СПИСАНИЕ НА БЪЛГАРСКОТО ГЕОЛОГИЧЕСКО ДРУЖЕСТВО, год. 67, кн. 1—3, 2006, с. 81—85
REVIEW OF THE BULGARIAN GEOLOGICAL SOCIETY, vol. 67, part 1—3, 2006, p. 81—85

# Fluorescing macerals in Bulgarian coals

*Anton Sotirov*

***Agency for Regional Development, 44 Demokratsiya Str., 2500 Kyustendil, Bulgaria;***
***E-mail: sotirov_anton@hotmail.com***

А. Сотиров. 2006. *Флуоресцентни мацерали в български въглища. — Сп. Бълг. геол. д-во, 67,* 1—3, 81—85.

**Резюме**. Изследван е мацералния състав на различни типове въглища от български басейни. Това са въглища от Софийския (плиоценски лигнити), Орановския (миоценски лигнити), Чукуровския (миоценски лигнити), Пернишкия (миоценски кафяви), Балканския (ценомански черни) и Добруджанския (вестфалски черни) басейн, както и от находище Катрище (миоценски лигнити). Общо микроскопски са изследвани 305 проби с отразена (546 nm) и флуоресцентна (синя) светлина. Най-разпространените флуоресциращи мацерали в изследваните въглища са споринит и резинит. Оценена е възможността за присъствие на церинит. Изучаваните български въглища с ниска степен на въглефикация са богати на мацерали от групата на липтинита (от 5% до 17%). Последните имат специфично площно разпределение. Басейните с ниска степен на въглефикация (предимно миоценските) са разположени много близо (20–60 km) един от друг по долината на р. Струма. Съдържанието на липтинитови мацерали намалява слабо, а след това се увеличава от север на юг в рамките на изучавания район (горното течение на р. Струма). Средната част на изучавания район по време на торфонатрупването вероятно е била бедна на растения, чийто материал е съдържал по-големи количества водород, като спорополенин, кутин, суберин, резин, восък, балсам, латекс, мазнини и масла. Вероятно условията в торфените блата са били неподходящи за тяхното съхранение (наличие на кислород, сухи периоди и бактериална деградация) като климатът е бил топъл и почти еднакъв за всички изучавани басейни. Вероятно една част от наблюдавания резинит е церинит, тъй като гладки восъчни частици в груби резинитови тела са наблюдавани в Орановските въглища.

*Ключови думи:* въглищна петрография, флуоресцентни мацерали, липтинит, България.

**Abstract.** Different types of coals are studied from Bulgarian basins about fluorescing macerals — Sofia (Pliocene, lignite), Oranovo (Miocene, lignite), Katrishte (Miocene, lignite), Kyustendil (Miocene, lignite), Chukurovo (Miocene, lignite), Pernik (Miocene, sub-bituminous), Balkan (Cenomanian, bituminous), and Dobrudja (Westphalian, bituminous). A total number of 305 samples are studied microscopically under reflected (546 nm) as well as fluorescing (blue excitation) light. The sporinite and resinite are the most distributed macerals in the studied coal. The possibility for presence of cerinite in some Bulgarian coal is evaluated. The studied Bulgarian low rank coals are rich of liptinite macerals (from 5% to 17%). The macerals from Liptinite group have specific surface distribution. The low rank coal basins (mainly Miocene) are situated very closely (20–60 km) along the Struma River valley. Liptinite firstly decreases and after that increases from North to South in the frame of the studied area — the upper part of Struma Valley. The middle part of the studied area was poor of hydrogen-rich plant materials as sporopolenin, cutin, suberin, resins, waxes, balsams, latex, fats, and oils. Probably the conditions of the peat bogs were not appropriate for their preservation (oxygen, dryness, bacterial degradation) as the climate was warm and almost identical for all basins. Probably one part of the resinite rich coal is cerinite. Smooth wax particles into rough resinite bodies were observed in the Oranovo lignite.

*Key words*: coal petrography, fluorescencing macerals, liptinite, Bulgaria.

## Introduction

This study presents a detailed examination of the Liptinite macerals in some Bulgarian coals in fluorescing (blue excitation) light. Taylor et al. (1998), Kruszewska (2003) and many other petrographers observed a dramatic difference between liptinite content in white and fluorescing light, which may result incorrect conclusions related with the fundamental science or industrial implication of the coal. Sotirov and Kortenski (2004) and Kortenski and Sotirov (2004) have done some investigations, related with the fluorescing macerals in Bulgarian coals.

Coals from eight Bulgarian basins are studied for their fluorescing macerals (macerals from the Liptinite group in the Stopes—Heerlen System, Taylor et al., 1998). These are the basins: Oranovo, Katrishte, Kyustendil, Chukurovo, Sofia, Balkan, and Dobrudja (fig. 1).

The age of the Oranovo basin is Middle Miocene (Vatsev, 1991) and its coal is lignite, according to the American classification (Taylor et al., 1998) and its random vitrinite reflectance is Rr=0.33%. The Katrishte lignite deposit is Middle Miocene (Vatsev, Bonev, 1994) with Rr=0.31%. The Kyustendil lignite basin is Upper Miocene (Kamenov, 1954) with

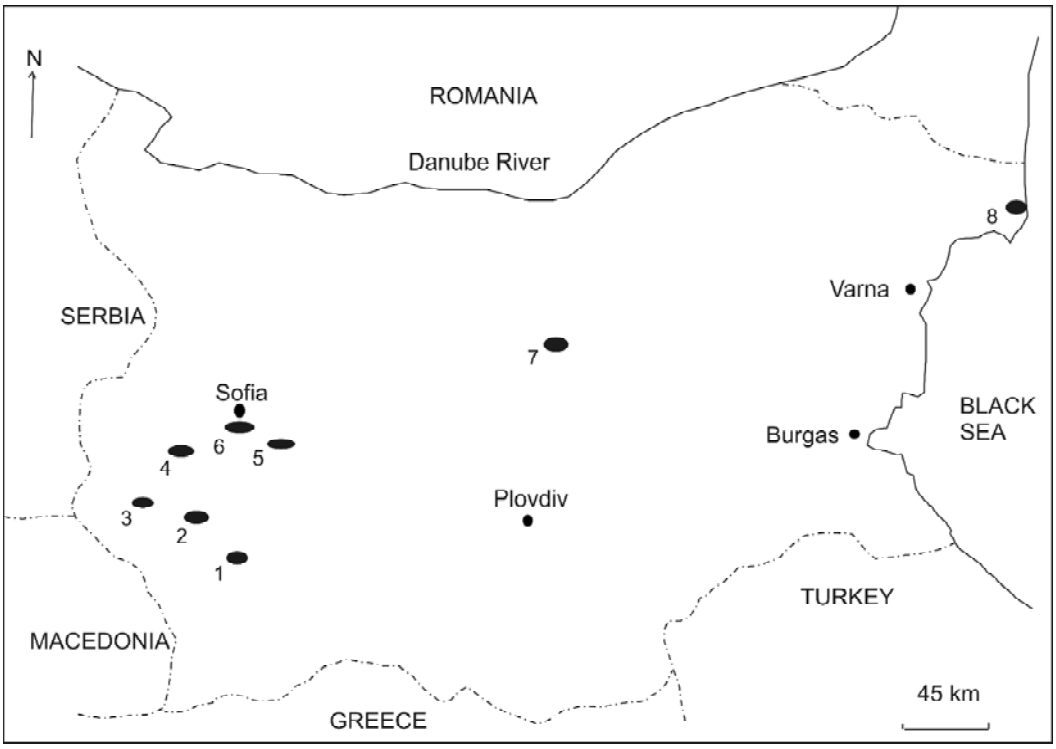


**Fig. 1. Location of the studied coal basins**

**Фиг. 1. Местоположение на изследваните въглищни басейни**

Rr=0.30%. The Pernik coal basin is Upper Oligocene–Low Miocene (Marinova, Zagorchev, 1994) and its coal is Sub-bituminous-B (Rr=0.48%). The age of the Chukurovo lignite is Helvetian (Palamarev, 1964) and Rr=0.37%. The coal from the Sofia basin is lignite (Rr=0.23%) and its age is Pliocene (Kortenski, 2002). All of the above mentioned coal basins are located along the Struma River valley in South-West Bulgaria.

Two coal basins with high rank coal are studied also. The Balkan basin, which is located in Central Bulgaria and its coal is High volatile bituminous-A (Rr is up to 2%) and its age is Cenomanian (Petrov, 1983). The other one is the Dobrudja basin with Westphalian age (Nikolov et al., 1988) and Rr=0.79% (High volatile bituminous-A).

## Methods and materials

A total number of 305 samples are studied as follows: from Sofia basin — 20, Kyustendil — 20, Katrishte — 43, Oranovo — 137, Chukurovo — 20, Pernik — 30, Balkan — 15, Dobrudja — 20. The coal pieces were crushed to a grain size 1–3 mm, covered by resin and polished for microscopic study under incident white (546 nm) and fluorescing (blue excitation) light. A microscope "Leica" with a computer program "Leica mpv_meas" and objectives 50x0.85 and 100x1.25 with oil immersion (glycerine) is used. The study of the coal from the Oranovo basin is done with a microscope Leitz-Wetzlar. An automatic counter "Prior–G" is used for counting of the macerals. Between 400 and 700 points (fluorescing and non-fluorescing) are counted on every sample for calculation of their percentage. The percentage of the macerals is calculated on the basis of the organic matter of the samples.

## Results and discussion

The studied coals have different amount of fluorescing macerals. The Sofia coal is very rich of these macerals (17%), and the Balkan coal comprises lowest amount (2%) (table 1).

*Sporinite* is the main fluorescing maceral in the studied Bulgarian coal (fig. 2, 3). Its amount in the low rank coals varies between below 1% (Chukurovo basin) and about 5% (Sofia basin). The reflectance of the sporinite of the Sofia coal is below 1% and the sporinite of the Pernik coal has reflectance 0.08–0.17% (Sotirov et al., 2002). The maceral variety microsporinite, represented from tenuisporinite (12%) and crassisporinite (less than 1%) (fig. 2) is found in the Dobrudja medium rank coal. In this coal is observed also macrosporinite (less than 1%) and there are many finds of sporangium (fig. 2). Marine and brackish peats, in contrast to freshwater peats, are characterized by small amount of sporinite (Taylor et al., 1998).

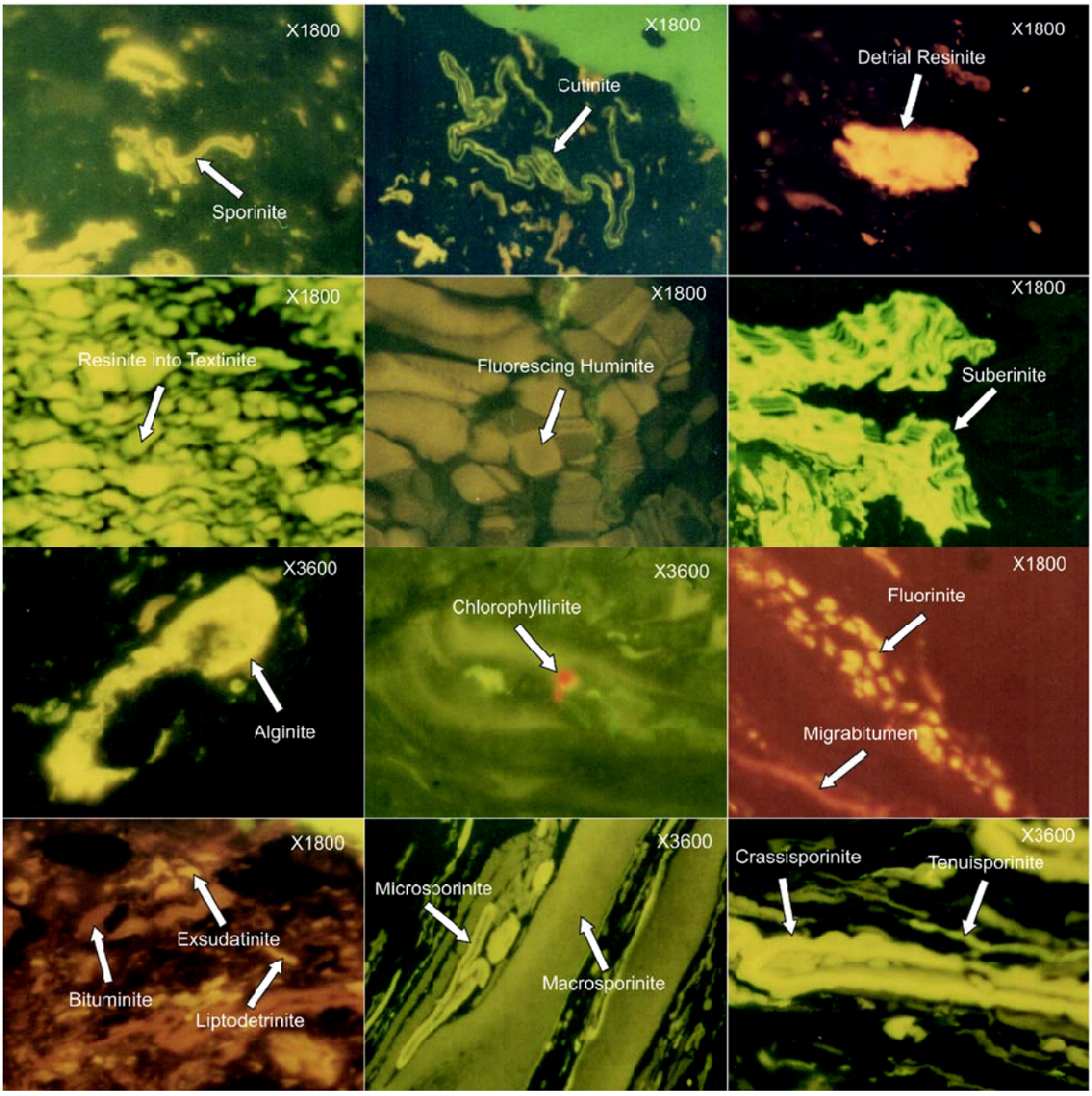


**Fig. 2. Fluorescing macerals in Bulgarian coals; fluorescence light, oil immersion**

**Фиг. 2. Флуоресцентни мацерали в български въглища; флуоресцентна светлина, маслена имерсия**

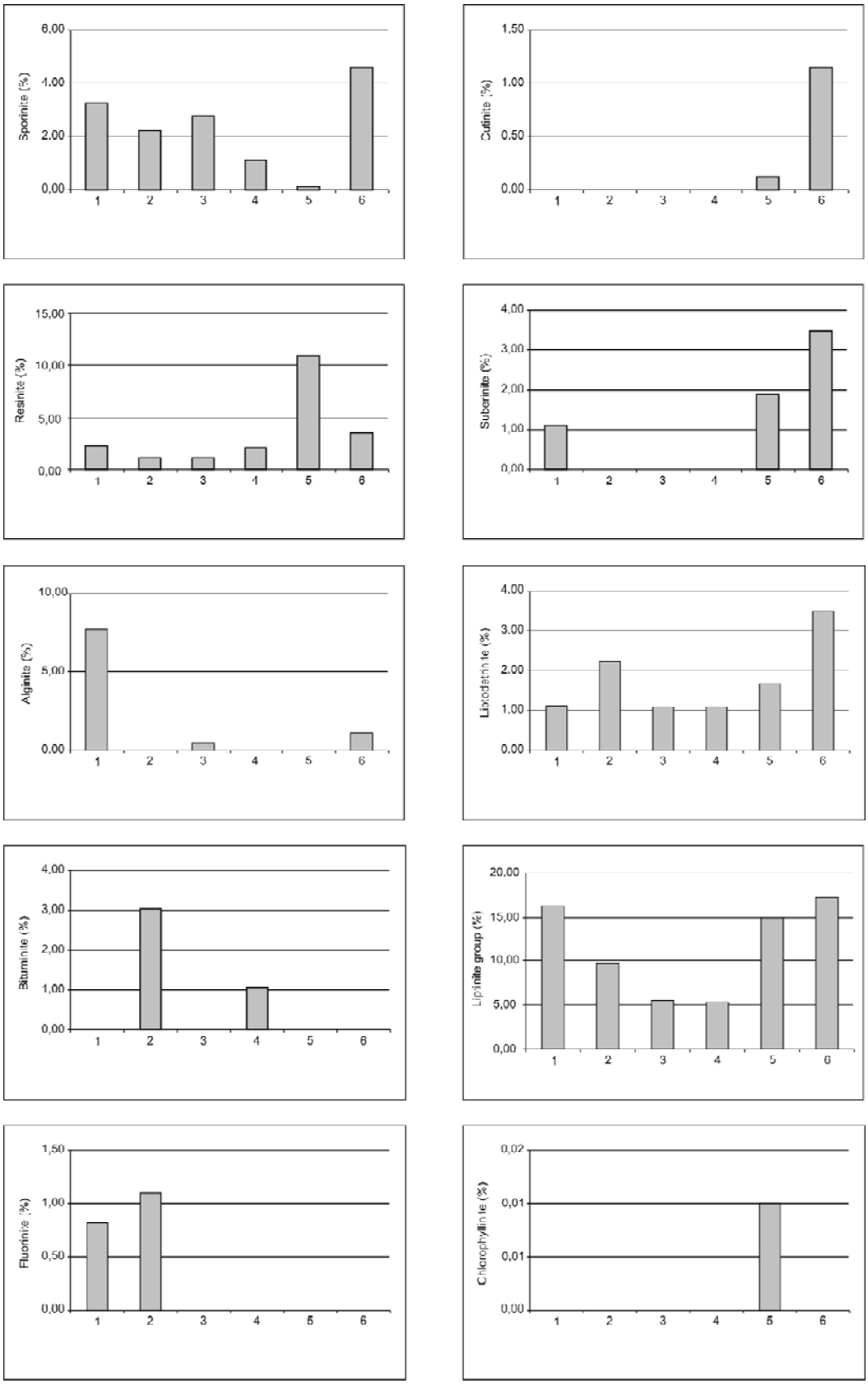


**Fig. 3. Percentage of the Liptinite macerals in the studied coals; axes Y (from South to North)**
*1*, Oranovo; *2,* Katrishte; *3,* Kyustendil; *4,* Pernik; *5,* Chukurovo; *6,* Sofia

**Фиг. 3 Процентни съдържания на мацерали от група литпинит в изследваните въглища; по ос Y (от юг към север)**
*1* — Ораново, *2* — Катрище, *3* — Кюстендил, *4* — Перник, *5* — Чукурово, *6* — София

*Cutinite* is established in the low rank coal (fig. 2, 3) in low amount — less 1%. Only the Sofia lignite comprises 1% cutinite. Cutinite is concentrated in certain subaquatic coals (Taylor et al., 1998).

*Resinite* is the second main fluorescing maceral (fig. 3). Some of the studied coals are enriched of resinite, for an example the Chukurovo lignite (11%). Detrial resinite and resinite filling textinite cells (fig. 2) were found in all low rank coals. It is "terpene resinite" (Taylor et al., 1998) with strong yellow to orange fluorescing color. Possible presence of "wax resinite" is established with this investigation. This kind of resinite is known as "cerinite" (Taylor et al., 1998). Because of its chemical composition it does not fluorescing under blue radiation, but it fluorescing, when is impregnated with resinite or bituminite (Van Krevelen, 1993). Probably one part of the resinite rich coal is cerinite. Smooth wax particles into rough resinite bodies were observed in the Oranovo lignite.

*Suberinite* (fig. 2, 3) is established in high amount in the Sofia lignite (3.5%). All other low rank coals comprise suberinite about 1% or less.

*Alginite* is frequently established maceral into the coal from the Oranovo basin (8%) (fig. 2, 3). The other low rank coals comprise alginite about or less than 1%. The modern algae grow at present oligotrophic and distrophic lakes (Taylor et al., 1998).

*Chlorophyllinite* is observed only in the coal from the Chukurovo basin (fig. 2, 3). The chlorophyll of green algae and green-colored leaves is preserved under severe anaerobic conditions, especially in moderate to cool climates, mainly in peats and soft brown coals (Taylor et al., 1998). Chlorophyllinite occurs also in non-sapropelic facies types, even in young ombrogenous peats. The Chukurovo lignite is especially studied for presence of this maceral. The particles are rounded and spherical with 1μm size and red fluorescence colors in association with leave-like yellow-greenish fluorescing relicts. The chlorophyllinite is established as a result of a long time search on the samples.

*Bituminite*. Most of the studied coals are very poor of bituminite and bitumen products. The Katrishte lignite comprises 3% bituminite and Pernik sub-bituminous coal — 1%. Bituminite is about 2% in the Balkan high volatile bituminous coal. Migrabitumen sometimes fills the cracks of the Katrishte coal (fig. 2, 3). The bituminite probably originates as bacterial decomposition products of algae and faunal plankton (Taylor et al., 1998).

*Litpodetrinite* is 3% in the Sofia basin and it is about 1–2% in the rest studied coals (fig. 2, 3). Liptodetrinite is concentrated in many subaquatic coals (Taylor et al., 1998).

*Exsudatinite* is established as single finds into cell cavities of funginite and fusinite from the Katrishte and Balkan coal (fig. 2).

*Fluorinite* demonstrates the lipid character of the liptinite better than the cerinite. It is found in the lignite from Katrishte (1%) and Oranovo (1%) (fig. 2, 3).

*Fluorescing huminite* with low fluoresce intensity is observed in the Oranovo lignite, which is a result of "vitrinisation" of resinite (fig. 2) and weak *fluorescing vitrinite* is observed in Dobrudja medium rank coal — result of "vitrinisation" of bituminite.

Table 1

*Average values of vitrinite reflectance (Rr, vol. %) and average content of the fluorescing maceral (vol. %), calculated on the basis of organic matter of the samples*

Таблица 1

*Средни стойности на отражателната способност на витринита (Rr, об. %) и средно съдържание на флуоресцентни мацерали (об. %), изчислени на базата на органичното вещество в пробите*

| Basin | Oranovo | Katrishte | Kyustendil | Pernik | Chukurovo | Sofia | Balkan | Dobrudja |
|---|---|---|---|---|---|---|---|---|
| Rank | lignite | lignite | lignite | sub-bituminous-B | lignite | lignite | high volatile bituminous-A | high volatile bituminous-A |
| Rr | 0.33 | 0.31 | 0.30 | 0.48 | 0.37 | 0.23 | 1.12 | 0.79 |
| Sporinite | 3 | 2 | 3 | 1 | <1 | 5 | | |
| Cutinite | <1 | <1 | <1 | <1 | <1 | 1 | 0 | 0 |
| Resinite | 2 | 1 | 1 | 2 | 11 | 3.5 | | |
| Suberinite | 1 | 0 | <1 | 0 | 2 | 3.5 | | |
| Alginite | 8 | <1 | <1 | <1 | <1 | 1 | | |
| Liptodetrinite | 1 | 2 | 1 | 1 | 2 | 3 | 0 | 2 |
| Fluorinite | 1 | 1 | 0 | 0 | 0 | 0 | | |
| Chlorophyllinite | 0 | 0 | 0 | 0 | <1 | 0 | | |
| Bituminite | 0 | 3 | 0 | 1 | 0 | 0 | 2 | <1 |
| Exsudatinite | | | | | | | 0 | <1 |
| Macro-sporinite | | | | | | | 0 | <1 |
| Tenui-sporinite | | | | | | | 0 | 12 |
| Crassi-sporinite | | | | | | | 0 | <1 |
| Total Liptinite group | 16 | 9 | 5 | 5 | 15 | 17 | 2 | 14 |

## Conclusion

The studied Bulgarian low rank coals are rich of liptinite macerals (from 5 to 17%). The macerals from Liptinite group have interesting surface distribution (fig. 3). The low rank coal basins (mainly Miocene) are situated very closely (20–60 km) from North to South along the Struma River valley. The liptinite firstly decreases and after that increases from North to South in the frame of the studied area — the upper flow of Struma River. The middle part of the studied area was poor of hydrogen-rich plant materials as sporopolenin, cutin, suberin, resins, waxes, balsams, latex, fats, and oils. Probably the conditions of the peat bog were not appropriate for their preservation (oxygen, dryness, bacterial degradation) as the climate was warm and almost identical for all basins.

## References


Kamenov, B. 1954. *Report for Preliminary Exploration of the Nikolichevtsi-Sovoliano Coal Basin, During 1950/1951.* Sofia, Geofond, 280 p. (in Bulgarian).

Kortenski, J. 2002. *Coal Geology and Organic Petrology.* Sofia, Univ. Mining and Geol. "St. Ivan Rilski", 225 p. (in Bulgarian).

Kortenski, J., A. Sotirov. 2004. Petrography of the Neogene lignite from the Sofia basin, Bulgaria. — *Int. Journ. Coal Geol.*, *57*, 117—126.

Kruszewska, K. J. 2003. Fluorescing macerals in South African coals. — *Int. Journ. Coal Geol.*, *54*, 79—94.

Marinova, R., I. Zagorchev. 1994. *Explanation notice of Geological Map of Bulgaria, 1:100 000, Sheet Pernik*. Sofia, Geology and Geophisics, 92 p. (in Bulgarian).

Nikolov, Z., E. Stefanova, I. Tenchov, K. Popova, A. Popov, T. Dimitrova, G. Manev, V. Parashkevova, I. Ivanov, I. Yanakiev, R. Peeva. 1988. *Geology of the Dobrudja Basin.* Sofia, Tehnika, 170 p. (in Bulgarian).

Palamarev, E. 1964. Paleo—botanical studies of the Chukurovo coal basin. — *Journ. Inst. of Botanic*, *13*, 5—80 (in Bulgarian).

Petrov, P. I. 1983. Cenomanian paralimnic sand-argillite geocomplex in Central Balkanides. — In: *Proceedings 30 years Univ. Mining and Geol. "St. Ivan Rilski", 2,* Sofia, 191—199 (in Bulgarian).

Sotirov, A., J. Kortenski. 2004. Petrography of the coal from the Oranovo-Simitli basin, Bulgaria and indices of the coal facies. — *Int. Journ. Coal Geol.*, *57*, 71—76.

Sotirov, A., T. Rainer, J. Kortenski. 2002. Relationship between the reflectance of the maceral groups from coal with different rank. — *Ann. Univ. of Mining and Geol. "St. Ivan Rilski", 45*, 1, 97—100.

Taylor, G. H., M. Teichmüller, A. Davis, C. F. K. Diessel, K. Littke, P. Robert. 1998. *Organic Petrology*. Berlin–Stuttgart, Gebr. Borntraeger, 704 p.

Van Krevelen, D. W. 1993. *Coal Typology, Physics, Chemistry, Constitution.* Amsterdam, Elsevier, 979 p.

Vatsev, M. 1991. Stratigrapfy of the Neogene from the Simitli and Brejani graben. — *Ann. Univ. Mining and Geol. "St. Ivan Rilski"*, *37*, 23—38 (in Bulgarian).

Vatsev, M., P. Bonev. 1994. Lithostratigraphy of Neogene of the Kyustendil graben (Southwest Bulgaria). — *Ann. Univ. Mining and Geol. "St. Ivan Rilski"*, *40*, 43—50 (in Bulgarian).


(Постъпила на 04.03.2006 г., приета за печат на 28.09.2006 г.)