

GEOLOGICAL CONDITIONS IN THE VINAŘICE ALLOTMENT OF THE Kladno COAL MINE

Roman Živor

Institute of Rock Structure and Mechanics of Academy of Sciences of Czech Republic
V Holešovičkách 41, 182 09 Prague, Czech Republic

ABSTRACT. The Mine Kladno 2 is situated within the rockburst-prone area of the Kladno coal basin. In the present paper, the geological structure of the Mine Kladno 2 is described with main attention to be paid to geological conditions within the shaft safety pillar.

KEY WORDS: Kladno and Týnec Formations; Main Seam of Kladno; Radnice and Nýřany Members; shaft safety pillar.

1. INTRODUCTION

The mining allotment Vinařice is a part of operations of Kladno (former Gottwald) mine within the Kladno coal district. It is situated within the cadastre territories of localities Vinařice, Třebichovice, Švermov and Libušín within the Kladno district and covers the area of 4.8 sq.km. The coal deposit is made accessible by two main development openings – the pits Mayrau and Robert at the mutual distance of about 50 m. The Mayrau pit has been opened in 1877 and the Robert pit in 1885; both shafts are 527 m deep. The mine had the name Mayrau since its opening till 1946. During the years 1946 – 1958 it was named Fierlinger I and since 1958 was named Gottwald II. Now (since 1990) it is designated as Shaft 2 of the Kladno mine (Mine Kladno 2).

Actually, the final extraction of coal reserves in the southern section of the deposit (Engert field) is carried out and mining works for drawing the residual stock, bound within the safety pillar of the Mayrau and Robert shafts, are in due course. Due to the fact that the Mine Kladno 2 is situated within the rockburst-prone area of the Kladno coal basin, safety pillar became an important model area for the research of rock-bursting phenomena and thus also a centre of interested attention of scientists of the Institute of Geotechnics. The purpose of this article is to get acquainted with the geological structure of the Mine Kladno 2, with main attention to be paid to geological conditions within the shaft safety pillar.

2. GEOLOGICAL STRUCTURE OF THE TERRITORY

The mining allotment of Vinařice is situated in the southeastern part of the Kladno basin, which is itself, in accordance with Project (1976), a part of the Central Bohemian limnic Carboniferous, forming a praeplatformic intra-mountain depression of the upper Palaeozoic (Havlena, 1971). The territory consists, geologically, of upper Proterozoic rocks, upper Carboniferous sediments and upper Cretaceous. The Tertiary is represented by the occurrence of basic volcanites and the Quaternary by less thick sediment types.

In respect of lithologic stratigraphy, Havlena and Pešek (1975, 1980) distinguish, in the Central Bohemian Carboniferous (Westphalian C to Stephanian C), from below upwards, four strata series: Kladno, Týnec, Slaný and Líně Formations. This zoning issues from the hitherto frequently used (and in principle still valid) separation by Weithofer (1896, 1902) into lower grey, lower red, upper grey and upper red zones, resp. formations. Within the mining field of Vinařice there occur, from the quoted lithic-stratigraphic units, the Kladno Formation, which is divided further into Radnice and Nýřany Members, and partially the Týnec Formation. The remaining members of the strata sequences of Carboniferous are denudated. The overall thickness of Carboniferous sediments attains here about 550 m and their deposition is subhorizontal with a slight dip (8°) towards NNW. The Carboniferous layers lie discordantly on their bedrock, represented by upper Proterozoic rocks, formed mostly by grey to dark grey phyllite slates, severely permeated by quartz stringers (Příbyl, 1959). The top wall of Carboniferous is represented by denudation relicts of Cretaceous layers belonging to Cenomanian and lower Turonian. At the site of the Mayrau pit, the Cretaceous sediments attain the thickness of 16 m.

The coal seams in this deposit are concentrated in the Radnice Group of Coals, which is bound to the basal part of the Kladno Formation – the lower Radnice Member. The upper Radnice Member and Nýřany Member at this deposit do not contain any coal seams. The Radnice Member is also typical by numerous volcanic horizons.

The Radnice Group of Coals consists, in the studied territory, of two coal seams – the "Basal" Seam of Kladno and the "Main" Seam of Kladno, which stratigraphically correspond to the Lower and Upper Radnice Seams in the Plzeň coal basin (Havlena and Pešek, 1980). The Basal Seam of Kladno is unworkable at this deposit, because of the low thickness and very poor quality of coal. All workable reserves are therefore concentrated in the Main Seam of Kladno with average thickness of 8 m, in places attaining a maximum of 10 m.

The deposit is tectonically affected by a number of faults, running mostly in the NW–SE direction. Like in other parts of the Kladno basin, they are mostly curved, compound faults with unstable course, varying displacement height and a considerably variable dip. The faults resp. their systems are quickly vicarized, pinched; in most cases, the matter is of systems of Y-branching fault zones with anticlonic concomitants forming a fault trough (Spudil et al., 1980) on a shorter or longer section. The most important fault within the allotment of Vinařice is the main fault of the Mayrau mine, running in the NW–SE direction eastwards of the

shaft pillar, and where the displacement height attains up to 117 m. In addition to this main fault, the deposit is affected by other tectonic faults of lower order and the same strike. One of them runs across the shaft pillar, where it disrupts the course of the coal seam. Its displacement height is from 8 m on E to 15 m on W side and the dip varies from 50° to 70° NE. The observation of the displacement activity of this fault in connection with mining operations should constitute one part of research projects studied on this deposit. More particular analyses of fault and joint structures in individual parts of the Kladno basin are quoted in Brož (1982, 1985).

Igneous rocks of the Tertiary age interfere with the NE part of the allotment by the stratovolcano Vinařická hora (Vinařice hill) formed of olivine nephelinite (Mísař et al., 1983). The volcanic stock is accompanied, in the underground, by a swarm of veinous effusions, which pierce the coal seam on several sites. The coal seam is heavily cokefied at contact areas with the igneous rock, at places up to the distance of 1 m (Pokorný and Petráček, 1963).

A basic conception of the territory's geological structure is given by its geological profile in Fig. 1 and the mining situation within the shaft safety pillar is illustrated in Fig. 2.

As far as the occurrence of rock bursts is concerned, the Vinařice allotment is situated within the so-called rockburst-prone area of the Kladno mine district, which lies eastwards of the shaft pillar of the former mine Gottwald I (Max) and where several conditions for the occurrence of rockburst are being created (Matějovský, 1980).

3. DETAILED CHARACTERISTICS OF THE CARBONIFEROUS LAYERS

Sediments of the Kladno Formation were formed in several basically differing surroundings. Havlena and Pešek (1980) differentiated in Radnice Member the lithic facies alluvial-diluvial, fluvial, lacustrine and phytogenic-volcanic. Sediments of the fluvial lithic facies dominate in Nýřany Member. The alluvial-diluvial lithic facies includes mostly the sediments of the type of the so-called basal breccia, representing, in this area, the origin of Carboniferous sedimentation. The fluvial lithic facies is characterized by arcose sandstones to arcoses, isolated conglomerates and grey, mostly thin aleurites and pelites. This type of sediments is mostly represented in the area, while the lacustrine lithic facies with strong predominance of aleurites and pelites is practically missing completely. The phytogenic-volcanic lithic facies is characterized by thick seams with considerable layers of volcanic rocks.

The cyclically arranged white-grey psammites a dark-red aleurite and pelite of the fluvial lithic facies prevail in the Týnec Formation.

The character of sediments of both formations is typically continental, i.e. it is variable both laterally and vertically. As basic environment in both cases, there was an outletless basin, where the sediments of the intracontinental alluvial plain of the mentioned lithic facies took their origin (Havlena and Pešek, 1980).

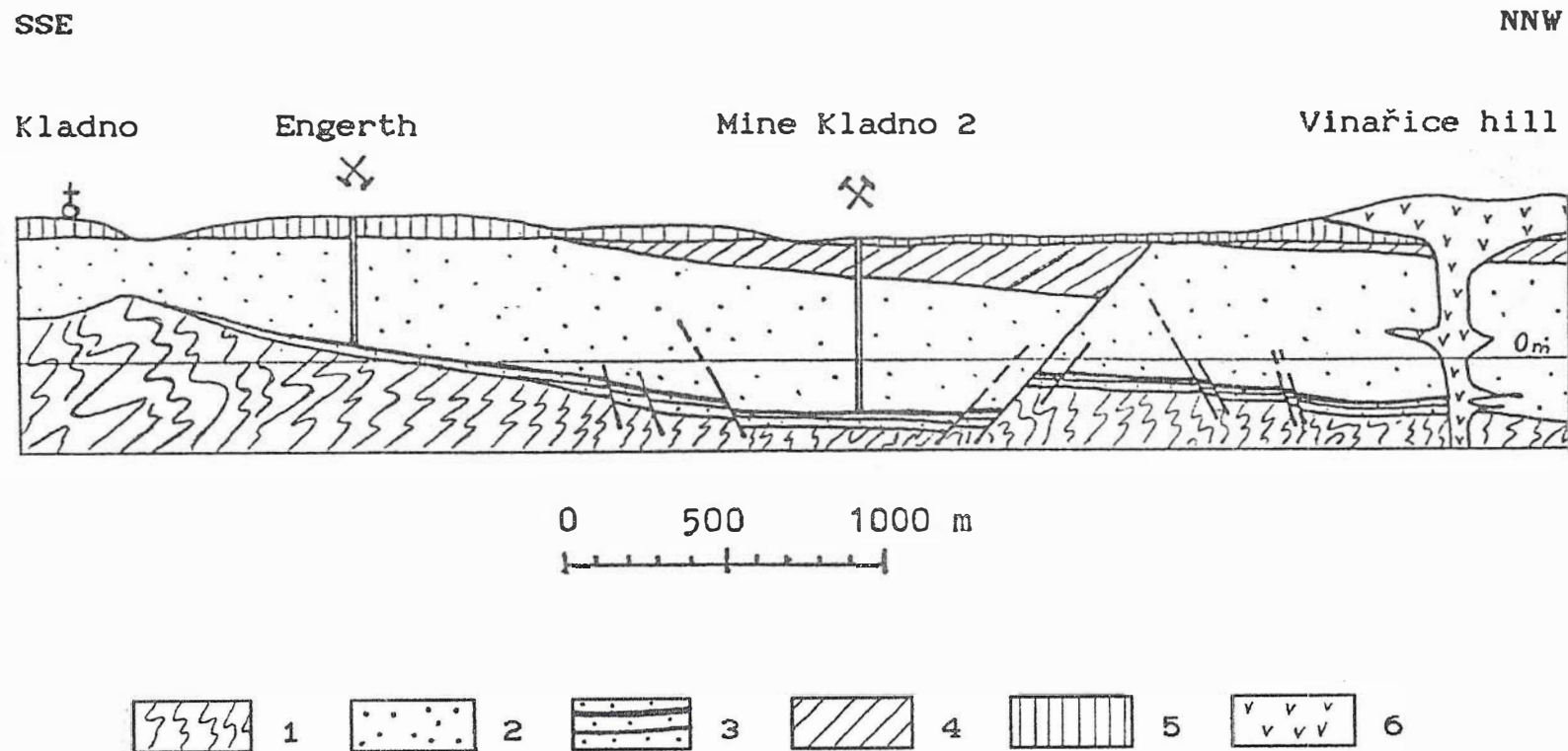


FIG.1: Geological section in the direction NNW-SSE across the mine Kladno 2 (modified according to Šusta 1924).

1 – upper Proterozoic, 2 – Kladno Formation, 3 – coal seams of the Radnice Group of Coals, 4 – Týnec Formation, 5 – upper Cretaceous, 6 – Tertiary neovolcanites.

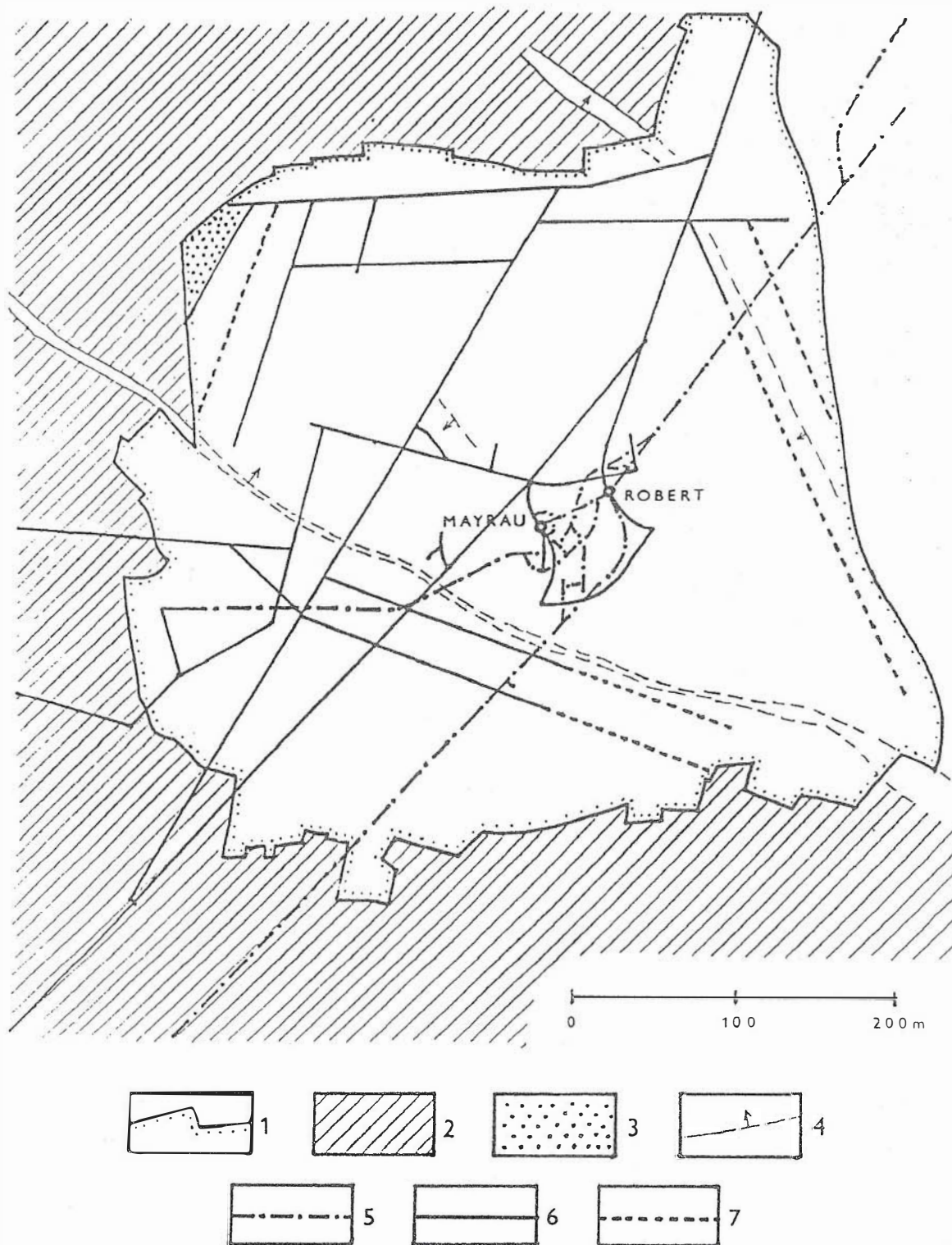


FIG.2: Situation of the shaft pillar of the Mine Kladno 2.
 1 - safety shaft pillar, 2 - excavated seam, 3 - excavated part
 of shaft pillar, 4 - faults, 5 - 7th level, 6 - 10th level, 7 - drift
 project

3.1 Lower Radnice Member

Lower Radnice Member represents the most diversified and, at the same time, economically the most important strata sequence of Carboniferous on this deposit. It includes as already mentioned, the Basal and Main Seam of Kladno, which are separated by an important volcanic layer, so-called Whetstone Horizon. The development of lower Radnice Member on the Mine Kladno 2, mentioned with more particulars in the following text, is illustrated in detail in Fig. 3.

3.1.1. *Underlying rock of the Radnice Group of Coals*

The thickness of Carboniferous bedrock strata between the Basal Seam of Kladno and Proterozoic varies from 1.5 m to 45 m (Příbyl, 1959). The thickness of these layers decreases simultaneously with pinching of seams on rising Proterozoic ridges. The Carboniferous sedimentation begins with the dark-grey basal breccia with fragments of various rocks a sandy binder. The next strata sequence is characterized by alternating of whitish coarse-grained sandstones with dark-grey claystones to siltstones. The underlying bed of the Basal Seam of Kladno consists of a dark-grey siltstone with roots and elliptic concretions of pelitesiderite (Orlov, 1942).

3.1.2. *Basal Seam of Kladno*

Basal Seam of Kladno is not developed within the entire allotment and its thickness attains here max. 1.5 m. The average thickness of this seam within the shaft pillar is 90 cm. The seam is formed of intergrown clayey coal (the so-called "kanafas" – stripped fabric) with ash content $A^d = 49 - 66\%$ (Pokorný and Petráček, 1963) and is not being extracted on this mine.

3.1.3. *Whetstone Horizon*

Whetstone Horizon is a volcanic layer of extraordinary stratigraphic importance, which – in the form of a gradationally stratified tuff – accompanies and thus identifies the Radnice Group of Coals almost in all areas of Central Bohemian Carboniferous. Coal miners have been well acquainted with it for more than 130 years. Feistmantel (1861) pointed as first to the whetstone slate ("Schleifsteinschiefer") and a detailed petrographic characteristic of rocks of the Whetstone Horizon was offered by the study Orlov (1942).

The Whetstone Horizon consists of different petrographic types of rocks, denoted by common miners' terms "bělka" (whitish rock) and "brousek" (whetstone). Arenaceous crystalline-vitrainic to vitrain-crystalline tuffs with a basic clayey substance of the type "bělka" are rocks of white-grey colour, whose appearance corresponds mostly to fine-grained and medium-grained sandstones. The clayey ashy (vitrainic) tuffs of the "whetstone" type and bright grey to grey colour have the appearance of claystones (Mašek, 1967). The average thickness, within the shaft safety pillar, of the whetstones is 1.5 m and that of "bělka" (whitish rocks) is 0.7 m.

On the Whetstone Horizon, on the dark-grey, strongly swelling claystone is deposited, with residues of Stigmara roots, which acceding coal sloams, transfers into carbonaceous shale, forming the immediate underlying rock of the Main Seam of

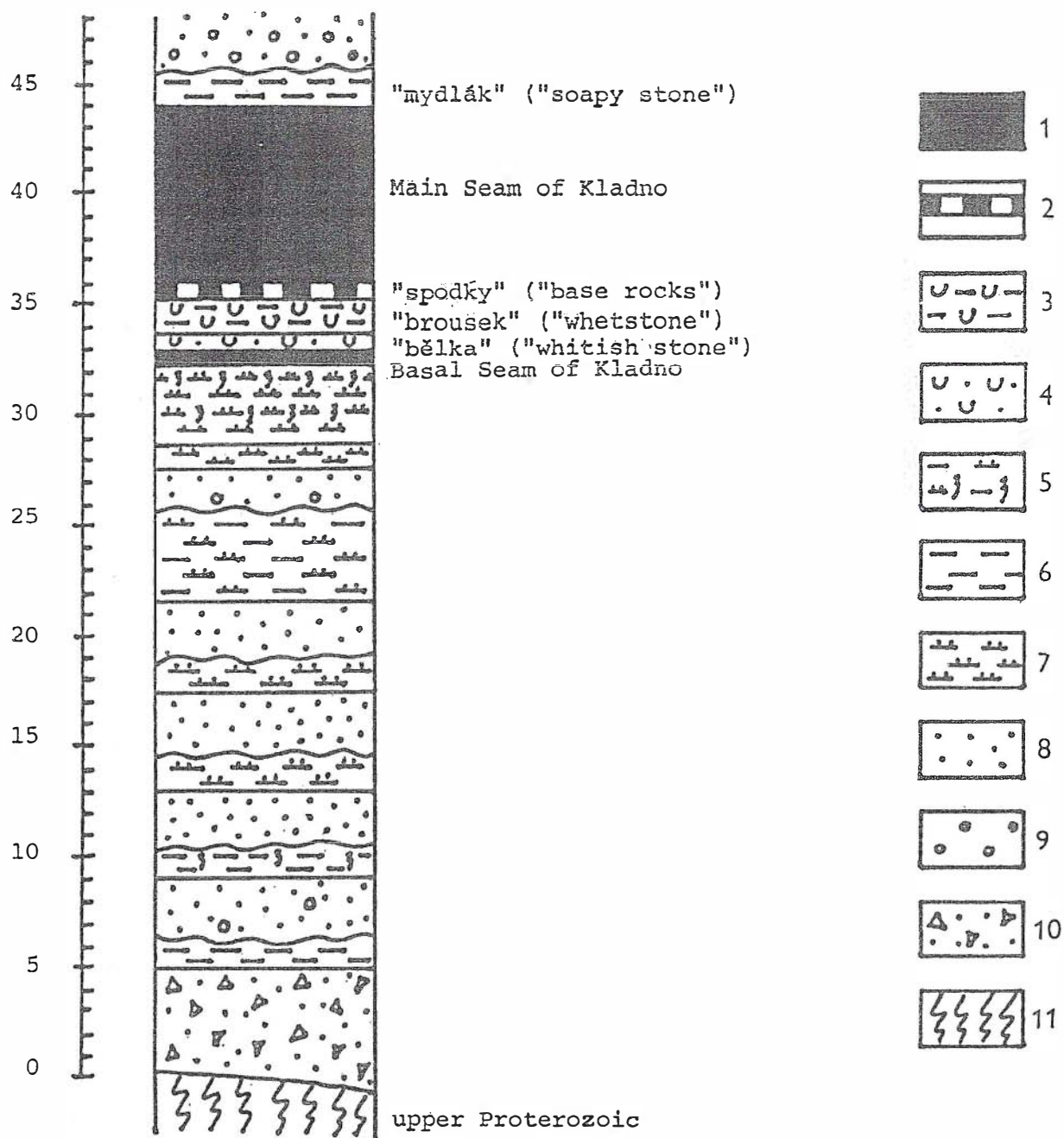


FIG.3: Development of the lower Radnice Member at the Mine Kladno 2 (modified according to Havlena 1964).

1 - coal, 2 - carbonaceous shale, 3 - laminated tuffogenic claystone, 4 - tuffogenic sandstone, 5 - siltstone or claystone with roots, 6 - claystone, 7 - siltstone, 8 - coarse-grained sandstone, 9 - conglomerate, 10 - basal breccia, 11 - phyllitic slate.

Kladno (the so-called "spodky" – "base rocks"). The thickness of this layer varies usually within several dm (Pokorný and Petráček, 1963).

3.1.4. Main Seam of Kladno

Main Seam of Kladno is the only exploited seam on the Mine Kladno 2. Its average thickness within the shaft pillar and its closest neighbourhood is 7.55 m (from 6.76 m to 8.70 m). The seam is usually divided by six tuffitic cliffs into several banks of varying thickness. These cliffs, locally called "opuka" ("clay slate", "marl"), have been known to miners since long ago, serving as guiding horizons for separation and observation of coal banks. They are clayey or clayey to arenaceous rocks, mostly of bright colour shades, characterized, above all, by considerable degree of secondary transformation, namely kaolinization, which concealed the original character of volcanic ash and sand (Mašek, 1967). The thickest of these sloams is (in the lower third of the seam) the so-called "big opuka (slate)" with average thickness of 12.5 cm. This sloam is actually visibly exposed in recently driven drifts at the northern border and in the middle of the shaft pillar, where it attains the thickness of 13 cm. Approximately 1 m above the "big opuka" lies the "small opuka (slate)", and at even higher level three layers (on some places even four) layers of "blue opuka (slate)". Tightly under the hanging wall of the seam, the "roof opuka (slate)" appears.

The coal seam itself consists mostly of bright coal, bright banded coal and banded coal, which dominate over dull and dull banded coal. The fact, that the brittle bright coal types predominate over dull types is – together with considerable seam thickness – in accordance with Příbyl (1978) one from geological factors, contributing to the occurrence of rockbursts in this area, unlike the rockburst-free area, where more plastic dull coal types dominate over bright ones and the average seam thickness is 5 m. Another factor is the deposition depth of the seam, which exceeds 480 m at the Mine Kladno 2, while it varies between 350 and 424 m in rockburst-free areas. A typical macropetrographic profile of the Main Seam of Kladno with the designation of individual "opuka (slate)" sloams and with the indicated thickness of individual differentiated layers is illustrated in Fig. 4. Basic chemical and technological parameters of the Main Seam of Kladno, established from 7 shear samples within the shaft safety pillar and its immediate neighbourhood, are in Tab. 1.

Like in other parts of the Kladno coal district, the Main Seam of Kladno is formed of autochthonous humites of the bituminous coal hemiphase of coalification (Havlena, 1964). According to the international classification, the following code numbers appertain to this coal: 700, 701, 710, and 711 (Pokorný and Petráček, 1963), i.e. flaming coal (high-volatile bituminous coal) of the VIIth commercial group, actually used solely as power plant coal.

3.1.5. Overlying rock of the seam

The immediate top wall of the Main Seam of Kladno contains an average 1.5 m thick layer of a blue-gray claystone with numerous plant fossils, called by miners "mydlák" ("soapy stone"), by which the sedimentation of the lower Radnice Member terminates. It is cohesionless and it caves (falls down) easily immediately after

TAB. 1. Basic chemical and technological parameters of the Main Seam Kladno

parameter		value range from – to	average value
ash content in anhydrous sample	A^d (%)	11.65 – 21.68	15.47
water content in original sample	W^r (%)	10.78 – 14.83	13.22
caloricity of original sample	Q_i^r (MJ/kg)	20.52 – 24.34	22.53
total heat value of combustibles	Q_s^{daf} (MJ/kg)	31.63 – 32.64	32.26

working out the seam (Havlena, 1964).

3.2. Upper Radnice Member, Nýřany Member and Týnec Formation

The entire complex of sediments of the upper Radnice Member, Nýřany Member and Týnec Formation has – on the Mine Kladno 2 – the thickness of 480 to 530 m and it occurs here in the fluvial lithic facies, characterized by the alternation of thicker psammite layers with isolated psephites and thinner layers of aleurites and pelites. Layers are arranged into incomplete sedimentation cycles.

Unlike the underlying lower Radnice Member, the information data on this thick rock complex in the overlying rock of the Main Seam of Kladno are very incomplete, being practically restricted only to original profiles of the pits Mayrau and Robert and crosscuts at the 7th level, i.e. about 100 m above the seam. Within the proper allotment of Vinařice and its neighbourhood, there does not exist any deep borehole and we can use, for the study of overlying rock (in addition to mentioned information), only analogies from relatively well surveyed areas of the Kačice field of the Mine Kladno 1 (former Nejedlý I) and the deposit Slaný, which has been recently studied by mining and geological drilling surveys.

3.2.1. Upper Radnice Member

Upper Radnice Member in the top wall of "mydlák" ("soapy stone") is represented by a considerably thick layer of bright-grey polymictic sandstones with varying grain size, passing at places into conglomerates (Příbyl, 1959). These sandstones and conglomerates attain, within the Vinařice allotment, the thickness of 40 to 70 m; the thickness within the shaft pillar varies around 60 m. They consist mostly of quartz grains; quartz prevails in the basic substance, less frequent are kaolinite and sericite, sometimes there occur also some carbonates (Příbyl, 1978). Sandstones with siliceous binder are strong, but brittle, and their caving into excavated stope is usually accompanied with rockbursts. The mentioned petrographic composition of these psamites and their considerable thickness are, according to

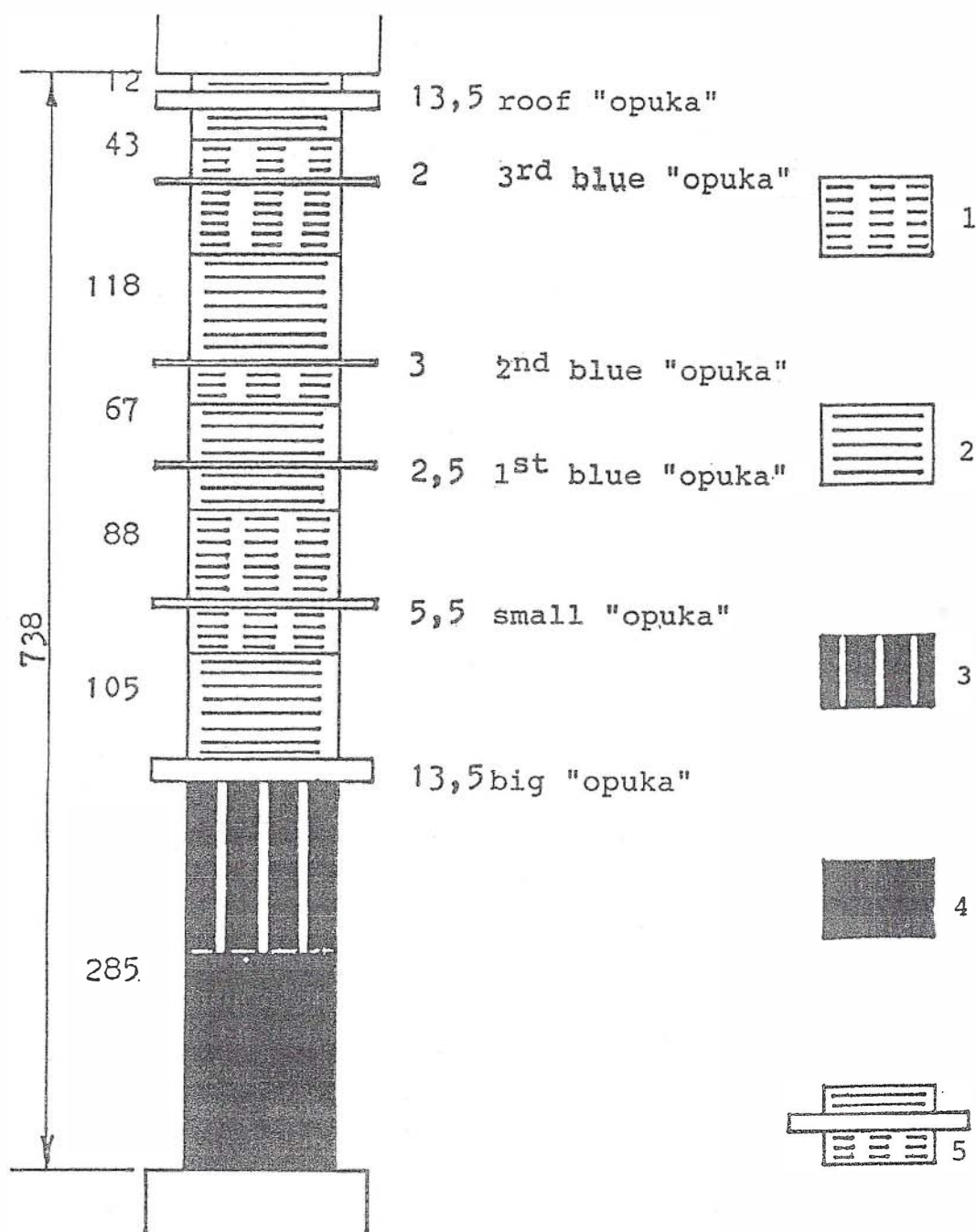


FIG.4: Macropetrographic profile of the Main Seam of Kladno in the western part of the shaft pillar of the Mine Kladno 2 (shear sample 1/76 – modified according to documentation of the Geological department of the Mine Kladno 2).
1 – bright banded coal, 2 – banded coal, 3 – dull banded coal, 4 – dull coal, 5 – "opuka" (arenaceous marl) cliffs.

Příbyl (1978), further geological factors, contributing to the occurrence of rockbursts in this area. The thickness of equivalent overlying sandstones in the rockburst-free area varies between 25 and 38 m and the basic substance of these sandstones consists mostly of kaolinite and sericite.

Unlike the Kačice and Slaný regions, where economically workable seams of the Lubná Group of Coals occur, the upper Radnice Member on the Kladno 2 mine do not contain any coal seams, neither the characteristic tuffitic layers. A single equivalent of the Lubná Group of Coals is a 10 cm thick small coal seam, encountered within the profile of the Robert pit.

Basal part of this psephite-psammite layer has been encountered in some mining openings in the shaft safety pillar, most recently during the driving of the inclined drift Ch 3100 at the northern pillar edge. A 3.5 – 4.3 m thick layer of banded siltstone ("soapy stone") in the immediate top wall of the Main Seam of Kladno is covered by an upto 8 m thick layer of bright-grey conglomerate, which passes into the overlying medium – to coarse-grained sandstones. This sandstone constitutes the dominant part of the profile of upper Radnice Member.

3.2.2. Nýřany Member

The boundary between the Radnice and Nýřany Members, characterized by an interruption of sedimentation (Havlena and Pešek, 1980), can be drawn probably at the base of the psephite layer in the depth of 453 m, i.e. about 62 m above the seam roof. The Nýřany Member represents, on this deposit, a 245 m thick complex of fluvial sediments with a pronounced cyclic structure. The basic cycles are mostly of the twin-member type sandstone – claystone with isolated positions of conglomerates. In the Kačice field of the Mine Kladno 1 and in the Slaný region, some cycles contain also small coal seams or their representants with thickness from several dm to more than 1 m. The Nýřany Member in the mining allotment of Vinařice does not contain these small seams; there occur only isolated, maximally some cm thick, layers of coal or carbonaceous shale and tiny coal smudges in sandstones and claystones.

Příbyl and Rudajev (1969) differentiated also in the Nýřany Member and, similarly also in the overlying Týnec Formation, several other thicker layers of sandstones and conglomerates, which create, by their physical-mechanical properties, a suitable medium, within the rock mass, for the stress accumulation and become thus foci of various types of rockbursts. The undermost of these layers, formed by white-grey coarse-grained sandstone and conglomerate, has been encountered in several mining openings at the 7th level. One of them is also crosscut 5001, running from the shaft in SW direction, in whose SE wall, at the stationing of 150 m, there is a chamber driven with length 5 m, width 3.5 m and height 3 m. This chamber was driven directly in the strike line of the already mentioned tectonic fault in the shaft safety pillar, which has been exposed there after removal of breasting at the chamber heading. The tectonic fault here has the strike of 110° and is dipping 70° towards NNE. Its width is 20 – 50 cm and it is filled with a black tectonic clay. According to information from the 10th level, the displacement height in this part of the shaft pillar is 11 m, but it can be assumed that it will be somewhat lower

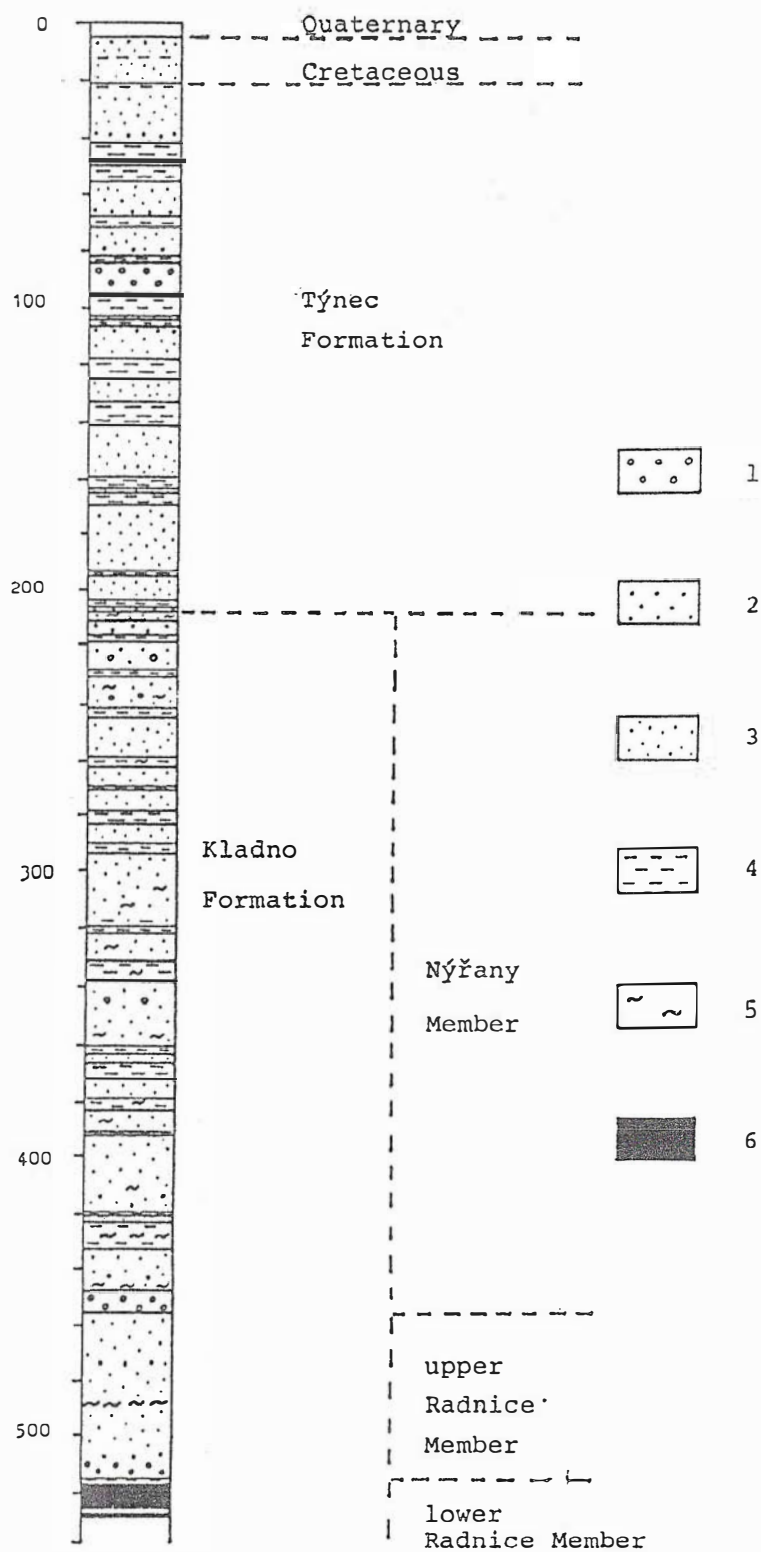


FIG.5: Development of overlying strata above the Main Seam of Kladno at the Mine Kladno 2.

1 - conglomerate, 2 - coarse-grained sandstone, 3 - medium-grained and fine-grained sandstone, 4 - siltstone and claystone, 5 - coal cliffs, 6 - coal.

at the 7th level, due to the probable extinction of the fault towards the overlying rock mass. The overlying floe is formed by white-grey, medium-grained arcose sandstone; the underlying floe consists bright-grey coarse-grained arcose sandstone to conglomerate and their underlying rock is formed by dark-grey claystone. That sandstone and claystone form stratigraphically the bedrock of the medium-grained sandstone from the neighbouring floe. The neighbourhood of the fault is characterized water inflow in the mining opening. One concentrated water outflows in the chamber's heading attain the abundance of about 1 l/min., but this is mostly matter of unconcentrated superficial outflows, because the rock mass in the neighbourhood of the fault is frequently fissured. The observation of hydrogeological parameters of inflows will be one research project conducted at this deposit. Other research projects, of which solution will be concentrated into this chamber, should be also the checking of the motion activity of the fault and stress alterations in its neighbourhood in connection with the mining activities.

3.2.3. Týnec Formation

Unlike the precedent stratigraphic boundary line, the border between the Kladno and Týnec Formations is not earmarked by any hiatus (Spudil et al., 1980) and the character of cyclicity is analogous to Nýřany Member. The change of climatic conditions induced only the colour alteration of aleurites and pelites into brown-red; further sediments are those of the fluvial lithic facies. According to Havlena and Pešek (1980), the border may be defined at the base of the cycle complexes, where there occurs systematically the aleurite-pelitic member of these cycles, i.e. at the depth of 208 m. Above that border, there do not occur any coal layers or cliffs, as it was the case in the underlying Nýřany Member. The overall thickness of the Týnec Formation is, according to the profile of the Robert pit, 192 m. This thickness, composition of rock and the sedimentation character are in full agreement with other parts of the Kladno coal district.

The above described development of upper Radnice Member, Nýřany Member and the Týnec Formation in the overlying rock of the Main Seam of Kladno at the Mine Kladno 2 is schematically illustrated in Fig. 5. Further completion of knowledge connected with this overlying rock complex and the application, of the accessible information on petrographic, physical and mechanical properties of rocks from surrounding areas of the Kladno basin to conditions of the Mine Kladno 2, should constitute the main geological program within the research project of rock-bursting phenomena at this mine.

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GEOLOGICKÉ POMĚRY V DOBÝVACÍM PROSTORU VINAŘICE DOLU KLADNO

Roman Živor

V dobývacím prostoru Vinařice dolu Kladno 2 (dříve Gottwald II) se v současné době dotěžují zásoby uhlí v jižní části ložiska (úsek Engert) a probíhají přípravné práce a odtěžování zbytkových zásob, vázaných v ochranném pilíři jam Mayrau a Robert. Důl se nachází v tzv. otřesové oblasti kladenské uhelné pánve a je proto předmětem zvýšeného zájmu pracovníků Ústavu struktury a mechaniky hornin AV ČR. V předloženém článku je podána charakteristika geologické stavby na dole Kladno 2, přičemž hlavní pozornost je věnována zejména geologickým poměrům v ochranném jámovém pilíři.

Po geologické stránce je území budováno horninami svrchního proterozoika, sedimenty svrchního karbonu a svrchní křídly a terciálními vulkanity. Karbonské sedimenty o celkové mocnosti cca 550 m jsou zastoupeny kladenským a týneckým souvrstvím; kladenské souvrství je členěno

dále na radnické a nýřanské vrstvy. Spodní radnické vrstvy obsahují základní a hlavní kladenskou sloj radnického souslojí, které jsou od sebe odděleny významnou tufitovou polohou – tzv. brouskovým obzorem. Základní kladenská sloj není vyvinuta na celém ložisku a vzhledem ke své malé mocnosti a špatné kvalitě není těžena. Jedinou těženou slojí je hlavní kladenská sloj s průměrnou mocností v jámovém pilíři 7,55 m. Celý nadložní komplex sedimentů (svrchní radnické vrstvy, nýřanské vrstvy a týnecké souvrství) se vyskytuje ve fluviatilní litofacii, charakterizované střídáním mocnějších poloh psamitů s ojedinělými psefity a méně mocných poloh aleuropelitů. Vrstvy jsou uspořádány do neúplných sedimentačních cyklů.