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THE MAIN GEOLOGICAL FACTORS INFLUENCING ON FORMATION OF INDICES OF COAL QUALITY (on the example of the coal deposit «Neryungrinskoye»)

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Genetic and epigenetic factors influencing on formation of a coal bed (its characteristics expressing by means of morphology, petrographic composition, degree of reducing, metamorphism, oxidation, and dislocation, physical properties and indices of coal quality) are considered. The main task of this research consisted in establishing of the significant factors influencing of the coal bed quality indices to a greater extent. Solution of the set task from positions of a system approach at study of rock massifs consisting in revealing and studying of many interconnected elements and estimation of their influence by means of alternate normalization of the main bounds is shown.

The study was carry out in conditions of the bed «Moshny» of the coal deposit «Neryungrinskoye» of the Southern-Yakutia basin. The experimental data were treated with use of the correlation-regression methods.

Results of researches allow to use geological information and geophysical methods for operative planning of geologic prospecting process and mining works in more total way.

Indices of coal bed quality are the most important characteristics which define the industrial – economical value and competitiveness of coal deposits.

The coal deposit «Neryungrinskoye» is located in the southern-eastern part of the Aldan-Chulman coalfield. The deposit area is 45 km². The deposit is localized in brachysyncline fold. The industrial coal reserves are connected with the neryungrinskaya suit of high jurassic age.

The suit is characterized by quick change of granulometric composition of rocks in cut and on area. Suit rocks are presented mainly by varigrained sandstones which content is 65...78 %. The dominating sandstones are fine-grained (27...39 %) and medium-grained (20...21 %) ones, the share of large-grained ones is 18 %. Aleurolites have subordinate value (10...17 %), argillites are very rare (0,5...0,9 %), content of gravelites and conglomerates is up to 9,5 %.

The main coal bed is the bed «Moshny», developed on the area about 20 km. The bed thickness is changed from 8...10 m up to 60 m with average thickness about 24 m. At analysis of the bed «Moshny» it is noted the go-

od expressed sequence of changing of petrographic types of coal from bright ones to semi-matt and matt ones. Increase of coal ash content at transition from the low layers to high ones occurs according to this change. Heterogeneity in the bed structure is kept on all the area of the deposit that allowed, having applied geophysical methods, to reveal bundles of petrographic complexes inside the bed layer.

This feature of the bed «Moshny» is of great importance at carrying out of prospecting, operation and processings of coal. Correlation bundles are widely used for coordination of geological cuts, making of special plans and maps, division of coals by their quality indices. There petrophysical cuts of the deposit «Neryungrinskoye» on Fig. 1, a, б. The cut is divided in the interval 100...500 m into 2 lithologic-geophysical steps 100...200 and 200...500 m (from above – downwards) within which limits change of physical properties – speed of distribution of longitudinal waves V_p , specific electric resistance ρ_n , factor of porosity K_n , density of the saturated rocks δ_s – with depth does not exceed accuracy of their definition by geophysical methods [1].

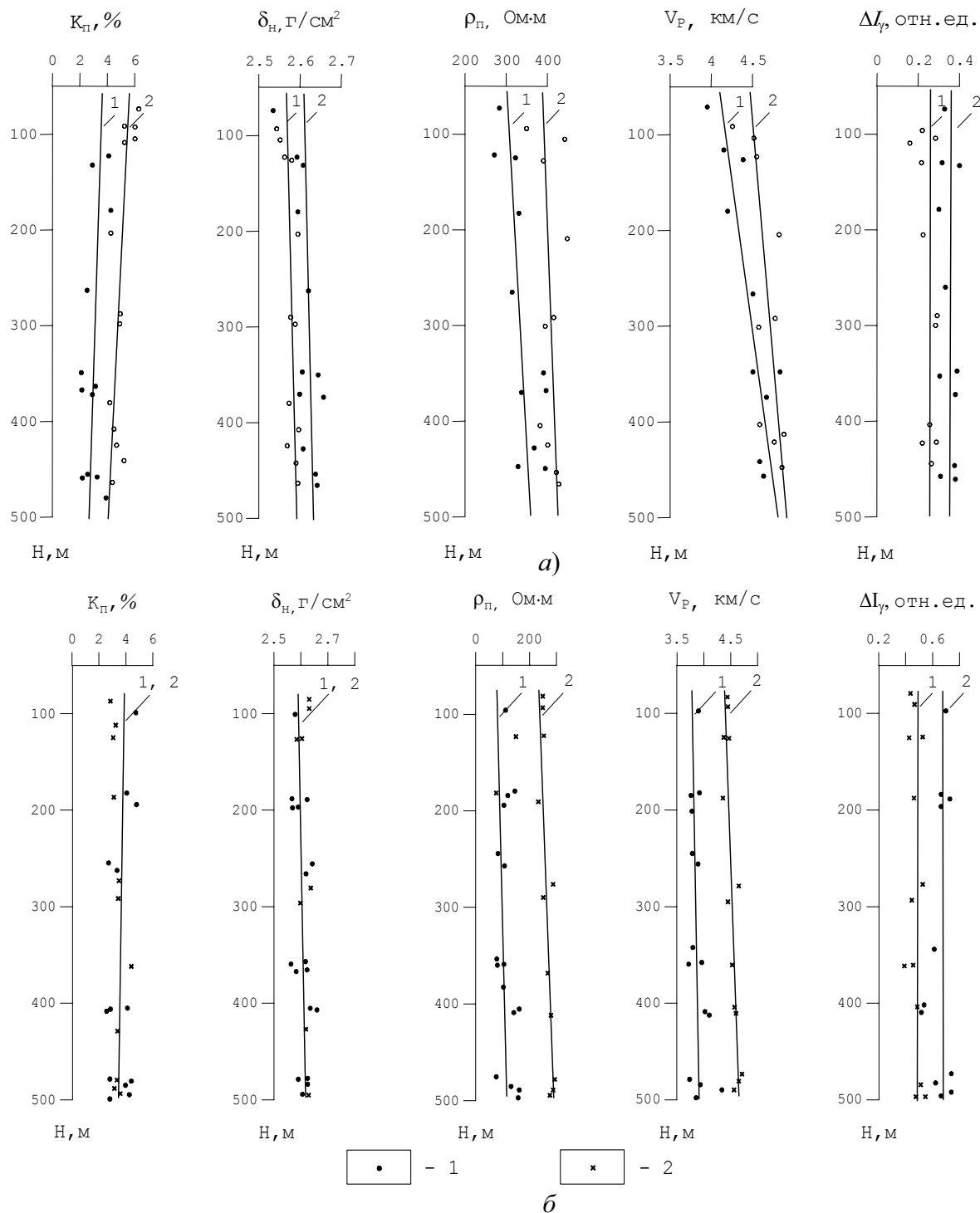


Fig. 1. Petrophysical cut of the coal deposit «Neryungrinskoye»: a) sandstones, б) aleurolites; 1 – fine-grained, 2 – medium-grained

The state of the coal bed is reflected in its natural and artificial physical fields investigated by means of geophysical methods, and characterized by change of physical properties of coals, enclosing rocks and indices of coal quality in dependence on metamorphism degree. Using the data of geophysical researches of bore holes, it is possible to study qualitative and quantitative properties of a coal bed (lithologic structure, capacity and occur-

rence depth, indices of coal quality, physical properties of rocks). The feature of the deposit «Neryungrinskoye» is presence of the very deep zone of oxidation of the bed «Moshny» and almost full absence of the zone of high decomposed unusable coal. The depth of the zone of oxidation in average on the deposit is defined by absolute marks 720...790 m and is more than 200 m on the vertical cut from the maximal mark of the watershed.

Change of physical properties of enclosing rocks and parameters of coal quality depends on maximal paleodepth of immersing during maximal metamorphism of coals and epigenesis of rocks. In the time of progressive epigenesis when physical properties of rocks and parameters of coal quality were formed, this depth was 4400...5150 m at temperature 110...130 °C. For the Southern-Yakut basin it is established, that with increase of paleodepth of immersing are increased: specific electric resistance of enclosing rocks – from 100 up to 450 Ohm·m, speed of distribution of longitudinal waves – from 3,5 up to 5 km /s, density of the rocks saturated with water – from 2,5 up to 2,7 g/cm³, density of dry rocks – from 2,42 up to 2,6 g/cm³, also reflective ability of vitrinite grows from 80 up to 90 %, and porosity of rocks decreases from 8 up to 2 %, an output of volatile matter – from 45 up to 15 % and work humidity – from 0,3 up to 0,2 %.

The coal deposit «Neryungrinskoye» is characterized by presence of the zone of permafrost rocks, enough the large thickness and complexity of the structure of the coal beds presented by several bundles of different petrographic structure, variability of indices of quality, on the area of the deposit and on bedding depth of coal beds. The generalized characteristic of the bed «Moshny» [2] is given in Table 1.

Table 1. Characteristics of the coals of the bed «Moshny2 of the deposit «Neryungrinskoye»

| Grade | Element composition, % | | | | | Indices of quality | | | | |
|----------------|------------------------|-----|-----|-----|-----|--------------------|-----------------------------------|----------------------|--------------------|-------|
| | C | H | N | O | S | W ^a , % | A _{30С} ^a , % | A ^{def} , % | R ^v , % | Y, mm |
| K ₉ | 91,0 | 4,7 | 1,2 | 3,2 | 0,2 | 0,4 | 5,7 | 17,2 | 1,57 | 12 |
| K ₆ | 90,9 | 4,7 | 0,9 | 3,3 | 0,3 | 0,5 | 10,8 | 18,1 | 1,60 | 7 |
| ЗСС | 88,5 | 4,7 | 1,4 | 5,2 | 0,3 | 1,1 | 7,6 | 20,5 | 1,52 | – |

Characters: A^d – ash content; V^{def} – output of volatile matter; W^a – humidity; Y – height of a plastic layer; R^v – reflection ability of vitrinite

Indices of coal quality have been formed as a result of influence of two groups of factors – primary (genetic) and secondary (epigenetic). It is necessary to relate to primary factors the following ones: intensity of tectonic movements, initial organic material, conditions of accumulation of organic and mineral mass caused by paleorelief, hydro-geological and paleoclimatic conditions, chemical composition of environment, material composition of underlying and overlapping rocks, as well as other factors. Totality of these factors can be determined as fascial conditions of sedimentation. The secondary one include postdiagenetic factors – temperature and pressure on depth of the maximal immersing, geological time [3].

Joint action of the listed factors forms a coal bed, its characteristics being expressed by morphology, petrographic structure, degree of reduction, metamorphism, oxidation, and dislocation, indices of quality and physical properties [4].

As the elements reflecting genetic factors, it is possible to accept: lithotypes in cover (L_c) and floor (L_f) of the coal bed, ash content of the coal bed (A^d).

Features of fascial conditions of sedimentation are displayed in values and variability of ash content of the coals. Ash content of the coals of the deposit «Neryungrinskoye» were defined with using of various geophysical methods, the main from them is the method of definition of coal ash content on the data of mGGL-s (selective microgamma-gamma logging). This method allows to have authentic definitions of coal ash content when geological sampling is not certified. Link of indices of coal quality with ash content of the coal bed is shown on fig. 2.

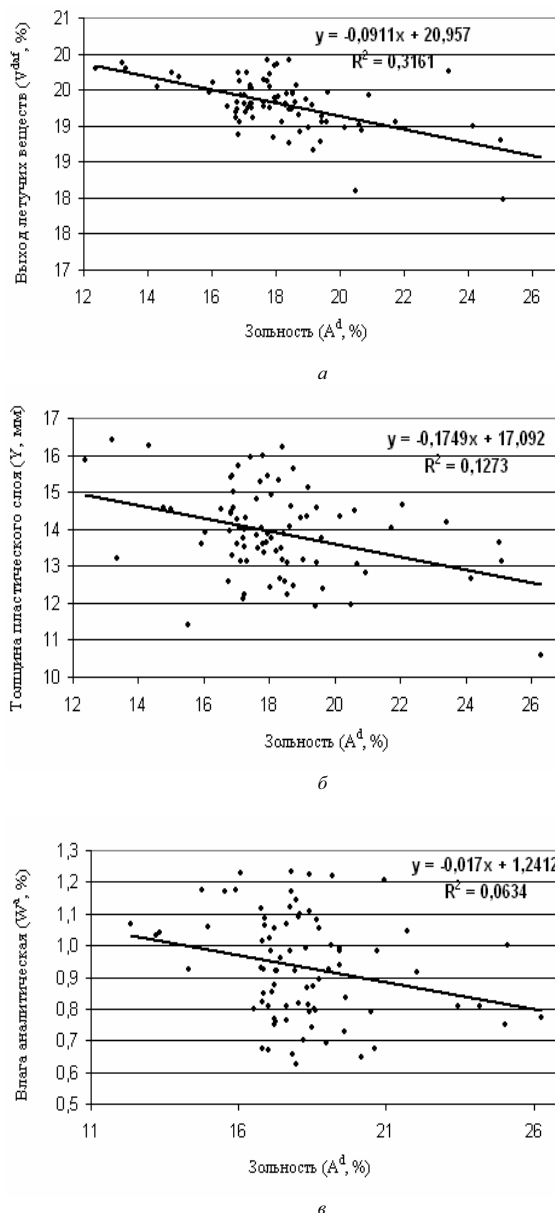


Fig. 2. A field of correlation and diagram of dependence of indices of coal quality on ash content of the coal bed (A^d, %): a) output of volatile matter (V^{def}, %), б) thickness of the plastic layer (Y, mm), в) analytical moisture (W^a, %)

Lithotypes in the cover and floor of the coal bed define tightness, and consequently energy and mass transfer in the «coal – enclosing rocks» system. At studying

of link of indices of coal quality with lithology of floor and cover of the coal bed it is established, that three classes of lateral rocks – coal, coaly rocks and other sandstone-aleurolite differences are traced enough precisely.

The analysis of influence of epigenetic factors was carried out by consideration of change of indices of coal quality with absolute occurrence depth of the coal layer (H_{abs}). Zones adjoining to border of permafrost rock extent (criterion of rejection is intervals of depths being lower than 50 m from the liquid level in the bore hole) were excluded from consideration.

Link of indices of coal quality with occurrence depth of the coal bed is shown on fig. 3.

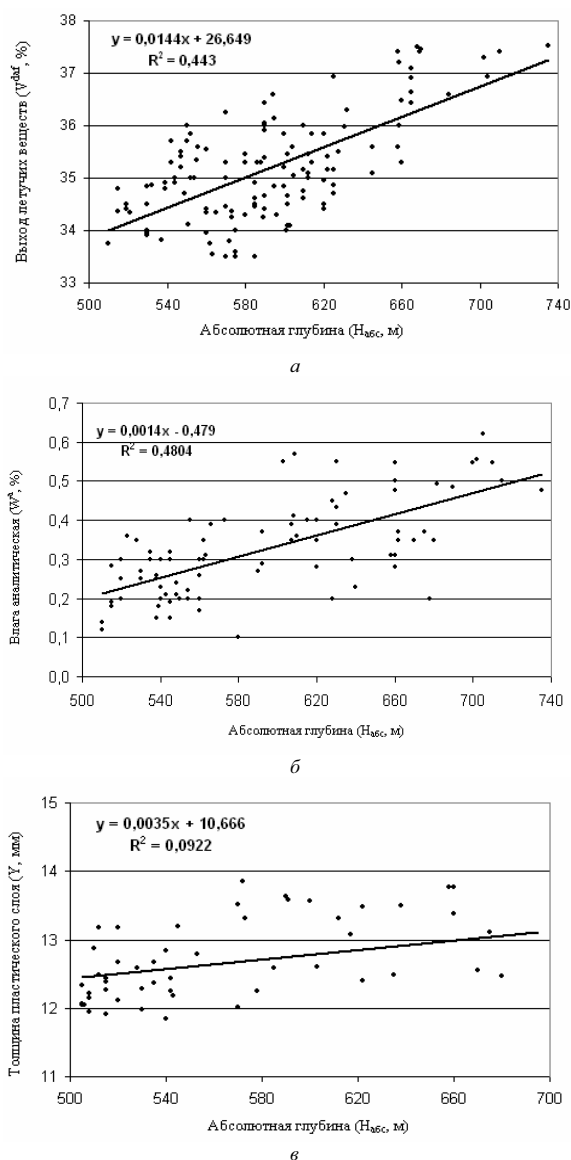


Fig. 3. A field of correlation and the diagram of dependence of coal quality indices on absolute occurrence depth of the bed (H_{abs} , m): a) output of volatile matter (V^{vol} , %), b) analytical moisture (W^a , %), c) thickness of the plastic layer (Y , mm)

The sufficient close link of absolute occurrence depth of the coal bed with output of volatile matter (V^{vol}) is established. The quantity of volatile matter output is increased with change of depth. Change of analytical moisture (W^a) from 0,1 up to 0,6 % is connected with water cutting of the bed with underground waters. The plastometric index (Y) (thickness of the plastic layer), characterizing the degree of oxidation of coals has slight link with absolute occurrence depth of the coal bed. However this tendency should not be connected with influence of regional metamorphism.

Interrelation of coal quality indices with depth from the bore hole mouth (H_{mo}) was studied by the same method. It is established, that analytical moisture (W^a) and thickness of the plastic layer (Y) increases with increase of depth from the bore hole mouth. The insignificant increase of volatile matter output (V^{vol}) is observed.

At studying of coal quality indices it is necessary to take into account the index of the bed bundle (n), geophysical parameter, which is measured by means of the mGGL-s and GL methods as well as coordinates of the considered interval (X , Y) for the analysis of influence of petrographic structure of coals and contents of mineral impurity in them. The degree of constancy of coal quality indices depends on thickness of bundles and coal (without rock and coaly bands), therefore it is necessary to weight these factors on own thickness. Also it is necessary to take into account an environment index as geophysical parameters are influenced with environment (air, water) especially as the high border of the water level, as a rule, is controlled by thickness of permafrost rocks.

The bed «Moshny» of the coal deposit «Neryungrinskoye» is presented by the large differences of mineral composition of ashes in different bundles of coal. In this connection, the method of lithological partitions of cuts of coal prospecting bore holes by geophysical data [5] was used. The bed «Moshny» was divided into five coal bundles with rocky bands. Correlation dependence between parameter (I_{rel}) (relative intensity of γ -radiation, measured by mGGL-s method) and ash content index was established. Using regression dependences ash content of coals of the bed «Moshny» was calculated by bundles composing it. The regression equations are given in Table 2 [6].

Table 2. Dependence of ash content (A_d) from geophysical parameter (I_{rel}) for the coal bed "Moshny" on bundles composing it

| Number of the bed bundle (n) | Coefficient of regression (R) | Regression equation |
|----------------------------------|-----------------------------------|-----------------------------------|
| 1 | 0,84 | $A^a=8,783-14,857\ln(I_{or})$ |
| 2 | 0,91 | $A^a=15,338(I_{or})^{-0,63058}$ |
| 3 | 0,88 | $A^a=94,961\exp(-2,1084(I_{or}))$ |
| 4 | 0,84 | $A^a=93,383\exp(-2,0687(I_{or}))$ |
| 5 | 0,91 | $A^a=19,823-13,035\ln(I_{or})$ |

At a choice of the basic geological factors influencing of coal quality indices, it is necessary to estimate

their influence by means of taken in turn normalization of the basic links. There are sufficiently steady correlation links between the above described geological factors. It turned out that such links are not observed for the coal deposit «Neryungrinskoye».

For example, dependence of volatile matter output (V^{daf}) on the basic geological factors is characterized by low value of plural correlation factor ($R=0,58$) [7]. The equation of regression has this form:

$$V^{daf} = 0,101H_{abc} - 1,122L_{\kappa} - 0,438L_n - 0,597A^d - 0,005H_{yc} - 37,209.$$

It follows from expanded, that studying of indices of quality of coals and coaly rocks should be begun from generalization of the geological factors causing formation and transformation of sediments and sedimentary rocks [8]. Quality of coal naturally changes in process of metamorphism and depends on petrographic composition of coals. To study formation of coals of the concrete deposits it is necessary to take into account the who-

le complex of attributes – degree of reduction of coals, their mineral impurity, fascial, and mineral composition of the rocks enclosing coals. It is expedient to study influence of metamorphism on genetically homogeneous objects, i. e. on the same layers in stratigraphic relation.

The following geological factors which influence in the greater degree on quality indices of the coal deposit «Neryungrinskoye» are determined: absolute mark of bedding of layer (H_{abs}), coordinate of the geological site (X, Y), depth from the bore hole mouth (H_{mo}), lithotypes of the immediate cover and floor of the coal bed (L_c, L_f), the index of the bed bundle (n), the index of environment, thickness of coal and thickness of the bed, relative parameter of geophysical methods of selective micro-gamma-gamma logging (mGGL-s) and gamma-logging (GL), ash content calculated by the method of correlation-regression analysis (A^d).

Research of formation of quality indices of coals has the large practical value to increase level of prospecting works on coal deposits.

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