Pseudosocka Beds with Coal in Borehole Tdp-1/84 Trobni Dol
(Eastern Sava Folds, Slovenia)

Psevdosoteške plasti s premogom v vrtini Tdp-1/84 Trobni Dol
(vzhodne Posavske gube)

Karel Grad, Stevo Dozet, Rajko Petrica & Lija Rijavec
Geološki zavod Ljubljana
Inštitut za geologijo, geotehniko in geofiziko
Dimičeva 14, 1000 Ljubljana, Slovenija

Key-words: coal, chemistry, stratigraphy, tectonics, Upper Oligocene, Miocene, eastern Sava Folds, Slovenia

Abstract

The sedimentary succession with coal in the Trobni Dol area was studied in detail. The coal district lies east of Laško and belongs to the eastern part of the Sava folds. Every attention was given to the stratigraphic problems of the Egerian succession as well as to the coal, his stratigraphic position and age. The Pseudosocka beds are subdivided into the lower Pseudosocka beds, the coal horizon and the upper Pseudosocka beds. The coal seams of the Trobni Dol sedimentary succession were formed in the Upper Oligocene, the Lower Egerian respectively. Finally, the correlation of the Pseudosocka beds from Trobni Dol and western Laško synclinorium area was performed.

Kratka vsebina

Introduction

Geologic investigations in the Trobni Dol area were carried out in the frame of the coal exploration programme in Slovenia. The scope of these investigations was to study the geology of the abandoned Trobni Dol and Pojerje coal mines as well as the area between Trobni dol, Breze and Pojerje (Fig. 1). With this purpose about 16 km$^2$ of the terrain among Breze, Trobni Dol and Pojerje was mapped in detail (Petrica,
Previous investigations

In the past the wider area of Trobni Dol was investigated many times owing to the coal and other mineral resources. A great number of printed and manual works exist on these investigations. The Zollikofer's description of the Tertiary beds among Konjiška gora, Macelj, Sotla and Savinja was one of the first and most important geological works. This work was the basis for the Bittner's and other subdivisions of the Tertiary in this area. Zollikofer (1861) ranged the coal-bearing beds at Zagorje and Trbovlje as well as their continuation to the east of Laško to the oldest Neogene. Stur (1871) described the Neogene beds of the wider area. As Socka beds he considered all continental strata of the region Socka-Trbovlje-Zagorje lying between the Triassic basement and the Marine marly clay. He noticed that the Socka beds of Laško originated in the fresh-water environment and that towards the east a brackish and a marine fauna prevails. Bittner (1884) divided the Tertiary beds between Laško and Zagorje into the "Socka" beds with coal, the marine Miocene beds (Marine clay and green sands, the lower Leitha limestone, the Laško marl and the upper Leitha limestone) as well as the brackish Sarmatian beds. Granigg (1910) noticed that the coal mine Trobni Dol lies in the southern limb of the Laško synclinorium. He mentioned a 72 cm thick coal seam which contains a 37 cm thick clay interbed. He ranged the beds with coal into the Govce beds.

In the period between both wars the study area was explored by A. Winkler, M. Munda and W. Petrascheck. Petrascheck (1926/29) distinguished two horizons of coal: a) - older, from the limnic and brackish "Socka" beds and b) - younger from the Aquitanian marine beds. Munda (1939, 1942, 1953) correlated the "Socka" beds of Senovo, Trobni Dol, Zagorje, Medvode and Bohinj. He mentioned that the Trobni Dol coal formation, can not be of Miocene age taking into account its fossil contents.

The period of most intensive geological investigations occurs after the Second World War with appearance of the following researchers: M. Hamrla, M. Munda, K. Grad, A. Nosan, D. Kuščer, L. Rijavec and others. Hamrla (1954, 1955, 1987) observed that the Laško Tertiary coal seam was getting thinner in the west-east direction. He considered that simultaneously with the predominant marine developments of the Oligocene beds in the east direction, conditions for formation of coal
were less favourable. In short brackish intervals only thin coal seams can be formed. Grad (1962, 1967) gave a geologic outline of the Kozje area. Among Tertiary beds he mentioned the Oligocene, Badenian and Sarmatian ones. He considered the main folding in the area to be Post-Pannonian. Nosan (1956) distinguished three facial types of the “Socka” beds:

1. the “Socka” beds at Zagorje-Hrastnik-Trbovlje,
2. the “Socka” beds in the Senovo basin and,
3. the “Socka” beds between Pohorje and Bohor.

Kuščer (1962, 1967) ascertained that in the Laško-Zagorje synclinorium occurs only one coal seam in the “Socka” beds. The coal passes downwards into a black shaly clay (black footwall) and upwards gradually into the light brown marly limestone and shale with sandy intercalations. Rijavec (1959, 1965, 1974, 1983, 1984 a, b, c, 1986) determined the Tertiary microfauna in the following areas: Rudnica and Boč, Loka at Žusem, Šmarje at Jelše as well as the Trobni Dol and its wider surroundings. She determined the microfauna from the surface and both boreholes of Trobni Dol.

The detailed investigations for the Geological map of Slovenia, the map sheet Celje on the scale of 1:100 000 with corresponding explanatory text written by Buser (1979) are of great importance. The author combined the results of the geological mapping and reconnaissance in the Celje map sheet area a detailed description of the mapping units. He attributed the main folding of the study region to Helvetian.

Lately, R. Petrica et al., P Mioč et al., S. Orehek et al., P. Kovič, M. Mišić, S. Dozet et al., G.S. Odin et al. and M. Jelen et al. contributed to the interpretation and explanation of geologic problematics of the area. Mioč et al. (1983) reported on results of geological and geophysical explorations in the Šmarjeta-Lahomno area. Mišić (1984) analysed with X-ray method the volcanic succession from the borehole Tdp1/84 in the hanging wall of the “Socka” beds. Jelen (1984) examined palinologically samples of the Oligocene marine clay and the “Socka” beds from the borehole Tdp1/84. D. Dozet (1985) and Dozet et al. (1994) reported on results of the geological investigations in the Rudnica anticline area. D. Dozet and R. Rijavec (1994) described geological conditions in the area of Šentjur-Planina-Trobni Dol-Loka at Žusem. Kovič (1984, 1985) described and systematically classified Tertiary rocks of the Trobni Dol area by means of microscopic examination of thin sections. Jelen et al. (1990) described changes of the Oligocene microfossil assemblages in the Zagorje region. Jelen et al. (1992, 1994) established that the “Socka” beds in the southern Karavanke and Socka area are of Middle and Upper Eocene age. Since the beds with coal in the area between Laško and Zagorje are of Oligocene age, they considered the Socka beds as Pseudosocka beds. Odin et al. (1994) presented the results of geochronological analysis of pyroclastic interbeds in the coal from Neža (Trbovlje). The analytical results indicate that the plagioclase samples were erupted at $25 \pm 1.0\text{ Ma}$ ($2\sigma$), therefore the Pseudosocka volcanoclastic layers containing the plagioclase were deposited during the Late Chattian. Petrica et al. (1995) described stratigraphy of the Upper Oligocene and Miocene beds in the Trobni Dol area.

Geographic setting

The Trobni Dol and Pojerje coal mine areas are situated in the eastern Sava folds 10 km east of Laško and 8 km south of Šentjur. This is the area of up to 800 metres
high narrow elevations of west-east direction as well as of steep and narrow valleys being formed by faulting and stream erosion. The access to the investigated area is possible through the Lahomnica valley from the Laško direction, along the Gračnica valley (Jurklošte, Marof) from the Rimsko Toplice direction, as well as from the Šentjur direction passing across Breze.

**Geology of the area Pre-Tertiary basement**

The Pre-Tertiary basement is exposed only along contacts with the Tertiary succession. Most of Tertiary overlies erosively and discordantly the Permo-Carboniferous micaceous shales, quartz sandstones and conglomerates. South of V. Grahovše and in the close vicinity of the abandoned Trobnj Dol coal mine crop out Permo-Carboniferous rocks and Triassic dolomite underlying the Tertiary beds. The other part of the Pre-Tertiary basement is probably built up from the Permian sandstones, Middle Triassic Pseudozilian shales and kerathophyre tuff as well as the Triassic dolomite, which are in tectonic contact with the Tertiary rocks at northern and southern edge of the investigated area.

Stratigraphic and tectonic relationships of the Pre-Tertiary rocks were not studied by us.

**Tertiary**

In the investigated area the Tertiary succession begins with the Upper Oligocene Pseudosocka beds, which lie discordantly upon the Triassic dolomite. Upwards follow grayish green Marine marly clay, green dacitic tuff and repeatedly clayey beds belonging to Egerian and passing upwards into the Govce beds. Discordantly upon the Govce beds rests the Badenian (Tortonian) succession which is discordantly overlain by the Sarmatian sediments. The complete development of the Tertiary beds is similar to the Tertiary developments in other parts of the Laško synclinorium.

**Upper Oligocene**

In the study area the Oligocene comprises the Pseudosocka beds, grayish green Marine marly clay and dacitic tuff. In this paper the Pseudosocka beds from the borehole Tdp-1/84 are considered in detail.

According to Stur (1871) the beds at Socka (north of Celje) and the coal-bearing beds between Zagorje and Trbovlje are described as Socka beds. Kusčer (1967), who studied the Tertiary area at Zagorje, used the name Socka beds dividing them into the lower and upper Socka beds. These beds are separated by the main coal seam. The lower Socka beds (footwall) are composed of clay, sand and locally gravel. The upper Socka beds are represented by marl, marly limestone and quartz shale. Upon the Socka beds lies conformably the bluish Marine marly clay with a rich microfauna. Recently, Jelen et al. (1992, 1994) established that the Socka beds from southern Karavanke are of Middle and Upper Eocene age. Since the beds with coal between Laško and Zagorje are of Oligocene age Jelen et al. (1992) as well as Odin et al. (1994) considered the up to that time Socka beds as Pseudosocka beds.
Pseudosocka beds—Lower Egerian

According to the data of the borehole Tdp-1/84 (Fig. 2) the oldest Tertiary rocks of the Tribni Dol area have a similar development as it can be seen between Zagorje and Laško where it is divided into the lower and upper Socka beds (Kuščer, 1967). In the eastern part of the Laško synclinorium there is few data about the Oligocene beds, owing to erosion of cover by younger sediments.

The **lower Pseudosocka beds** in the borehole Tdp-1/84 consist of brownish and gray massive clay, individual regular lenses of fine gravel (up to 1 cm thick) and of rare coal veinlets. The thickness of the lower Pseudosocka beds attains 14.85 metres.

Approximately in the middle of the clay, which by analogy with the Laško synclinorium can be nominated the footwall clay, about 5.50 m above the Triassic dolomite, occurs the first, about 30 cm thick coal seam that passes upwards into a 30 cm thick layer of clayey coal. The coal has the calorific value 20.36 MJ/kg (as received basis, a.r.b.), whereas the clayey coal reaches 4.29 MJ/kg (a.r.b.) only. In the borehole Tdp-1 the coal is overlain by an about 8.75 m thick grayish clay. Immediately above the footwall clay lies a 40 cm thick second coal seam. The core from the borehole was crushed, so it is possible that the coal is thicker. The calorific value of the coal is 15.94 MJ/kg (a.r.b.). According to the stratigraphic position this coal seam can be correlated with the coal seam exploited in the Laško synclinorium between Laško and Zagorje.

The **upper Pseudosocka beds** start with a 26.85 m thick succession of the hanging wall marl. It consists of fine laminated grayish and yellowish marl, limy marl and marly limestone. In the upper part of the marl, approximately 3 metres under the boundary of the succession, a 30 cm thick coal seam of good quality occurs, resembling at first sight to anthracite. The calorific value of this coal is relatively high, 22.50 MJ/kg (a.r.b.).

The hanging wall marl was formed in a shallow, calm and predominantly brackish environment. It is laminated in the lower part, and it shows the signs of flaser-bedding in the upper part. Above the hanging wall marl in the borehole Tdp-1/84 follows upwards a 42 m thick succession composed of rhythmic alternation of dark gray sandstone and siltstone characterised by organic admixture and bioturbation. This succession starts with a 2.15 m thick horizon of a black clay and claystone containing numerous small pelecypods with thin shells. Upwards lie conformably the following beds:

- Black claystone. Thickness 2.1 metres.
- Grayish, fine-grained sandstone alternating with siltstone. Thickness 1.6 metres.
- Gray, fine to medium-grained, massive sandstone. Thickness 5.8 metres.
- Dark gray flaser bedded siltstone. Thickness 0.40 metres.
- Gray to yellowish gray sandstone with carbonate admixture, and white up to 2 cm thick calcite veins. Thickness 2.3 metres.
- Dark gray, here and there flaser-bedded siltstone containing rare thin pelecypod shells. Thickness 3.4 metres.
- Gray, massive, medium-grained, bioturbated carbonate sandstone. Thickness 3.4 metres.
- Gray, massive, medium-grained bioturbated carbonate sandstone. Thickness 4.0 metres.
- Thin-bedded, fine-grained, laminated sandstone and siltstone alternating with dark gray shale. Thickness 2.8 metres.
**Fig. 2. Geologic column of the Pseudosocka Beds with coal seams in the Tdp-1/84 borehole at Trobni Dol**

<table>
<thead>
<tr>
<th>AGE</th>
<th>FORMATION</th>
<th>MEMBER</th>
<th>THICKNESS (m)</th>
<th>DEPTH (m)</th>
<th>GEOLGIC COLUMN</th>
<th>ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UPPER OLIGOCENE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER PSEUDOSOCKA BEDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER PSEUDOSOCKA BEDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TRASSIC</td>
<td>ANISIAN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LITHOLOGIC COMPOSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grayish green marine marly clay</td>
</tr>
<tr>
<td>Medium-grained sandstone passing upwards into fine-grained sandstone; bioturbation</td>
</tr>
<tr>
<td>Siltstone; &quot;flaser bedding&quot;</td>
</tr>
<tr>
<td>Coarse-grained sandstone passing upwards into medium- and fine-grained sandstone</td>
</tr>
<tr>
<td>Gray massive sandstone passing into siltstone</td>
</tr>
<tr>
<td>Claystone alternating with siltstone; pyrite grains</td>
</tr>
<tr>
<td>Marly limestone with numerous pelecypods and gastropods</td>
</tr>
<tr>
<td>Massive sandstone</td>
</tr>
<tr>
<td>Fine-grained sandstone and coarse-grained siltstone; distinctive lamination</td>
</tr>
<tr>
<td>Massive, medium- and fine-grained sandstone-siltstone</td>
</tr>
<tr>
<td>Dark gray siltstone; flaser bedding, rare pelecypods</td>
</tr>
<tr>
<td>Massive sandstone, carbonate admixture, calcite veinlets 0.40 cm. Dark gray siltstone, &quot;flaser bedding&quot;</td>
</tr>
<tr>
<td>Gray, fine- to medium-grained, massive sandstone; bioturbation, dip 35°</td>
</tr>
<tr>
<td>Fine-grained sandstone alternating with siltstone</td>
</tr>
<tr>
<td>Black siltstone</td>
</tr>
<tr>
<td>Black claystone and numerous small pelecypods</td>
</tr>
<tr>
<td>15 cm thick coal seam</td>
</tr>
<tr>
<td>Laminated marly limestone</td>
</tr>
<tr>
<td>30 cm thick coal seam (22.496 MJ/kg)</td>
</tr>
<tr>
<td>Compact finely laminated brownish and grayish yellow, marly limestone and limy marl; flaser bedding</td>
</tr>
<tr>
<td>40 cm thick coal seam; main coal seam (15.935 MJ/kg)</td>
</tr>
<tr>
<td>Grayish, medium compact massive clay with lenses of gravel</td>
</tr>
<tr>
<td>Clay (80 cm) with 3 thin layers of coal</td>
</tr>
<tr>
<td>30 cm thick coal seam (20.356 MJ/kg); above 30 cm of coal clay</td>
</tr>
<tr>
<td>Grayish brown massive clay; lenses of fine gravel; Rare &quot;veinlets&quot; of coal</td>
</tr>
<tr>
<td>Medium gray mylonitized dolomite with pyrite crystals</td>
</tr>
</tbody>
</table>

Sl. 2. Geološki stolpec psevdosoteških plasti s premogom v vrtini Tdp-1/84, Trobni Dol
The abandoned Trobni Dol and Pojerje coal mines have been known for a long time. Their geology was already studied in the last century. The first data about the Trobni Dol area were presented by Zollikofer (1861), who studied the stratigraphic position of the productive formation. Granigg (1910) noted that in the Martin pit a lenslike, about 60 cm thick coal seam was mined. South of Martin pit there was another pit with a 70 cm thick coal seam containing a 37 cm thick sterile interlayer. In the hanging wall Petrascheck (1926/29) found a shale with *Cyrena* and a clay upon the shale. The exploited coal seam was 0.6–1 metres thick. He mentioned a shale with *Cyrena* in the hanging wall and a 40 cm thick bed of limnic limestone in the footwall. Under the limnic limestone he noticed an other 20 cm thick coal seam.

According to the exploration borehole Tdp-1/84 data in the Trobni Dol area three thin coal seams occur in the Pseudosocka beds:

- The first coal seam is 30 cm thick. It lies in the footwall clay, 5.50 m above the Pre-Tertiary basement that is composed of the Triassic dolomite.
- The second coal seam with the thickness of 40 cm is situated at the contact between the footwall clay and the hanging wall marl. By its stratigraphic position this coal is correlative with the coal excavated in the coal mines of the Laško synclinorium between Zagorje and Laško. We supposed that this coal was mined in the Trobni Dol area although, according to the Petrascheck’s description (1926/29), it is not possible with certainty to conclude.
- The highest, 30 cm thick coal seam is situated in the uppermost part of the hanging wall marl and has the highest calorific value according to chemical analysis. The coal quality was estimated on the basis of the coal analyses from the borehole Tdp-1/84 and from the surface. Owing to limited possibilities of sampling in the borehole the results of analyses have a limited value.

Chemical composition of the Trobni Dol coal seams

The results of the proximate and ultimate analyses of the coal from the borehole Tdp-1/84 and from the surface in the Trobni Dol area have been obtained. On the
surface the Pseudosocka beds were only partly exposed, therefore the connections of individual samples with coal horizons are not certain.

The coal sample No 47 has been collected east of the road Aškerc-Trobni Dol. The 20 cm thick coal outcrop is situated under the beds of the upper Socka limy marl. The results of the proximate and ultimate coal analyses from the surface are the following (table 1).

<table>
<thead>
<tr>
<th>Sample: Vzorec: Sample Vzorec:</th>
<th>Trobni Dol – 351/82</th>
<th>Outcrop No: 47 Izdanek št. 47</th>
</tr>
</thead>
</table>

### Proximate analysis Osnovna analiza

<table>
<thead>
<tr>
<th></th>
<th>As received basis V dostavljennem stanju</th>
<th>Dry basis (at 105°C) V suhem stanju</th>
<th>Dry ash-free basis Brez vlage in pepela</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total moisture</td>
<td>%</td>
<td>19.57</td>
<td>–</td>
</tr>
<tr>
<td>Celotna vлага</td>
<td>%</td>
<td>10.22</td>
<td>12.77</td>
</tr>
<tr>
<td>Ash – Pepel</td>
<td>%</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Combustible matters</td>
<td>%</td>
<td>70.21</td>
<td>87.29</td>
</tr>
<tr>
<td>Gorljive snovi</td>
<td>%</td>
<td>46.89</td>
<td>58.30</td>
</tr>
<tr>
<td>Coke – Koks</td>
<td>%</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>%</td>
<td>33.54</td>
<td>41.70</td>
</tr>
<tr>
<td>Hlapne snovi</td>
<td>%</td>
<td>36.67</td>
<td>45.59</td>
</tr>
<tr>
<td>C-fix – C fiks</td>
<td>%</td>
<td></td>
<td>52.23</td>
</tr>
<tr>
<td>S total</td>
<td>%</td>
<td>2.54</td>
<td>3.16</td>
</tr>
<tr>
<td>Celotno žveplo</td>
<td>%</td>
<td>0.35</td>
<td>0.43</td>
</tr>
<tr>
<td>S in ash</td>
<td>%</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Žveplo v pepelu</td>
<td>%</td>
<td>2.19</td>
<td>2.73</td>
</tr>
<tr>
<td>S combustible</td>
<td>%</td>
<td></td>
<td>3.13</td>
</tr>
<tr>
<td>Gorljivo žveplo</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calorific value</td>
<td>MJ/kg</td>
<td>19.6026</td>
<td>24.9784</td>
</tr>
<tr>
<td>Kurilnost</td>
<td></td>
<td>28.6168</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ultimate analysis</th>
<th>Elementarna analiza</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon – Ogljik</td>
<td>C %</td>
</tr>
<tr>
<td>Hydrogen – Vodik</td>
<td>H %</td>
</tr>
<tr>
<td>Sulphur – Žveplo</td>
<td>S %</td>
</tr>
<tr>
<td>Oxygen + Nytrogen</td>
<td>O+N %</td>
</tr>
<tr>
<td>Kisik + Dušik</td>
<td></td>
</tr>
</tbody>
</table>
The results of the coal analyses of the samples from the borehole Tdp-1/84 on the “as received basis” are the following (table 2).

Table 2. The chemical analysis of the coal samples from the borehole Tdp-1/84

<table>
<thead>
<tr>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total moisture</td>
<td>9.93</td>
<td>9.16</td>
</tr>
<tr>
<td>Skupna vlaga</td>
<td>19.07</td>
<td>29.47</td>
</tr>
<tr>
<td>Ash – Pepel</td>
<td>71.00</td>
<td>61.37</td>
</tr>
<tr>
<td>Combustible matter</td>
<td>58.50</td>
<td>64.02</td>
</tr>
<tr>
<td>Gornjive snovi</td>
<td>39.43</td>
<td>34.55</td>
</tr>
<tr>
<td>Coke – Koks</td>
<td>31.57</td>
<td>26.82</td>
</tr>
<tr>
<td>C-fix – C-fiks</td>
<td>1.10</td>
<td>0.98</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>0.06</td>
<td>0.26</td>
</tr>
<tr>
<td>Hlapne snovi</td>
<td>1.04</td>
<td>0.72</td>
</tr>
<tr>
<td>S total</td>
<td>20.356</td>
<td>15.935</td>
</tr>
<tr>
<td>Celoto žvepli</td>
<td>0.06</td>
<td>0.26</td>
</tr>
<tr>
<td>S in ash</td>
<td>1.04</td>
<td>0.72</td>
</tr>
<tr>
<td>Žvepli v pepelu</td>
<td>20.356</td>
<td>15.935</td>
</tr>
<tr>
<td>S combustible</td>
<td>0.06</td>
<td>0.26</td>
</tr>
<tr>
<td>Gornjivo žvepli</td>
<td>1.04</td>
<td>0.72</td>
</tr>
<tr>
<td>Calorific value MJ/kg</td>
<td>0.06</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Hamlja (1987) examined the mean random huminite-vitrinite reflectance of the coal from the borehole Tdp-1/84 at the depth of 368 m. This coal horizon is situated along the contact between the footwall clay and the hanging wall marl. By its stratigraphic position and maturation it is comparable with the coal seam in the Laško synclinorium. It is known that the maturation of the organic substance in a sediment is reflected in change of chemical and physical parameters. The attained stadium of transformation is named the stage of maturation or rank. The Trobni Dol coal was characterized by Hamlja (1987) as a brilliant brown coal (“Glanzbraunkohle”) with the following values of the coal rank parameters: mean random vitrinite reflectance 0.60 %, carbon content 69 % (dry ash-free basis; d.a.f.), volatile matter 47.8 % (d.a.f.) and the total moisture content 25 %. The maximal depth of burial was estimated to 800 metres. The rank of the Trobni Dol coal is relatively high with respect to the coals
westward of the studied area. In Laško the coal rank amounts to 0.32% and in Zagorje and Trbovlje 0.30%. Hamrla (1987) explained the anomalous rank of coal from the Trobni Dol area with possible thermal influence of andesite-dacite volcanism in the coal hanging wall. Petrascheck (1926/29) concluded that the higher maturity of the coal is caused by influences of marine environment after the formation of peat.

Fossils and age of coal-bearing beds

The age of coal was defined on the basis of macro and microfauna. Stur (1871a,b) studied the rich macrofauna from the hanging wall beds and established their brackish character on the basis of certain marine species. In the yellowish white limestone from the Trobni Dol area he determined the following fossils:

*Natica helicina* Brocchi
*Tympanotonus margaritaceum* var. *marginatum* Grateloup
*Pirenella plicata* var. *papillata* Sandberger
*Pirenella plicata* var. *pustulata* Al. Brogniart
*Cerithium rahtii* Al. Brogniart
*Littorinella acuta* Al. Brogniart
*Melania cf. falcicostata* Hofmann
*Cytherea incrassata* var. *styriaca* Rolle
*Cyrena semistriata* Deshayes

In the dark gray sandy shale, which is most probably equivalent of the silty and sandy succession above the hanging wall marl, Stur (1871) mentioned the following fossils:

*Brotia escheri* Brogniart
*Brotia sotzkanensis* Stur
*Unio eibiswaldensis* Stur
*Chara* sp.

Stur (1871a,b) considered that the sediments from the Trobni Dol are the brackish and partly marine equivalent of the lacustrine “Socka” beds of Trbovlje. He correlated the brackish “Socka” beds with the Upper Oligocene beds and Cyrena marl in Siebenbürgen and Upper Bavaria. Granigg (1910) ranged the Trobni Dol coal beds into the Lower Miocene Govce beds. Petrascheck (1926/29) also mentioned the lacustrine limestone from the footwall of the main coal seam. According to the borehole Tdp-1/84 data the hanging wall limestone and marl are developed only in the footwall of the third coal seam. From the hanging wall marl, which is usually 60 cm thick, Petrascheck (1926/29) quoted beside above enumerated also some other fossils, namely:

*Congeria basteroti* Deshayes
*Cardium thunense* (?) Mayer
*Cerithium galeotti* Nyst
*Neritina picta* Ferrusac
Beside brackish forms Stur (1871a,b) found in the waste material a dark gray sandy coal shale containing lacustrine fossils. The author could not define the position of these beds considering them brackish and marine. Mund a (1939) tried repeatedly to determine the macrofauna of the coal-bearing succession, but the gathered material from the dump was not good enough to get new data and to permit conclusions. He considered the “Socka” beds to be of the Chattian age.

On the basis of determined microfossils Rijavec (1983, 1984a,c) concluded on the Oligocene age of the Trobni Dol coal horizons. At the depth 309.00 m to 326.00 m the washouts from the borehole Tdp-1/84 contain rare foraminifera Cyclamina sp., Quinqueloculina sp., Ostracoda as well as imprints and calcitic cores of gastropod tests. In this interval, at the depth to 313.10 m to 315.10 m, an interlayer of marly limestone in the sandy and silty succession was found. It is interesting that in the marly limestone, the richest fossiliferous layer in the whole borehole Tdp-1/84, numerous undeterminable gastropods and pelecypods have been found. We do not know with certainty whether Stur, Petrascheck, Munda and others found the macrofauna in a bed corresponding to this horizon, but it is very probable. In the borehole we found another horizon with less macrofauna in the immediate hanging wall marl at the basis of the sandy-silty succession.

Jelen (1984) examined 15 samples from the borehole Tdp-1/84 and examined 30 thin sections of the Pseudosocka beds and Oligocene Marine clay. In positive samples the palynological contents was poorly preserved. In the clayey coal at the depth 376.80 m Jelen (1984) determined the following palynologic species:

- Spores: Verrucatosporites favus favus Thomson & Pflug
  Verrucatosporites sp.
  Laevigatosporites sp.

- Pollen: Monocolpopollenites tranquillus tranquillus Thomson & Pflug
  Inaperturopollenites hiatus Thomson & Pflug

In the sample of silt at the depth 312.80 m Jelen (1984) determined the following palynological contents:

- Spores: Verrucatosporites favus favus Thomson & Pflug
  Polypodiaceoisporites sp.

- Pollen: Inaperturopollenites hiatus Thomson & Pflug
  Engelhardtioidites microcoryphaues verus Thomson & Pflug
  Monocolpopollenites sp.

Jelen concluded that in the lower part of the borehole Tdp-1/84 as well as in the “Socka” beds of the Zagorje coal basin undistinct similarities of the palynological spectrum can be shown. Similarités are also observed in the upper “Socka” beds of both areas.

**Grayish Green Marine Marly Clay and Tuff – Lower Egerian**

At the depth of 299.50 metres in the borehole Tdp-1/84 (Fig. 3) rests without discordance upon a sandstone the grayish green Marine marly clay. In the clay a foraminiferal fauna appears already 50 cm above the underlaying sandstone. The
<table>
<thead>
<tr>
<th>AGE</th>
<th>FORMATION</th>
<th>MEMBER</th>
<th>DEPTH</th>
<th>GEOLOGIC COLUMN</th>
<th>ANALYSIS</th>
<th>LITHOLOGIC COMPOSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(m)</td>
<td>GEOLSKO STOLPEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mi</td>
<td>Mi+</td>
<td>Mi+</td>
<td>Mi+</td>
<td>Mi+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>140.1</td>
<td>Mi+</td>
<td>Mi+</td>
<td>Mi+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250.0</td>
<td>Mi+</td>
<td>Mi+</td>
<td>Mi+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>299.5</td>
<td>Mi+</td>
<td>Mi+</td>
<td>Mi+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3. Geologic column of the Upper Oligocene Marine marly clay and dacito-andesitic tuff from the borehole Tdp-1/84 at Trobni Dol

Mi - Micropaleontologic analysis; PI - Palynologic analysis; + Positive; - Sterile

Sl. 3. Geološki stolpec zgornjeoligocenske morske lapornate gline (sivice) in dacitnoandezitnega tufa v vrtini Tdp-1/84

Mi - Mikropaleontološka analiza; PI - Palinološka analiza; + Vsebuje mikrofavno; - Sterilna
microfauna occurs upwards in numerous samples of the clay up to 159.40 metres. At that point begins a sedimentary succession composed of alternating dacite-andesitic fine-grained tuff, lapilli tuff and pyroclastic breccia. This succession goes on continually upwards as far as to the point of 28.50 metres where the grayish green Marine marly clay reappears, alternating with tuffs to up to 12.50 metres, the base of the overlying alluvial deposits. In the grayish Marine marly clay above the tuffs Rijavec (1984a,c) found similar microfauna as under the tuffs. On the basis of microfauna from the interval 16.7 m to 27 m Rijavec ascertained the probable Lower Egerian age of the beds. Beside numerous foraminifera Almaena osnabrugensis also foraminifer Anomaloides granosus is present. In numerous samples of the Marine marly clay between 158.30 m and 299 m Rijavec (1984a,c) determined the following Upper Oligocene (Egerian) foraminifera: Glomospira charoides (Parker & Jones), Cyclammina acutidorsata (Hantken), Spiroleptammina carinata (d’Orbigny), Martinottiella communis (d’Orbigny), Cyclogyra polygyra (Reuss), Nodosaria longiscata d’Orbigny, Vaginulinopsis gladius (Phillippi), Vaginulinopsis pseudodecorata Hagn, Glandulina laevigata d’Orbigny, Sphaeroidina bulloides d’Orbigny, Stainforthia schreibersiana (Czjzek), Uvigerina cf. farinosa Hantken, Siphonina reticulata (Czjzek), Cibicides lobatus (Walker & Jacob) Pullenia bulboides (d’Orbigny), Gyroidina soldanii d’Orbigny, Anomalina affinis (Hantken), Cibicidoides ungerianus (d’Orbigny) Hantzawaia boueana (d’Orbigny), Melonis soldanii (d’Orbigny), Almaena osnabrugensis (Roemer), Hoeglundina elegans (d’Orbigny), Bathysiphon filiformis Sars, Haplophragmoides sp., Textularia sp., Gaudryina sp., Nodosaria sp., Lenticulina sp., Guttulina sp., Uvigerina sp., Chilostomella sp., Gyroidina sp., Heterolepa sp., Melonis sp., Miliolidae.

In the Marine marly clay above the dacite-andesitic pyroclastic succession at the depth from 28.50 m to 12.50 m Rijavec (1984a, c) determined the following foraminifera: Glomospira charoides (Parker & Jones), Martinottiella communis (d’Orbigny), Glandulina laevigata d’Orbigny, Sphaeroidina bulloides d’Orbigny, Uvigerina hantkeni Cushman & Edwards, Pullenia bulboides (d’Orbigny), Gyroidina soldanii d’Orbigny, Anomalina affinis (Hantken), Anomalinoides granosus (Hantken), Cibicidoides ungerianus (d’Orbigny), Heterolepa dutemplei (d’Orbigny), Melonis soldanii (d’Orbigny), Almaena osnabrugensis (Roemer), Globigerina div. sp., Textularia sp., Cyclogyra sp., Lenticulina sp., Guttulina sp., Uvigerina sp., Heterolepa sp., Miliolidae.

Beside foraminifera in the Marine marly clay fish teeth, echinoid spines as well as limonitized and pyritized gastropod cores also occur. For the Lower Egerian age are still characteristic numerous Paleogene foraminifera Vaginulinopsis pseudodecorata, Vaginulinopsis gladius and Uvigerina hantkeni. In the Lower Egerian beds estward and westward of Trobni Dol beside the above enumerated foraminifera also species Tritaxia (Clavulinoides) szaboi and Planularia kubinyii are found. The grayish Marine marly clay is the most characteristic and regional wide-extended Oligocene sediment in the Laško synclinorium, Gorenjska and the Savinja valley area. If andesitic tuffs occur, they usually lie in the hanging wall of the Marine marly clay. However, the Marine marly clay resembles very much to the Kiscell clay in Hungary. Opinions about the more precise age of the Marine marly clay and underlying Pseudosocka beds are still very different. A group of researchers (Kuščer, 1967; Buser, 1977, 1979; Cimerman, 1979; Pavšić, 1985; Jelen et al., 1990) attributed them the Middle Oligocene (Rupelian). Pavšić proved the age by means of nanoplankton. Jelen’s statements about the Middle Oligocene
repose on palynological research. On the basis of several ten years of investigations of foraminifera in Slovenia Rijavec (1984 a, b, c) and Rijavec & Pleničar (1979), arrived at a decision that the Marine marly clay is of Egerian age. In favour of this age also speak the results of investigations of miogypsinas and lepidocyclinas at Zagorje (Pappp, 1954).

Lately, the results of absolute age datation on the basis of plagioclase from the volcanoclastic layers within the coal seam at Zagorje caused a great sensation (Odin et al., 1994). The analytical results indicate that the plagioclase samples were erupted at 25.0 ± 1.0 Ma (2σ), therefore the volcanoclastic layers (Pseudosocka beds) containing the plagioclase were deposited during the Late Chattian. The precise age corresponds to the Lower Egerian, accurately to Late Chattian. The grayish green Marine marly clay lies directly upon the Pseudosocka beds with coal: according to this their Lower Egerian age is confirmed. Regarding numerous unsolved questions it will be necessary to continue systematic research of individual Oligocene basins in Slovenia. This research is also interesting and important for adjacent regions i.e. for the whole sedimentary area of the former Paratethys. Indications exist that from Hungary across Slovenia to Italy there was a relatively uniform sedimentary basin.

Oligo-Miocene and Miocene beds

Over the andesitic tuff lie the beds which were deposited between the Upper Oligocene and the Lower Miocene, and which can not be subdivided either by fauna or lithologically. Accordingly, the grayish green to brownish sandy clay as well as the beds of sandy clay sandstone and sand are ranged into the Upper Egerian (Petica et al., 1995). According to lithologic and paleontologic characteristics the sandy-clayey beds, which in other parts of the Laško synclinorium overlie the Marine marly clay, correspond to the lower Govce beds. In the Trobni Dol area the upper Govce beds (Eggenburgian), Laško beds (Badenian) and incomplete Sarmatian beds are developed, too. The enumerated beds are already described in detail (see: Dozet & Rijavec, 1994; Petica et al., 1995).

Structural relations

The investigated area is a part of the eastern continuation of the Tertiary belt which appears at Moravče and passes through Zagorje, Trbovlje, Hrastnik, Laško and east of Savinja. The entire Tertiary belt belongs to the Sava folds tectonic unit. Kuščer (1967) denominated the belt as Laško synclinorium, whereas other authors use the name Laško syncline.

The Tertiary beds of the investigated area were subjected to two types of deformations:

1) The deformations originated during the Tertiary sedimentation, manifested as erosional and tectonical-erosional discordances between the Pseudosocka beds and Pre-Tertiary basement, the Lower Miocene and Badenian (Tortonian) beds as well as the Badenian and Sarmatian ones.

2) The deformations occurred after the deposition of the Sarmatian beds. They were caused by orogenic activity which folded the Tertiary beds of the whole area. Kuščer (1967) found that the main orogenic phase in the Sava folds, which caused
the folding of the Tertiary beds and influenced the origin of structures, was the Attic orogenic phase that was active in the Lower Pliocene. Forces which caused the folding were acting from the north to the south. To the second type of tectonic deformations two synclines (Laško, Planina) and the anticline Rudnica between them are ranged.

During and after the folding came to a faulting and deformation of the folded structures. Fault systems with directions NW-SE, SW-NE, N-S and W-E originated. The strongest fault systems were those with the NW-SE and W-E direction. In the Laško syncline the synform was preserved undisturbed. Deformations arose at the northern flank where along the W-E fault at Podgorje one part of this limb sank, so that in the northern flank area the andesitic tuff came in tectonic contact with the Pre-Tertiary rocks. However, in the northern flank a normal succession of beds without any essential changes is observed. The synclinal core is built of Laško marl strata.

The southern limb of the Laško syncline is also deformed. The preserved part of northern syncline and the core are somewhat sunk along the W-E fault regarding the southern limb which in the central part of investigated area strongly turned to the NE.

Between Resje and Matizel the southern limb of the syncline is divided in some smaller local synforms and antiforms. Only in the western part of the investigated area the southern limb preserved his shape. The limb was deformed along NW-SE, W-E and N-S faults. In the southern limb of the Laško syncline the upper Pseudosocka beds, Oligocene Marine clay, Govce beds and Laško beds are developed.

The crest of the Rudnica anticline is deformed similarly as the southern limb of the Laško syncline. It turns to the NE and becomes divided between Matizel and Resje in several smaller folds, synforms and antiforms respectively. Because of predominantly clayey sediments and consequently a small density of measured dips it is not possible to define everywhere the crest of the anticline. The anticlinal crest passes through the grayish green marly clay in the western part of the investigated area, and east of the road Mala Breza-Trobnj Dol it is totally invisible.

The southern Planina syncline is also strongly deformed, especially its southern limb which is overthrusted by the beds of the Pre-Tertiary basement. In the northern limb there are the same sediments as in the Laško syncline, with distinction that the Upper Oligocene sandy beds and Pseudosocka beds do not outcrop there. In the eastern part of the mapped area the northern limb continues up to Matizel. The sandy clayey Egerian beds outcrop there, whereas in the western part of the mapped area the grayish green Egerian clay is to be found. Upwards in the northern limb the normal Tertiary succession follows. In the synclinal core there are Sarmatian sandy marly clays and Sarmatian conglomerate, belonging according Winkler (1924) to the Carynthic Delta. The anticlinal axis has a direction SE-NE. The southern limb between Globoko and Mirni Dol is strongly tectonically deformed. In this area the Pre-Tertiary basement lies over the southern limb of the Planina syncline. For that reason the Sarmatian and Egerian beds are in inverse position. Consequently, between Mirni Dol and Globoko the Planina syncline passes to a plunging fold. Inside of the plunging southern limb of the syncline it also came to thrusting of Tertiary beds (Sarmatian and Egerian beds). In the eastern part of the area between Pojerje and Blatni Vrh it came to folding and smaller overthrusting. Also in the southern part of the Planina syncline the development of beds is normal from the Upper Oligocene to the Middle Sarmatian, but they are owing to strong tectonic deformations very thinned.

In the mapped area the most expressive fault system has the NW-SE direction.
Suggestion for further investigations

The most perspective area for investigation with exploration boring, regarding the results of detailed geological mappings and the boreholes, is the southern limb area of the Laško syncline. Especially perspective is the southern limb, from the road Trobni dol-Breze towards the west in the continuation of the Trobni Dol Oto coal field. In this part of the limb an about 30 cm thick coal seam outcrops. The coal lies between clastic and marly sediments corresponding to the Pseudosocka beds. The western part of the southern limb is not deformed so much that it would come to folding within the southern limb; in such a manner this part of fold preserved its shape. The beds in the southern limb area dip 25° to 35° towards NW. Regarding all these conditions we believe that this area is favourable for further investigation with exploration drilling.

The northern limb of the Laško syncline at Podgorje, can also be prospective for further coal investigation with drilling since these beds are not tectonically deformed except along the contact with the Pre-Tertiary basement. If taking into account the thickness of individual litostratigraphic members found out by detailed geological mapping we expect there a coal seam at the depth about 300-350 metres. Less prospective is the area of the Planina syncline and eastern part of the southern limb of the Laško syncline. In this part of the investigated area, in Egerian outcrops and along the contact with the Pre-Tertiary basement, there are no Pseudosocka or analogous beds, because towards the north they wedged out. Over the Pre-Tertiary basement lie sandy-clayey beds containing coal lenses. In the beds of gray to white sand and sandstone at Laška Vas we found several about 10-20 cm thick outcrops of coal. This syncline is also strongly tectonically affected. Its southern part is overturned so that the Pre-Tertiary rocks are overthrusted upon the Tertiary ones.

In the Planina syncline area of some interest is the Pojerje locality where before the Second World War an up to 4 metres thick coal seam was excavated. For this area it would be necessary to find out whether the coal seam appears also in the north-eastern continuation of the abandoned Pojerje coal-mine; therefore, the area is prospective for investigation with drilling. The eastern part of the southern limb of the Laško syncline is divided along the faults into several smaller folds with steep limbs. At present stage of investigations of the terrain this part is not suitable for exploration by drilling.

Summary

In the Trobni Dol area lie discordantly over the Pre-Tertiary basement Oligocene Pseudosocka beds intercalated with thinner seams of brown coal. They are comparable with the productive Pseudosocka beds in the wider Laško synclinorium area.
Discussions and Conclusions

The Pseudosocka beds at Trobni Dol, 8 km east of Laško, show certain litostratigraphic differences in the upper part regarding their development towards the west. Namely, the Pseudosocka beds between Laško and Zagorje end with the hanging wall marl. At Zagorje Kuščer (1967) mentioned a special development of the upper Pseudosocka beds that are composed of grayish brown shale which often contains leaf imprints. There are several interlayers of sand within the shale succession resembling the Govce sand. East of the Kotredež brook there are clastic quartz sediments within the shale. Kuščer (1967) considered them the hanging wall. The Oligocene Marine clay with foraminifera at Potoška vas near Zagorje lies concordantly upon the shale. A similar stratigraphic position can be seen in the Trobni Dol borehole Tdp-1/84 where the Marine clay lies concordantly upon the hanging wall marl in the borehole Tdp-1/84 does not represent any lateral equivalent in the area of the Laško synclinorium. The Pseudosocka beds of the area studied are divisible into the lower Pseudosocka beds, the main coal horizon, and the upper Pseudosocka beds. In the borehole Tdp-1/84 three coal seams occur. On the other hand, in the mapped
area some other very thin (up to 1 cm) coal seams are to be found in the uppermost part of the Pseudosocka succession. Determined macro- and microfauna indicates that the Trobni Dol coal is of the Upper Oligocene age.

The characteristics of the footwall, main coal horizon and hanging wall sediments indicate the following chronology of the geologic events:

1. Supply of continental waters which filled the depression with clay and sandy material, and deposition of the footwall clay.
2. Periodical ingressions of the sea caused mixing of the marine, brackish and limnic sedimentation and fauna.
3. The gathered fauna indicates predominantly brackish and limnic character of the coal-bearing beds. Limnic are probably the lower Pseudosocka beds under the main coal horizon.
4. The hanging wall marl is mostly a brackish sediment formed in a shallow lagoon. After the formation of the hanging wall marl owing to the intensive shallowing of the sea repeated filling up with sandy material occurred.
5. After the deposition of the hanging wall marls it came in the lagoon to a stronger continental water supply which filled up the lagoon with sandy material. In a brackish environment a vegetation reappeared, what is proved by lenselike coal seams and charred plant remains in the Upper Pseudosocka beds.
6. The sinking of the investigated area was intensified and the lagoon was flooded with the sea water; in a new somewhat deeper environment the marine Upper Oligocene grayish green limy clay was deposited what is proved by a rich foraminiferal fauna.

Acknowledgements

We are greatly indebted to Prof. Dr. Vasja Mikuž for revision of macrofauna from the Pseudosocka beds according to data of Stur, Petrascheck and Munda. For technical assistance in drafting and typing we would like to thank Ms. Metka Karer and Ms. Marjeta Oman.
Psevdosoteške plasti s premogom v vrtini Tdp-1/84 Trobni Dol (vzhodne Posavske gube)

Cilj članka je podrobneje prikazati zaporedje in razvoj oligocenske skladovnice Trobnega Dola in ga primerjati z razvojem zahodne v Laškem sinklinoriju. V okviru raziskav premoga na območju Trobnega Dola vzhodno od Laškega sta bili poleg geološkega kartiranja površine na območju premogovnika Trobni Dol izvrtani raziskovalni vrtini Tdp-1/84 globine 385 m in Tdp-2/84 globine 400 m. Za preučevanje litostatigrafskih razmer je pomembnejša vrtina Tdp-1/84, ker je prevrtala normalno zaporedje oligocenskih plasti in dosegla predterciarno podlago. Vrtina Tdp-2/84 zaradi tektoskih razmer ni dosegla produktivnih plasti s premogom.

Na sl. 2 in sl. 3 je prikazan razvoj oligocenskih plasti Trobnega Dola, ki jih po mikropaleontoloških raziskavah foraminifer prištevamo k zgornji oligoceni oz. spodnji egeriji. Psevdosoteške plasti so limnično-brakične. Pričenjajo se s talno glino in z vložkom premoga. Na talni glini je v vrtini 40 cm debela plast svetlega rjavega premoga. Na krovni premoga je 27 m debela skladovnica drobnoplastovitega krovnega lapornega apnenca. Krovni lapor je prekrit z 42 m debelim sedimentnim zaporedjem, ki ga sestavlja ritično menjavanje peščenjaka in meljevca. Te plasti prehajajo brez diskordance v 140 m debelo laporno glino, bogato s foraminiferami, ki kažejo na spodnji egerij. Ta glina je zelo razširjena v osrednji Sloveniji, podobna pa je Kiscelski glini na Madžarskem. V normalnem zaporedju leži na laporasti glini 131 m debela piroklastična skladovnica, ki je produkt visoko silicijske dacitne magme. Piroklastiti prehajajo navzgor v laporasto glino s podobno foraminiferno mikrovabo, kakršna je v njihovi talnini.

Večino litostratigrafskih členov iz Trobnega Dola moremo primerjati z razmerami zahodne v Laškem sinklinoriju, kjer je razvit premogov sloj, ki ga odkopavajo v več premogovnikih. Spodnji produktivni del v Trobnem Dolu prištevamo k Psevdosoteškim plastem. Te so bile doslej obravnave kot Soteske plasti. Omenili smo že, da se psevdosoteška skladovnica Trobnega Dola pričenja s talno glino, ki vsebuje tanko vložko drobnega proda in 30 cm debel vložek premoga in da talni glini sledi v vrtini 40 cm debela plast rjavega premoga. Slednjega primerjamo po legi in glede na značaj talnine in krovnine s produktivnim premogovim slojem med Laškim in Zagorjem. Premog pripada svetlemu rjavemu premogu in ima odsevnost 0,60 % Ro, ki je najvišja med oligocenskimi vrstami premoga Laškega sinklinorija. Visoko odsevnost premoga je mogoče razložiti s termičnim vplivom vulkanizma pri Trobnem Dolu.

S korelacijo litostatigrafskih členov smo ugotovili, da v krovnini lapornor leže le 42 m debela skladovnica Trobnega Dola, ki jo sestavlja ritično menjavanje peščenjaka in meljevca, ni značilna za Psevdosoteške plasti proti zahodu. Piroklastiti so v Laškem sinklinoriju razkriti v večjem obsegu le na območju Rudnice; zahodno od Trobnega Dola pa se v lapornati glini pojavljajo samo tanjši vložki tufov in tufitov.
References


Buser, S. 1977: Osnovna geološka karta SFRJ, list Celje 1:100 000. – Zvezi geološki zavod, Beograd.

Buser, S. 1979: Tolmač lista Celje. Osnovna geološka karta SFRJ 1:100 000. – Zvezi geološki zavod, 72pp., Beograd.


Grad, K. 1967: Geologija Kokonskega. – Geogr. zbornik, 4 razr. SAZU, 10, 7–16, Ljubljana.


Hamlra, M. 1955: Geologija Rudnice s posebnim ozirom na rudne pojave. – Geologija, 3, 81–109, Ljubljana.


Kočič, P. 1985: Sedimentološke raziskave v severovzhodni Sloveniji. – Geološki zavod, 14 pp., Ljubljana.


Munda, M. 1942: Poročilo o nahajališču rjavega premoga v Babni gori pri Žusmu. – Geološki zavod, Ljubljana.


Nosan, A. 1956: Razvoj oligocena in miocena v Sloveniji. – Prvi jugosl. geol. kongres (Bled), 47 pp., Ljubljana.

Rijavec, L. 1984b: Oligocen i miocen područja izmed Rudnice in Boča (Istočna Slovenija) na osnovi mikrofosila. – Disertacija, 142 pp., Zagreb.
Stur, D. 1871a: Geologie der Steiermark, 654 pp., Graz.