rozprzestrzenieniem, liczbą pokładów węglowych i miąższością. Największe znaczenie gospodarcze mają węgle środkowego i górnego miocenu (ryc. 2). Węgle trzeciorzędowe rozprzestrzeniają się na znacznych obszarach Polski zachodniej i środkowej w formie pokładów i rozległych soczew leżących prawie poziomo (ryc. 3). Niektóre ze złóż pokładowych zostały wtórnie zaburzone glacjalnie (ryc. 4). Niewielkie wystąpienia i złoża trzeciorzędowych węgli brunatnych są znane w molasowych osadach karpackiego rowu przedgórskiego oraz w zapadliskach śródgórskich na terenie Karpat (ryc. 1).

Z przedstawionego przeglądu wynika, że największe pod względem zasobności złoża węgli brunatnych w Polsce związane są z trzeciorzędową formacją węglonośną rozwiniętą na platformie paleozoicznej (ryc. 1, 2).

РЕЗЮМЕ

Месторождения и накопления бурого угля в Польше находятся в осадках нижней и верхней юры, верхнего мела и третичного периода. Промышленно использованные месторождения бурого угля связаны с миоценом распространенным на Польской Низменности (рис. 1).

Нижнеюрские бурые угли связаны главным образом с межконтинентальными осадками распространенными в пределах литостратиграфических комплексов разного возраста — с геттанжского до тоарского яруса. Они образовались во время трансгрессивной стадии развития мезозойского осадочного комплекса платформенного покрова. Подобным характером отличаются верхнеюрские болотные отложения с обломками бурого угля из южной части любельской мульды. Верхнемеловые бурые угли находятся в северносудетской мульде в пределах комплекса пластов, который начинает регрессивную фазу развития эпиварисцийского осадочного покрова в той части Польши.

Угленосные третичные отложения расположены в Польше на территории трёх геологических единиц: эпиплатформенного третичного северо-западноевропейского бассейна, охватывающего Польскую Низменность, альпийского предкарпатского прогиба и альпийской карпатской цепи (рис. 1). Образование третичной угленосной формации Польской Низменности связано с общими закономерностями развития осадочного платформенного покрова. В палеогене преобладают эпиконтинентальные морские осадки регрессивного цикла, прерванного несколькими трансгрессивными эпизодами (рис. 2). Угленосные континентальные осадки палеогена синхронические с морской формацией, имеют второстепенный характер. Неоген, а местами и верхний олигоцен, представлены межконтинентальной и бракической угленосной формацией, переходящей выше в глинистую формацию (рис. 2).

В разрезе третичного периода на Польской Низменности находится 10 угленосных горизонтов, называемых группами пластов. Они отличаются друг от друга распространением, количеством угольных пластов и мощностью. Основное хозяйственное значение имеют угли среднего и верхнего миоцена (рис. 2). Третичные угли распространяются на большой территории западной и центральной Польши в форме пластов и больших, почти горизонтальных линз (рис. 3). Некоторые пласты были вторично нарушены гляциальными процессами (рис. 4).

Небольшие накопления и месторождения третичных бурых углей находятся в молассовых осадках карпатской предгорной впадины, а также в межгорных прогибах на территории Карпат (рис. 1).

Из представленного выше обзора видно, что самые богатые месторождения бурого угля в Польше связаны с третичной угленосной формацией распространенной на палеозойской платформе (рис. 1, 2).