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CHANGE OF THE SUBSTANTIAL COMPOSITION AND QUALITY OF COALS ALONG THE STAGES OF COAL ACCUMULATION DURING THE CARBONIFEROUS IN THE UKRAINE

Summary. Substantial composition and quality of coal vary considerably laterally and along the vertical section. The main factors caused the variability of coal types are flooding and flowing of pit bogs which in their turn were affected by paleogeography and paleotectonics. The study of the composition and quality of coals is of great importance for the understanding of initial stages of coal accumulation and for evaluation of ecological consequences of their utility.

WPŁYW WARUNKÓW AKUMULACJI MATERIAŁU WĘGLOTWÓRCZEGO W POSZCZEGÓLNYCH PIĘTRACH KARBONU UKRAINY NA ZMIENNOŚĆ SKŁADU PETROGRAFICZNEGO I JAKOŚCI WĘGLA

Streszczenie. Skład petrograficzny i jakość węgla zmieniają się w sposób znaczący zarówno lateralnie, jak i w profilu pionowym utworów karbońskich. Głównymi przyczynami, które spowodowały to zróżnicowanie, były podtapianie oraz zalewanie torfowisk pod wpływem zmieniających się warunków paleogeograficznych i paleotektonicznych. Badania składu petrograficznego i jakości węgla mają zasadnicze znaczenie dla zrozumienia procesów akumulacji materiału węglotwórczego, a także pozwalają prognozować skutki ekologiczne użytkowania węgla.

One of the most important problems of the coal geology is estimation of influence of different factors of coal accumulation on the substantial composition of coals. Accepting in general the multifactor character of this process the workers have different conceptions on the leading role of certain factors in the accumulation of different types of coals. Some researchers consider the paleotectonics and paleogeography, namely - speed of subsidence of peat formation area and degree of flooding and flowing bogs as most important, the others give the preference to climate and initial plant material (1,11,13).

We believe that the comparative analysis of types and substantial compositions of the Carboniferous coals of the SW part of the East European Platform along the stages of coal accumulation during the Carboniferous can help considerably to the understand this process. (Fig. 1). Five stages of the Carboniferous coal accumulation differ tectonically and

paleogeographically, by climate and character of vegetation which cause the conditions of accumulation, composition and quality of coals. Petrographic types and compositions of coals varied laterally as well as along the vertical profile of coalbearing deposits.

During the Tournaisian - Early Visean the coal accumulation took place in the Dnieper-Donets Depression (DDD) where transgressive-regressive bog-marine poorly coal measures was formed. The coals of this age are durainous and clarain-durainous with (lipoidal and fusinized matter, attrital, desmiite-attrital and fragmentary-desmiite-attrital structure, transitional to the reduction degree. The coals are mainly asheous and high-asheous with average content of ash 24.8 %, from low to high-sulphurous with average content of sulphur 4.7 %.

During the late Visean - Late Serpukhovian time coal accumulation was widespread. Peat formation took place in the seaside swamp lowlands environments.

The regressive Lower Carboniferous coal measures were formed in the Foredeep Dobrudja. The coals are represented by clarains, duraino-clarains with lipoidal and fusinized material and attrital structure. The coals are mainly transitional up to reduction degree, from low to high-asheous with average content of ash 14.25 %, low to high-sulphurous with average content of sulphur 2.2 %.

At the same time the lower regressive boggy-maritime poorly coal-measured subformation formed in the Lvov-Volhyn' Basin (LVB). The coals are mostly durain-clarainous and less extent - clarain and clarain-durain with fusinite and attrital structure. According to the degree of reduction they are of low reduction to the transitional ones. The coals are from low- to high-asheous, with average ash content 13.7 %, from low- to high-sulphurous with average content of sulphur 3.8 %.

In the Dnieper-Donets Depression the second stage was characterized by accumulation of the Lower Carboniferous boggy-lagoonal-marine coal measures mostly with the durain and clarain-durain coals with lipoidal and fusinized material, commonly with attrital structure. The coals are transitional by the degree of reduction. The coals are asheous and high-asheous with average content of ash 15 %, from low- to highsulphurous, with average content of sulphur 3.3 %.

The Lower Carboniferous coal measures formed during this time in the Western and Southern Donbas includes three subformations. The lower (late Visean) boggy-marine poorly coal-measured subformation includes clarain and durain-clarain coals with fusinized and lipoidal material, high-asheous and high-sulphurous (8). The middle (Early Serpukhovian) boggy-lagoonal highly coal-measured subformation contains clarain-duraineous and duraineous coals with fusinized and lipoidal material and attrital structure. The coals are commonly of low reduction, from low-asheous to medium-asheous with average ash content 6.7 %, from low- to medium content of sulphur 1.9 % The upper (late Serpukhovian) boggy-marine poorly coal-measured subformation contains the coals analogous to those of the lower subformation (8).

During the late Serpukhovian-Early Bashkirian stage there formed in LVB the alluvial-lacustrine-boggy-lagoonal regressive-transgressive highly coal-measured subformation with mostly durain-clarain coals, less common - clarain-durain coals with fusinite, attrital, and less common - fragmentary-attrital structures, transitional and of reduction. By the ash content they are from low- to high-asheous with predominance of medium-asheous to asheous. By the sulphur content they are mostly medium- and high-sulphurous (2,3).

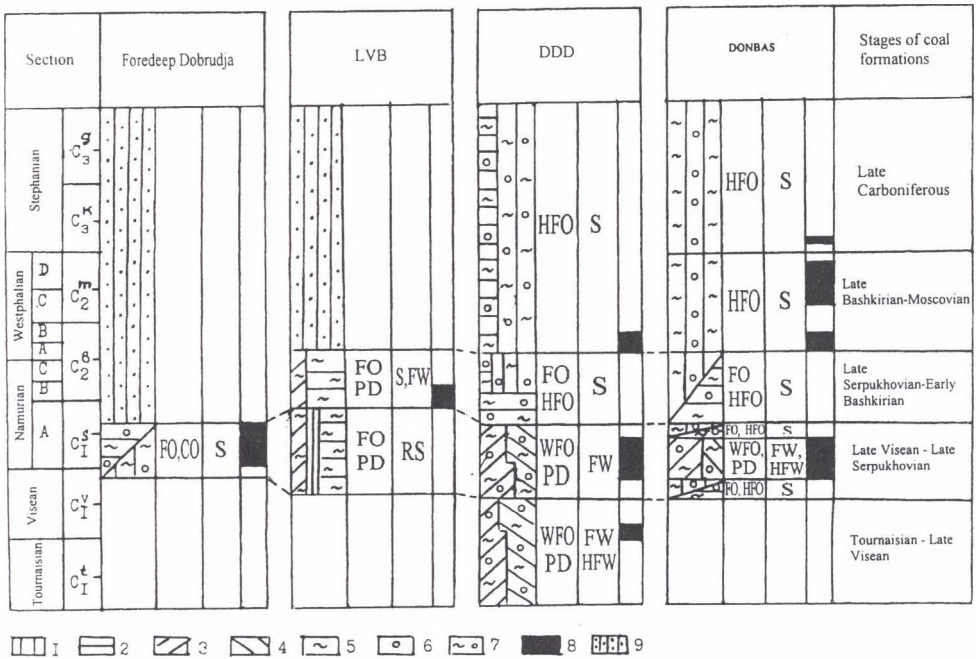
In DDD during this time the lower poorly coal-measured part of the alluvial-boggy-marine coal measures accumulated. The coals are clarain and durain-clarain with fusinized and lipoidal material, attrital, and less common - desmiite-attrital and fragmentary-attrital structure; by degree of reduction they are mostly transitional. The coal are mainly high-asheous, with average content of ash 21 %, most common low sulphurous although the average of sulphur is 4.4 %.

During the same time in Donbas the lower part of the alluvial-boggy-marine coal measures have been formed. It includes the clarain and durain-clarain coals with lipoidal and fusinized material, desmiite-attrital structures, of low reduction and transitional, with high ash and sulphur content as a rule.(8)

During the Late Bashkirian - Moscovian stage there formed in DDD mainly clarain and, to a less extent, durain-clarain coals with fusinized and lipoidal material, with attrital, and, less common, desmiite-attrital and fragmentary-attrital structure. The coals are mainly transitional as to the degree of reduction. They are asheous and high-asheous with average content of ash 18.4 % and sulphurous and high-sulphurous with average content of sulphur 3.8 %

During the same period in Donbas the middle highly coal-measured part of alluvial-boggy-marine formation with clarain coals with fusinized and lipoidal material, attrital and fragmentary-attrital structure were formed. The coals are mostly reduced. According to the analyses of coals from the mines of the Central Donbas the coals are low-asheous (5.2%0 and medium-sulphurous (2.1 %).

Substantial composition of coals formed during the late Carboniferous underwent essential changes nor in DDD neither in Donbas (see Fig. 1).



1. Clarain, 2. Durain – clarain, 3. Clarain-durain, 4. Durain, 5. With inertinite, 6. With exinite, 7. Mixed, 8. Maximum of coal manifestation and coal content, 9. Hiatuses in sedimentation
FO-flooded, HFO-highly flooded, PD-periodically drained, WFO-weakly flooded, S-stagnant, RS-relatively stagnant, FW-flowing, HFW-highly flowing.

Stages of coal formation: 1-Tournaisian-Late Visean, 2-Late Visean-Late Serpukhovian, 3-Late Serpukhovian-Early Bashkirian, 4-Late Bashkirian-Moscovian, 5-Late Carboniferous.

Stratigraphical section: Tournaisian, Visean, Namurian, Westphalian, Stephanian

Fig. 1. Petrographical correlation of coals and environments of coal accumulation

Rys. 1. Petrograficzna korelacja etapów węglotwórczości i środowisk facjalnych

Comparative analysis of petrographic types of coals proves that they are highly variable in time and space. These changes could be observed in a vertical section in DDD where peat accumulation took place during the whole stages of the Carboniferous Coal Formation. There durain and clarain-durain coals of the Tournaisian-Late Viséan (DDD) and Late Viséan - Late Serpukhovian (DDD, Donbas) stages were replaced by durainclarain and clarain coals of the Late Serpukhovian and early Bashkirian, which, in their turn, were replaced mostly by clarain coals of the Late Bashkirian- Moscovian and Late Carboniferous. It is illustrated by the changes of microconstituent composition of coals of DDD and Donbas according to the stages of coal formation which testify the regularity of increase of vitrinite content from early to later stages (Tab. 1).

Table 1
Variation of microcomponent composition of coals in vertical section along the stages of coal accumulation

Microcomponents Stages	Vitrinite		Inertinite		Exinite	
	Donbas	DDD	Donbas	DDD	Donbas	DDD
Late Carboniferous	-	-	-	-	-	-
Late Bashkirian - Moscovian	79	76	13	10	8	14
Late Serpukhovian-early Bashkirian	79	79	13	11	8	10
Late Viséan-Late Serpukhovian	55	52	23	30	22	17
Tournaisian - Late Viséan	-	36	-	34	-	30

In LVB there is no essential changes of coal types at the boundary between the Lower and Middle Carboniferous.

The evaluation of the variability of coal composition laterally can be done for the Late Viséan - Late Serpukhovian (II) and Late Serpukhovian - Early Bashkirian (III) stages characterised by widespread peat accumulation over the territory of the Ukraine. As it is shown in Fig. 1 in the Foredeep Dobrudja and LVB the coals of the second stage are represented mostly by durain-clarain and clarain. In the east in DDD and Donbas durain and clarain coals prevail. In contrary the Late Serpukhovian- Early Bashkirian coals (III stage) of LVB are characterised by widespread durain-clarain and clarain-durain coals, but in DDD and Donbas the role of clarain coals increase in the composition of the coal coals. It can be illustrated by average data of microcomponent coal composition changes which tell us about considerable decreasing of the vitrinite content from the Foredeep Dobrudja towards DDD during the second stage and about the opposite tendency during the third stage (Tabl. 2).

Table 2
Lateral changes of microcomponent composition of coals

Microcomponents	Stages	Basins and coal-measured area			
		Poredeep Dobrudja	LVB	DDD	Donbas
Vitrinite	III/II	-/81	70/76	79/52	79/55
Inertinite	III/II	-/11	23/19	11/30	13/23
Exinite	III/II	-/8	7/5	10/17	8/22

As to the reasons of the coal types changes vertically through the sequence and laterally it should be pointed out that during the Early and Middle Carboniferous Ukraine was situated in the southern equatorial belt of the Westphalian floral zone characterized by humid warm climate (5). Some aridization was observed in the Tournaisian and Late Serpukhovian - Early Bashkirian But until the end of the Middle Carboniferous when the signs of global aridization were manifested the climatic changes were not considerable enough to cause the abovementioned changes of coal types.

Analysis of the abovementioned material has discovered a certain dependence between the substantial composition of coals and paleogeographical environments of peat accumulation. As a rule, lustrous and semi-lustrous (clarain and durain-clarain) coals are characteristic of the coal measures accumulated in the environments of maritime lowlands and, in contrary, dull and semi-dull (durain and clrain-durain) coals belong to subformations of mostly terrestrial and transitional facies. The same dependence between the compositions of coals and environments of their formation was observed in the other coal basins out of Ukraine. For example, in the Moscow Basin the lower mainly continental subformation contains durain and clarain-durain coals, and the upper one accumulated in marine and transitional environments is characterized by clarain-durain, durain-clarain and clarain coals (12). In the Kisel Basin (7) similar to the Lower Carboniferous formation of Donbas the lower and upper parts of coal measures are represented by durain-clarain and clarain coals, but the middle one, most continental contains durain and clarain-durain coals. Similar changes of the coal types in relation to the environments of coal measures are observed in the Lower Carboniferous coal measures of Byelorussia (6).

Close relationship between the substantial composition of coals and certain paleogeographical conditions testifies the reasons and Factors of general order caused directed process of coal formation. Following many scientists (4,7,14) we consider the flooding and flowing of paleopeat bogs as the most important factors.

Formational analysis of the Carboniferous coal-bearing deposits of LVB and Donbas has shown (9,10) that in the widespread marine environments accumulation of pits took place within the limits of swampy lowlands at the open sea coast. Direct proximity of paleopit bogs to the sea caused their considerable flooding and weak flowing that in its turn assisted intensive heliofication of the plant material and formation of clarain and durain-clarain coals. In case of restricted marine environments and widespread continental ones the paleopit bogs were characterized by smaller flooding, frequent dewatering (draining) and greater flowing. Accumulation of initial substance took place in the conditions of oxygen access, extensive decay of lignin of cellulose tissues and evacuation of humic acids. In the result the organic mass was enriched by most persistent microconstituents (spores, cuticulae etc.), and durain and clarain-durain coals were formed.

The abovementioned data permit to characterize the pit accumulation in Ukraine as follows. At the initial (Tournaisian-Late Viséan) stage pit accumulation took place in the conditions of weakly flooding, periodically draining, flowing and high flowing forest bogs (DDD). Late Viséan - Late Serpukhovian pit formation in the western regions (Foredeep Dobruja and LVB) was in highly flooding and flooding, periodically draining, stagnant and relatively stagnant forest bogs. Due to considerable tectonic activity of the northern slope of the Ukrainian Shield paleopit bogs of DDD and Donbas were characterized more weak flooding and greater flowing. During the formation of early Serpukhovian commercial coal-measured subformation of Donbas pit accumulation took place probably in quagmire and forest quagmire (morass) weakly flooded, periodically drained and highly flowing bogs.

During the late Serpukhovian - Early Bashkirian flooded, periodically drained stagnant and flowing paleoite bogs existed in LVB. Due to more widespread marine environments in DDD and Donbas pit formation took place there in flooded stagnant bogs. Highly flooded and stagnant bogs were common during the Middle and Late Carboniferous as well.

The following conclusions can be done:

1. Substantial composition and quality of the Carboniferous coals of the Ukrainian coal basins are considerably variable laterally and vertically throughout the section.
2. Main factors affected the formation of coal types were flooding and flowing of pit bogs, which in their turn were caused by paleogeography and palcotectonics.
3. Essential variation of substantial composition and quality of the Lower Carboniferous coals do not correspond to the conception of rather monotonous mainly clarain and durain-clarain sporal type of coals and of exceptionally widespread environments of highly flowing pit bogs in the Early Carboniferous. Studied materials are of great importance for understanding of processes of initial period of coal accumulation. Investigation of substantial composition and quality of coals play important role in evaluation of ecological consequences of their utilisation.

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