The geology, petrography and mineralogy composition of coal from the Nováky deposit

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Geologická, petrografická a mineralogická kompozícia uhlia z ložiska Nováky

Na území regiónu Vtáčnik - Horná Nitra sa vyskytujú významné zdroje energetických surovín na Slovensku. Patrí k nim aj ložisko Nováky. Hlbšie podložie je reprezentované horninami veporika a to vápencami, slieňmi a dolomitmi križňanského príkrovu, ktoré sú prekryté hronikom, reprezentovaným malužickým súvrstvím (perm-trias) melafýrových hornín. Najstaršia časť neogénnej výplne panvy je reprezentovaná čausianskym súvrstvím (egenburg), pričom naň diskordantne nasadá kamenské súvrstvie (báden), reprezentované pestrým súborom hornín, tvorených redeponovanými produktami vulkanizmu vo forme konglomerátov, ktoré tvorí priame podložie produktívneho nováckeho súvrstvia. V nadloží nováckeho súvrstvia sú vyvinuté "nadložné íly" košianskeho súvrstvia. Na denudovaný reliéf územia boli uložené sedimenty lehotského súvrstvia.

Vzorky lignitu z ložiska Nováky sú budované prevažne xylitickým detritom, s hrubšími xylitickými vložkami. V macerálovej skupine huminitu má pomerne výrazné zastúpenie denzinit, ulminit B (svetlá varieta), korpohuminit, gelinit a textinit A (tmavá varieta). Macerálová skupina liptinitu je zastúpená suberinitom, rezinitom, sporinitom, kutinitom, liptodetrinitom, bituminitom a identifikovaný bol aj fluorinit. Minerálna prímes je tvorená najmä ílovým materiálom a pyritom. Auripigment a realgár vytvára jemné nálety na vrstevných plochách a tieto minerály vystupujú v spojitosti s rôznymi modifikáciami kremeňa a podieľajú na vysokom obsahu As v nováckom uhlí. Okrem týchto minerálov sa v uhlí nachadzájú aj sekundárne sírany (sádrovec, anhydrid, melanterit).

Key words*: uhlie, petrografia, mineralógia, ložisko Nováky.*

Introduction

In some countries, including the Slovak Republic caustobioliths have been the most important source of energy.

During the geological development of the Slovak Republic territory, suitable conditions for the formation of coal-bearing formations were created several times. Within the stratigraphical span, it presents the period from the Carboniferous to the Pliocene. The West Carpathians as a part of the Alpine mobile zone are characterized by a complex tectonic development with an intensive manifestation within a relatively small space. Frequent vertical motions of the Earth`s crust precluded the formation of a more extensive, flat and shallow basin enabling a greater concentration of plant detritus and hence the formation of greater, extensive accumulation space with the coal-bearing sedimentation.

„Nováky“ coal deposit represents one of the most important accumulation of caustobioliths in the Slovak Republic. The deposit is situated in the Prievidza district. The deposit boundary passes the line: upper ending of the „Koš“ village, „Lehota pod Vtáčnikom“, northern edge of „Kamenec pod Vtáčnikom“, „Nováky“, „Horné Lelovce“, „Opatovce nad Nitrou“ and southern edge of „Prievidza“. The deposit position is pictured in the Figure 1.

The deposit is regionally geologically in the subarea 9E- inner basins, the unit 9EE-Upper Nitra basin and in subarea 10A-Middle Slovakia neovolcanites, the unit 10AE-volcanites of the „Vtáčnik“ mountains. (Vass et al., 1988).

A lot of information about the geological structure was obtained in the exploration process and the mining activity on the deposit. Acquired information was gradually evaluated and in the integrated form summarised in final reports and resource calculations in particular stages of the exploration. That all was in single localities or in the whole deposit.

Coal exploited in the Nováky mine is used for the power industry. The aim of our work was to evaluate the geology, petrography and mineralogy composition of Nováky deposit.

Geological setting

The limestone-dolomite of Triassic age and sediments of Central-Carpatian Paleogene are the oldest verified rocks in the basin creating the deeper deposit underlier (Brodňan, 1970). The „ Kamenec“ formation, marked as a complex of subjacent tuffites, creates the underlying bed of the productive „Nováky“ formation. The formation is created by diversing localities of tufaceous sandstone's, conglomerates and claystones with irregular

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bedding to lensing. New lithogenetic types in the development of formation redefine the „Kamenec“ formation as a volcanosedimentary formation of redeposited and autochthonous pyroclastic rocks with epiclastogene volcanic rocks and coal segments. (Šimon et al., 1994) Upper formation boundary is not sharp; the formation gradually passes into „Nováky“ formation created with coal, bone coals and inner coal seam clays. The only, „main coal seam“ thick 8-10 m is developed in the main part of the deposit. The boundary of the deposit is created partly with tectonics and balk. Dirtbands, built with lightgrey to white sand tuffites, are in the coal seam. Dirtband „b“-thick dirtband and dirtbands „e“ and „f“-sisters are marked as the most characteristic. The main coal seam is created with coal which belongs to lignitic humites from the coal petrographic section. Coal is mostly in hemi and orthophase development at the „Nováky“ coal deposit. The main coal seam layer splits to several individual coal berms because of the dirting of the quality of the coal seam part partly in the southern, but mostly in the north-western deposit part. It becomes to the splitting of the coal berm „h3“ because of the separation of the lower coal seam part. The remaining coal seam part splits locally to coal berms „h1“ and „h2“.

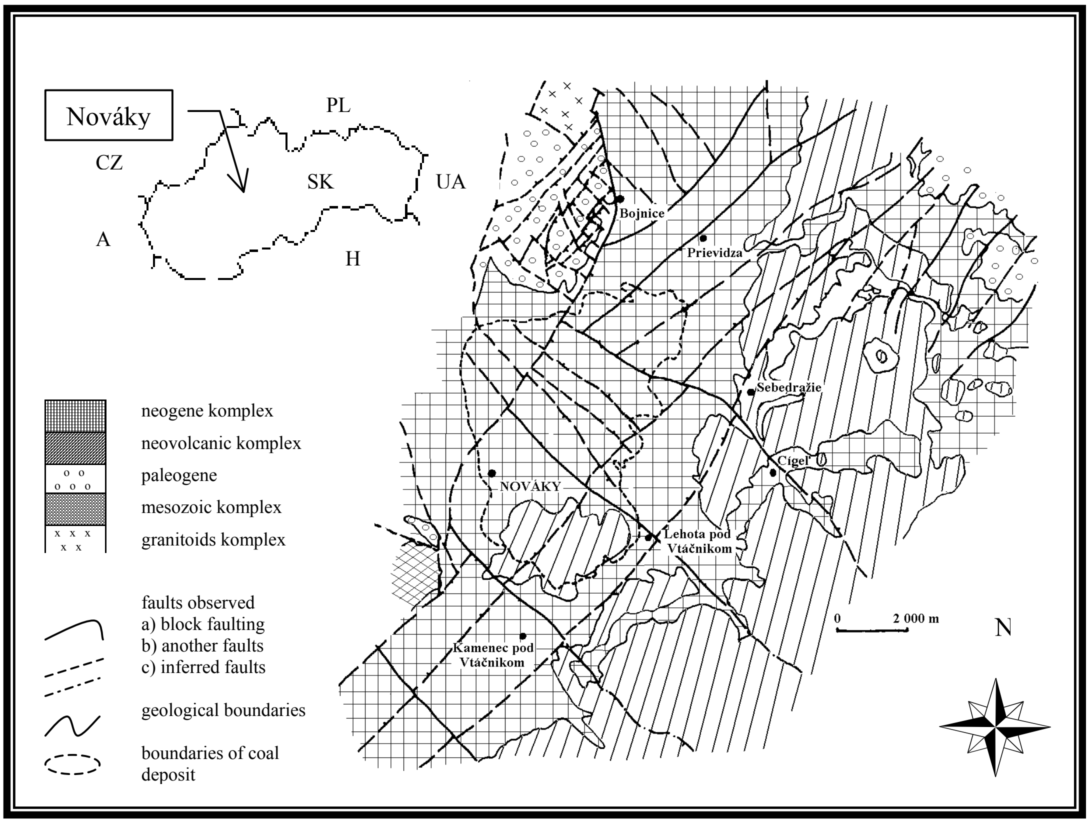


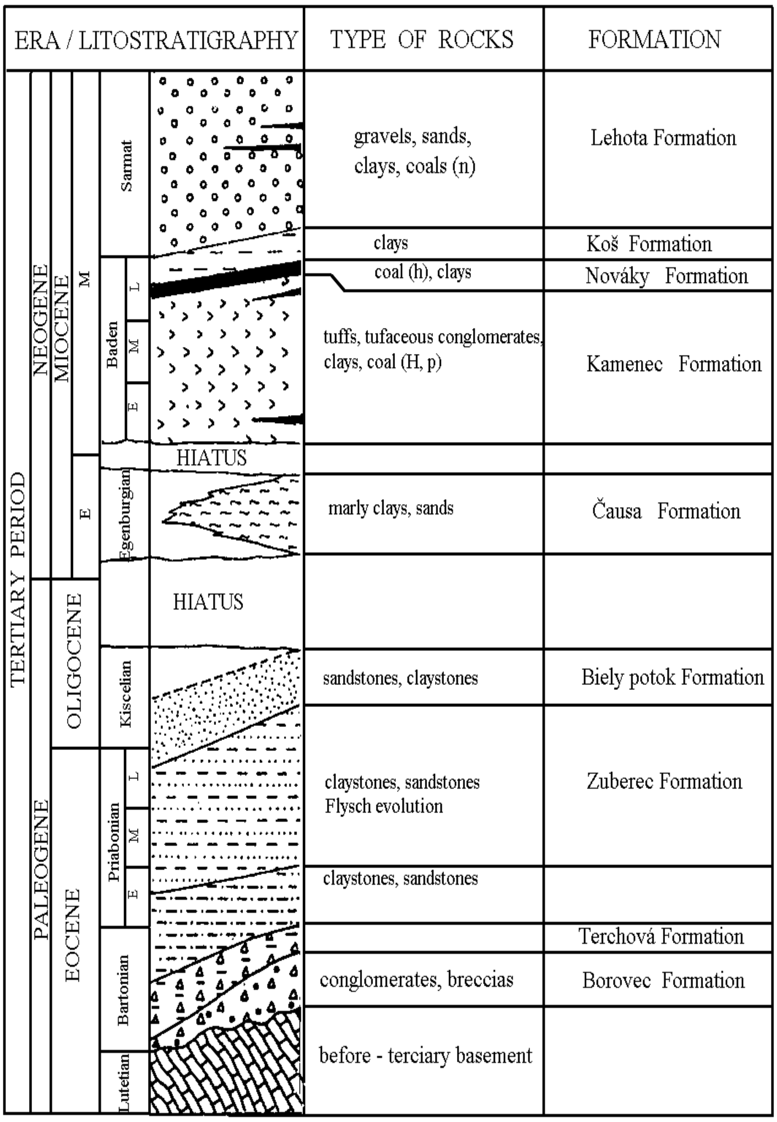
Figure 1. The Nováky deposit position and a geological sketch map.
Obr. č. 1. Situačná mapa a geologická schéma ložiska Nováky.

The thickness of individual coal berms is between 1,1 and 5,0 m. Inner coal seam layers are created with clays, sandy clays and bone coals.

The roof of productive layers is built by „Koš“ formation - thick formation of roof clays. The whole area was destroyed by a tectonic activity which broke the deposit into a very complicated system of fault troughs and horsts in the last phase of this formation sedimentation. The two tectonic fault systems can be defined on the deposit:

- major, which forms basic tectonic structure of the deposit,
- minor, which represents the tectonic failure of the tectonic blocks created by major tectonic faults.

The course of the main tectonic faults is in the southern part of the deposit north-south and in the northern part of the deposit north-west to south-east. The „Lehota“ formation, created with gravels and sands and sandy clays is developed over the roof clays. The Quarternary sediments are over the „ Lehota“ formation.



Tab.1. Stratigraphy of the Nováky coal interval (Verbich,1998). E - upper, M - middle, L- lower, n - overlying coal seam ,h - main coal seam,H - deep coal seam, p – base coal seam.
Tab.1. Stratigrafická tabuľka Nováckeho uhľonosného intervalu (Verbich, 1998).

Macropetrography and micropetrography characterisation

The macropetrographic determination of a layer has a great importance for the further assessment of its physical and technological properties.

Coal – the petrographic analyses prove that the layer belongs to lignitic humites of the degree of interface of lignitic hemi to orthophase. The prevailing kinds are less xylitic detritus, xylite and types of the lignitic orthophase, laminated detritus. The xylitic component has mainly a brown colour, in more calificated types it is matt shiny. The detritus is black and brown with the earthen appearance. The xylitic and detritic lamina alternate chaotically. There are visible transitions between the individual phases. In certain cases, the accumulation of mineral charcoal was observed that is brittle and occurs in clusters. The ways of occurrence and the quantitative share of the individual types of coal show that the layers were mainly formed in the areas of subaquatic and aquatic vegetation.

The microscopic study issued from the principles of coal petrography (Taylor, 1998). The petrographic evaluation of the coal matter samples consisted of the determination of reflectance of gelified huminite macerals (R_0), maceral group contents of huminite, liptinite, inertinite and the determination of the mineral content with emphasis on the various forms of iron sulphides. Microscopic and microphotometric measurement of the polished surface of the coal grains was performed on an UMSP 30 Petro microscope-microphotometer (Zeiss-Opton) in oil imersion (n=1,518) and in the reflected light at the wavelength of 546 nm. Total magnification was 400 x.

The sample examined were lignitic humites with variable xylite, detrite and mineral contents. Huminite reflectance varies from 0,30 - 0,33 % corresponding to the lignitic orthotype. Huminite concentration varies from 60 to 83.3 % and is the most abundant maceral group. The maceral ulminite, textinite and densinite contributes to the high huminite content a characteristic of orthotypic brown coals (Figure 2). The concentration of attrinite and gelinite is substantially lower, i. e. 2,4 % and 1,6 - 3 % respectively. Corpohuminite (Figure 2F) contents does not exceed 4 %.

Liptinite is formed by waxy and resinous substances. The maceral composition of liptinite was determined by a fluorescence measurement. The remaining liptinite macerals, i.e. cutinite, resinite, exsudatinite, bituminite, suberinite, and fluorinite are accessories (Figure 2).

The content of inertinite (fusinite (Figure 2H), sklerotinite (Figure 2E) and inertodetrinite) is low (1,8-2,5%).

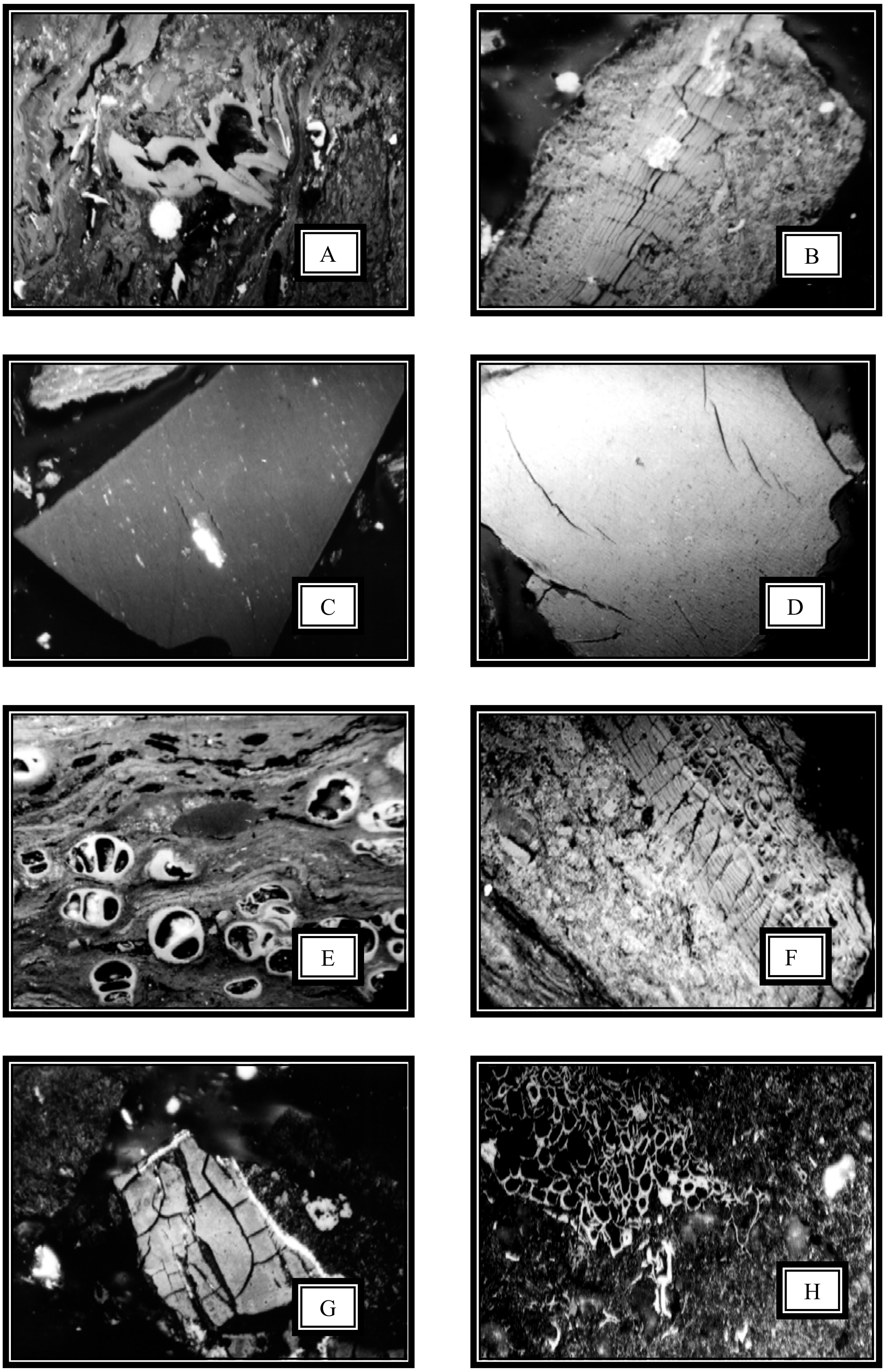


Figure 2. Types of macerals in coal from the Nováky mine (magnified 400x, oil imersion): A.(semifusinite, textoulminite, inertodetrinite, densinite, resinite, framboidal pyrite); B. (corpohuminite, suberinite, densinite, pyrite); C. (EU-ulminite varieta A; D. (EU - ulminite varietaB); E.(sclerotinite, ulminite, textoulminite, resnite;, F. (corpohuminite, suberinite, densinite, inertodetrinite); G.(EU - ulminite, pyrite); H (fusinite).

Obr. č. 2. Typy macerálov v uhlí z bane Nováky (zväčšenie 400x, olejová imerzia): A. (semifuzinit, textoulminit, inertodetrinit, denzinit, rezinit, framboidálny pyrit); B. (korpohuminit, suberinit, denzinit, pyrit); C. (EU-ulminit, varieta A); D. (EU-ulminit varieta B); E. (sklerotinit, ulminit, textoulminit, rezinit); F. (korpohuminit, suberinit, denzinit, inertodetrinit); G. (EU-ulminit, pyrit), H (fuzinit).

Mineralogy characterisation

The coal deposit of Nováky, owing to a varying rock composition of the surrounding mountains and intensive volcanic activities before, during and after the coal deposit settling, has one of the richest parageneses of minerals. Mineral additions are present both in the concentrated form as inorganic slices in the coal and in the form of mineral additions directly in the coal mass. The bond of minerals in the coal deposit has the following forms:

- primary bond in original plants
- bond to the mineral additons in the coal:
- clastic and chemogenous minerals from the sedimentation period;
- minerals arising during diagenesis - coalification
- minerals arising from hydrotherms penetrating the deposit
- minerals arising in the deposit that was already formed, during the circulation of water after tectonic faults
- secondary minerals arising from the decomposition of certain minerals formed by the above - mentioned processes
- bond to freely bound water in the coal in the sediments.

The minerals found out through the mineralogical investigation are given in Table 2 (Verbich, 1998).

Tab.2. Minerals identified in Nováky coal.
Tab.2. Minerály identifikované v Nováckom uhlí.

CLAY MINERALS	Kaolinite, Illite, Montmorillonite, Halloysite
CARBONATES	Calcite, Siderite, Manganocalcite
OXIDES, HYDROXIDES	Quartz, Magnetite, Opal, Limonite,
SULPHIDES	Pyrite, Marcasite, Realgar, Orpiment
PHOSPHATES	Apatite, Phosphorite
SULPHATES	Gypsum, Anhydrite, Melanterite
SILICATES	Biotite, Chlorite, Amphibole, Muscovite, Garnet, Plagioclase, Feldspar, Hydromica, Pyroxenes

Syngenetic mineral additions consist mainly of clayey and tufagenic material that forms a part of the layer structure; besides the macroscopically evident syngenetic mineral additions.

The postgenetic mineral additions consist mainly of pyrite, marcasite, sporadically melnikovite and various modifications of silica that occur mainly as the fracture filling or they incrust the structural components of coal. Pyrite inclusions occuring in the coal of Nováky are of various kinds and they can be divided into three groups:

- relatively coarse inclusions of compact grained pyrite. They occur in the form of continuous interlayers, lentils, concretions and fracture filling. Their thickness is usually from x mm to 3 - 5 cm.
- fine inclusions of the porous or tabular structure form fine interlayers, plates and veinlets that are dispersed in the whole coal mass non-uniformly.
- microscopis inclusions that are distributed in the coal mass non-uniformly. The usual shape of the microscopic parts is spherical and they have a diameter from 25 to 40 μm.

Various modifications of silica form an another postgenetic mineral addition that is not a carrier of an increased content of harmful secondary elements from the chemical point of view, despite of the fact that it is often a significant component of the coal ash matters. It is mainly present as a clastic product of the sedimentation mode. Besides the crystalline form of SiO_2, its amorphous form - opal - is present relatively often. It forms the filling of fractures and contraction cracks in coal. It was formed in the diagenetic stage of the feldspar carbonisation.

Orpiment makes a major contribution to the high content of arsenic in coal. It is the question of an anomalous increase of realgar and orpiment that form fine deposit on the layer surfaces and they also occur in connection with various modifications of silica, especially the colloform one that sporadically fills tectonicaly damaged parts of a layer. The accurate genetic classification of these minerals is not unambiguous because from the viewpoint of their occurrence, realgar and orpiment occur as the filling of damaged zones, they can be classified among epigenetic mineral additions, but they also occur on the layer surfaces and their syngenetic origin also cannot be excluded.

As regards calcite, besides its occurrence in ash matters, the occurrence of calcified organic residues - microboxes - is also usual.

Magnetite and limonite also occurs, but rarely.

Gypsum and anhydrite are minerals that are very close each other, both genetically and by development. In the coal deposit of Nováky they occur in two generations. The older generation is formed by free crystals and their fragments, coatings, filling of cavities with druse-like development. The second generation is formed by so-called "secondary" gypsum that forms microscopic "bloom" on fragments of coal, claystone.

Conclusion

The economic important coal deposits in Slovak republic are bounded for Tertiary horizons of the limnic and paralic development. The overall composition and properties of Slovak coal from the Nováky mine depend slightly on their geological position in the basin.

Coal - petrographic analyses prove that the layer belongs to lignitic humites (lignitic hemi to orthophase). The main part of the organic material consists of huminite (60 - 83,3%) especially ulminite and textinite macerals. Of the macerals of the liptinite group (5,6 - 11,9%) sporinite and resinite are present in the greatest amounts, with smaller contents of kutinite, suberinite and fluorinite. The content of inertinite (fusinite, sclerotinite and inertodetrinite) is low (1,8 - 2,5%).

The mineral phases determined appear intimately associated with macerals and in layers within the organic matter. Their nature and the moment of their sedimentation are related to the depositional environment. The mineral admixture has been determined as syngenetic (clays, tuffogenic and detrital material) on the one hand and as postgenetic, mainly formed by various modifications of quartz, arsenic sulphides (realgar, orpiment), carbonates (calcite, manganocalcite, siderite) and sulfates (gypsum, anhydrite, melanterite), on the other hand, on the basis of the origin. The sulphides of iron can be found in both groups.

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