ГОДИШНИК НА МИННО-ГЕОЛОЖКИЯ УНИВЕРСИТЕТ “СВ. ИВАН РИЛСКИ”, Том 49, Св. I, Геология и геофизика, 2006
ANNUAL OF THE UNIVERSITY OF MINING AND GEOLOGY “ST. IVAN RILSKI”, Vol. 49, Part I, Geology and Geophysics, 2006

FACIAL CHARACTERISTICS OF THE ROMAN FORMATION (APTIAN) - AN EXAMPLE OF ONE SECTION NEAR MEZDRA, WESTERN FOREBALCAN

George Ajdanlijsky[1], Alexander Zdravkov[1], Jordan Koertenski[1], Doris Reischenbacher[2]

[1] *University of Mining and Geology “St. Ivan Rilski”, Sofia 1700*
[2] *Institut für Goewissenschaften, Montanuniversität Leoben, Leoben A-8700, Austria*

ABSTRACT. A detail lithofacial section of part of the Roman Formation (Aptian) western of Mezdra Railway Station was developed. Medium-grained sandstones with planar, low-angle cross-bedded and massive structure dominated. Relatively thin beds and lenses of hiporocks, argillaceous and marls are also observed. Levels with gypsum as well as solitary thin coal-seams are detected.
Sedimentary cycles with thickness from 1.7 to over 4 m are established in the section. The bottom of the cycles is marked by erosional and synsedimentary deformation structure, intra- and extraclasts, predominantly vertical bioturbations and coursing of the rock’s texture. The middle parts of the cycles contain fine- to very fine-grained rocks mainly with planar structure. The bioturbations, as far as are presented here, are predominantly horizontal. Towards the top of the cycles, together with the relatively coursing of the rocks development of paleosol features is established, whereas and some level with gypsum are determined.
To the purpose of the facial interpretation specialized mineralogical, petrographical and geochemical studies of samples from the coal-seams are conducted.
Conclusions about the conditions and the processes of sedimentation during the forming of the rocks of the Roman Formation in this area are done, including the main direction of sedimentary paleotransport, paleolandscape and paleoclimat characteristic.

ФАЦИАЛНИ ОСОБЕНОСТИ НА РОМАНСКАТА СВИТА (АПТ) НА ПРИМЕРА НА ЕДИН РАЗРЕЗ КРАЙ МЕЗДРА, ЗАПАДЕН ПРЕДБАЛКАН

Георги Айданлийски[1], Александър Здравков[1], Йордан Кортенски[1], Дорис Рейшенбахер[2]
[1] *Минно-геоложки университет “Св. Иван Рилски”, София 1700*
[2] *Геоложки институт, Минен университет Леобен, Леобен A-8700, Австрия*

РЕЗЮМЕ. Разработен е детайлен литофациален разрез на част от Романската свита (апт) западно от гара Мездра. Доминират среднозърнестите пясъчници с хоризонтална, нискоъгълно-косослоеста и масивна текстура. Наблюдават се още относително тънки пластове и лещи от хипоскали, аргилити и мергели. Установени са нива с гипс, както и единични тънки въглищни пластове.
В разреза са установени и характеризирани седиментационни цикли с дебелина от 1.7 до над 4 m. Началото на циклите е маркирано от разнообразни ерозионни текстури, интра- и екстракласти, текстури на синседиментационна деформация, предимно вертикални биотурбации и огрубяване на структурата на скалите. В средната част на циклите преобладават по-дребно и финозърнести скали с предимно хоризонталнослоеста текстура, а биотурбациите, доколкото са проявени, са предимно хоризонтални. Към горнището на циклите, наред с относително огрубяване на скалите, се установява развитие на палеопедогенни белези, а на места и на нива с гипс.
За целите на фациалната интерпретация са проведени и специализирани минераложки, петрографски и геохимични изследвания на проби от въглищните пластове.
Направени са изводи за условията и процесите на утайконатрупване при формирането на скалите на Романската свита в този район, в това число преобладаващата посока на седиментен палеотранспорт, характера на палеоландшафта и на палеоклимата.

Introduction

The Roman Formation (Nikolov, In: Ivanov and Nikolov (eds), 1983) is composed by sandstones, marls, siltstones and claystones, alternating irregularly with Urgonian limestones. The age of these rocks is Lower Cretaceous – from Upper Barremian to Aptian stage. At some levels the unit contains thin coal seams. The thickness of the Roman Fm varies in large diapason – from several hundred meters to over thousand meters. The area of distribution of this unit is the area of Iskar fall, in the Western edge of the central Fore Balkan and in some parts of the Eastern Fore Balkan. Most widely these rocks are outcropped in Central-North Bulgaria, mainly between the towns of Vratza and Sevlievo.

In the studied area the sandstones of the Roman Fm overlay with short lithological transition the marls of the Sumer Formation (Upper Aptian) and are covered through disconformity by the sandstones of the Darmantzi glauconitic-sandy-limestone Formation (Upper Campanian – Lower Maastrichtian). The thickness of the Roman Fm here is about 400 m.

Except some very short reports (Айданлийски, В: Синьовски и др., 2004) and despite of its wide distribution in North Bulgaria the Roman Fm is still poorly studied in view of its lithofacial properties and inner stratigraphical architecture. For this reason, detailed lithofacial and stratigraphic descriptions of concrete section of the unit practically do not exist in the literature.

This paper presents the first, more detailed lithological and high-resolution stratigraphic description of part of the Roman

Fm in the area of the Iskar Gorge. Object of study is one section of the unit situated on the road Botevgrad-Mezdra, about 2 km NE of Rebarkovo village, immediately east of Kteta hamlet (Fig. 1). On the basis of detailed field and laboratory lithofacial studies a model of the depositional style is proposed. After specialized petrographical study of coal sample new data about the specificity of the depositional environment during the deposition of the sediments of the Roman Formation is obtained.

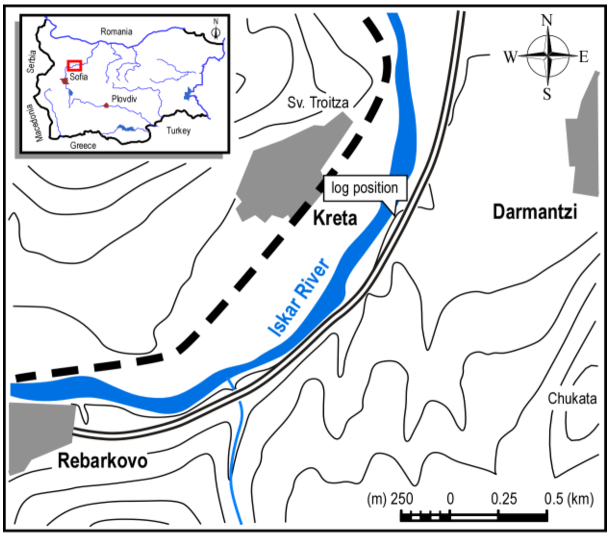


Fig. 1. Schematic map with position of the studied section

Material and methods

The object of the study is an about 65 m thick section from the lower part of the upper half of the Roman Formation. The lithofacial documentation of the studied succession is based on the Miall (1996) lithofacial scheme which was adapted and modified according its specificity. The lithological determinations in the rock samples are according to the proposed by Султанов (1980) classification of clay-carbonate rocks. The field color description of the rocks in the section is based on the Rock-Color Chart (1991).

Special attention was paid to the coal sample, which was investigated in order to provide some additional data against the specificity of the depositional environment. A representative part of the sample was crushed to <250 μm and then analyzed with Leco CS 300 instrument in order to establish the Total Organic Carbon (TOC) and sulphur contents. Rock Eval pyrolysis in duplicate, using a RockEval 2+ instrument was performed. The amount of hydrocarbons, released from the organic matter during gradual heating in a helium stream was normalized to the TOC to calculate the Hydrogen Index (HI; mgHC/gTOC). As a maturation parameter the temperature of maximum hydrocarbon generation T_{max} (°C) was established. Ash and moisture content measurements followed standard procedures (Deutsches Institut für Normung, 1978, 1980).

For microscopic investigations, the coal sample was crushed to a maximum size of 1 mm, mounted with epoxy resin, ground and polished. Maceral analysis was performed by Single-scan method (Taylor et al., 1998) with Leica MPV microscope, equipped with reflected white and blue irradiation light. At least 300 points were counted, using automatic point counter "Prior G". Huminite reflectance was measured on eu-ulminite. At least 50 points were measured, using Yttrium-Aluminum-Garnet standard with reflectance 0.899%.

Results

Lithofacial characteristic

The studied log is dominated by medium grained, well to poorly sorted, medium to thick bedded, limy to clayey sandstones (Fig. 2). In the lower part of the outcrop predominate the low-angel cross-bedded and horizontal laminated structures (lithofacieses Sl and Sh), while to the top of the sequence the planar and trough cross-bedded structures (lithofacieses Sp and Str) are more typical (Fig. 3). The massive and small-scale cross-bedded (mainly current ripple) sandstones are rarer. Sinsedimentary deformations (mainly slumps) with varying scales, are detected in several levels. Horizontal and rarely vertical bioturbation structures are observed mainly in the lower part of the studied log.

Other typical feature of the sandstones is the presence of extra- (mainly quartz) and intraformational clasts – mudclasts. Pebbly in size, usually well to medium rounded, they do not exceed several percentages in the sandstones and occupy the lamina surfaces. Just in several levels they form thin lag deposits (lithofacies Gm), where imbrications structure can be seen.

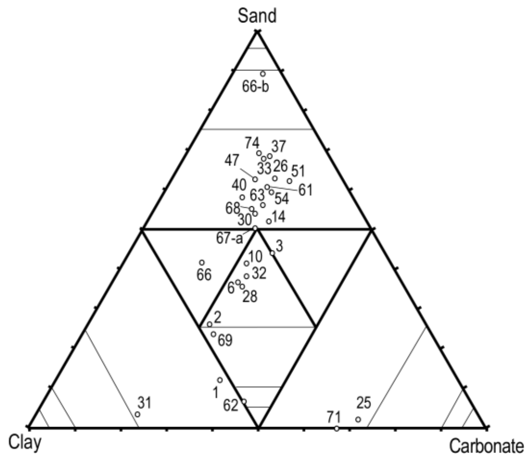
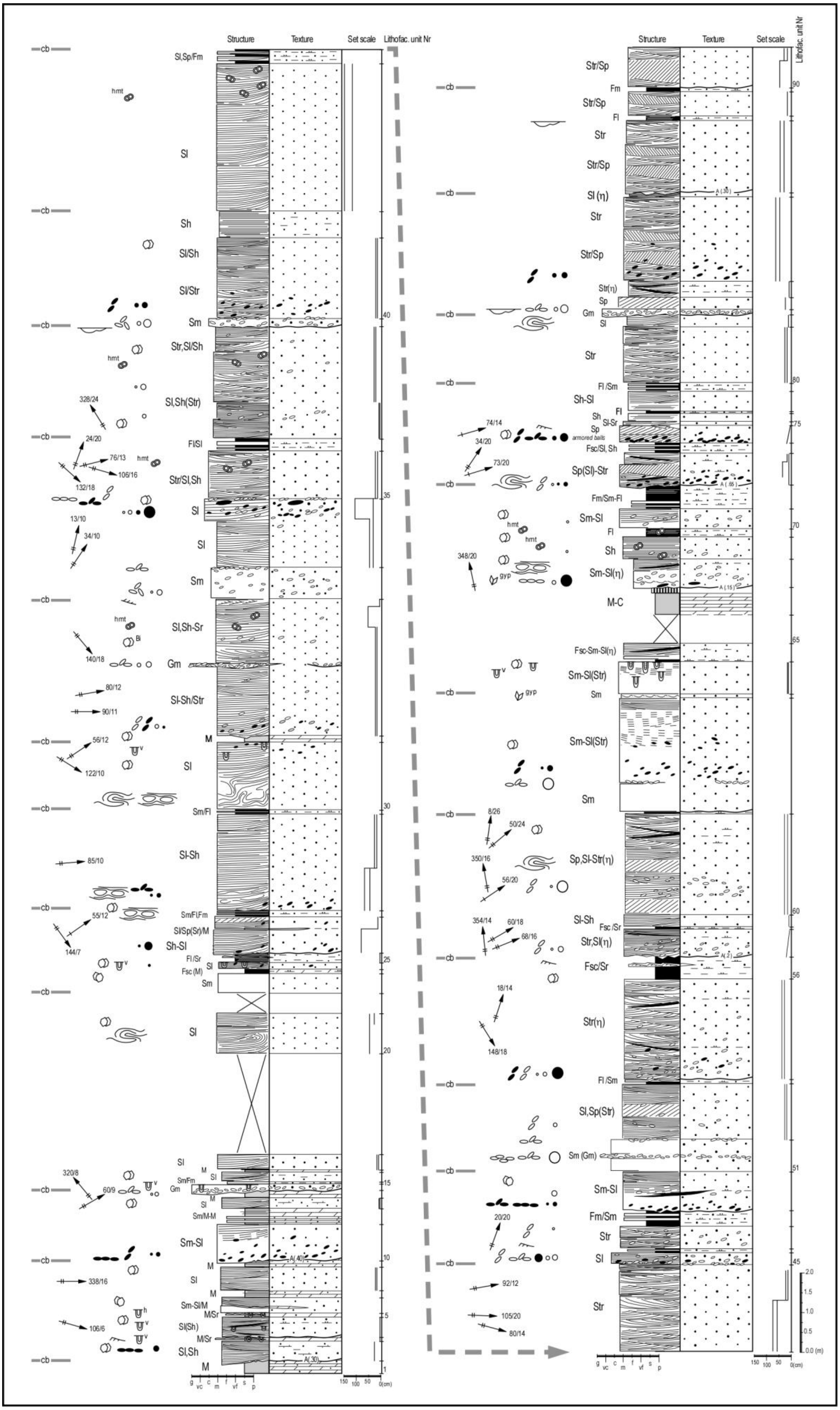


Fig. 2. Lithological characteristics of the representative for the studied outcrop rocks (according to the classification diagram of Sultanov, 1980)

The fine-grained rocks are presented mainly by sandy- and clayey siltstones with massive (lithofacies Fm) and laminated structure (lithofacies Fl), silty to pure claystones (lithofacies Fsc) and sandy, silty to pure marls (lithofacies M). Usually they form thinner than the sandstones packages where intercalation is seen. On the top of such package, dominated by marls, thin coal seam – lithofacies C, was detected (Fig. 3).



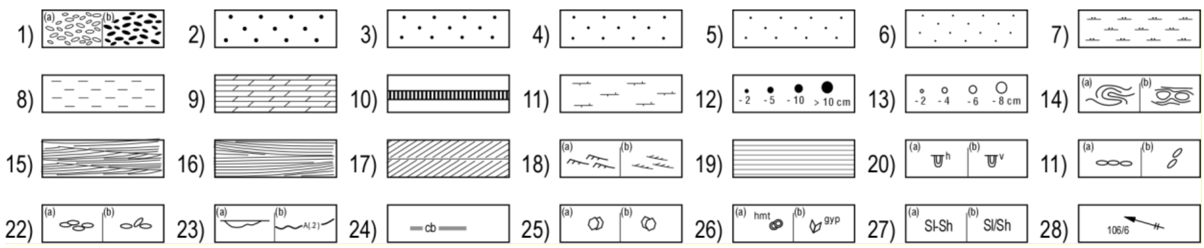


Fig. 3. Lithofacial log of the studied section. Lithology: (1) gravel - a) extraformational and b) intraformational; (2-6) sandstone: 2) very coarse; 3) coarse; 4) medium; 5) fine; 6) very fine; (7) siltstone; (8) claystone; (9) marl; (10) coal seam; (11) limy; (12-13) gravel size: 12) intraformational clasts; 13) extraformational clasts; Structures: (14) synsedimentary deformation – a) slump and b) slide; (15) trough cross-bedding; (16) low-angle cross-bedding; (17) planar cross-bedding; (18) small-scale cross-bedding – a) current and b) climbing ripples; (19) horizontal lamination; (20) bioturbation – a) horizontal and b) vertical; Clasts arrangement: (21) matrix supported – along the a) horizontal and b) cross-bedding lamination; (22) grain supported – a) lenses and b) imbrication; (23) boundaries – a) small scale erosional (scour structure) and b) main erosional surface with erosion amplitude; (24) cycle boundary; Mineralogy: (25) terrigenous mica – a) along the lamination and b) chaotic; (26) – a) paleosol feature and b) evaporate gypsum; (27) lithofacieses – a) transition and b) alternation; (28) paleotransport direction

Other specific characteristic of the studied succession is the existence of the paleosol features and the development of gypsum nodules and thin crusts. The palesol products are presented mainly by small usually solitary, rare as clusters (honeycomb), powder ferro-oxide concretion.

The systematic measurements of the structure that indicate the direction of the paleotransport, mainly trough cross-bedding, reveal oriented generally eastward sedimentary transport system.

Sedimentary cyclicity

The obtained data permit the distinguishing of asymmetrical and symmetrical sedimentary cycles. The bottom of the cycles is marked by erosional surface, often covered by lithofacies Sm, enriched by intra- and extraformational clasts. The sandstones are coarser and purely sorted. The amplitude of the erosion reaches 60 cm, but usually is about 20-30 cm. When the sandstones are laminated different in scale synsedimentary deformation structure – mainly slumps, can be observed.

The middle parts of the cycles are predominantly composed of fine- to very fine-grained rocks, mainly with planar structure. The bioturbations, as far as they are presented here, are mainly horizontal. Towards the top of the cycles, together with the relatively coarsing of the rocks, some development of immature paleosol features and uneven level with gypsum are detected. Some sinsedimentary deformations are observed as well. The bioturbation structures, where they are developed, are mainly vertical.

The thickness of the sedimentary cycles vary in range from 1.7 to 4.3 m, with pronounced domination of the cycles with thickness about 2.1-2.6 m.

Coal formation

The peat/coal deposition in alluvial valley/upper delta facies is generally controlled by the quantity of the terrigenous mineral matter, carried by the rivers, and usually results in formation of very high ash peats, due to the enormous mineral influx. A modern example of such coal-bearing strata is the Mississippi delta, which contains up to 5 m thick peat, interfingering with levee and crevasse splay deposits (Fisk, 1960: in McCabe, 1987), with an average ash content of 72 wt. % (dry-free basis; db). The development of the upper deltaic facies is related with the formation of meandering or anastomozing alluvial valleys, transporting the main part of the mineral matter. However, these active channels occupy only minor proportion of the whole deltaic plain and enclose large flood plain areas between them. The later can occasionally be flooded, especially in the wet seasons by overflow of the river banks. Within these areas organic matter can accumulate, usually in lacrustine environment, resulting in deposition of peat, containing large quantities of alginite, allochtonous liptinite macerals and inertinites (Diessel, 1992). It is possible in some cases a mire, which was initially developed as well- or poorly drained low-lying mire to be converted to a raised one (McCabe, 1987), due to the enhanced peat growth, combined with slow rate of basin subsidence. In such mires, as well as ones, located in remote areas, away from the fluvial sediment source, the nutrients supply diminishes and may even stop for an extended period of time (Diessel, 1992). This results in changes of the depositional environment, in which the organic matter accumulate, and establishment of oligotrophic conditions. These mires are mainly rein-fed and are able to build upwards, due to the ability to maintain their own water table (McCabe, 1987). Raised mires form in climatically very different conditions – from tropical to cold climates. However, distinction can be made between the peat from tropical climates, which are mainly forested, and of temperate regions, which are not (McCabe, 1987). Although no direct data regarding the climate during the Early Cretaceous in Bulgaria is supplied, the maceral composition of the coal indicates, that the climate was warm enough to favour development of mixed forested plant community. In addition, the petrographic composition of the studied coal represents a way to indirectly establish the paleoclimate. An analogous can be made with two late Oligocene coal deposits, located in West Bulgaria, i.e. Pernik and Bobov Dol deposits, which were developed in warm tempered climate (Palamarev et al., 1998). The “Mezdra coal” contains variable amounts of a specific type of resinite (Figs. 4a, b, d), characterized by medium reflectance and very weak fluorescence (Taylor et al., 1998), which is also typical for the Pernik (Zdravkov, unpublished data) and Bobov Dol (Zdravkov, Kortenski, 2004, in press) deposits. During the bituminization process large amounts of hydrocarbons are produced from this resinite (Taylor et al., 1998), which later infill the cell lumens of textinite/texto-ulminite in the form of low reflecting and strong fluorescing exsudatinite (Figs. 4a, b). The presence of this type of resinite in these deposits suggests the growth of similar plant communities and thus provides a way to indirectly establish the climatic conditions during peat formation in Mezdra region.

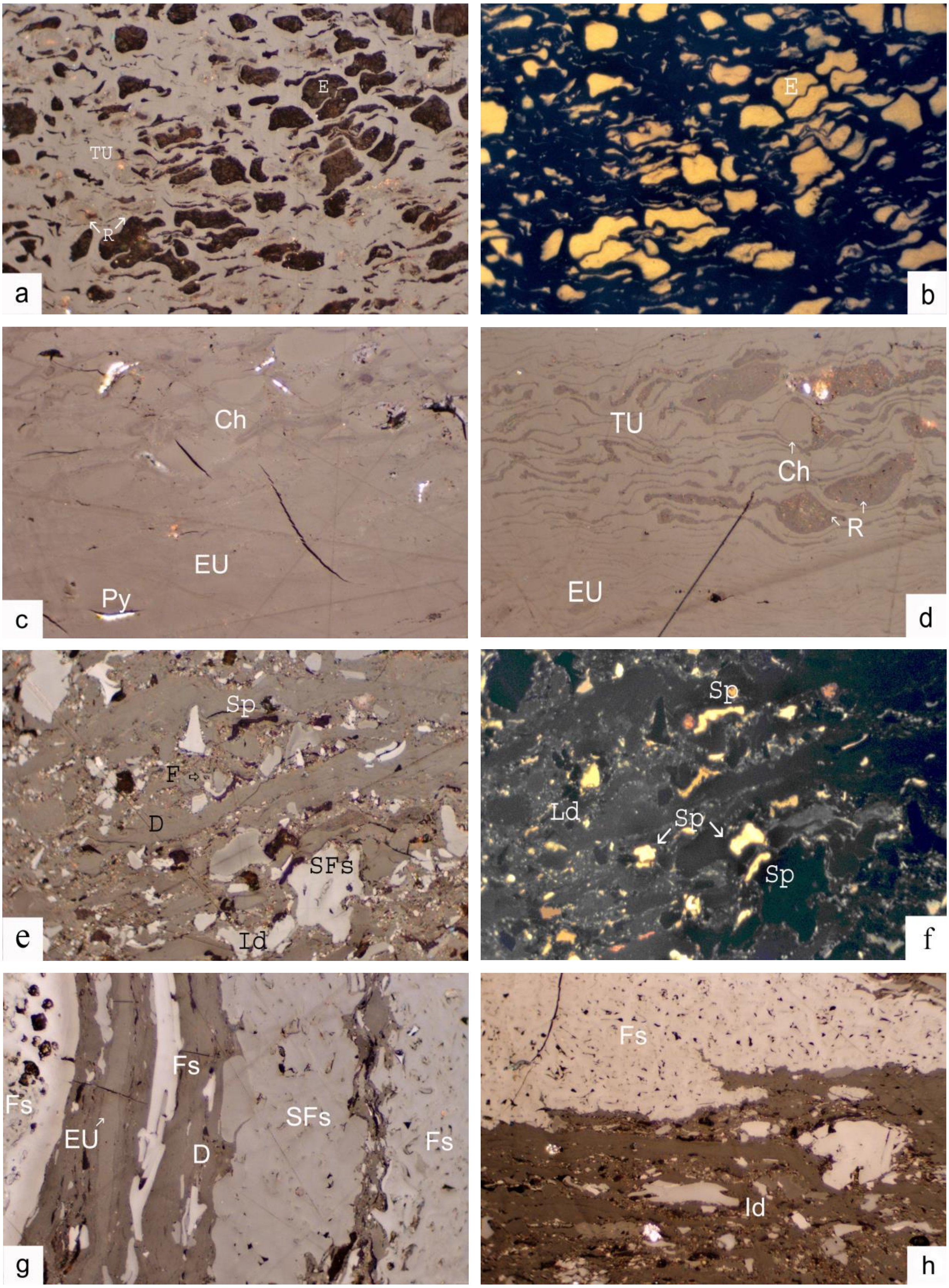


Fig. 4. Representative photomicrographs of the studied coal sample: a) transition form textinite to texto-ulminite (TU) with cell lumens, filled by low reflecting exsudatinite (E), 500x, reflected light; b) same as a), 500x, fluorescent light; c) coprohuminite (Ch), filling the lumens of texto-ulminite, in association with eu-ulminite (EU), diagenetic pyrite (Py) was formed in cracks in the eu-ulminite, 500x, reflected light; d) texto-ulminite (TU) with resinite (R) and coprohuminite (Ch) in its lumens, in association with eu-ulminite (EU), 500x, reflected light; e) densinite groundmass (D) with inertodetrinite (Id), semifusinite (SFs), funginite (F) and microspores (Sp), 500x, reflected light; f) same as e) – microsporinite (Sp) and liptodetrinite (Ld), 500x, fluorescent light; g) association of pyrofusinite (Fs) and semifusinite (SFs), 500x, reflected light; h) densinite groundmass with pyrofusinite (Fs) and inertodetrinite (Id), 500x, reflected light

The other liptinite macerals (mainly microsporinite and litodetrinite, Figs. 4e, f) in the studied coal sample are determined only in very small amounts.

Raised mires are usually characterized by more acidic conditions, then in other peat forming environments (Diessel, 1992; Taylor et al., 1998). This fact, as well as the restricted nutrients supply, due to the almost complete lack of mineral influx (ash content < 5 vol.%), reflects in decrease of the bacterial activity and thus in better tissue preservation (Taylor et al., 1998). Especially resistant were the tissues, which cell walls were primarily impregnated by resinous or tannin-derived substances. As a consequence, up to 13% of texto-ulminite (Figs. 1a, b, c, d), sometimes in transition to textinite (Fig. 4a), were detected in the analyzed coal. During the coalification process the major part of the resinite has been converted to exsudatinite, whereas almost 4% of coprohuminite cell excretions (Figs. 4c, d) were formed from the tannin-impregnated cell walls. The other part of the woody tissues (around 20%), which were not impregnated in the living plant, were easily converted to completely gelified eu-ulminite particles (Fig. 4c, d), closely associating with the texto-ulminite. In contrast to the woody plants, the herbaceous vegetation, which is rich in cellulose (Stach et al., 1982) usually degrade easily even in the absence of bacteria, thus forming a major part of the humodetrinite. The established mire conditions allow us to speculate that the high amount of densinitic groundmass (42 vol.%; Figs. 4e, g, h) in the studied coal sample indicates an enhanced contribution of herbaceous vegetation to the peat formation, rather then a severe humification of wood plants. In addition to the maceral composition high amount (up to 18%) of inertinite macerals was found in the coal. Their presence indicates low levels of the water table (Diessel, 1992), resulting in establishment of more oxidizing conditions and increasing the wildfire frequency. The Inertinite group is represented mainly by inertodetrinite (Figs. 4e, h), while the contents of both pyrofusinite (Figs. 4g, h) and semifusinite (Fig.4g) do not exceed 3.5 vol.%. Single fungal remains (ICCP, 2001) can rarely be seen too.

As a consequence of the deposition in a raised mire the studied coal is characterized by low ash content (<5%). However, the sulfur content is generally high (3.54 %). However, sulphur-bearing minerals (mainly diagenetic pyrite) were detected in very small amounts. This is most probably as a result of the lack of Fe ions, which are commonly transported into the mire adsorbed on clay minerals. The absence of mineral influx thus restricts the quantity of the Fe. In addition, since there is not enough energy for purely chemical reduction of sulphates to sulfides, the iron sulfide in peat can only be formed due to bacterial activity (Neavel, 1966), which as noted above is more or less decreased in raised mires. Therefore, the main amount of S probably occurs in organic complexes. According to the values of the Huminite reflectance (Rr = 0.47) and the TOC (71.6%, daf) the coal is on sub-bituminous stage of coalification (Taylor et al., 1998). This corroborates well with the results from the pyrolisis experiments, which indicate an immature organic matter (Tmax = 423 °C) with low hydrocarbon potential (HI = 105.3).

Conclussions

On the base of the obtained during the current study data we can conclude that the formation of the sediments of the Roman Fm pass in terrestrial conditions with relatively insignificant marine influence and source area, situated to the west of the studied location. The described above lithofacies architecture and cyclicity is characteristic for the delta-plain sedimentary environments which sporadically have been covered by marine waters. In such settings the channel distribution processes dominates forming wide and relatively flat delta plain. The coal formation indicates a local development of raised mires under warm tempered climate.

References

Паламарев, Е., Д. Иванов, Г. Китанов. 1998. Нови данни за фосилната флора от Бобовдолския басейн и нейното биостратиграфско значение. – *Сп. Бълг. геол. д-во*, *59*, 2-3, 13-21.

Синьовски, Д., М. Антонов, В. Желев, Г. Айданлийски, С. Вангелов, К. Стойкова. 2004. Маршрут III. Лютиброд-Челопек. - В: *Геоложки маршрути в северната част на Искърския пролом* (ред. Синьовски, Д.). С., Изд. Ваньо Недков, 43-50.

Султанов, А. Т. 1980. Новая классификационная диаграмма глинесто-карбонатных пород системы карбонат-глина-обломочный компонент. – *Докл. БАН, 33*, 8, 1103-1106.

Deutsches Institut für Normung. 1978. Feste Brennstoffe; Bestimmung des Wassergehaltes, DIN 51718.

Deutsches Institut für Normung. 1978. Feste Brennstoffe; Bestimmung des Aschegehaltes, DIN 51719.

Diessel, C. F. K. 1992. *Coal-bearing Depositional Systems*. Springer, Berlin, 721 p.

ICCP. 2001. The new inertinite classification (ICCP System 1994) – *Fuel*, *80*, 459-471.

McCabe, P.J. 1987. Facies studies of coal and coal-bearing strata. – In: Scott, A. (ed.) *Coal and Coal-bearing Strata: Recent Advances.* Geological society special publication 32, Blackwell Scientific Publications, Oxford, 51-66.

Miall, A. D. 1996. *The Geology of Fluvial Deposits. Sedimentary Facies, Basin Analysis and Petroleum Geology*. Springer, 582 p.

Neavel, R. C. 1966. *Sulfur in Coal: Its Distribution in the Seam and in Mine Products*. Ph.D. Thesis, Penn. State Univ., 332 p.

Nikolov, T. 1983. Coupe de la Formation de Roman. – In: *Reunion extraordinare de la Sociètè gèologique de France en Bulgarie* (Eds. Ivanov, J., T. Nikolov). Sofia, Presse univers., 50-51.

Rock-Color Chart. 1991. (7th print.) Geol. Soc. Amer., Boulder, Co.

Stach, E., M. Mackowsky, M. Teichmüller, G. Taylor, D. Chandra, R. Teichmüllerл 1982. *Stach's Textbook of Coal Petrology*. Gebrüder Borntraeger, Berlin.

Taylor, G., M. Teichmuller, A. Davis, C. Diessel, R. Littke, P. Robert. 1998. *Organic Petrology*. Berlin-Stuttgart, Gebrüder Borntraeger, 704 p.

Zdravkov, A., J. Kortenski. 2004. Petrology and depositional environment of the coal from Bobov Dol basin, Bulgaria. – *Ann. Univ. Min. Geol., 47*, 1, 101-108.

Recommended for publication by Department of
Geology and Paleontology, Faculty of Geology and Prospecting