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GEOLOGICAL CHARACTERISTICS OF THE “STRMOSTEN” COAL DEPOSIT IN THE REMBAS-RESAVICA SUB-BITUMINOUS COAL MINE**

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Abstract

The Strmosten brown coal deposit, situated in the northern part of the Senje-Resavica Basin, has been the focus of long-term exploration to determine its reserves, quality, and geological framework. Investigations comprised field geological observations, drilling campaigns, underground workings, and laboratory analyses of collected samples. It was determined that the deposit includes multiple brown coal layers of variable quality developed within the Paleogene succession. Petrographic studies and huminite reflectance analysis reveal the presence of dull to semi-bright brown coals with an average huminite reflectance of 0.45%. The tectonic setting is complex, with pronounced fault structures affecting deposit continuity. Based on the processed data, assessments of on-balance and off-balance reserves, as well as potential mining conditions in the Rembas-Resavica Brown Coal Mine, were performed. The results provide a basis for further planning and economic evaluation of exploitation in the brown coal mine.

Keywords: „Strmosten“ deposit, brown coal, geological exploration

1 INTRODUCTION

The intermontane Senje-Resavica brown coal basin (also known as Resavica – Morava basin) is located 160 km south-east of Belgrade near the Resavica town (21.35-21.75° E, 44.15-43.95° N; Figure 1). It is a north-south elongated tectonic depression with a total length of 45 km, width of about 7 km, and cover area over 200 km². The basin is filled up by Lower Miocene fresh water bright brown coal-bearing sediments

[1], with very complex geological setting. Permian sandstone and Mesozoic rocks overthrusting Miocene sediments [2]. Coal exploration and underground exploitation in the Senj-Resavica basin have been ongoing for over 160 years, and today are carried out within the Rembas-Resavica coal mine company. Within the basin, several deposits (exploitation fields) were separated from north to south [2]: Strmosten, Jelovac,

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Leskovica, Đulska sinklinala, Ravna Reka, Pasuljanske livade and Mine Senje. Strmosten, Jelovac, Ravna Reka-IV blok and Mine Senje are currently being exploited.

The Strmosten and Jelovac deposits (mines) are located in the northern part of the basin, while Ravna Reka – Block IV situated in central part Mine Senje covers the southern part of the basin. All four mines are interconnected by underground headings (Strmosten, Jelovac, Bučar, Northern and Southern headings) which link them to the coal preparation (separation) plant located in Resavica. The Resava-Morava coal basin and surrounding areas have been studied over the past two centuries by both domestic and foreign researchers. The basin is a covered type with rare outcrops, so 19th–20th century studies were mainly mining-oriented, while late 20th and early 21st century research used drilling. Coal exploitation began in 1853 at the Senjski Mine. One of the first researchers was Hofman (1875), who produced the first geological map linking coal to Permian sandstones. Later, Žujović (1888) assigned productive series to the Tertiary, while Cvijić (1893) distinguished the “Ravanička” limestones as a separate unit. Other notable contributions came from Šulc (1896), Antula (1900), Ilić (1905), Radovanović (1907), Jakšić (1930, 1935), and Petković (1937), improving knowledge of the basin’s geology [3].

Studies of tectonic structures were significant, particularly Petković (1935) who described two main thrust phases of Permian sandstones over coal-bearing sediments, and Luković (1937), who added a third thrust. Pantić (1953, 1956) identified Miocene freshwater deposits under Tortonian marine formations. Maksimović (1956) conducted extensive field research and created a detailed geological map of the basin, forming a basis for later studies.

Further important contributions came from Andrejić (1988a, b), Aksentijević

(1988a, b), Grubić and Đoković (1982–1987), Grubić et al. (1989, 1992), and Đinović (1991). Montan-geological studies were performed from 1987 to 1992 (Cvetičanin et al.) and in 2002 (Blečić, 2002) to define geological conditions and reserves. Systematic exploration has been ongoing since 1947 (Andrejić 1988–1998; Aksentijević 1988; Glišić 2006).

Petrographic studies of Senjski Mine coal were conducted by Podgajni (1957), Ercegovac and Podgajni (1961), and Ercegovac (1998). Sedimentological research was carried out by Grubin (1996), with Obradović and Vasić (2007) providing a synthesized overview of previous investigations [3].

The Strmosten deposit situated in the northern part of the Senje–Resava Basin has a polygonal shape, with 2.25 km in length (NW–SE direction) and 0.65 km in width (NE–SW direction), and cover an area of 0.44 km² [2].

The Strmosten deposit represents a significant part of the Senje–Resava basin in terms of balance reserves of coal. This deposit encompasses an area characterized by complex lithological and tectonic settings. Detailed geological investigations—conducted through drilling, underground workings, and laboratory analyses—have enabled precise delineation of deposit boundaries, its stratigraphic position, structural framework, and coal quality [2].

The objective of this study is to present the results of the conducted geological exploration of the Strmosten deposit, with a special focus on its geological framework, lithological characteristics, tectonics, and the distribution of the coal deposits. Understanding the internal structure and genesis of the deposit is crucial for planning and executing efficient and safe exploitation, as well as for evaluating the scope of further exploration and mining activities [2].

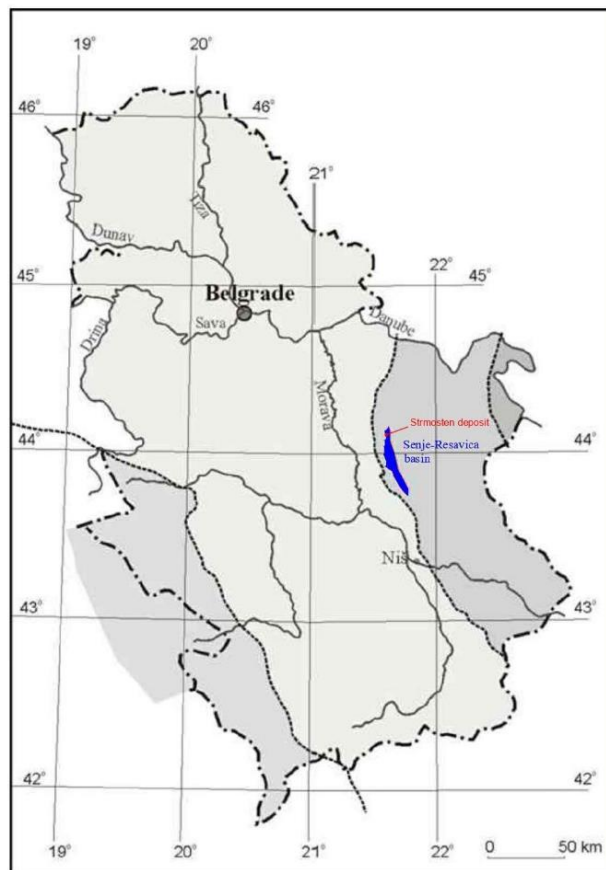


Figure 1 Geographical map showing the location of the Strmosten deposit ([4] modified 2026)

2. GEOLOGICAL SETTING

2.1 Lithological setting of the Senje-Resavica basin

The Senje-Resavica basin consist of Paleozoic schist, Permian sandstone, Mesozoic carbonate sediments, Cenozoic dacite-andesite, coal-bearing sediments and sediments ([2,5], Figure 2 and 3).

The Paleozoic period includes rocks such as Ordovician, Silurian, and Devonian phyllites, shales, sericite schist, chlorite schist, and sandstones. Additionally, Permian red sandstone overlays the coal-bearing layers found within the basin and its under

lying floor. Mesozoic sedimentary rocks include dolomitic limestone, Triassic variegated sandstone, and Jurassic to Cretaceous limestones that range from stratified to massive. Urgonian Cretaceous limestone lies beneath the Miocene series. The Paleogene unit consists of igneous rocks known as banatite. These are andesite and dacite associated with the Ridanj-Krepoljin-Senje fault zone. Tertiary rocks include conglomerates, sandstones, gravels, sands, breccias, coal,

coaly shale, shale, and marl of Lower Miocene age, corresponding to the Aquitanian-Burdigalian stages in the International Stratigraphic Classification. Additionally, Pliocene (Pl) sediments are present, comprising weakly cemented conglomerates, sandstones, sands, sandy limestone, freshwater limestone, coal, and tufa. The complex coal seam in the Senje-Resavica basin has three layers in the northeast, and two layers in the central, eastern, and western areas of the Strmosten deposit as well as in the Jelovac and Senje deposits. The Quaternary is represented by terrace sediments, debris, dilu-

vium, proluvium, alluvium. Most widespread are alluvial deposits, followed by terrace and proluvial sediments in the Resavica and Resava valleys [5].

2.2 Lithological setting of the Strmosten deposit

The paleorelief of the Strmosten deposit consist of Cretaceous limestones and dacite-andesite and andesite, while Permian red sandstone overtrasting early Miocene coal-bearing sediments. Pliocene and Quaternary sediments transgressively laying over the Permian sandstone [5].

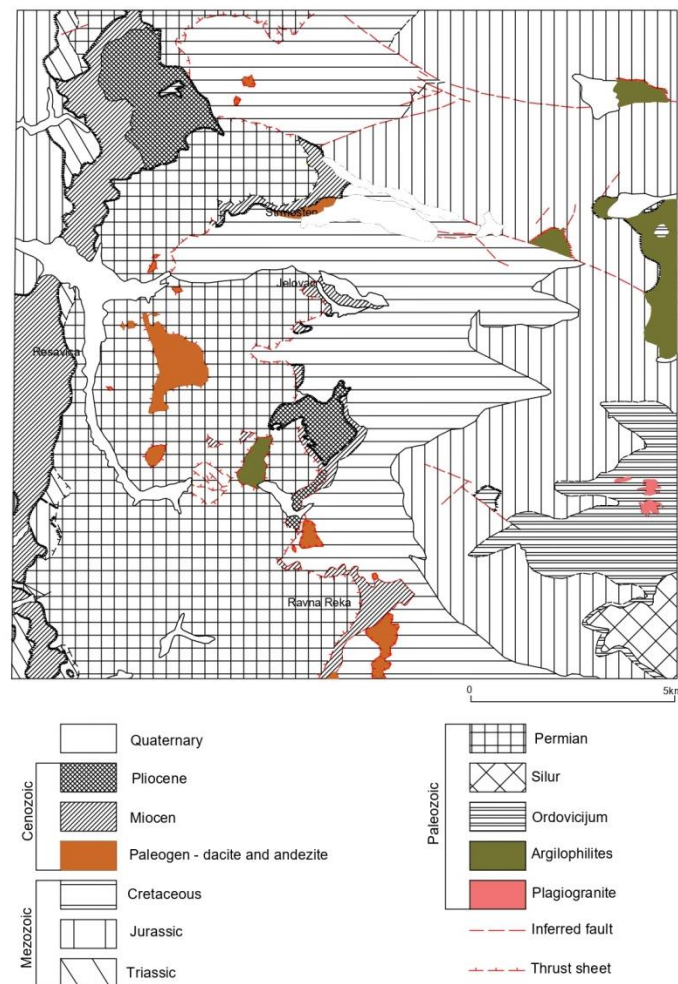


Figure 2 Overview geological map of the Resavica area, scale 1:100,000. ([6] digitized 2026)

Erathem	System	Series	Lithology	Thickness (m)	Description
CENOZOIC	Quaternary		all		Alluvium
	Neogene	Pliocene	PI	250	Conglomerate, sand, carbonate tuffa
		Miocene	M _{1,2}		Clay, sandstone, coal, rarely marlstone, conglomerate and breccia
	Paleogene	Apt	K ₁ ⁴	500	Sandstone and claystone
		Barremian	K ₂ ^{3,4}		Massive limestone of Urgonian facies
		Albanian	K ₁ ¹⁻²		Bedded and laminate limestone
	MEZOZOIC	Cretaceous			Dacite and andesite
		Jurassic	J ₃ ³	400	Tick-bedded and massive limestone, occasionally reefal with corals, Nerinea and sferactinia
			J ₃ ¹⁻²	300	Bedded limestone with lenses of jasper nodules
PALEOZOIC		Middle	J ₂	50	Dolomite
			J ₂	50	Limestone, conlomerat and dolomite
	Permian		P	80	Red sandstone
	Devonian		D	150	Sandstone and claystones
	Silurian		S	400	Argillites and rare sandstone
	Ordovician		O	700	Argillophilites and sandstone

Figure 3 General stratigraphic column of the Senje-Resavica Basin ([6] digitized 2026)

Based on geological exploration, the Strmosten deposit comprises the following lithological units ([3,5]; Figure 4):

- Cretaceous limestones with Paleogene andesite intrusions (paleorelief)
- Basal series (Lower Miocene),
- Underlying series (Lower Miocene),
- Coal seam (Lower Miocene),
- Overlying series (Lower Miocene),
- Permian red sandstone formation and
- Pliocene and Quaternary sediments.

Cretaceous limestones with Paleogene andesite intrusions (paleorelief). Paleorelief of the deposit area, as well as of the basin, consist of Lower Cretaceous limestones with andesite intrusions. Cretaceous limestones occur in the northeastern and southern parts of the deposit area, while andesites have been identified in the southeastern sector. The highest determined thickness is 263.80 m, although it is assumed to be around 1,500 m.

Basal series. The oldest unit of the Miocene succession consists of coarse-clastic sediments (breccias and conglomerates). In terms of composition, these are heterolithic conglomerates composed of clasts of limestone, dacite, and red sandstones. Their thickness decreases from east to west where they pinch out, so in some locations the coal seam lies directly on the limestones.

Underlying series. The series consist of gray-green clayey sandstones with minor interbeds of re-deposited red sandstones in deeper parts, clayey sandstones, mudstones, conglomerates, and more rarely lapilli tuffs. Sediments of Underlying series lie above the basal series with a gradual transition with the maximum thickness of 204.7 m.

Coal seam. The Strmosten deposit hosts a one coal seam with several layers. In the northeastern part of the deposit, it is subdivided into three layers, while in the central, eastern, and western parts it typically splits into two layers. The investigations have established a gradual shift of footwall sand

stone into a coal seam with coal inclusions in the upper parts of floor sandstone [6].

The total thickness of the coal seam in the Strmosten deposit, ranges from 0.05 m to 25.30 m the average of 7.33 m. Coal thickness is approximately 5.87 m [7]. Interburden sediments in the layer are built of marl and coal clay, marl, clayey sandstone and sandstone. Throughout the deposit, the two parts are generally separated by gray clayey sandstones and clays, whose thickness varies from approximately 1 m in the east to about 7 m toward the west. In certain parts of the deposit, in addition to the typical development of the coal seam with marl in the roof, the occurrence of coal above the marl has also been recorded. Above the strongly tectonized marls, there is an intercalated coal seam up to 1.5 m thick, located between the red sandstone and the marl. Based on the distribution and relationships between the lithological units, it is concluded that this coal has a local extent and is probably of allochthonous origin, associated with overthrusting together with the red sandstones.

The coal-bearing series extends in a southeast–northwest direction with a dip to the southwest at an angle of 10° to 20°, while in the eastern parts of the deposit it shifts to a northeast–southwest orientation, dipping toward the northwest.

Overlying series. Overlying series consist of whitish-gray clayey tuffs, clays, and clayey gray-green sandstones. These sediments are partially or completely eroded. A primary characteristic of the remnants of these sediments is their limited thickness and pronounced fissility-resulting from tectonic movements-especially evident in the tuffs. The maximum thickness of the overlying sediments reaches 25.1 m [5].

Permian red sandstone formation. The Permian formation consists of fine- to coarse-grained quartz sandstones ranging in color from red to reddish. The cement matrix is carbonate to siliceous in composition and locally clayey. The thickness of this formation

varies from 176.9 m in the southern part of the to 523.2 m in the western part [5].

Pliocene and quaternary sediments. Pliocene sediments have been identified in the northeastern part of the Strmosten deposit and transgressively lie over the Permian red sandstones. Investigations have revealed the

presence of freshwater limestones, sandy limestones, weakly consolidated sandstones, clays, conglomerates, and coal. Quaternary deposits are represented by alluvial and colluvial formations. The thickness of the Pliocene and Quaternary sediments varies from 0.8 m to 143.0 m [5].

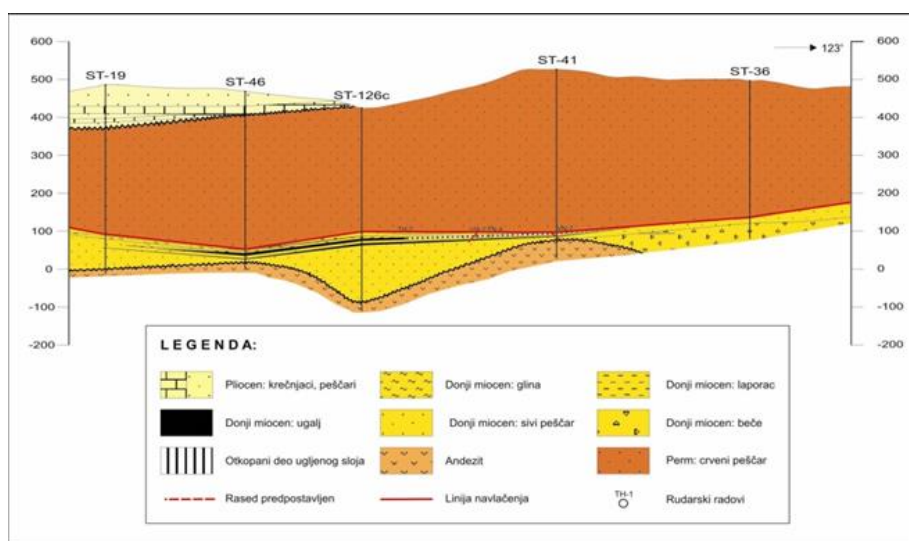


Figure 4 Geological crosssection of the Strmosten deposit ([7] modified 2006)

2.3 Tectonic setting of the Senje-Resavica basin

Tectonically, the Senja-Resavica basin is characterized by a very complex structure with a large number of small-throw faults alongside regional nappes, thrust sheets, and klippes (Figure 5).

The Senje-Resavica basin is a complex tectonic structure that occupies northern part of the western Rtanj and Kučaj nappe. Two large tectonic units are identified in the basin, viz.: (1) Kučaj-Beljanica anticline (autochthon) and (2) nappe of red sandstone and Mesozoic limestone (Ravanica mono

cline, allochthon). The autochthonous tectonic unit Kučaj-Beljanica includes all deposits of the Senje-Resavica coal basin. The allochthon consists of red Permian sandstone and Ravanica limestone thrust over Mesozoic limestones of Rtanj and Kučaj mountains and over Tertiary volcanic rocks along the Ridanj-Krepoljin fracture. It was due to the intricate tectonic pattern of the Senje-Resavica basin with decametric blocks that coal measures deformed and render difficult explorations and coal mining [5].

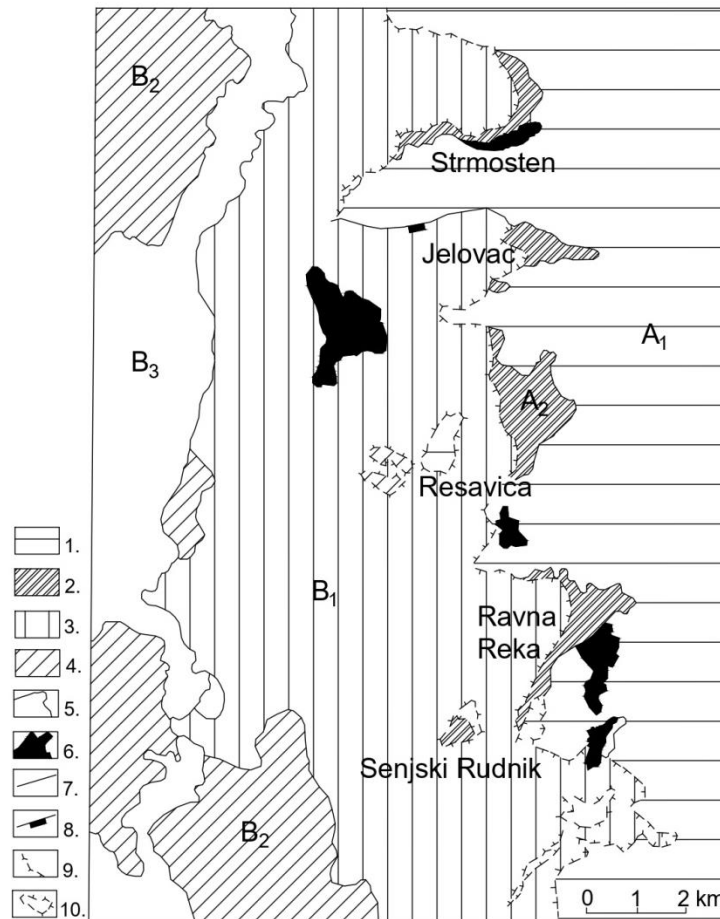


Figure 5 General tectonic map of the Senje–Resava Basin ([4], modified 2026)

1. A1 - First structural level of the autochthon; 2. A2 – Second structural level of the autochthon;
 3. B1 – First structural level of the allochthon; 4. B2 – Second structural level of the allochthon;
 5. B3 – Third structural level of the allochthon; 6. Dacite-andesites; 7. Geological boundary;
 8. Relatively downthrown block; 9. Thrust front; 10. Tectonic window.

2.4 Tectonic setting of the Strmosten deposit

The Strmosten deposit lies in the northern area of the western part of the Rtanj and Kučaj nappe. For the development of the tectonic structure of the Strmosten deposit, the “second klippe” may have been significant, when tectonic movements, reactivating faults (such as the Resava fault) in the al

ready mobile Ridanj–Krepoljin–Senje zone, led to relative subsidence of the autochthonous terrain, over which a red sandstone allochthon was thrust. the Strmosten deposit is located in the southwestern block of the relatively downthrown side of the Resava fault, where four structural levels can be distinguished [5]:

The first structural level comprises Cretaceous limestones and dacites, which form the paleorelief for the productive Miocene coal-bearing series. Photogeological analysis has determined that the limestones in the southern part of the deposit trend east–west or southeast–northwest with a dip toward the north or northeast [5].

The second structural level comprises the rocks of the lower Miocene coal-bearing series. This series lies erosively and discordantly over the first structural level. The coal seam within the Miocene succession trends southeast–northwest with a dip toward the southwest of 10° – 30° , while above elevation 290.0 m in the eastern part of the deposit it shifts to a northeast–southwest trend with a dip toward the northwest. This configuration gives the deposit an apparent undulating appearance due to numerous faults. Tectonic movements during thrusting of the red sandstones onto the Miocene coal-bearing series and the coal deposit severely fractured it into small blocks. The resulting gravity-type faults have a major influence on both the spatial extent of the deposit and the variability of coal thickness. Because the thrust surface of the red sandstones lies directly above the coal deposit in most of the area, even faults with small throws reduce deposit thickness in the footwall side of the faults. Movements that caused tearing of the Permian red sandstones (the overlying unit) together with the coal deposit produced faults of various sizes, with throws ranging from tens of meters down to less than one meter. Such faults occur in the southern part of the deposit, with fault surfaces dipping toward the southwest [5].

The third structural level comprises the Permian red sandstones, which have been tectonically thrust over the Miocene coal-bearing series. Several fault systems have been identified, of which the most pronounced have a strike of approximately 55° . During the development of underground mine workings, clear evidence of

movement—slickensides along the contact surface between the red sandstones and Miocene sediments with an approximate east–west orientation—has been observed [5].

The fourth structural level consists of Miocene and Pliocene freshwater sediments that lie erosively and tectonically discordant over the Permian red sandstones. These sediments are gently inclined toward the west [5].

3 EXPLORATION AND DELINEATION OF THE DEPOSIT

Numerous exploration activities have been carried out within the area of the Strmosten brown coal deposit, largely based on exploratory drilling, mining operations, and laboratory tests of coal quality. These works aimed to characterize the deposit conditions, determine the shape and structure of the deposit, establish the spatial position of coal layers along with their qualitative and technological characteristics, and also to ascertain the physical–mechanical properties of the rocks within the deposit, to a degree sufficient for successful exploitation. To achieve understanding of these characteristics in the Strmosten deposit area, several investigation methods were employed: geological investigation methods, surveying works, hydrogeological studies, geophysical surveys, and laboratory analyses [5].

In the exploration methodology for the Strmosten deposit, exploratory drilling plays a dominant role: boreholes were drilled from the surface, and with the initiation of underground mining works, underground exploration boreholes were also drilled [5].

Delineation of the deposit was performed based on the results of exploration activities—exploratory drilling and mining works. The deposit boundary (the zero contour) was drawn halfway between locations with positive exploration results (i.e., confirmed coal intersections) and those with

negative results (no coal). The primary criterion for delineating the coal layer, i.e., for defining the working contour in the Strmosten deposit, is a minimum recoverable deposit thickness of 1.0 m. The maximum permissible thickness of barren, clayey interlayers is up to 0.5 m (any interlayer exceeding 0.5 m is treated as waste and is not included in the coal deposit). Based on these criteria, the delineation of remaining reserves in this deposit was carried out. Consequently, the remaining portion of the Strmosten deposit is bounded partly by the contour of old workings and partly by the contour projected from results obtained through exploration drilling [5].

4 HYDROGEOLOGICAL CHARACTERISTICS OF THE DEPOSIT

Based on geological studies of the Strmosten deposit and its surroundings, according to the relative abundance of rock types (from most to least widespread) participating in the deposit's framework, three rock groups can be distinguished [5]:

- Permian sandstones,
- Paleorelief rocks (limestones and dacites),
- Miocene coal-bearing series.

These sediments, on the basis of their structural-textural characteristics, porosity, and hydrogeological properties, can be classified into two groups: rocks in which aquifers may develop, and conditionally non-water-bearing rocks.

4.1 Types of aquifers

According to porosity in the lithological members of the Strmosten deposit, three aquifer types may develop: fractured-type aquifers, karstic aquifers, and fissure aquifers [5].

- **Karstic aquifer potential in Cretaceous limestones.** Lower Cretaceous limestones that form the paleorelief

(and its margins to the northeast, southeast, and south—e.g., Veliki kamen, Belo Brdo) show karst features (dolines and other karst landforms) at surface, enabling full infiltration of precipitation. Deeper zones of these limestones contain abundant fractures and caverns filled with younger sediments (sands and sandy clays). Given this infill, observed water inflow does not typically exceed about 2.5 L/s (based on measurements from 1974 to 1991), although greater inflow is possible if fractures and caverns become flushed or newly connected.

- **Fractured aquifer potential in Permian red sandstones.** Although Permian red sandstones are generally hydrogeological isolators due to their primary lithology, their tectonic deformation (thrusting over the Miocene coal-bearing series) creates fracture systems enabling fissure-type aquifers. Moreover, the cement in these sandstones includes siliceous-iron and carbonate-iron matrices (in addition to less favorable clay-iron cement), which are relatively more favorable for fissure permeability. At surface, in the zone of weathering, these red sandstones exhibit intergranular porosity, allowing formation of small, compact aquifers that discharge as springs or seeps. In the red sandstones and at their contacts with Miocene sediments, water inflow into mine workings generally does not exceed about 0.5 L/s.
- **Fractured/low-permeability behavior in dacite-andesites and andesites.** Dacite-andesites and andesites crop out in the southeastern part of the deposit and, together with limestones, form the paleorelief above the Miocene coal-bearing series. These rocks are generally of low permeability, but due to the

presence of fracture networks they may develop fractured-type aquifers of limited yield.

4.2 Conditionally non–water-bearing rocks

This group includes all Miocene rocks, i.e., the entire coal-bearing series (sandstones, coal, clayey sandstones, clays, carbonaceous clays, mudstones, and tuffs). These rocks outcrop in the eastern and southeastern parts of the Strmosten deposit and occur in underground workings. Within the Miocene sediments, seepage and wetting from the coal deposit and tuffs may occur, mainly near contacts with red sandstones or along fault zones. Mining works in the productive series have confirmed localized wetting and minor inflows—i.e., low-yield aquifers within these rocks.

Hydrogeological investigations and existing mining operations have identified occurrences of water in parts of the deposit underlain or overlain by permeable rocks. Water may also accumulate in higher-level old workings, with possible inflow from those accumulations into active mine workings if connectivity exists.

These classifications and observations are essential for drainage planning, water-management design in underground workings, and risk assessment of inflows during exploration and exploitation of the Strmosten deposit [5].

5 GEOTECHNICAL CHARACTERISTICS OF THE DEPOSIT

Based on long time of investigation data at the Strmosten deposit, four engineering–

geological environments can be distinguished [5]:

- the Permian red sandstone complex,
- the Coal seam with preserved overburden sediments,
- the Underlying sandstone complex,
- the paleorelief.

The Permian red sandstone complex is composed of compact fine- to coarse-grained quartz sandstones, thrust over the productive Miocene succession and its substratum. According to the compressive strength classification [5], with values ranging from 15.80 to 78.68 MPa, these rocks fall into the category from very weak to strong. Lower compressive strength is observed only in tectonically damaged zones where rock mass disintegration has occurred.

The coal deposit with preserved overburden sediments beneath the red sandstone cover exhibits compressive strength between 24.55 and 38.24 MPa; accordingly, this environment belongs to the group of soft to moderately strong rocks.

The floor sandstones have compressive strength values from 9.70 to 72.65 MPa, placing them, per [5], in the range from very weak to moderately strong rocks.

The paleorelief of the basin consists of Lower Cretaceous limestones and andesite intrusions. Based on compressive strength, this environment belongs to the group of hard, well-cemented rocks. Investigations of the physical and mechanical properties of coal and the accompanying rocks of the “Strmosten” deposit were carried out on several occasions, with the aim of defining their basic geomechanical characteristics. The obtained results are presented in the table 1.

Table 1 Average values of physical–mechanical characteristics of coal and associated rocks of the Strmosten deposit [3,5]

Rock type	Unit weight (γ) [t/m ³]	Compressive strength (σ_c) [Mpa]	Tensile strength (σ_t) [Mpa]	Cohe- sion (c) [MPa]	Internal friction angle (φ) [°]
Coal	1,33	24,533	3,146	11,150	38°
Red sandstone	2,57	65,20	5,123	12,270	56°47'
Floor sandstone	2,31	13,420	1,50	2,880	50°36'
Clayey sandstone	2,42	9,70	1,150	2,880	50°
Carbonaceous clay	2,21	4,778	-	-	52°

6 COAL QUALITY

Petrographic investigations have shown that the coal of the Senje–Resava Basin belongs to the group of bright brown coals. According to data obtained by petrographic and organic-geochemical analysis [7], mean huminite reflectance values in the Strmosten deposit range from 0.43% to 0.46%, while the average value for the entire basin is $0.45 \pm 0.04\%$. These higher values may be attributed to greater depth, more pronounced tectonic disturbance, and proximity to the thrust-sheet root. The Lower Miocene, hard brown coals of the studied basins are typical humic coals with huminite concentrations between 37.9 and 85.5 vol.%, liptinite less

than 17 vol.% and inertinite less than 14 vol.%. Ulminite is the most abundant maceral with variable amounts of gelinite and densinite. Suberinite, sporinite and liptodetrinite are the most common macerals of the liptinite group, while inertodetrinite and funginite are the most abundant macerals of the inertinite group [8,9].

Statistical processing of data obtained from technical analyses determined the arithmetic mean values of quality parameters for the remaining coal reserves in the Strmosten deposit. The results are presented in Table 2, separately for the main and floor parts of the deposit [4,9].

Table 2 Arithmetic mean values of quality parameters for the remaining coal reserves of the Strmosten deposit

	W ^{ar} [%]	A [%]	St [%]	Sa [%]	So [%]	VM [%]	CM [%]	Coke yield [%]	C _{fix} [%]	GCV [kJ/kg]	NCV [kJ/kg]
Main part of the seam	16,96	14,89	1,21	0,62	0,62	36,04	68,15	47,00	32,11	19.092	18.039
Floor part of the seam	14,52	30,65	1,73	0,51	0,99	31,52	54,83	53,96	23,31	15.524	14.793

Legend: W^{ar} – Total moisture content, as received basis; A – Ash; St – Total sulfur; Sa – Sulfur in Ash; So – Combustible sulfur; VM – Volatile Matter; CM – Combustible Matter; C_{fix} – Fixed Carbon; GCV – Gross Calorific Value; NCV – Net Calorific Value.

In the coals of the Senje–Resava Basin, geochemical analyses were conducted on the contents of twelve potentially toxic trace elements (PTTEs): As, Be, Cd, Co, Cr, Cu,

Hg, Mn, Ni, Pb, Sb, and Se. The arsenic content (11.00–160.00 mg/kg, average 45.38 mg/kg; Table 3) is six times higher compared to the Clarke value for lignites

(7.4 ± 1.4 ppm) and slightly higher than the world average value for lignites. Compared to the geometric mean values for world lignites, the coal from the Senje–Resava Basin shows higher contents of cobalt, chromium,

mercury, manganese, nickel, lead, and antimony. A high manganese content was recorded in the Strmosten deposit. Beryllium, cadmium, copper, and selenium exhibit low concentrations [6,10].

Table 3 Contents of potentially toxic and radioactive trace elements (mg/kg) in brown coals Senje-Resava basin

Element	As	Be	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Sb	Se	U	Th
Min	11,00	0,11	0,02	0,82	2,54	2,27	0,16	20,90	2,74	0,85	0,13	0,20	0,19	0,29
Max	160,00	1,46	0,45	49,90	39,60	23,10	1,16	212,00	41,10	12,20	1,54	1,80	4,14	3,56
AMV	45,38	0,57	0,10	10,88	13,42	7,97	0,38	69,62	15,13	5,23	0,54	0,89	1,71	1,22
GMV	31,46	0,40	0,06	5,86	10,00	6,27	0,30	54,39	10,14	3,68	0,44	0,75	1,08	0,97

Legend: min –minimum value in coal; max-maximum value in coal; AMV- arithmetic mean value in coal
GMV- geometric mean value in coal

7. RESERVES OF COAL

The coal reserves of the Strmosten deposit have been determined based on existing geological investigations and processed in accordance with applicable

classifications and criteria for balance and nonbalance reserves. The total geological reserves and their distribution by classes are shown in Table 4 [3,5].

Table 4 Coal reserves of the Strmosten deposit according to the reserve book

	RESERVE*			RESOURCES*		
Class	balance			nonbalance		
Category	A	B	C ₁	A	B	C ₁
Main + floor deposit	327.480	928.970	1.690.930	113.110		
Total by classes	2.947.380			113.110		
Geological reserves	3.060.490					

Legend: * in accordance with the JORC Code

8. CONCLUSIONS

Based on the conducted geological, tectonic, hydrogeological, geotechnical, and coal quality investigations, it can be concluded that the Strmosten deposit represents a significant and complex part of the Senje–Resavica brown coal basin. The deposit is characterized by highly heterogeneous lithological composition and a very complex tectonic structure, which has a strong influence on both the geometry of coal seams and the conditions of exploitation.

The coal-bearing series of Lower Miocene age shows variable thickness and internal structure, with the coal seam divided into two or three layers depending on the location within the deposit. The presence of numerous faults and overthrust structures, especially the influence of Permian red sandstones, has led to fragmentation of the coal deposit into smaller blocks, which complicates exploration and mining activities.

Hydrogeological conditions indicate generally low water inflow, although local occurrences of aquifers within fractured limestones and sandstones may present challenges during mining operations. Geotechnical characteristics of the rocks range from very weak to strong, depending on lithology and tectonic disturbance, requiring careful planning and support design in underground workings.

Coal quality analysis shows that the Strmosten coal belongs to the group of bright brown coals with satisfactory calorific values, making it suitable for energy production. However, variations in ash content and other quality parameters between different parts of the seam must be taken into account in exploitation planning.

The total geological reserves confirm that the Strmosten deposit has significant economic potential. Nevertheless, due to complex geological conditions, further detailed exploration and modern mining approaches are necessary to ensure safe, efficient, and economically viable exploitation.

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