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*Magyar Állami
Földtani Intézet*

Abstract Book

*56th Annual Meeting
of the International Committee for
Coal and Organic Petrology*

Environmental management implications
of organic facies studies



12–18th September 2004, Budapest

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Oral presentations

Advanced coal technologies will meet the challenges of the 21st century

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Key words: energy policy, clean coal technologies, environment, Hungary

The latest forecasts suggest that the world's population would grow from 6 billion at the end of the 20th century to 8 billion in 2020, with 90% of the projected increase to take place in the developing world. Thus, the main challenge the energy sector will face is to continue to supply secure and affordable energy to meet the growing demand. Although most of the developed countries are involved in the energy conservation programs, global energy consumption will continue to increase, driven by economic growth and the need of the developing countries. The world demand is expected to increase by almost 70% over the next 30 years, mostly in the developing countries (IEA, 2002).

To meet the growing demand, the world cannot ignore any of the energy sources available. Though there are no risk-free ways of producing energy, whether in terms of human physical safety, security of supply or environmental impact, the solution to this would be policies focused on creating a diverse and balanced energy mix, where the strengths of one energy source can help make up for the disadvantages of the others.

A necessity of the environmental protection and the common goal of lowering emissions were the reasons for active renewables' development. However, the practice shows that, despite all efforts, the renewable energies can only make a limited contribution to the world energy supply due to its high cost and practical limits, where CO₂ avoidance costs are well in excess of €50/t CO₂. Thus, according to the IEA forecasts, the renewables will still account for less than 5% of the world electricity supply by 2030 (IEA, 2002).

Other fuels will have to provide a great amount of the additional energy required over the period, where fossil fuels are of the key importance. "Fossil fuels, though environmentally challenged, can meet the criteria of security and affordability. Technology, driven by the right incentives, offers possible answers to the environmental problems..." (ROBERT PRIDDLE, IEA, 2002).

The volatility of oil prices, which have jumped 20% this year, and was due to the political tensions in the Middle East, OPEC's supply management, and China's rapid development (Fig. 1), as well as the gas price increase, made Governments think of the alternative sources of energy in order to stay in the frame of a sustainable energy policy.

All these factors prove that coal will continue to be vital for global energy security, being abundantly available, affordable, reliable, and easy-and-safe to transport. As the majority would argue, coal is the most carbon intensive fuel for electricity. However, it turns out to be a short-sighted analysis, because when we are talking about the climate

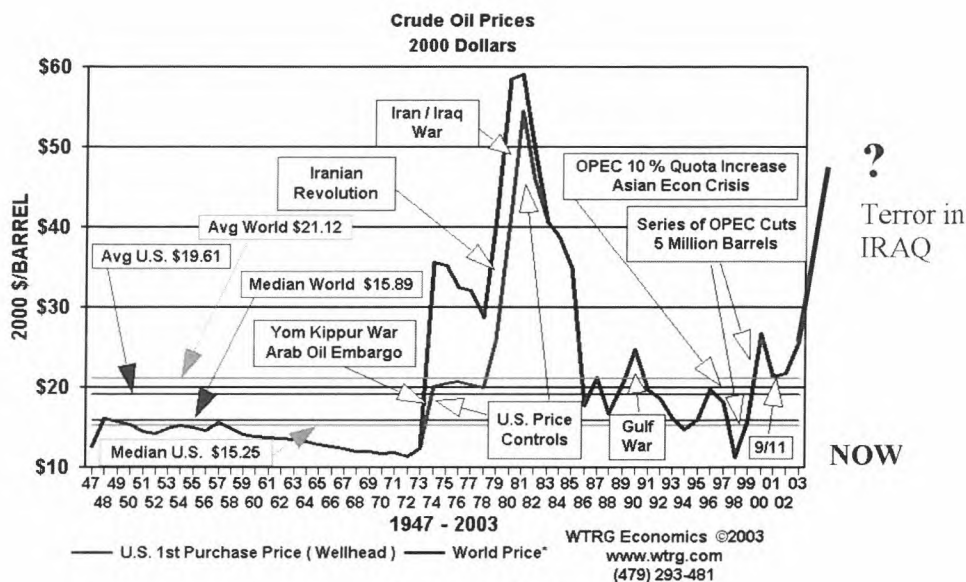


Fig. 1. Crude Oil Prices

change and GHGs, we need to address the impact of all six GHGs on the basis of a life-cycle analysis (e.g. from the gas well to the point of use). This type of analysis shows that switching from one fossil fuel to another only achieves a relatively small reduction in overall GHG emissions.

For sustainable development to occur, technology transfer is vital to facilitate the efficient management of resources and to ensure access to the clean coal technologies now available for environmental protection, which could in long term help achieve the ultimate objective of low- CO_2 or even zero- CO_2 power generation.

It has already been proven that technical solutions such as improved combustion efficiency and reduced emissions, coal gasification, new approaches to carbon capture and storage, and the production of hydrogen from coal would contribute to a sustainable energy policy. Technological advances including CO_2 sequestration will bring CO_2 avoidance costs down to below € 50/ t CO_2 , hence technology of this kind would outperform most renewables-based power generation systems.

The question of making clean coal technologies affordable is crucial for the Hungarian market as well, where the share of coal in the fuel consumption of power plants is 25%. Many of these power plants are obsolete and should be reconstructed due to the pressing environmental requirements, which became even stricter after EU accession. These factors and still not solved situation with Paks NPP should be taken into account by the government and the major players of the energy sector when building a *long-term sustainable energy policy* and addressing the question of further usage of coal as a main part of the Hungarian fuel mix. Their commitment to improving coal's sustainability by supporting the major research efforts, credible input to policy making and aid funding would not only accelerate the clean coal technologies' uptake, but also address the local sustainability issues, enhancing economic and social development of the country.

A Short History of the Oil and Gas E&P in Hungary

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It is hardly known outside of the region, that the modern oil production from subsurface layers started in the outer zones of the Carpathians as early as the first half of 1850-ies, i.e. a couple of years earlier than Colonel Drake's first well in 1859, Titusville, Pennsylvania. Similarly this region has witnessed in the early 20th century the first commercial application of what is called today geophysical exploration through applying the torsion balance (the grandfather of the modern gravimeters) to detect subsurface uplifts as potential accumulations of oil and gas. The modern production technologies to assist the natural driving forces (water influx, gas expansion) water injection and gas (re)injection were introduced in oilfields in Hungary in early 1940's. Subsequently, with the advent of up-to-date IOR, EOR technologies, Hungarian scientists and engineers took a leading role in the field size application of CO₂ injection, horizontal wells in addition to the extensive laboratory and pilot tests on the application of different types of chemical flooding, nitrogene and rich gas injections.

Until today a total of about 300 million toe (~2 billion boe) has been produced from underneath the Hungarian soil. These figures however do not indicate that the petroleum industry in Hungary survived six political regimes with the alternation of different economic philosophies from a full state control/monopoly to a fully private economy. Not surprisingly the main challenges have always been the same:

- what extent should the state involved in the exploration and production of oil and gas?
- what extent should the state support and encouraged the private investors through promote the exploration by financing reconnaissance phase evaluations traditionally conducted through the Geological Survey(s)?
- how to prevent the prevalence of short termism of the operators with no early exploration success?

Recently the region (i.e. the Carpathian Basin in general and its central part, the Pannonian Basin in particular) has become a training field to demonstrate how to revitalize the exploration in a mature to supermature oil and gas province with an access to a well developed petroleum infrastructure and with an availability skilled labour force to apply E&P high tech efficiently. Case histories indicate, that the modern technology is an adequate tool but not a silver bullet: a skilled human resource is the "sine qua non" of a successful future.

Influence of coal petrography on mercury distribution in coal seams; Examples from Pennsylvanian coals in Indiana, U.S.A.

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Key words: mercury, coal, Pennsylvanian, Indiana

Coal samples (several benches from each location) were collected from twelve Indiana mines to study the distributions of mercury between different coal seams and within individual seams. Coal mines sampled were located in Parke, Clay, Sullivan, Greene, Knox, Daviess, Gibson, Warrick, and Spencer Counties (Fig. 1), and the analyzed coals included the Danville, Hymera, Springfield, Minshall/Bufaloville, Upper Block, and Lower Block Coal Members, an unnamed coal in the Mansfield Formation, and the Mariah Hill Coal Member. Average mercury concentrations for the raw coal of

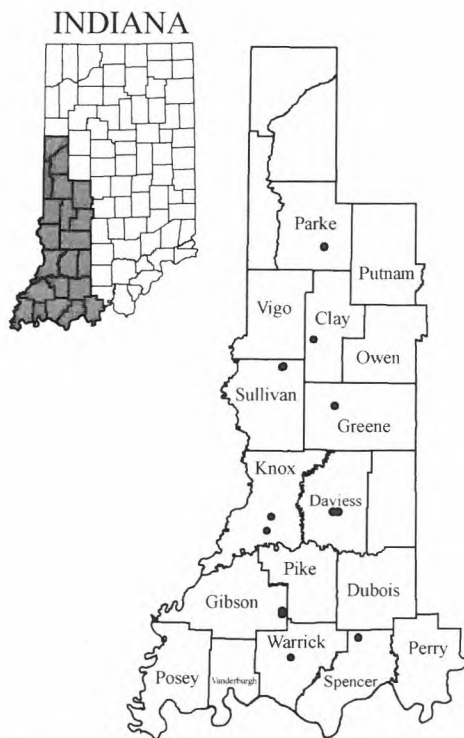


Fig. 1. Map showing the mines studied in southwestern Indiana

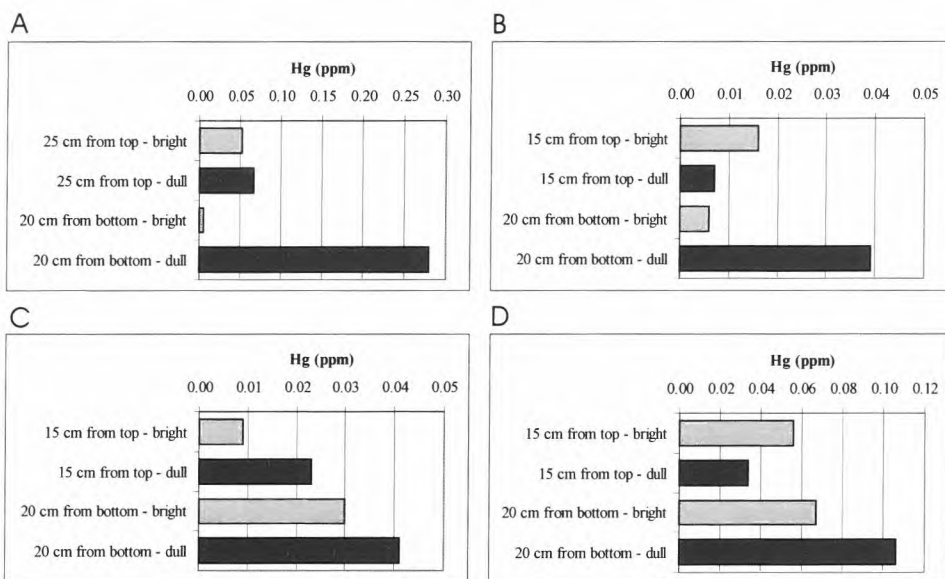


Fig. 2. Comparison of mercury content in vitrain (bright) and durain (dull) lithotypes in four coal beds from Indiana. A — Midway Mine in Daviess County — Buffaloville coal, Hg content for the whole seam is 0.1 ppm; B — Billings Mine in Daviess County — Lower Block coal (thickness 53 cm), Average Hg content for the whole coal seam is 0.04 ppm; C — Billing Mine in Daviess County — Upper Block coal, Hg content for the whole coal seam is 0.07 ppm; D — Cypress Creek Mine in Warrick County — Springfield coal (thickness 130 cm), Average Hg content for the whole coal seam is 0.06 ppm

the whole seam samples ranged from 0.03 ppm to 0.31 ppm, and mercury contents in their washed (float) fractions ranged from 0.02 ppm to 0.15 ppm.

In high-sulfur coals, mercury content showed positive relationship with total sulfur and pyritic sulfur content, suggesting its association with pyrite. Occasionally, where no relationship with pyrite occurred, a relationship with ash yield was noted, suggesting an association with mineral matter other than pyrite. In high-sulfur coals, no relationships between petrographic composition of coal and mercury contents were detected. In low-sulfur coals, relationships between petrographic composition and mercury were coal- and site-specific. In most cases, the mercury content was higher in coals having higher liptinite content, and often mercury content decreased with an increase in vitrinite content. The site-specific nature of mercury relationships is also supported by mercury contents in lithotypes. The analyses of vitrain and durain pairs from different coal beds demonstrated that mercury preference for specific lithotypes is not universal. In some coal beds, it is higher in durain than in vitrain (Fig. 2A, C), whereas in others vitrain has more mercury than durain (for example, upper part of the coal bed in Fig. 2B). It is not uncommon that these relationships differ between lower and upper parts of the coal beds (Fig. 2B, D). Our ongoing study on the determination of mercury speciation in sequentially extracted coal fractions may help to understand these varying relationships.

Coal dispersal in the marine environment around a marine coal terminal, British Columbia, Canada

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A 1999 assessment of sediments, adjacent to the Roberts Bank coal terminal in Delta, British Columbia, Canada, shows that the concentration of coal particles (reported as non-hydrolyzable solids or NHS) has increased substantially since 1977. NHS concentrations have doubled from a mean concentration of 1.80% (1977) to 3.60% (1999). Since 1977 the main deposition of coal has occurred in the vicinity of the coal-loading terminals, where concentrations of 10.47% and 11.90% NHS occur.

The settling properties of coal particles (<53 μm up to >2.36 mm) were examined to understand the dispersal of coal in marine waters. No change in settling velocity of coal particles occurred with increasing saturation of oxidation. However, the proportion of buoyant coal particles decreases with increasing oxidation in all size fractions, reflecting the decrease of coal hydrophobicity with oxidation.

The distribution of coal around the terminals agrees with particle settling velocity and buoyancy, with coal concentration decreasing rapidly away from the terminal. Coarser sediment fractions contain the highest coal (NHS) concentrations and carbon/nitrogen ratios when compared to finer fractions. Coal particles >2.36 mm (settling velocities ?10.54 cm/s) settle out close to the terminal (depending on currents), whilst small (<53 μm) and weakly oxidized coal particles travel further and take longer to settle out (settling velocities ?0.16 cm/s). This results in a wider dispersal of coal particles, and a corresponding decrease in the coal concentration.

Coal distribution would likely affect benthic flora and fauna (most susceptible to coal dust coverage and possible anoxic conditions that might arise during coal oxidation) within very close proximity (0–300 m) to the coal-loading terminal.

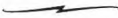
Coal Petrology and Chemistry of Permian coals from the Paraná Basin:

1. Santa Terezinha, Leão-Butiá and Candiota Coalfields, Rio Grande do Sul, Brazil

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The current paper presents results on coal seam development and characterisation in Permian coal-bearing strata from the Paraná Basin, southern Brazil (Candiota, Leão-Butiá and Santa Terezinha Coalfields). Sequence stratigraphic analysis shows that peat accumulation in Permian time was closely linked to transgressive/regressive cycles, with peat accumulation occurring in a predominantly back barrier type setting. Coal petrographic analysis indicates subbituminous coals at Candiota and Leão-Butiá and high volatile bituminous coals at Santa Terezinha. Locally the coal seams are thermally altered by volcanic intrusions.

The organic matter is dominated by vitrinite and inertinite macerals. Chemical analysis indicates that all coal seams are high in ash yields (mean 48.5 wt.%), with sulphur averaging 1.66 wt.%. The average concentrations for elements of environmental concern (As, Se, Pb, Cd, Hg, Tl) are similar to or less than the mean values for U.S. coal.



Organic facies in the Late Cretaceous to Tertiary of the Gippsland and Bass Basin, South Eastern Australia

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Sedimentary basins developed along the southern rift margins of the Australian continent show a Cretaceous to Recent section with the development of coal measures sections being more prominent in the more eastern basins. The coals have been extensively mined onshore, and the offshore areas have been subject to intensive exploration for oil and gas. Gippsland Basin was the first major oil province developed within Australia and contains two giant fields, Kingfish and Halibut. The oils and associated gas are clearly derived from the coal measures sections, although there is still debate concerning the contribution of the coals as opposed to that from the dispersed organic matter (dom).

The sections drilled range down to the upper part of the Cretaceous. The coals show three distinct organic facies and these can be related to the progression of climatic conditions that were associated with the opening of the seaway between the Australian and Antarctic continents and the development of the circumpolar current. This current is still a major factor in the present climate of southern Australia and its initiation coincides with a major change in organic facies.

Extensive analyses have been made on the coals that are mined within the Latrobe Valley (E of Melbourne) and at Bacchus Marsh (SW of Melbourne). Approximately 2000 samples have been examined from oil and gas exploration wells, mainly in the offshore areas. Most of the samples have been cuttings, but about 25% are sidewall cores, and a smaller proportion is from conventional cores.

The oldest of the facies is termed the Lower Eastern View Facies and is found within the upper part of the Cretaceous section, the Paleocene and the lower part of the Eocene. It is characterised by coals that have an aspect similar to that of most older coals such as those from the Carboniferous and the Permian. Liptinite contents are typically moderate and inertinite content ranges from low to high, but all of the populations represent inertinite derived from higher plants, being dominated by semifusinite, inertodetrinite and fusinite. Micrinite tends to be rare. Two subfacies are recognised, one with >50% inertinite and one with <50% inertinite. It is probable that these subfacies show a systematic distribution, but the lateral coverage of data is insufficient to show this. Cutinite and sporinite are the main liptinite macerals in these coals.

Within the lower part of the Eocene, the Upper Eastern View Facies constitutes a transitional facies. The diverse inertinite population characteristic of the Lower Eastern View Facies is present but, in addition, funginite is also present. Liptinite is locally a major component and the main components are sporinite and resinite.

The uppermost facies is termed the Latrobe Valley Facies and the coals that outcrop within the Latrobe Valley belong to this facies. These coals are dominated by vitrinite and resemble the maceral compositions of most other coals of Tertiary age. The overall content of liptinite is moderate, averaging about 8%. However, the range is high with some relatively thick plies of seams containing up to 45%. Suberinite and resinite are the most prominent liptinite macerals, although sporinite and cutinite are locally prominent. Apart from the organic facies within the Latrobe Valley Facies, it is also associated with the presence of ultra-thick coal seams – some over 100 m in thickness. In part, this change may be related to the changed peat conditions, but a lower overall rate of basin subsidence is likely to be an additional factor in this change.

Vitrinite reflectance ranges from about 0.30% in the shallower part of the section up to about 1.20% in some of the deeper sections. The relationship between depth and vitrinite reflectance is complicated by the existence of a relatively early phase of coalification that mainly affected the nearshore parts of the sedimentary basins. In the deeper offshore parts of the basins, relatively low vitrinite reflectance values persist to considerable depths. Thus at about 3,500 metres in the near-offshore Tuna field reflectances reach about 1.00% whereas at similar depths in the deep-water Hapuku field, vitrinite reflectance values are between 0.40% and 0.45%. Some complexities in the distribution of vitrinite reflectance are also due to zones with overpressuring.

Some of the sections are sufficiently thick for transitions to be seen between the textures typical of brown coals (such as textinite and attrinite) through intermediate textures (such as ulminite or texto-ulminite and densinite) to those typical of bituminous coals (telocollinite and desmocollinite).

The oils are probably derived in the main from the Lower Eastern View Facies coals. In this respect, the oilfields differ from those of provinces such as the Mahakam Delta in Indonesia, or the NW Jawa Basin where the coals are all similar in facies to the Latrobe Valley Facies. The significance of this is that the major sources of the oils are coals that are similar in organic facies to those of many of the older coal measures sequences.

A number of fallacies have been “read into the literature” and it is worth highlighting some of these. The coals are not marine coals (concept proposed by a major oil company at one stage). Indeed, marine influence is generally minor and pyrite is usually not prominent. Although a small number of layers with lamalginite are known, most of the coals contain no alginite. Thus, the proposal that the coals are an unusual algal rich facies is untrue.

Many features within the coals indicate that oil generation is relatively early in the maturation history. Exsudatinitite is present, but possibly only in the few areas where igneous intrusions are found. Certainly, meta-exsudatinitite is restricted to contact altered aureoles.

The transition from the Lower Eastern View Facies to the Latrobe Valley Facies is associated with the establishment of the circumpolar current and the development of a wet Mediterranean type of climate. This permitted the development of forest communities similar to those found nowadays in the wetter parts of western Tasmania and the SW part of the South Island of New Zealand.



Lithofacies analysis of coal seams from the upper part of the coal-bearing measures of the Upper Silesia Coal Basin (Westphalian, Poland)

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Keywords: Coal lithotypes, Coal facies, Peat-forming environments, Upper Silesia Coal Basin

Two units compose the upper part of the coal-bearing measures of the Upper Silesia Coal Basin: Mudstone Series and Krakow Sandstone Series. Both series are composed of continental deposits. Sediments of the Mudstone Series were laid down on an extensive, subsiding alluvial plain, crossed by low-gradient, high-sinuosity, suspended load-dominated rivers. Fine-grained deposits — mudstone and subordinate claystones — are predominant. Coal seams are numerous, and usually thin. The Krakow Sandstone Series is interpreted as deposits of a fluvial system of the distal, sandy, braided rivers. The Krakow Sandstone Series deposits consist of thick sandstone bodies subordinately intercalated with thin, fine-grained packets of mudstones and coal. This series contains a few tens of coal seams thicker than 10 cm.

Coal petrography and facies analysis are based mainly on many boreholes documentation. Personnel of the Polish Geological Institute have described all coal seams and coal layers in these boreholes. Some coal seams have been described and sampled during working in the underground mines by the author. The coal seams have been described by presenting their thickness, occurrence of non-coal partings and lithotype composition. For lithotype identification, the terminology adopted from LIPIARSKI (1973) has been used. Lithotype associations and their thickness have interpreted the depositional environments of the original peat swamps. To determine the conditions existing in the paleo-peatbog the modified lithofacies scheme introduced by POKROŃSKI (1994) has been used. This scheme was verified by microfacies analysis and modified by the author. Six associations of lithotypes and related peat-forming mires are presented in Table 1.

Eight lithotypes were distinguished in the studied coals: vitrain, clarain, durain, fusain, clarovitrain, vitroclarain, duroclarain, clarodurain. In the Mudstone Series, vitrinoclarain and clarovitrain are the major macroscopic components of the coal seams.

Table 1. Description of the lithofacies distinguished in the studied coal seams

Lithotype composition	Type of peat-forming environments
Fusain, clarovitrain, vitroclarain with fusain lenses and layers (more than 33%)	Dry forest swamp
Clarovitrain, vitroclarain mainly thick and medium banded	Wet forest swamp
Thin-banded vitroclarain, medium- and thick banded duroclarain,	Wet mixed swamp (wet fen)
Thin-banded vitroclarain, thin- and medium-banded clarodurain with fusain lenses and layers (more than 33%)	Dry mixed swamp (dry fen)
Durain, clarodurain and thin-banded duroclarain	Herbaceous swamp
Coal shales, shaly coal, shale with streaks of coal	Clastic swamp

The coal seams from Krakow Sandstone Series are characterized predominantly by vitroclarain and clarodurain. In both units intercalations of partings occur frequently in the coal seams. Additionally, some coal seams from Mudstone Series contain many lenses and layers of fusain.

Lithofacies analysis demonstrates that coal seams from Mudstone Series are originated mostly from mixed swamp (fen) and wet forest swamp. Peat deposition occurred predominantly in the wet forest swamp during the formation of Krakow Sandstone Series coal seams. In the Mudstone Series peat bogs phytogenic sedimentation most frequently started in forest swamp environment whereas the beginning of mires development in Krakow Sandstone Series took place in herbaceous and mixed swamp conditions. No vertical trend has been found in the variation of peat bog types throughout the Mudstone Series. During sedimentation of Krakow Sandstone Series depositional environments of peat bog changed from wet forest swamp in the lower part, across herbaceous swamp in the middle part, up to forest and mixed swamp conditions in the upper part.

Variability of petrographic structure of the studied coal seams shows frequent changes in the conditions of the peatbog. Changing groundwater levels, plant communities and proximity to active fluvial channels controlled these changes.

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Organic facies and palynofacies: nomenclature, classification and application for petroleum source rocks evaluation

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Key words: Organic facies, palynofacies, nomenclature, classification

The present paper discusses petrographic and palynological characteristics of organic facies and its application for petroleum source rock evaluation. The investigations presented were carried out on the basis of previous investigation on Mesozoic and Tertiary formations of the Montenegrin littoral (1) and on Tertiary sedimentary organic facies and palynofacies from Pre-Badenian («Red series» and Ottnangian–Karpatian), Badenian, Sarmatian and Pannonian s.l. of the Pannonian Basin (Serbia; 2).

The investigations were basically aimed to determine all the relevant petrographic and geochemical characteristics of organic facies and their correlation to the lithologic composition, sedimentation conditions and paleoenvironments. Application of recent geological and geochemical methods give a new insight into the problems concerning determination of the potential and efficiency of petroleum source rocks.

In this study, qualitative and quantitative analysis of organic matter have been performed using different analytical methods and samples (whole rock samples, kerogen concentrates; transmitted and reflected normal and fluorescent light). Type of organic facies was used as a criterion for identification, accumulation and transformation of the organic matter. Paleocological study of organic facies and palynofacies were used to identify types of vegetation and deduce conclusion on the sedimentary environment.

Various types of organic facies and palynofacies were classified in relation to the origin of the organic matter. All sedimentary organic constituents of continental (allochthonous — huminite/vitrinite, inertinite, cuticle, wood fragments, tracheids, spores and pollens) and marine (mostly autochthonous — dinocysts, algae, foraminifera test linings, acritarchs and amorphous organic matter) origin have been grouped according to different classification systems (1, 2, 3). A summary of this classification is proposed in Table 1, with remarks on approximate corresponding coal macerals and selected kerogen types. For the classification of organic facies, Rock Eval analyses have been carried out parallel to the microscopical investigation.

On the basis of organic facies and palynofacies analyses it is possible to recognize different depositional environments and provide an information on source rock potential. The category of gas-prone material include non-fluorescent, generally orange or brown, translucent, structured organic matter, but also translucent, non-fluorescent, structurless material. The most important constituents of oil-prone material are fluorescent amorphous organic matter and fluorescent non-alginitic palynomorph, cuticle and membranous debris. The highly oil-prone material consists of mostly fluorescent organic matter

Table 1. Organic facies and palynofacies, nomenclature and classification

CATEGORY			CONSTITUENT	MACERAL	KEROGEN TYPE
Structured OM (SOM)	Structured terrestrial plant material (STPM)	Phytoclasts	Cuticle (leaf-epidermal tissues) Plant tissue (cortex tissues of stem or root) Woody tissues (secondary xylem) – Gymnosperm tracheid tissue – Angiosperm tracheid tissue – Structured gelified tissue Biochemically oxidized wood (charcoal)	Cutinite Suberinite/Telinite Telinite (Collinite) Inertinite	II (oil prone) III (gas prone) III (gas prone) IV (inert)
			Fungal remains	Hyphae (fungal filaments, spores)	Sclerotinite (Inertinite) IV (inert)
		Palynomorphs	Sporomorphs (spores and pollen grain) Algae (phytoplankton) – marine phytoplankton (Dinocysts, Acricrarcha, Prasinophita) – fresh-water algae (Botryococcus) Zoomorphs (Scolecodonts, Chitinozoa, foraminiferal linings)	Liptinite Alginite —	II (oil prone) I (oil prone) —
Structureless OM (SLOM)	Amorphous OM (AOM)	Phytoplankton	Highly degraded OM; faecal pellets (fluorescent AOM)	Liptinite (Bituminite, Amorphinite)	II (oil prone)
		Bacteria	Cyanobacteria, Thiobacteria	Lamalginite	II / I (oil prone)
		Higher plant decomposition products	Degraded higher plant debris, humic cell-filling material (non-fluorescent AOM)	Hebamorphanite Vitrinite (Collinite ?)	III (gas prone)

including structured material derived from chlorococcale and prasinophyte algae, and amorphous material derived from cyanobacteria and thiobacteria. Resins and some cuticles are the only significant terrestrially derived components belonging to this group.

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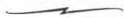
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Comparisons of organic geochemical data to organic petrological observations and classification of organic matter

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Among organic-rich rocks the oil shales and canneloid coals are the most important liquid hydrocarbon reserves. Often, little regard is given the immature sediments because they are considered to have no commercial interest. Their importance will increase in the not too distant future. A number of different types of oil shales have been distinguished on the basis of the nature of organic matter present. It has been demonstrated that bulk organic matter in sedimentary rocks is composed of the entities termed macerals. COOK and SHERWOOD (1991) established a classification of oil shales and sapropelic coals based on relative abundances of macerals. We use their terms in present study. Petrological methods should desirably be complemented by organic geochemical techniques. This study is intended to provide a basis for understanding that sapropelic organic-rich sediments dominated by particular macerals are chemically distinct.

Samples. 35 samples used in this study were chosen because of their diverse petrographic and chemical character. These samples represent typical sedimentary organic matters from oil shales, including different kerogen types, and are well described in the literature. The samples are immature (prior to oil generation zone), except a Bazhenov shale (Ro: ~0.8%; peak of oil generation).

Petrographic Observations. Visual kerogen analysis was used to determine the type of kerogen in whole rock by microscope. These analyses combine the using of normal reflected light (identify the vitrinite, inertinite, bituminite macerals) and fluorescent light (identify the primary and secondary liptinite macerals). The rates of components (relative abundance) of kerogen are estimated. Reflectance of vitrinite (and/or huminite) macerals were measured for estimating the level of organic maturation.

Sample preparation and chemical analyses. Samples were crushed, extracted, demineralized and kerogen reextracted. The purity of prepared kerogen concentrates were checked by X-ray diffraction (XRD) and their C, H, N, S and Fe contents were determined. Pyrolysis-gas chromatography was performed on kerogens.

Results. Some of the results are summarised in Table I. The *cannel coals* are predominated by terrestrial organic material, with considerable primary liptinite (higher plant derived) content. The *lamosites* are predominated by alginite (lamalginite) containing considerable fluorescent amorphous kerogen. The *telosites* are predominated alginite (telalginite), with subordinated fluorescent amorphous kerogen content. The *bitosites* are predominated by fluorescent amorphous kerogen as groundmass (biodegraded algal and bacterial remnants), with subordinated fluorescent bituminite content.

Table I. Selected data to compare the classified samples based on petrological methods

Type of samples	^a Prim. Liptinite/ Alginite (%)	^b ΣAmorphous/ Amorph. alginite (%)	^c ΣTerrestrial /Vitrinite (%)	R _o %	^d EOM/ TOC mg/g	^e Oct/Xyl	^f Phenol %	^g Pr/17
CANNEL (range)	10-35 / 0-8	0-*(3) / 0-*(3)	70-90 / 38-77	0.41-0.58	20-56	0.16-0.4	50-70	0.2-0.8
(mean)	24 / 4	1 / 1	79 / 56	0.5	43	0.28	59	0.5
LAMOSITE(range)	85-90 / 85-90	31-70 / 30-60	4-5 / 2-6	0.25-0.37	144-176	0.3-1.2	17-24	1.2-1.8
(mean)	87 / 87	50 / 45	4 / 3	0.31	160	0.78	20	1.45
TELOSITE(range)	40-98 / 40-98	0-*(55) / 0-*(47)	2-48 / 0-28	0.23-0.65	2-70	1.4-10.3	6-36	0.1-0.9
(mean)	79 / 78	*(29) / *(22)	9 / 6	0.49	29	5.3	16	0.3
Torbanite(range)	40-90 / 40-90	0-*(55) / 0-*(45)	2-48 / 0-28	0.41-0.65	2-52	1.4-10.3	6-30	0.1-0.5
(mean)	75 / 73	*(26) / *(17)	12 / 8	0.54	26	6	13	0.2
Tasmanite(range)	95 / 95	*(49) / *(47)	3 / 3	0.39	70	3.1	18	0.9
Kukersite(range)	98 / 98	28 / 28	0 / 0	0.23	22	2.6	36	0.5
BITOSITE(range)	58-90 / 58-90	80-85 / 55-85	2-7 / 2-6	0.35-0.47	22-104	0.6-1.6	22-28	0.4-0.6
(mean)	79 / 79	83 / 73	5 / 4	0.43	65	1	25	0.5
BITUMENOSITE (range)	20-30 / 15-18	55-(67) / 5-(15)	7-19 / 3-6	0.44-0.82	49-129	0.6-1.2	15-22	0.2-0.9
(mean)	25 / 16	(62) / (12)	13 / 5	0.58	85	0.9	17	0.5

^a primary liptinite: structured and amorphous liptinite (alginite, sporopollenite, cutinite, resinite, liptodetrinite, bituminite (relative abundance); ^bΣAmorphous: primary (alga and/or bacteria origin) and secondary (migrabitumen=solid bitumen, mineral bitumen groundmass) amorphous liptinite; *(): partly amorphous - (half quantity of the total); ^cΣterrestrial organic content: vitrinite (and/or huminite) + primary inertinite + terrestrial origin liptinite (cutinite, sporopollenite, resinite); / vitrinite (and/or huminite); ^dEOM/TOC: soluble bitumen/total organic carbon ; ^eOct/Xyl: the ratio of oct-1-ene and (m+p)-xylenes in pyrolysate; ^fPhenol: relative proportions of oct-1-ene, (m+p)-xylenes and phenol in pyrolysate; ^gPr/17: prist-(1+2)-enes/n-heptadec-(ane+ene)

The *bitumenosites* are predominated by fluorescent bitumenite (migrabitumen: pre-oil solid bitumens are early-generation products of rich source rocks, which have migrated minimal distances to fractures, CURIALE 1986), with subordinated primary liptinite content. Pyrolysis-gas chromatography provides a direct compositional link with products expected to be formed from kerogens studied during catagenesis by offering a more detailed insight into kerogen structure. Numerous homologue series have been found in pyrolysates and both their relative and absolute abundances have been exploited to infer precursors, extent and type of diagenetic processes and level of early catagenesis. Numerous homologue series have been found in pyrolysates and both their relative and absolute abundances have been exploited to infer precursors, extent and type of diagenetic processes. Based on relative proportions of oct-1-ene, (m+p)-xylenes and phenol in pyrolysates, the samples can be divided into groups. The oct-1-ene/(m+p)-xylenes ratio has a positive correlation with H/C ratios. The source properties of the samples can be determined on the proportion of different hydrocarbon groups in pyrolysate (C₂-C₅-, C₆-C₁₄- and C₁₅+ - *n*-alk-1-enes and *n*-alkanes). The variety of organofacies and differences in depositional settings can be demonstrated by the relative abundances of homologues{e.g. ratios of 2-methylthiophene/toluene and prist-(1+2)-ene/n-heptadec-(ane+ene)}.

The combination of petrological and chemical techniques is useful in identifying the nature and diversity of organic matter in organic rich sediments and estimating the environments in which they were formed. The approach is that of building a genetic correlation between maceral and kerogen pyrolysate compositions to provide framework for classification.

Acknowledgement

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Genetic-industrial Classification of brown coals in Serbia

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Key words: Brown coals, classification, codification, Serbia

The present paper is the first proposal of genetic-industrial classification of brown coals in Serbia. The analysed brown coals derive from different lithostratigraphic units, mostly of Miocene age. Classification-codification of Serbian low rank coals were studied from petrological, chemical and technological point of view. Most of these characteristics were included as parameters of the codification system for low rank coals (1, 2, 3). The proposed classification scheme for Serbian brown coals is based on different parameters determined by microscopic and technological or chemical techniques. The proposed classification comprise three groups of parameters, selected according to their basic characteristics. The genetic parameters, the mean random reflectance of huminite/vitrinite and volatile matter content are used to determine the degree of coalification. The petrographic composition (huminite, liptinite and inertinite) determines the type of coal (petrographic parameter; mmf). Diessel's Gelification Index (GI) and Tissue Preservation Index (TPI), controlled by the deposition systems, are used to characterise properties of coal seams. Rank and type of coal have important influence on technological properties of coals; they are not sufficient to determine the behaviour of this coal under specific conditions of utilization. Application of organic geochemistry, particularly using biomarkers in paleoenvironments reconstruction, have contributed to the better knowledge of brown coals genesis. Supplementary parameters, according to international standards, are chosen to qualify the different technological classes of those coals.

There are three classes of brown coals in Serbia: soft brown coals, dull brown coals, and bright brown coals.

Soft brown coals (SBC) of Serbia contains high percentage of total moisture (43–56%), and ash (30–43%, dry basis). Total sulphur content (dry basis) usually ranges between 1 and 4%. These coals have high volatile matter content (55–75%, daf), and low carbon content (54–65%, daf). SBC of Serbia are characterized by vitrinite reflectance of 0.26–0.30% R_r and NCV (daf) between 20 and 25 MJ/kg. Deposits of SBC in Serbia have enormous energetic and economic importance, since these coals are used for combustion in thermal power plants. The most important coal-bearing basins are Kolubara, Kostolac, Kovin, Kosovo, Metohija, Drenica and Mazgos.

Dull brown coals (DBC) of Serbia have 17–47% of total moisture, 18–35% of ash content (dry basis), 1–3.5% of total sulphur content (dry basis), 50–60% of volatile matter content (daf), 63–67% of carbon content (daf), NCV 24–27 MJ/kg (daf), and huminite/vitrinite reflectance 0.31–0.40% R_r. DBC in Serbia, with relatively large geological

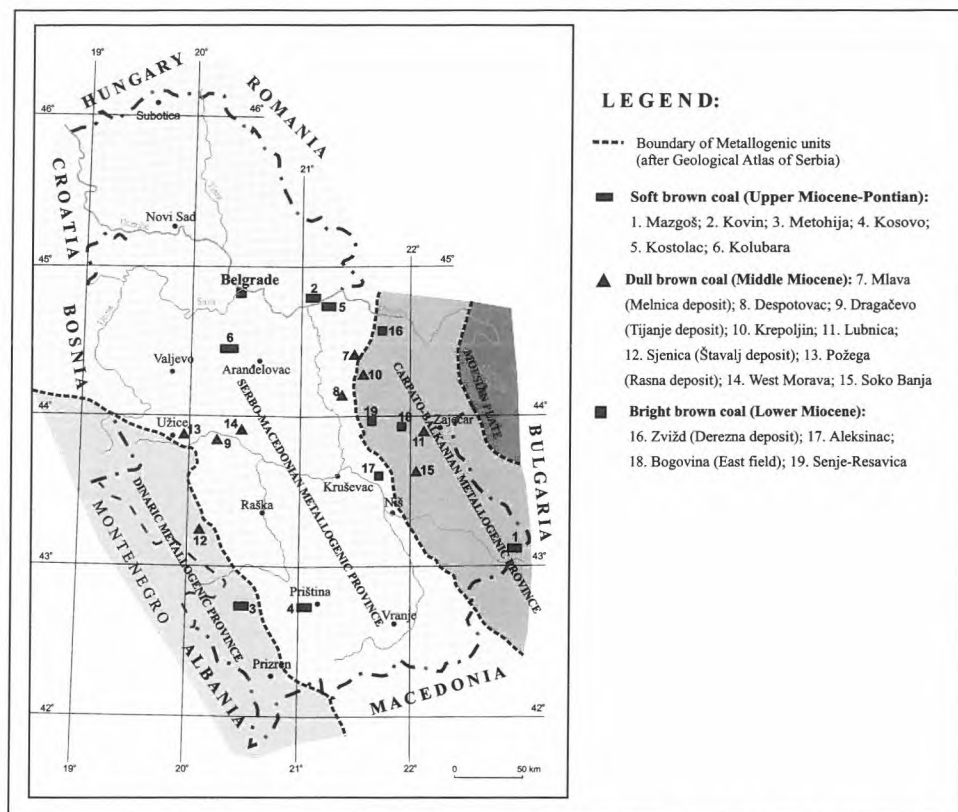


Fig 1. Geographic position of investigated brown coal basins in Serbia

resources, have also economic importance. Basins that belong to this group are Mlava (Melnica deposit), Despotovac, Dragacevo (Tijanje deposit), Krepoljin, Lubnica, Sjenica (Štavalj deposit), Požega (Rasna deposit), West Morava and Soko Banja.

Bright brown coals (BBC) of Serbia have 13–28% of total moisture, 14–27% of ash (dry basis), 1–6% of total sulphur (dry basis), 50–60% of volatile matter content (daf), 65–72% of carbon content (daf), NCV 25–29 MJ/kg (daf), and huminite/vitrinite reflectance of 0.41–0.47% Rr. BBC of Serbia are characterised by black colour, banded structure made of detritic and dopleritic coal, and absence of vegetal texture. The most important coal-bearing basins are Zvižd (Derezna deposit), Aleksinac, Bogovina (East field) and Senje-Resavica.

Geographic position of investigated brown coals basins in Serbia is given on Fig. 1.

A new genetic-industrial classification of low rank coals in Serbia include all necessary parameters required for utilisation of those coals.

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How petrography can establish the relationship between xylite and activated carbon

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Key words: xylite, activated carbon, adsorption, petrology, environment

Abstract

The necessity of xylite ecological valorization represents through the Project LIFE 02 ENV/RO/000461 a new way of practical application of environmental management in Romania. The main project objective consists in creating a valuable, environmental superior product — xylite activated carbon — by developing a non-polluting technology that involves adequate solutions for xylite wastes processing, gases combustion and heat treating. The advantages offered as well by the raw materials quality — which can reduce the excessive forest exploitation — as by the clean technological solution lead to an efficient and advanced environmental protection with lower energy costs, providing a measure of the path to sustainability. The paper answers the question how the activities foreseen within this task will be carried out by petrographical researches.

Introduction

To obtain activated carbon from xylitic coals, the raw material is first pyrolysed and then partially oxidized with steam or CO₂ at higher temperatures. The use of xylite is determined as well by their physical-chemical and structural characteristics similar to the hardwood as by the estimated resources, which are sufficient for a long-term exploitation. The low mineral matter and petrographical structural composition, which generally consists of woody material influences the structure and texture of the pyrogenated and activated xylite. The porous structure of the intermediate and final products depend on the coal rank, grain size and carbonization-activation processing parameters. In previous studies, we have shown the effect of the xylite quality and thermal treatment conditions as important steps in the preparation of a developed microporosity (PREDEANU, PANAITESCU 2004).

Experimental

The mechanical preparation of xylite by crushing and sieving determined the establishment of an optimal particle-size distribution with an average ash content of 2.5%, fol-

lowed by pyrogenation in a rotary furnace at max. 500 °C and activation in an overheated steam flow at 950–1000 °C, that allowed the obtaining of an activated carbon with an increased adsorption capacity. The properties of the intermediate and final products were microscopically investigated being also determined the ash and carbon content, the iodine number and the specific surface area BET.

Results and discussion

The xylite structural composition used as raw material for charcoal and activated carbon manufacturing, has been microscopically assessed using a research microscope in natural reflected and fluorescent light, with crossed nicols and oil immersion. The type — mainly structured woody material — and percent of the petrographical components on grain sizes is presented in Table 1. All xylite components have small quantities of inertinite as mono- or pluricellular funginite. In Fig. 1 appears cellular textinite with liptinite impregnation (a, b) and well preserved cellulose structures (c). The type of original raw material highly influences the characteristics of charcoal, Fig. 2 (a, b) and the activated carbon, Fig. 2 (c). It was found that for the same activation time, can be obtained higher adsorption surfaces by 25–35% in case of xylite stump with a more dense structure, than in case of fibrous xylite.

Table 1. The mean distribution of petrographical components on xylite grain sizes, % vol

Component	Grain size, mm		
	10–20	20–40	+40
Textinite	41.8	36.1	52.3
cellular + cellulose	28.6	25.1	29.4
fibrous	13.2	11.0	22.9
textoulminite	30.2	38.4	31.0
Total structured woody material	72.0	74.5	83.3
ulminite	11.7	11.2	8.3
Total woody material	83.7	85.7	91.5
Liptinite	2.0	2.1	2.4
Total organic material	91.4	94.3	97.2
Mineral matter	8.6	5.7	2.8

The main problem for the physical-textural structure of the activated carbon is their porosity, element that determines their adsorption capacity. The porosity depends as well on the initial structure of raw material, on the temperature and carbonisation rates, as on the activation conditions. High carbonisation rates lead to the formation of a large number of fine pores, which, after a specific activation for larger periods, lead to the obtaining of high quality products. As higher the specific surface is as greater the adsorption capacity is obtained. Some interesting aspects have being taken into account including the correlation of different coal micro components with the activating agents used. The results are presented qualitatively, as structural type and texture and quantitatively as size and repartition on different fractions, being correlated to the original petrographical components, the raw material grain size and pyrogenation-activation parameters.

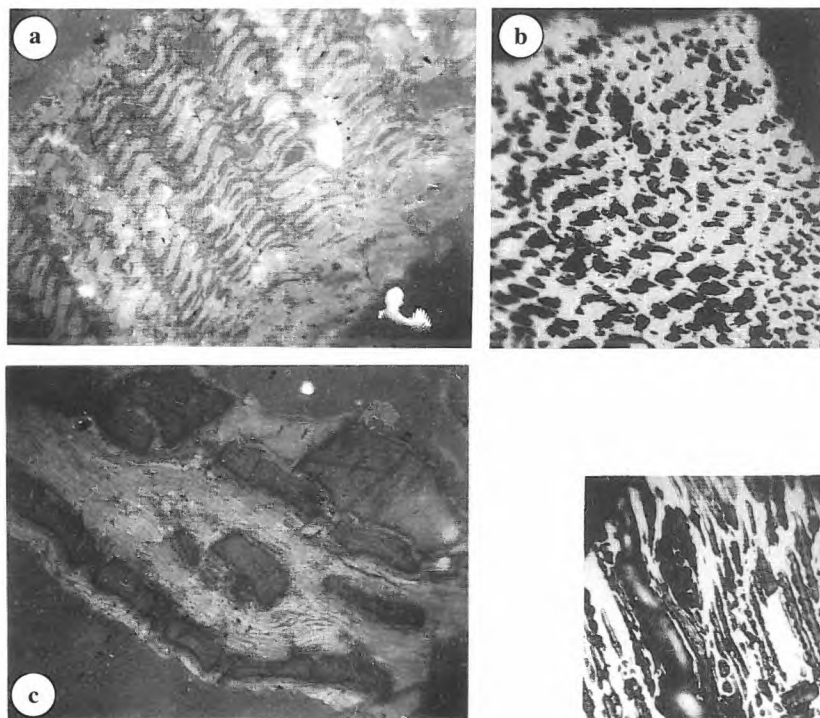


Fig. 1. Cellular textinite with liptinite impregnation in LR (a) and LF (b) and cellulose (c) in xylite, oil im., 250×

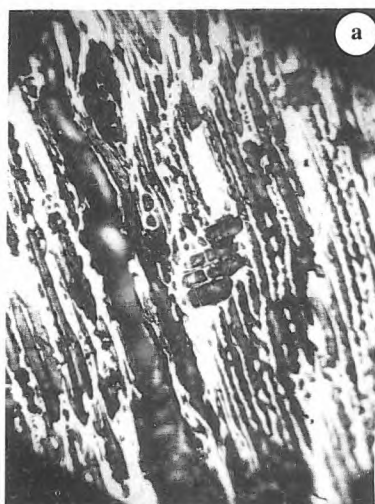
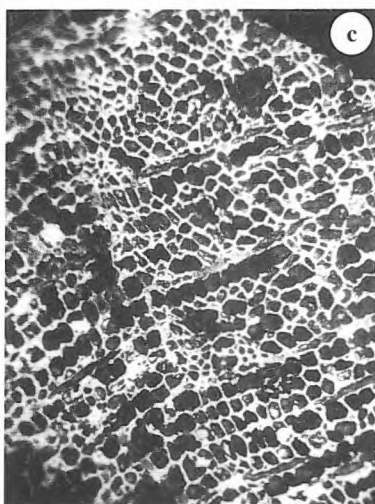
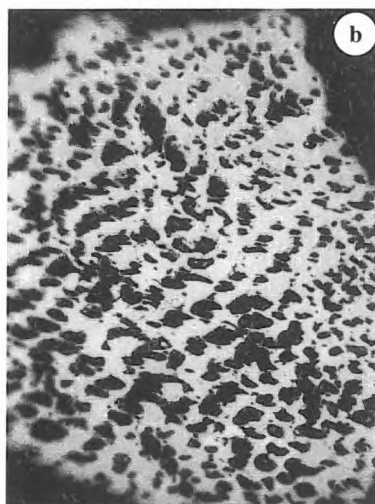


Fig. 2. Structural aspects of xylite charcoal (a, b) and activated carbon (c), LR, oil im., 250×



Conclusion

The technology of xylite activated carbon manufacturing creates a new eco-product with a homogeneous porous structure comparable or higher to the classical adsorbents, with an increased requirement for the process of waste water purification, its utilisation being based on the concern to control the environmental pollution and to rise the life quality.

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Petrological recognition of secondary altered organic matter in the Zechstein Kupferschiefer from Poland

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Key words: Kupferschiefer, vitrinite-like matter, bitumen, oxidation

Organic matter dispersed in the Zechstein Kupferschiefer was studied petrographically. Whole profiles of Kupferschiefer were investigated, but studies were focused on the oxidized facies (Rote Fäule) and its transition to black shales. Microscopic studies revealed significant differences in composition of organics in particular geochemical facies. The predominating role of liptinite was noticed in reduced facies, with special superiority of bituminite and alginite, which are diagnostic macerals for black shales. Percentage of bituminite locally exceeds 90%. However the rest of macerals of liptinite group (i.e. sporinite and liptodetrinite), as well as amorphous sapropelic mass (ASM), occur there in significantly lower amounts. The humic organic components (vitrinite and inertinite) are common constituents but they occur in small amounts in all facies of the Kupferschiefer.

In the organic matter composition of both oxidized and transitional zones, gradual decrease of structural macerals of liptinite group was observed. Secondary bituminite macerals being products of thermal alteration of bituminite were also noted. This kind of organic matter, widely distributed in oxidized part of the Kupferschiefer, represents a type of maceral resembling vitrinite, therefore the term vitrinite-like matter/maceral is used here to describe them. Vitrinite-like macerals are characterized by homogenous texture and elongate shape concordant to microstratification. The origin of the vitrinite-like matter is connected with the alteration processes of lipoidal material (mainly bituminite). The occurrence of the vitrinite-like matter within oxidized shales indicates that it was formed due to the flow of oxidizing fluids. The vitrinite-like macerals are clearly visible in the transitional zone, while towards the base of the reduced Kupferschiefer shales only minor amounts of vitrinite-like matter occur. This tendency seems to be a result of an upward strong activity of oxidizing fluids in the lowermost part of the Kupferschiefer horizon.

In the oxidized shale, the elevated content of refractor is typical comparing to the reduced Kupferschiefer. Occurrence of solid bitumen, which infiltrates the sediment, is also a specific feature of the oxidized Kupferschiefer. Bitumens form a common association with mineral matter, termed as bituminous-mineral matrix (BTM), which is clearly recognizable by ultraviolet irradiation, showing weak fluorescence of yellow or orange colour. The formation of this category of solid hydrocarbons should be related rather to the external source, such as Carboniferous clastic rocks enriched in organic matter, which are probably the source rocks for numerous deposits of hydrocarbons, occurring in the

Permian and Mesozoic reservoir rocks of the Polish Lowland (KARNKOWSKI, 1993; NOWAK, 2003).

In general, the autochthonous vitrinite reflectance level is typical for the oil window and varies from 0.5 to 1.4%, increasing towards the oxidized basal Kupferschiefer (OSZCZEPALSKI et al., 2002, SPECZIK et al., 2003). Elevated Ro values assume relation to post depositional changes in vitrinite caused by oxidation (SPECZIK & PÜTTMANN, 1987; OSZCZEPALSKI, 1989; SUN et al., 1995; OSZCZEPALSKI et al., 2002; SPECZIK et al., 2003). Characteristically the reflectance of vitrinite-like matter, slightly lower than Ro of vitrinite in the same sample, shows similar trends. Comparable reflectance data for both vitrinite and vitrinite-like matter indicates that they have undergone similar maturation pathway, which is characteristic for proper vitrinite (NOWAK, 2003). Taking certain limitations into consideration, vitrinite-like matter reflectance may be applied as a quite useful coalification parameter.

Acknowledgements

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Uncertainties of maturity calculations in basin modelling: a multiple 1D probabilistic approach

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Introduction

Basin modeling is one of the most applied quantitative tools in petroleum exploration studies. A single model requires the input of numerous parameters such as surface temperature through time, heatflow through time, erosional events, lithology and lithologic characteristics, stratigraphy, and organic matter type. The determination of parameter values is one of the major problems in basin modeling and the effects of uncertainties are usually not taken into account.

Despite the existence of major uncertainties in input parameters and models, the tendency in basin modeling goes to sophisticated, time consuming 3D modeling of petroleum systems. Scenario modeling with 3D models allows evaluation of parameter variation, however, quantification of uncertainties with these sophisticated models is very time consuming. Multiple 1D modeling of the maturity development of a source rock is much faster and can take a series of uncertainties into account. A software tool was developed and tested for this multiple 1D approach. The presented approach gives important supplementary information to the information achieved by basin modeling programs and should therefore precede basin modeling studies.

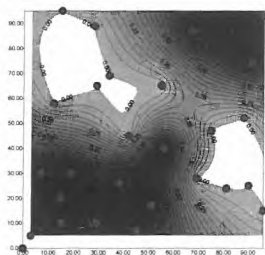
Method

The developed software tool is based on backward modeling. The software is designed in such a way that known well information can be used, but also that a set of depth grids can serve as input. A set of pseudo 1D wells is generated from these depth grids according to a selected grid lay-out. This allows the use of the software in virgin area with seismic information but without well penetrations.

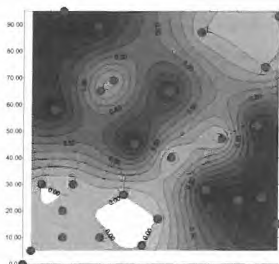
Input is provided about the present-day stratigraphy, lithology, erosional (uplift) events, surface temperature and the range of parameter values within boundary conditions. Basement heat flow is one of the most influential parameters on maturity and difficult to quantify. In our model heat flow is constraint by the tectonic development of the basin in time. A heatflow profile through time is calculated, including its uncertainties, from an evaluation of lithospheric stretching.

Decompaction routines are used in basin modelling packages to calculate sediment thickness and material properties such as thermal conductivity. However, compaction in

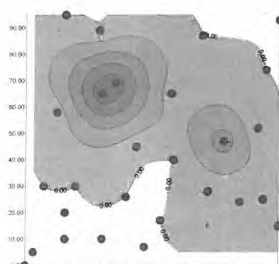
%Rr < 0.6
before oil window



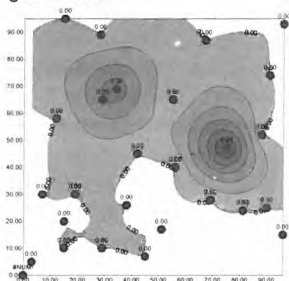
%Rr 0.6 - 0.9
early oil window



%Rr 0.9 - 1.1
late oil window



%Rr 1.1 - 1.5
gas window



%Rr > 1.5
past gas window

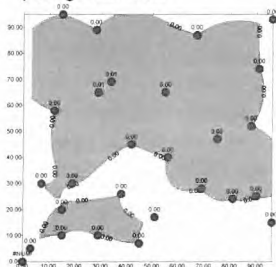


Fig. 1. Maps of the calculated probabilities of the maturity of the dataset of synthetic wells (in medium grey.) The maps show the probability that the source rock is immature (top left corner), in the oil window (in the middle at the top), in the late oil window (the top right corner), in the gas window (lower left corner), and overmature (middle at the bottom). The probability increases from light grey to dark grey

nature depends on initial porosity, composition, and effective stress, and a considerable range of empirical and numerical porosity depth trends exists (GILES et al., 1998).

Therefore, it was decided to vary the porosity depth curves in the evaluation to address these uncertainties. In computing the decompaction a Newton-Raphson technique is used and exponential porosity-depth relations were applied with two parameters: surface porosity and scale length for compaction. Porosity is not allowed to increase in an uplift phase.

Different approaches exist for the calculation of vitrinite reflectance (TISSOT & ESPITALIE (1975), BURNHAM, SWEENEY (1989), LARTER (1989), WAPLES (1980). In this study the Burnham & Sweeney approach has been applied.

For the quantification of uncertainties, a Monte Carlo approach has been used. Uncertainties can be translated into a probability density function (pdf) for each of the parameters involved. For each new "experiment" first samples are drawn from these densities. On combining these runs it becomes apparent how VR values are distributed. Typical magnitudes of uncertainty follow easily, as standard deviations, or alternatively as the P_{10} or P_{90} . After completing the Monte Carlo analysis, not only can the best estimate of the interpretation be given, but also the most likely range of errors. A tornado plot error analysis is generated showing the relative importance of each parameter in the overall error.

Results

The uncertainty analysis results in a distribution of probabilities of vitrinite reflectance values. These can be used to plot maturity trends of single (pseudo) wells at a chosen moment in geological history. Also contour maps can be plotted of the probabilities, as shown by the example.

Example

A dataset of synthetic wells was constructed and all were modelled. Burial history varied between all wells. Uncertainties were given on all input data. The resulting probabilities were plotted in maturity maps, indicating the probability that a source rock is immature, in the (late) oil window, in the gas window, or overmature (Figure 4). The results indicate that only for few wells the maturity stage can be predicted with a certainty of over 90%. For large part of the area, however, the maturity stage can not be indicated with such a high level of certainty. This information can not be deduced from maturity maps that plot single maturity values.

Conclusions

The developed tool for maturity modelling allows for a quick sensitivity analysis of parameters and the quantification of uncertainties. The multiple 1D approach provides supplementary information to subsequent basin modelling studies. The results are also useful for fast screening of the maturity of source rocks in an early exploration stage. The created probability maps can be easily combined with other (geological) information, e.g. in Geographical Information Systems.

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Poster presentations

Applications of Organic Petrology in Sediment and Soil Contamination Studies

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Key words: airborne contaminants, charcoal, sorption capacity, organic pollutants

Organic-petrological methods have proven effective in revealing the nature and provenance of organic materials. This includes organic contaminants found in soils and sediments.

Recent studies have demonstrated that the characterisation of organic matter using incident light and fluorescence microscopy within sediment or soil samples is a prerequisite to understanding or predicting the sorption behaviour of organic pollutants (KLEINEIDAM et al. 1999, 2002; KARAPANAGIOTI et al. 1999, 2000). The investigation of soils and sediments demonstrates the heterogeneous character of organic matter and proves the presence of coal and charcoal particles of fossil origin in the majority of the samples. The heterogeneity of the organic matter is found responsible for variations in the sorption behaviour of organic pollutants like polycyclic aromatic hydrocarbons in soils and sediments.

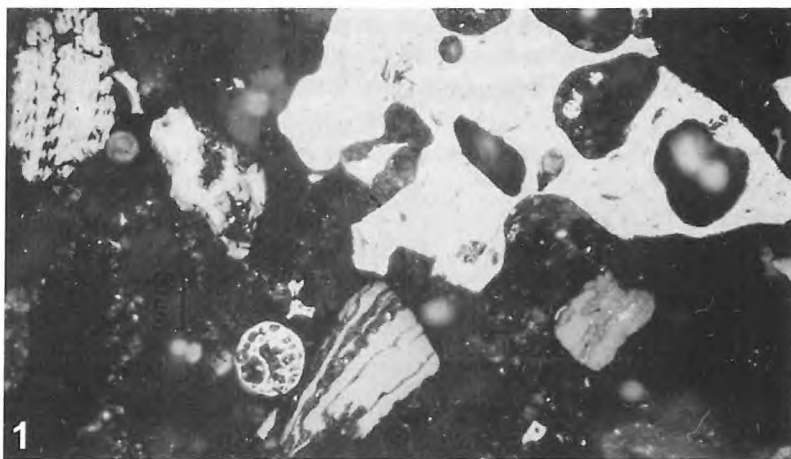


Fig.1. Photomicrograph of different airborne contaminants in a soil from an industrialised area in Germany: hard coal coke (upper right), high-volatile bituminous coal (bottom right), char and shaly coal (bottom), semifusinite from coal, and inorganic fly ash sphere (upper left), heated altered coal maceral (center left)

Photomicrograph taken of a polished section prepared from densimetric concentrate; oil immersion; field 690 µm wide

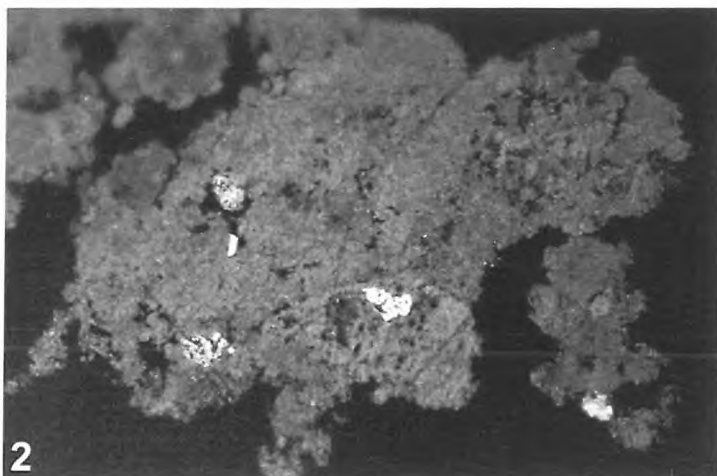


Fig. 2. Large particle of diesel soot observed by incident light microscopy. Note the high reflecting inclusions with vesicles in the fine porous soot matrix, Photomicrograph taken of a polished section; oil immersion; field 80 μ m wide

Organic petrography is a valuable tool to characterise and quantify airborne contaminants (e.g. raw brown coal, hard coal, coke, char, oil products, soot, inorganic fly ashes) in soils from highly industrialised areas (KIEM et al., 2003; LIGOUIS et al., in press) and will be further developed. The observed soil contamination is due to dust emission by coal mines, to fuel combustion, and to coking plants.

The selected studies show that organic-petrological techniques can be combined with chemical analyses as an effective tool for use in the environmental sciences.

In conclusion, organic petrology is a precise tool for:

1. the characterisation of heterogeneous organic matter present in soils and sediments.
2. the identification and classification of airborne contaminants in topsoils, which makes it possible both to characterise the emission sites and to gain insight into transport distance and transport processes.
3. the determination of size and weathering grade of airborne particles.
4. a possible correlation between organic matter and sorption properties with reference to the hydrophobic organic contaminants.

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The environmental impact of trace element contents of Indiana and Western Kentucky coals

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Key words : trace elements, coal, Indiana, Western Kentucky

Distribution of trace elements in coal beds influences both the properties of coal combustion products and the level of pollutants to the atmosphere. Because of the planned regulations of emissions from coal-burning power plants, the determination and prediction of HAPS (Hazardous Air Pollutants; Title III of the Clean Air Act Amendments of 1990) emissions has become a very important issue in the United States. This study examines the distribution of trace elements in the Pennsylvanian coal beds of Indiana and Western Kentucky. In these two states, coal is the dominant source of electricity generation (> 95 %). Special emphasis is placed on trace elements of major environmental concern such as Hg, Se, As, and Cl. The trends in their distribution have been mapped for the major coal seams in both states. Hg and As (Fig. 1) commonly show similar distribution

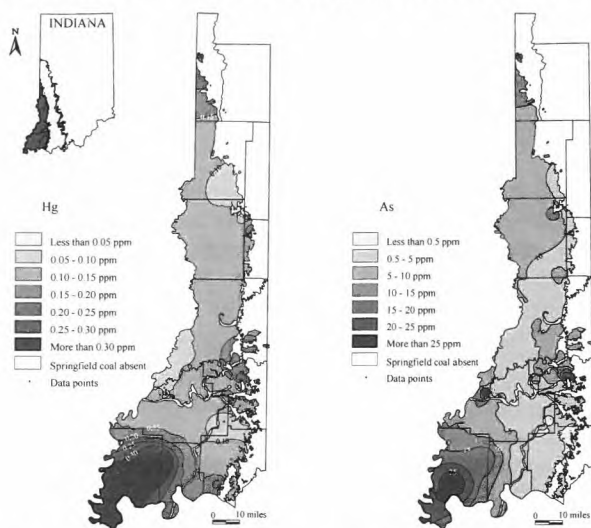


Fig. 1. Hg and As distribution patterns for the Springfield coal in Indiana (in ppm, whole coal basis)

patterns, suggesting similar controls on their concentrations, and their association with pyrite in particular. Trends for Se and Cl are different. Based on the trace element distribution, strategies in coal use are suggested to address forthcoming environmental regulations.

Characteristics of variability of trace elements in coal ash from the 610 and 620 coal seams (the Poruba beds) of the Upper Silesian Coal Basin

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Key words: trace elements, coal ash, rock band, coal seams

The coal seams 610 and 620 from the Poruba beds (Namurian A) are characterized by considerable variability of content of trace elements in coal ash (HANAK, KOKOWSKA-PAWŁOWSKA 2002), thought to be connected with the occurrence of the rock bands in these coal seams.

Therefore before sampling, lithologic and petrographic profiles were done.

In examined profiles of the coal seams complex lithotypes, characterized by laminated structure, were found. These lithotypes were determined according to Diessel's classification (1992), mainly: semi-vitreous laminated coal, rarely vitreous laminated coal and dull laminated coal.

In four examined profiles of the coal seams one or two rock bands occurred. Two profiles didn't include rock bands.

The coals of these seams are of similar rank, and are distinguished by values of the random reflectance of vitrinite $R_r = 0.90 - 1.05\%$.

The coal channel samples and lump samples of lithotypes were taken from the area of the contact of the coal seams with the rocks of the roof, base and bands.

The content of macerals and minerals in coal samples was investigated. Then, the samples were ashed at the temperature of 815 °C, and the content of the following trace elements: B, Ba, Cd, Co, Cr, Ni, Pb, Zn, Ag, Sr, Cl, Na, K, Mg in coal ashes was determined.

Predominate part of the trace elements presented the minimal content in the coal samples from the coal seam 620. This profile does not include the rock bands.

For showing the relation between the content of trace elements and the occurrence of rock bands within the seam, the content of the trace elements in coal lithotypes from the coal/rocks contact was investigated.

The variability of the content of trace elements in the selected profiles of the coal seams 610 and 620 was showed in the Figure 1. It shows that the trace elements usually have higher content in the coal ash samples, which occur under the rock bands. The maximum content of the trace elements was observed in the roofs of the coal seams, rarely in the floor.

According to the Figure 1 the variability of the content of trace elements in the investigated samples of coal ash has no relation to the type and the petrographic composition of the lithotypes.

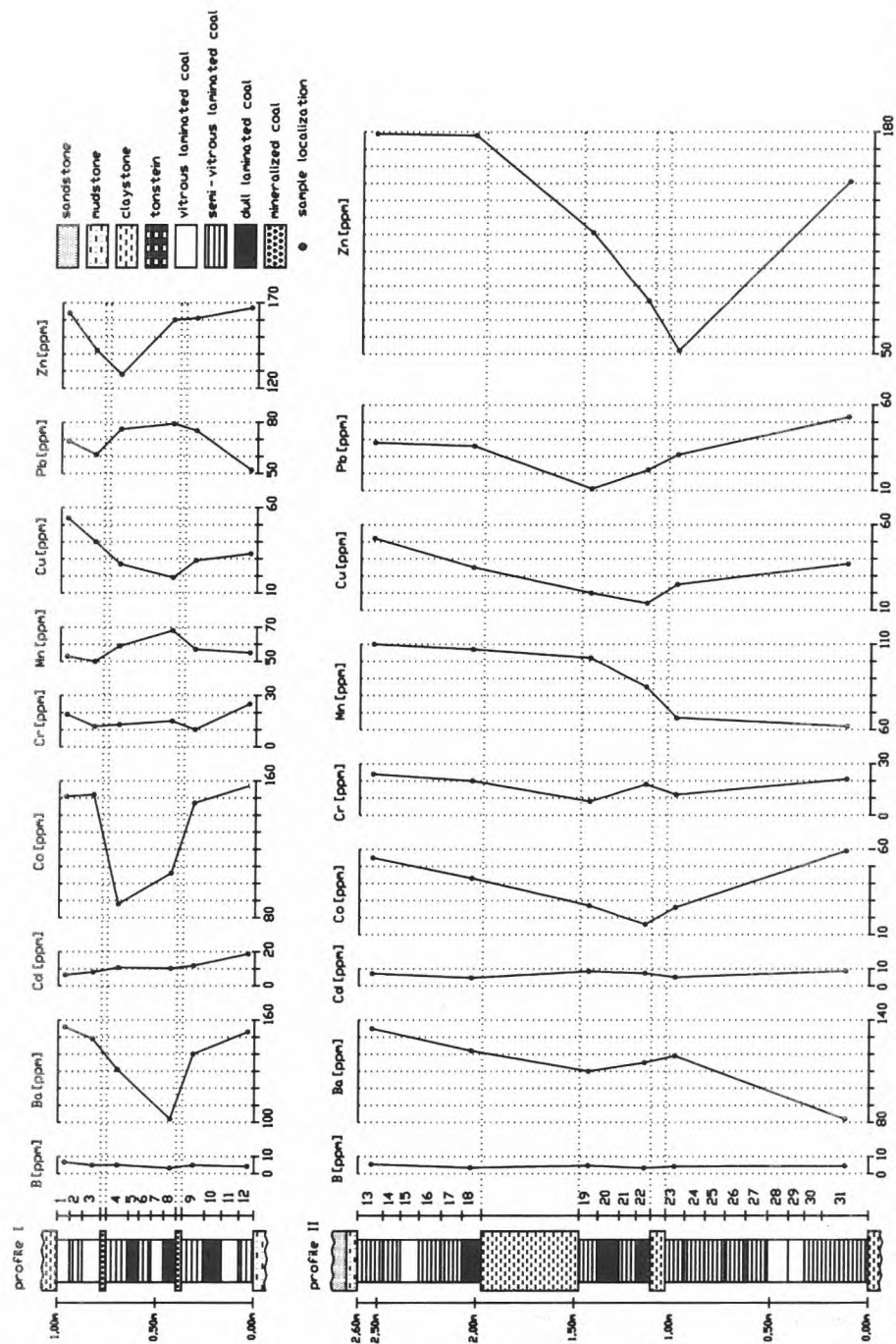



Figure 1. Lithological and petrographic profiles of 610 coal seam (profile I) and 620 coal seam (profile II) and the content of trace elements on the background of the coal seam profile

It proves that the occurrence of the trace elements, identified in the coal ash from the coal seams 610 and 620, is connected with the presence of inorganic matter.

Acknowledgement

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Chemical characterization of Fly Ash from a Portuguese Power Plant

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Key words: coal, fly ash, metals

The Centro de Geologia da Universidade do Porto (Portugal) and the Instituto Nacional de Engenharia, Tecnologia e Inovação (Lisboa, Portugal) conducted a study of coal fly ash sampled from a 314MW power plant equipped with low-NO_x burners and burning low sulphur coals.

The flue gases go through electrostatic precipitators (ESPs) before they are exhausted to the atmosphere through a 221m stack and 99.8% of the particles are collected in the ESPs. In this study, fly ash samples were collected from the hoppers of the economizers, the re-heaters and the ESPs (hopper 12 and 42 of the ESPs).

The fly ash samples were dry screened at 100, 200, 325 and 500 mesh (150, 75, 42 and 25 µm, respectively). Then, the fly ash screened samples were submitted to a chemical digestion for the total solubilization of the elements to be determined by ICP-MS. The samples were prepared according with a specification of the ASTM E 926-94 ("Determination of major elements in coal ash" — BCR Project No. 327).

Preliminary results from the reheaters, economizers and ESPs are as follow:

— In the economiser, the higher concentrations of the metals are, in general, associated with the lower size sample, with the exception of Mn with higher values associated with the middle size samples.

— In the air re-heater the Cr, Cu and Zn concentrations are highest in the lower and in the high size samples; therefore there is a decrease in the middle size samples. For the middle size samples, the Pb concentrations are low with values lying under the limit of quantification. Finally, the Ni concentration does not vary with the sample size.

— In the hopper 12 of ESPs Cr, Cu, Pb and Ni the concentrations decrease as the sample size increases, and the Mn concentrations are higher in the middle size samples.

— In the hopper 42 of ESPs the concentrations of the metals lie under the same values determined in all sample sizes, with the exception being Zn that increases as the sample size increases.

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CO₂ capture and storage in abandoned coalmines: presenting the “COSEQ” European Union S&T research proposal

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Key words: capture, climate change, CO₂, storage

On behalf of: CEEETA — Research Centre for Energy, Transport and Environment Economics, Lisbon, Portugal; GIPEGO — Organic Petrology and Geochemistry Unit, Faculty of Sciences, University of Porto, Portugal; IDMEC/IST — Research Group on Sustainable Energy Development, Lisbon, Portugal; and INETI — National Institute of Engineering, Technology and Innovation, Lisbon, Portugal.

Potential impact and relevance

Studies worldwide of “Climate change” demonstrate the unquestionable need for the abatement of greenhouse gases both in the medium and in the long term. CO₂, a major component of greenhouse gases (GHG), besides natural origin, is produced from human activities principally during the generation of electricity in thermal power plants and in other major industrial activities such as oil refineries, cement and ceramic plants and iron and steel works. Apart from transports, these sources account dramatically for CO₂ emissions, and the above-referred industrial activities are likely to continue for decades in Europe.

Although there is research on the substitution of coal by renewable energy sources, there are many obstacles, which hinder the rapid growth of these technologies. Furthermore the drive for the development of near zero emission fossil fuel based energy conversion systems includes, as a component technology, the separation, capture and storage of CO₂. Therefore, in the transition to a future new energy supply infrastructure based on carbon-free systems, we will continue to produce enormous amounts of CO₂.

Additionally, it is demonstrated that improving the efficiency of thermal power plants and switching from coal to natural gas does not resolve, *per se*, the required CO₂ reduction. Moreover, CO₂ capture and sequestration is applicable to industrial emissions only and not to other human activities such as transport, agriculture and household routines.

As for power generation we will remain quite dependent on coal, oil and natural gas in the next decades, we have to find better ways of reducing CO₂ emissions. The above factors in combination with the EU Directive 2003/87/EC, which refers to GHG emissions trading, serve to highlight the relevance of the proposed project. In fact, there is no doubt that this EU Directive represents an anticipated major goal related with Kyoto Protocol performance.

Scientific and technical objectives

The storage of CO₂ is the last stage in the sequence of sequestration following processes of pre- or post-combustion capture in fossil fuel power plants or capture technologies applicable in other CO₂ generating industries. CO₂ capture integration into a particular industrial process is one of the key issues to be investigated taking into account that the first priority is the equilibrium choice between the best technology and the need of a reduction in costs in order to be competitive.

The disposal of the captured CO₂ presents long-term challenges that may be best addressed through geological storage in favourable locations. Amongst the technologies proposed for CO₂ storage in natural bodies, there are some still at the very early stages of development and therefore require much greater understanding before they can be put into practice. In contrast, geologic storage in coal seams of abandoned mines is a technology presently easy to implement and is considered to be the best longer-term option (GENTZIS, 2000). In this case the CO₂ is considered to be stored as adsorbed/dissolved in coal pores/matrix under already well known conditions, most of them recently developed in the scope of Coalbed Methane (CBM) prospecting, exploring and exploiting (OZDEMIR et al, 2004; LARSEN, 2004; RODRIGUES, 2002). However, although this is the most promising way to mitigate CO₂ emissions, the involved methodologies still require concentrated research to be fully developed.

The **scientific objectives** of the project are to define the CO₂ storage capacity in a range of coal beds of different geological characteristics. The storage capacities will be assessed through the use of sorption isotherms. The **technical objectives** are to establish the feasibility of a CO₂-free industry based on CO₂ storage in abandoned coalmines done by a systematic study of mines selected.

The expected outcome of the project is an assessment of the scientific controls to the adsorption of CO₂ in a range of typical coal seams, and the selection of abandoned coalmines in Europe as suitable sites for storage.

Outline implementation

To achieve the objectives, the following Work Packages (WP) and Tasks (T) should be considered:

WP1 — Characterisation and evaluation of abandoned coalmines

T1 — Mine characteristics and selection criteria

T2 — Modelling of selected mines - Site full evaluation

T3 – Monitoring of Coalmine Methane (CMM) emissions

Research activities will comprise general coal analyses, and new data to be obtained in the scope of the project related to CO₂ sorption (adsorption + desorption) isotherms to define the coal maximum storage capacity, coal porosity, and CO₂ diffusion coefficient.

The "cleat system" will be studied in detail to define the way-in of CO₂ circulation to the coal pores/matrix in which the gas will be stored under adsorbed conditions and as a result of borehole injection.

As mined coal seams still contain CMM and water (“moisture holding capacity” or “equilibrium moisture”) their amounts in coal pores in the seams should be measured as they influence CO₂ injection conditions.

The utilization of the above indicated coal properties as tools for mine selection is the first crucial step and should be considered as an innovative approach.

To complete the basin characteristics the site modelling will be carried out to obtain the full evaluation of the site in terms of coal reserves/resources and underground geometry of existing seams.

WP2 — CO₂ capture and storage technologies

T4 — CO₂ capture from different CO₂ generating industries

T5 — Transport

T6 — CO₂ storage technologies in abandoned coal mines (Borehole drilling and injection tests) Pilot feasibility tests

Performed activities will include:

Detailed studies of different CO₂ capture technologies and the selection of the most suitable one: status of technologies and case studies;

Transport conditions between the industrial plants to abandoned coal mine sites;

Detailed studies of storage technologies, mainly borehole drilling and injection conditions in coal seams of abandoned mines (alternatively in deep non-mined seams, in which case a CBM enhanced production study should also be taken into account). As a final result, pilot feasibility tests are also foreseen.

WP3 — Economic and socio-economic analysis

T7 — Refinement of monitoring and statistics of CO₂ emissions by the industry;

T8 — Economics of capture + storage costs versus allowance trading costs;

T9 — Socio-economic analysis.

An essential part of the final phase will be an economic evaluation of the project, since the technologies under study will only be applicable in practice if the costs are competitive with those of gas emission allowances trading under the EU Directive 2003/87/EC.

Envisaged consortium

The successful implementation and execution of the proposed project will require a high quality multidisciplinary team. The aim therefore is to involve partners from all fields of S&T in such an investigation including those involved in geology, engineering, economics and the relevant industries. Partners for the Consortium will be drawn from universities, research centres, geological surveys, engineering companies and owners of suitable coalbed sites in each of the participating countries.

The close co-operation between the S&T and the industrial teams of different EU countries, which will include personnel considered to be excellent in their fields, will ensure enough critical mass to implement a credible joint project, and favour additional economic and social benefits by promoting high qualification of the different staffs.

Preliminary contacts have already been made with key players and they have confirmed their interest and readiness to participate in the proposal. Furthermore a proposal of this nature is considered most appropriate as at present there is only one consistent

project (RECOPOL) that has been developed in the EU, with a similar scope, i.e. in close relation to CBM enhanced production.


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Coal Petrology and Coal Seam Methane Generation in the Gloucester Basin, NSW, Australia

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Key words : Coalbed methane, coal rank, coal petrology

Introduction

The Gloucester Basin, NSW, Australia is a Permian infrabasin filled with up to 2,000 m of coal-bearing fluvio-deltaic sediments. At the Stratford prospect in the northern part of the basin, the sequence contains 6 major coal seams and more than 20 minor seams. The coal seams are gassy and contain up to 27 m³/t gas (daf). The gassy Stratford prospect serves as a model for detailed coal petrology studies in relation to coal bed methane evaluation. A detailed coal petrology investigation of 200 coal core samples, some of them oriented, has been used to prepare a 3-D model of thermal maturity in the basin in conjunction with coal type and coal microstructure. The model has been compared with the coal bed methane parameters, including methane content, methane purity and coal seam permeability.

Geological Setting

The Gloucester Basin is a canoe-shaped trough containing about 4000 m of Permian volcanics and deltaic sediments. Sediments and volcanics of Carboniferous age form the basin basement, upon which the basal unit, the Early Permian *Alum Mountain Volcanics*, rests unconformably. This unit is 2000 m thick, and consists of mostly sub aerial acid volcanics, with very minor fluvial sediments and coal. This is conformably overlain by 2000 m of Late Permian fluvio-deltaic sediments of the Dewrang Group and Gloucester Coal Measures. The coal bed methane resources identified thus far at the Stratford prospect are located entirely within the Gloucester Coal Measures.

The *Gloucester Coal Measures* have been subdivided as follows:

- The Waukivory Creek Formation at the base, a sandy delta plain sequence up to 400 m thick, with seven major coal seams; minor tuffs are present in some of the upper seams; important gas reservoirs include the Triple and the Avon seams;
- The Dog Trap Creek Formation, a highly variable lower delta plain facies about 100 m thick, with irregular tuffaceous mudstone beds, locally up to 12 m thick; mudstone bands, interpreted as lake deposits, are relatively common, as are pebble and sand distributary channel deposits; gas reservoirs include the Glenview seams;

- The marine Speldon Formation, consisting of burrowed and bioturbated shoreline sand and beach deposits, from 50 m to 80 m thick;
- The coal-rich Wenham Formation and the partly contemporaneous and variably present alluvial channel deposits of the Wards River Conglomerate, from 30 m to 40 m in total thickness; the Bucketts Way and Bowens Road seams constitute the gas reservoirs;
- The Jilleon Formation, a 200–300 m thick sequence of delta plain sand and mud deposits, with alluvial channels and numerous coal seams; gas reservoirs include the Fairbairns Lane, Roseville and Cloverdale seams; and
- The Leloma Formation, up to 600 m thick, with a distinctive 10 m thick tuffaceous claystone named the Jo Doth Tuff in the middle; this unit contains delta plain sand and mud deposits, with mostly minor coal seams and minor tuffs.

Petrographic Characteristics of Coal Seams

The major coal seam packages can be distinguished by their maceral/sub-maceral content. One of the most striking properties of the Stratford coals is their very high vitrinite content, which averages about 80%. The only seam with high inertinite content is the *Bowens Road* seam, which contains 60–70% inertinite, with some plies containing well above 85% inertinite. This high inertinite content may help to identify the seam regionally. The lowest inertinite content has been found in the Roseville and Cloverdale seams. The *Cloverdale seam* and *Roseville seam*, which together contain more than 13 individual splits, are the richest in telocollinite, and lowest in inertinite content. Much of this telocollinite contains a well-developed slit pattern.

The relatively high proportion of desmocollinite (on average of 40–45%) in the *Avon seam* is unique at the Stratford prospect and very high for Permian coals in Australia. The *Triple seams* are typically rich in telocollinite (around 50%), with lesser desmocollinite (30%) and inertinite (20%). The Triple seams, in places, contain substantial proportions of *secretinite*, a distinctive and comparatively rare submaceral of the inertinite group.

Coal Rank and Gas Content

At the Stratford prospect, the coal rank is within the zone of the main stage of thermogenic gas generation. Mean maximum vitrinite (telocollinite) reflectance (R_{Vmax}) ranges from 0.85 to 1.5%, and the vertical coalification gradient is at $0.085 R_{Vmax}/100$ m. The gas content, with some notable exceptions, follows the rank pattern and also increases with depth. The results indicate that there is a strong genetic relationship between the coalification pattern in the basin and coalbed methane generation.

Perhydrous, liptinite-rich desmocollinite is believed to be favourable for methane generation. The presence of substantial quantities of desmocollinite in the *Avon seam* (the most important seam in terms of gas resources according to WEBER, SMITH, 2001) may prove to be an indicator of high methane content. GURBA, WEBER (2001) and GURBA, FASSETT (2000) have shown that desmocollinite is a substantial constituent of coals in some major coalbed methane basins, in particular the San Juan Basin, U.S.A. There is


also a relationship between coal microstructure and permeability. Microstructures are common in vitrinite in Stratford coals. These microstructures are slit-like, have specific orientations, and are believed to be genetically related to devolatilisation. As suggested by GURBA, WEBER (2001) the slits might enhance permeability and/or provide additional sites for methane adsorption.

The present study and the study by GURBA, WEBER (2001) of coal rank and type variations in coal bed methane basins have established links between specific coal petrology parameters and thermogenic methane generation (and perhaps adsorption) during coalification. The high concentrations of methane present at Stratford are at least in part due to fundamental coal properties.

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Facies analysis of Tertiary coals from Skilvika Formation, Bellsund (Spitsbergen)

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Key words: Tertiary coal, Coal facies, peat-forming environments, Spitsbergen

Samples for this study were collected from the Skilvika Formation by Birkenmajer for petrological analysis in four outcrops: Calypsostranda (Tyvjobekken, gorge), Calypsobyen (old mine — dump heap), Reinsdyrbekken, Skilvika (main section). Sixteen samples were prepared from coals and coaly shales in the form of polished particulate pellets according to the ICCP standard for petrographical analysis. For maceral identification, the terminology adopted from the ICCP System was used.


To determine the conditions in the paleo-peatbog facies indices TPI and GI introduced by Diessel (1986) and coal facies analysis by Strehlau (1989) were used.

On the analysed samples, the random reflectance of collotelinite was measured and the mean value of R_o is 0.52%. The coals are classified as subbituminous A rank according to the ASTM classification.

The vitrinite group macerals are the dominant in the microscopical structure of the coal beds and layers occurred in coaly shales from Calypsostranda, Calypsobyen and Slikvika (main section) outcrops. They are mainly telinite and collotelinite. High values of TPI, and GI indexes are recorded in these coals. Coal layers in the Reinsdyrbekken outcrop are dominated by detritic macerals: vitro — and inertodetrinite. Sporinite is abundant. Vitrinite group is represented mainly by collotelinite. High content of inertodetrinite and collodetrinite indicate low values of TPI, and GI indexes.

According to the petrographical data the coal seams from Calypsostranda, Calypsobyen and Slikvika — main section outcrops represent mainly telocollinite subfacies and originated from the wet forest swamp, at high groundwater level condition. These swamps occurred in the inner part of a peatbog situated out of the indirect influences of the delta distributary or river channels. The coaly shales from these outcrops represent “shale with streaks of coal” subfacies. During the development of these coaly shales the phytogenic deposits derived mostly from the nearby existing wet forest swamp in the vicinity of the delta distributary or river channels. These swamps were subjected to the influences of river channels, with higher clastic sediment supply. The coal layers in the Reinsdyrbekken coaly shales outcrop represent cannel coal type of sapropelic coal facies and were generated in the inner part of inter-channel area lakes.

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Petrography and depositional environment of the No. 308 coal seam (Upper Carboniferous) from the Upper Silesian Coal Basin, Poland

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Key words : coal, petrography, macerals, depositional environment

Lump samples of coal, representing the full thickness (2.1 m) of the No. 208 coal seam, were collected in mine. Microscope investigations were carried out using a self-developed method that enables obtaining a continuous petrographical profile (“microprofile”) and computerized data processing. The macerals and maceral-groups content distinguished along the profile were averaged using the method to show the average changes and presented in diagrams. The proposed facies diagram is based on an assumption that oscillations of water table in a peat-bog affects the petrographic composition, while stronger influxes into the peat-bog increase the mineral matter content of the coal. The author has identified three major types of peat-bog environments in which plant material were deposited in the Carboniferous period. There are: permanently inundated — planar mire (PM) with two sub-environments — PM “margin” and PM “central”, temporarily inundated — transitional mire (TM) with two sub-environments — TM “wet” and TM “dry”, and elevated — domed mire (DM) with two sub-environments — DM “progressive” and DM “regressive”.

Palynological and petrographical reconstruction of peat accumulation in the Trans-Carpathians and in the Pannonian Basin at Ilnitsa and Visonta coalfields

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Key words: brown coals, petrography, palynology, swamps

The study of petrographic composition, quality, and spore and pollen complexes of brown coals allows the reconstruction of palaeoconditions of peat accumulation at Ilnitsa and Visonta coalfields. The objective of this research is to provide comparative characteristics of Late Miocene – Pliocene coals in the Trans-Carpathians (Ukraine) and in the Great Hungarian Plain (Hungary) to reconstruct the accumulation conditions in the palaeopeat-bogs by petrographic composition, proximal analysis and palynological data. The results show the predominance of the vitrinite group, in average 79% of the organic substances for Ilnitsa and 86% — for Visonta. The liptinite content is 14% (Ilnitsa) and 10% (Visonta); the inertinite content is 7% and 4%, accordingly. The mineral component amounts are ranging from 1 to 29% in Ilnitsa coals and from 11 to 19% in Visonta. The presence of admixtures of tuff material and opal in the mineral matter are typical in the Ilnitsa coals.

The Ilnitsa coal parameters testify high-ash and sulphur content. The volatile matter content is 63%, the carbon content is 65%, the vitrinite reflectance is (0,31–0,32%), corresponds to brown coal rank B₁. In contrast to Ilnitsa, the Visonta coals have less ash content but the sulphur content varies from 0.8% to 6.3%. The carbon content is (73%) and the vitrinite reflectance is (0.27–0.29%), corresponds to brown coal rank B₁. The chemical composition of the ash is siliceous in both coalfields. A wider spectrum and larger number of rare and diffuse elements are typical in the Ilnitsa coals.

The palynological studies indicate a general picture of the vegetation throughout the peat accumulation; it shows a rather monotonous, warm-temperate, mixed deciduous forest with some subtropical elements in the Ilnitsa region as well as swamp forests with numerous *Taxodium*, and rather many *Glyptostrobus*, *Nyssa*, *Alnus* and *Osmunda*. Sphagnum were important in the mesotrophic swamps, especially during the fourth coal seam accumulation. Bushes like *Myrica* and *Salix* occupied the marginal part of the swamp. Mixed and deciduous forests invaded the drier habitats on the elevated area. Some change in the composition of mixed and deciduous forests took place during the process of peat formation particularly due to volcanic activity with abundance of ash, when subtropical and light-dependent elements disappeared from the forest communities. During the accumulation of the second and first seams the plant communities were restored, and they were more abundant than during the accumulation of the fifth and fourth seams. The average annual temperature changes calculated for the time period of

the five coal seams as well are +14.3 °C for the fifth and fourth, +13 °C for the third, and +13.8 °C for the second and first ones.

The forest vegetation in Visonta location was different from the Ilnitsa forest communities. The mixed, deciduous and swamp forests were predominant and contain different taxa. Conifer forests were more abundant (Pinaceae family) as well as wet forest swamp with *Glyptostrobus* and existed during all period of the peat accumulation on the Visonta location. *Taxodium*, *Alnus*, *Nyssa* are very rare, and only single *Osmunda* was described in the studied profile. Pollens of other desiduous plants were also rare. These were single *Quercus*, *Carpinus*, *Fagus*, *Ulmus*, *Zelkova*, *Castanea*, *Carya*, *Pterocarya* and *Ilex* without subtropical elements.

The climate, according to the results of spore and pollen analyses, changed in time. At the beginning of the peat accumulation (horizon 4) the annual temperature was +13.7 °C in average and later in the upper 2/3's of the coal seam (horizon 9) it had become +12.7 °C. The tendency of cooling both in Visonta and Ilnitsa is very clear but in the Trans-Carpathians the temperature was higher.

The peat accumulation in Ilnitsa location began in the very beginning of Romanian (may be in the end of Dacian) and finished in the Late Romanian (Eastern Parathetys local stage terms). The second and first seams were accumulated during this time. According to the results of spore and pollen analyses the Visonta coals might correspond to the two upper seams of Ilnitsa.

The results of complex studies have shown that during Late Miocene-Pliocene age an allochthonous-autochthonous peat accumulation occurred. In the Ilnitsa location wet forest swamp and swamp lakes prevailed rather rare than delta distributary or river channels. On the contrary, in Visonta the organic matter accumulated in lacustrine-alluvial plain in wet forest conditions with elevated water supply.

These circumstances reflect the character of the vegetation and preservation of peat under the influence of bio- and geochemical factors. These can also explain the differences in the petrographical, chemical, geochemical and palynological characteristics between Ilnitsa and Visonta.

Organic microfacies and palynology of the Ajka Coal Formation of the Transdanubian Central Range in Hungary

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Key words: sub-bituminous coal, microfacies, palynology, Cretaceous

In the territory of Hungary the most complete Upper Cretaceous sequence can be observed in the Transdanubian Central Range, a part of the Pelso Tectonic Unit. The starting Senonian sediment is the Ajka Coal Formation, which consists of a nearly 150 m thick sandy, clayey and coal sequence.

Lithostratigraphic evidence shows that the coal formation developed in the beginning in limnic riparian forest, later in swampy environment. Finally the environment changed to paralic mangrove lagoon.

During the period of deposition of coal a tropical monsoon climate is supposed to have prevailed, under which an overwhelmingly wind pollinated, now extinct forest vegetation thrived, represented by the angiosperm *Normapolles* pollen group.

The coal formation consists of four palynological dominance zones, including six subzones. The accumulation of the source material of coal started during the *Trilobosporites* Dominance Zone "B" and ended during the *Hungaropollis krutzschii* Dominance Zone "D". The main period of coal deposition in the area was the *Brecolpites* – *Oculopollis zaklinskaiae* Dominance Zone "C", when the most economic and the thickest coal seams were formed. According to the integrated biostratigraphy the sedimentation lasted until the Late Santonian.


Studying the organic microfacies the quantity of the amorphous OM, fusain, cuticle, amber, colloid-size organic grains and the ratio of the *Normapolles* (wind pollinated) fernspores to (water transported) sporomorphs were observed and compared.

Based on the above-mentioned results wet forest swamp, inner and outer belt with weekly or strongly moving water, and deeper aquatic environments were differentiated.

The macroscopic observations in the coal mine distinguished seven coal seams, numbered 0 to VI. These observations are in very good accordance with the study of microscopic organic microfacies.

The Ajka coal is rich in fusain while vitrain and durain are much less abundant. Generally the coal is rich in amber. In the so-called "amber seam", which is a real liptobiolite, the very special amber type "ajkaite" can be found. The calorific value of the coal is in the range of 15.5–18 MJ/kg.

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Organic Petrology Characterization of Shales from Buçaco Basin, Central Portugal: Preliminar Study

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Key words: Buçaco Basin, organic petrology, coal, dispersed organic matter

Geological Setting

The Buçaco Basin, north of Coimbra (Portugal), is a N-S aligned basin alongside the Porto–Tomar–Ferreira do Alentejo shear zone, which includes a sequence of Carboniferous/Permian age. Two tightly compressed, faulted synclines were identified: Algeriz Syncline to the east and north, and Santa Cristina Syncline to west and south (LEMOIS DE SOUSA, WAGNER 1983). The stratigraphy of the Buçaco Basin comprises, from bottom to top, the following sequence (WAGNER et al. 1983): Algeriz Formation, Vale da Mó Formation, and Monsarros Formation. The Algeriz Formation includes a basal breccia, irregularly developed as a result of the palaeotopography. It also incorporates red mud flow deposits and mass transported conglomerates of proximal alluvial fan facies linked to tectonic instability at the basin margin. Vale da Mó Formation corresponds to lacustrine deposits. This formation commences with massive red beds, generally silty mudstones, which are often fining upwards passing gradually into grey mudstones and shales with organic materials at the top of the formation, and one thin coal seam. These grey shales contain an assemblage of macroscopic plant remains considered by WAGNER et al. (1983) as Upper Stephanian C-Autunian. The upper part of the sequence, Monsarros Formation, includes fluvial conglomeratic deposits predominantly in the base, with red beds (siltstones and mudstones) to the top.

Petrographic characterization of the dispersed organic matter (DOM) present in the grey mudstones, as well as the coal seam from Vale da Mó Formation, is the aim of the present research.

Analytical Procedures

This study presents the preliminary results of the petrographic characterization of the dispersed organic matter of the grey mudstones from Vale da Mó Formation. A sample from coal seam was also studied. Samples were taken near Salgueiral and Algeriz villages.

Following the procedure outlined by ALPERN et al. (1993), the petrographic characterization of organic matter samples were made both on “whole rock” (WR) and “light fraction” (LF) using a microscope equipped with reflected white light and fluorescent blue

light. The WR correspond to the fraction less than 1mm mounted in epoxy resin, while LF are organic concentrates obtained by heavy liquid separation, mounted on plexiglass slides. The terminology used to identify and describe the organic matter was the one proposed by the International Committee for Coal and Organic Petrology — ICCP. Reflectance measurements were taken using a MPV2 Leitz microscope under standard conditions.

Results and Discussion

Macroscopically, the samples studied are grey to brown pelites. Terrestrial plant remains are frequent and, sometimes woody tissues of barks, stems, and leaves were recognised. Organic matter is abundant and well preserved. The organic particles are typically large/medium-sized as well as small and thin. The latter often represent microlayering. The organic matter is attributed mainly to macerals of the vitrinite group, but inertinite and liptinite are also present, although in scarce amounts. Vitrinite appears essentially as telovitrinite, both telinite and collotelinite. Gelinite with dessication cracks was also identified. Cutinite is the common maceral of liptinite group; however sporinite and resinite were also observed. Coaly particles (clarite) were occasionally observed. Consequently, the organic matter of the grey mudstones from Vale da M6 Formation consists of type III kerogen, derived from higher order land plants. The coal sample of the same formation is vitrinite-rich (92%; predominantly collotelinite) with small percentages of liptinite (6%) and inertinite (2%). Sporinite occurs as megaspores and microspores, and cutinite as thin-walled cuticles.

The mean random vitrinite reflectance for the coal was quantified at 0.77% (Medium Rank Bituminous C). Reflectance of the grey mudstones organic matter ranged between 0.84 to 0.88% with a very wide distribution in the histograms and two populations seem to be present, one with mean reflectance of 0.80% and the other with 1.09%. The first population is closest to that of the coal sample and the second one a little higher (Medium Rank Bituminous B). These two populations are thought to be autochthonous since they occur as large- to medium-sized particles. The population with the highest reflectance was not attributed to reworking because the organic matter of the black shales from a metasedimentary sequence of Middle/late Devonian and early Carboniferous age occurs in the Porto-Tomar-Ferreira do Alentejo shear zone, and has a 1.30% reflectance (CHAMINÉ et al. 2003).

Conclusions

The organic matter of the grey mudstones from Vale da M6 Formation consists of type III kerogen that originated from higher order land plants. Considering the vitrinite reflectance of this organic matter and an effective heating time of 40my (Permian duration) the palaeotemperature is estimated to be in the region of 120–130 °C (BOSTICK et al. 1979). Similar temperatures were obtained using the Barker method (TAYLOR et al. 1998).

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Evaluation of Petrology and Reactivity of Coal Blends for Use in Pulverized Coal Injection (PCI)

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In the present study, a South Brazilian subbituminous coal was blended with two imported low volatile coals from Australia to obtain data on the reactivity of the coals and coal blends and to study, if the subbituminous coals from Brazil can in part substitute the imported coals in PCI. For this purpose three blends were produced with successively higher contents of subbituminous coal (25%, 50% and 75%), followed by determination of coal petrological and reactivity properties.

Petrographic composition of the coal blends were determined following the ICCP system for analysis of coalblends. This system consists of the measurement of low reflecting and high reflecting vitrinites in the blend and the determination of the relative amounts of these components, and by maceral analysis identifying the amounts of inertinite, liptinite and mineral matter associated with the low reflecting vitrinite and the high reflecting vitrinite. Another group, commonly occurring in minor amounts, is formed by non-assignable components. Both methods yielded results very close to the actual proportions of low and high rank coals in the blends.

The evaluation of reactivity was based on monitoring the mass loss in a thermogravimetric analyser using a dioxide atmosphere up to 1050 °C. The results indicate that the subbituminous coal has a much higher conversion index than the imported coals, suggesting that blends with a proportion of up to 50% subbituminous coal have adequate properties for PCI.

Density fractionation of a high-ash Brazilian sub-bituminous coal – implications for chemical and petrological properties

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In order to improve the combustion characteristics of a high-ash Brazilian coal (Seam Camada Candiota Inferior, Candiota Coalfield), laboratory-scale “sink and float” tests were carried out to reduce the sulfur contents and ash yields. The separation was achieved by applying dense liquids (ethyleneglycol, perchloroethylene and bromoform), with densities varying from 1,3 to 2,4 g/cm³, and the resulting fractions were analyzed chemically and petrologically.

As expected, the ash yields increase with the densities, ranging from <5 vol% at 1.3 g/m³ to >60 vol% in the 2.2–2.4 g/cm³ fractions. The mineral matter, as determined by microscopy, occurs mainly in form of clay minerals, with moderate contributions of quartz and pyrite, and minor carbonate.

The contents in vitrinite and inertinite macerals groups show distinct trends in regard to density. On a mineral matter-free basis, vitrinite group macerals comprise over 80 Vol% in the 1.3–1.4 g/cm³ fractions, whereas they are <50 vol% in the 2.2–2.4 g/cm³ fractions. Inertinite macerals show the opposite trend, with <20 vol% in the 1.3–1.5 g/cm³ density range, and values >50 vol% in the 2.1–2.4 g/cm³ fractions. The seam has a relatively low content of liptinite (4 vol%), and there is no systematic trend apparent in regard to enrichment by density fractionation.

The density cut at 2,1 g/cm³ was chosen to simulate a gravity-based coal preparation route, yielding a good mass recovery (87.95%) and reductions in the total sulfur content (1 wt.%) and ash yield (47.47 wt.%). The distribution of macerals in the laboratory-scale preparation process shows a significant increase in the maceral inertodetrinite in the “sink-fraction”, whereas fusinite and sporinite macerals are enriched in the “float-fraction”. This indicates that in Candiota coal a high proportion of inertodetrinite is associated with mineral matter, mainly in the form of clay minerals, whereas fusinite and sporinite tend to be associated with the organic matter.

Variation of Mineral Phases of Mozambican Coals with Different Heating Temperatures

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Key words: Mozambique coals, mineralogy, heating

This poster presents the study of the changes of mineral phases of Mozambican coals with different heating temperatures. This is the first study on the subject carried out in Mozambican coals.

Coal samples were collected in two Karoo basins, Chicôa-Mecúcoè and Moatize, both in NW Mozambique and both placed along the Zambezi River Valley in Tete Province (Fig. 1). Chicôa-Mecúcoè coals were collected in trenches (<10 meters deep) and Moatize coals in seams mined underground. Therefore, the study allows comparing the behavior of coals collected superficially and underground.

Samples were splitted into 6 sub-samples, 5 of them subjected to different heating temperatures: 200 °C, 400 °C, 600 °C, 800 °C and 1000 °C. The heating was done gradually, in 30 min steps, until reaching the desired temperature, and then heated for another 30 min. The 6 sub-samples (including the non-heated) were then analyzed with a XRD, to study the different mineral phases resulting from such heating. Besides, one natural coke sample was also subjected to the same study, to compare its behavior as a natural heated material with artificially heated coals.

Comparing the variation of weight % from the original sample with the weight % of ashes resulting from the different heating temperatures, Chicôa-Mecúcoè coals (surface samples) show a greater variation than the Moatize coals (underground samples). Coke sample shows even a lower weight % variation (Fig. 2). This fact must be due to the epigenetic minerals deposited within the Chicôa-Mecúcoè coals which are more easily destructed during heating than the others.

The following minerals were detected for the different heating temperatures: chlorite, illite, kaolinite, montmorillonite, illite/smectite, calcite, dolomite, feldspars, mellilite, hematite, pyrite, rutile, diopside, wollastonite, quartz and anhydrite. Coke sample was not analyzed for mineral phases. Almost all minerals occur in the different heating resulting ashes, but with different amounts. Some minerals (kaolinite, chlorite and montmorillonite) disappear (or were not detected) in higher temperature ashes. Chlorite, illite/smectite (Fig. 3) montmorillonite and calcite show a steady decrease to higher temperatures. On the contrary, diopside, wollastonite and quartz (Fig. 4) show an increase. Other minerals, such as illite, kaolinite, feldspars (Fig. 5), mellilite, hematite and rutile show an irregular behaviour. In these three figures, differences between coals from Upper and Lower banks of Chipanga Seam of Moatize Basin can be seen. The greatest alterations of the inorganic constituents of these coals occur normally between 400 °C and 800 °C.

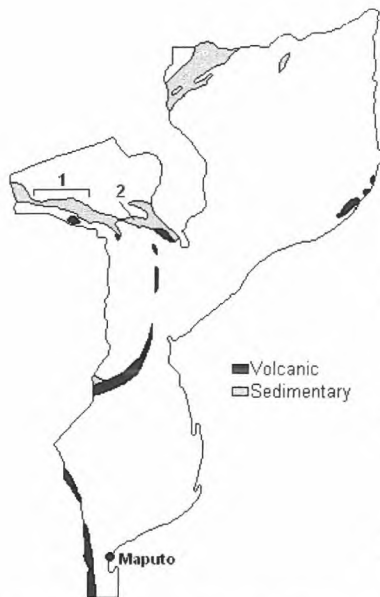


Fig. 1. Karoo Formations in Mozambique, with location of Chicôa-Mecúcoè (1) and Moatize (2) basins

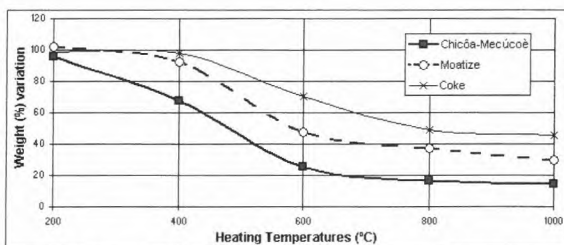


Fig. 2. Weight (%) variation between successive heating stages (average values)

NB: For Figs. 3, 4 & 5: MRIP — Medium Relative Intensity Peaks; CM — Chicôa-Mecúcoè Basin; LB and UB — Lower and Upper Banks of Chipanga Seam, Moatize Basin

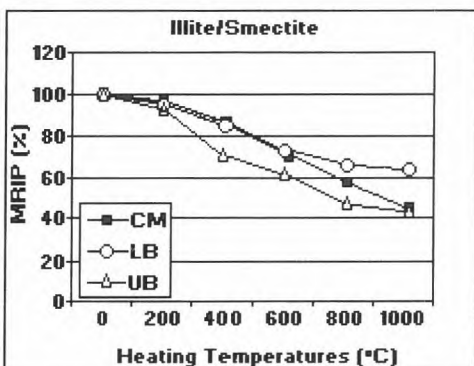
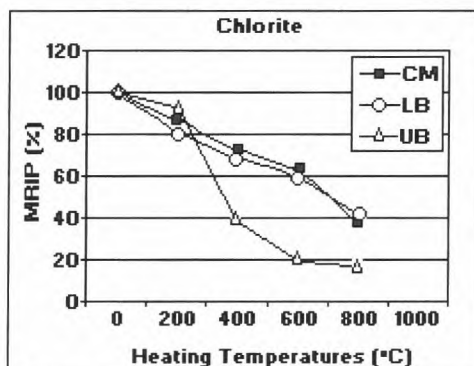


Fig. 3. Decreasing variation of Chlorite and Illite/Smectite concentration on ashes obtained at different temperatures

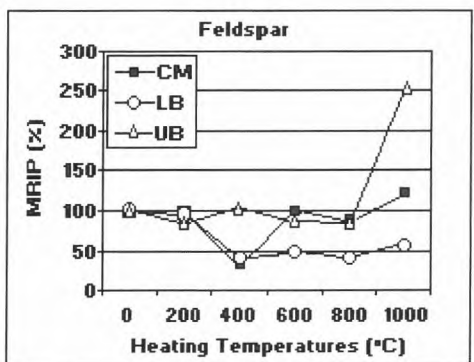
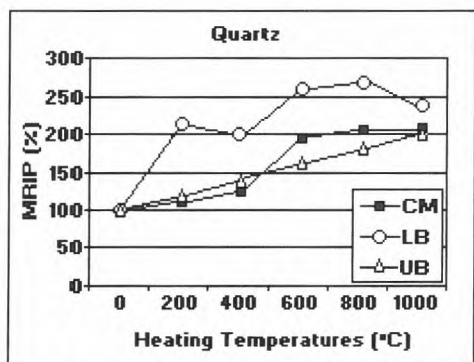


Fig. 4. Increasing variation of Quartz concentration on ashes obtained at different temperatures

Fig. 5. Irregular variation of Feldspar concentration on ashes obtained at different temperatures

The variations of mineral compositions of the several ashes are reflected in their varied colorations resulting from different heating temperatures.

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Impacts of Lignite and Peat Inertinite Content on Phenanthrene Sorption

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Key words: maceral analysis, organic carbon normalized sorption distribution coefficient (K_{oc}), phenanthrene sorption, sorption nonlinearity

Previous studies on organic contaminant transport and fate have employed organic petrography methods to correlate organic matter facies and sediment sorption characteristics (KLEINEIDAM et al., 1999; GHOSH et al., 2000; KARAPANAGIOTI et al., 2000). Inertinite has been identified as the maceral most responsible for high sorption capacity and sorption nonlinearity (KARAPANAGIOTI and SABATINI, 2000; KARAPANAGIOTI et al., 2001). However, most sorption studies were conducted with sedimentary organic matter, which is highly heterogeneous. This heterogeneity does not allow further investigation of the effects of inertinite on the sorption characteristics. In the present work, we use pure peat (two samples from Philippi and Keri peatlands, respectively) and lignite (two samples from Almyros deposit) that have been previously characterized using coal petrographic methods. Phenanthrene is commonly used in sorption studies as a model organic chemical and thus, it is also used in the present work to facilitate comparison of our results with previous studies. Both peat and lignite material demonstrate nonlinear isotherms described with the Freundlich model. Peat samples with similar organic carbon content (52 wt.%, on dry, ash-free basis) but different inertinite percentages (20 vol.% and 2 vol.%, on total organic basis) demonstrate varying sorption properties. The peat sample with the higher inertinite percentage demonstrates higher sorption capacity (K_{fr}) and affinity [measured as organic carbon normalized sorption distribution coefficient (K_{oc})]. The lignite sample that has the higher inertinite content (14 vol.% versus <1 vol.%, on total organic basis) although it has lower organic carbon content (49 wt.% versus 62 wt.%, on dry, ash-free basis), not only demonstrates higher sorption affinity (log K_{oc} of 6 versus 5.4) but it also has a higher capacity (4.4×10^5 versus 1.6×10^5 L/Kg) at low phenanthrene aqueous concentrations (1 $\mu\text{g/L}$). This last observation implies that inertinite affects more the different sorption mechanisms than the rest of the organic matter. At high phenanthrene concentrations, peat samples demonstrate lower affinity than the lignite samples regardless the inertinite content. This probably suggests that the inertinite content could be a measure of sorption nonlinearity and affinity only among samples of the same maturity. Organic carbon content, organic matter maturity, and inertinite content are important properties that affect sorption characteristics of organic matter.

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Characteristic macerals coming from lignite deposits of Ptolemais tectonic graben (Greece)

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Key words: Greece, Ptolemais, lignite, petrography

A number of characteristic macerals coming from lignite basin of Ptolemais is presented in this poster. Lignite deposits in Ptolemais provide the Greek economy with its most important source of fuel for electrical generation on which the electrification of the country depends. Today, from the lignite coming from Ptolemais area produces nearly 64% of the country's electrical energy.

Collected samples are from several lignite seams from lignite deposits situated in Ptolemais basin. Moreover, all samples are from representative drillholes. The geological framework of the region is only presented briefly since the region has been already described in many studies.

Criterion for selecting the lignite deposits of study was to fully represent the diversity of sediments along the tectonic graben. Stratigraphic columns of all cores and geological map of Ptolemais area is presented, indicating the locations of the most important lignite deposits of Achalada, Amynteon, Lakia, Proastio, Pontokomi, Southfield and Prosilio.

The petrographic characterization of these deposits is mentioned, classified in lists and histograms, together with images of characteristic macerals of the studied lignite seams.

In all studied samples huminite is the prevailing maceral group (80–90%) while all samples display a distinct prevalence in detrohuminite maceral subgroup. Liptinite and Inertinite maceral groups show very low contents (10% and 5%, respectively).

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Coals of the Oil-bearing Basin of West Siberia

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West Siberia is the plane, which represents the largest sedimentary basin (megasynecline), formed by Mesozoic and Cenozoic deposits. This basin is unique because great resources of oil, gas, condensate, coal, peat and bituminous rocks (oil shales) are confined in its interior. Oil and gas form the basis of power engineering in Russia and are mined intensively but coal still remains to be explored and exploited. Meanwhile the geological reserves of coal in the West Siberia basin exceed 50 Gt.

As far as considerable research and study has been given to oil and gas in the region, the data on coalbearing characteristics had only factual evidence (the position of coal beds in the sequence, their thickness) and no detail study had been carried out. The works by Yuzvitski A. Z. et al. (2000, 2003) were the result of such investigation. The distribution of coalbearing deposits of different age (C, T, J, K, Pg, and N) on the territory of West Siberia was described and analyzed in that papers.

Last year the authors realized an opportunity to get coal samples for detailed investigation in Shaimski region of West Siberia, which is situated in the western part of the basin, near Urals. Coals of Triassic and Jurassic age from the depth of 1650–2400m from more than 10 boreholes were sampled (over 70 samples). The coals were studied by petrographic (petrographic composition and vitrinite reflectance measurements) and chemical methods ($V^{daf}\%$, $W^a\%$, $A^d\%$, $C^{daf}\%$ and other were determined).

Two groups of coals were established among studied samples. The first is represented by coals with vitrinite macerals as dominant (70–90%). The vitrinite macerals are usually represented by telovitrinite (collotelinite) and gelovitrinite (corpogelinite and gelinite). Inertinite (18–20%) or less common exinite (1–4%, rare to 10–12%) macerals are also present in these coals. The second group differs by the inertinite, which prevalent in its composition (41–50%). Among inertinite telo- and gelovitrinite and exinite macerals are found in these coals. The coals of the second type are not widely spread.

The main parameters of quality, determined in the present investigation are following: ash content (A^d) — usually 10–20%, rare 2.4–2.7%; volatile matter content (V^{daf}) — 34–45%; vitrinite reflectance (R_r^o) — 0.5–0.7%.

The analysis of analytical results (V^{daf} , C^{daf} , R_r) and their correlation demonstrated that Triassic and Jurassic coals of the western part of the West Siberian basin are transitional from brown to bituminous or bituminous with high volatile matter content.



Carboniferous Dombarovsk anthracite deposits, South Urals, Russia

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Key words: anthracites, organic matter metamorphism

Our investigations are devoted to the study of the extent of transformation of the Lower Carboniferous sedimentary complexes located on the Ural eastern slope. These are similar in age and composition, but differ in tectonic setting, dislocation and extent of metamorphic transformation. Lower Carboniferous coal-bearing sedimentary complexes are widespread over the entire eastern slope of the Urals. The Man'in coal occurrence is located to the north. The eastern part of the Sverdlovsk region in the middle Urals host several coal deposits in the Egorshin-Kamensk district (near Yekaterinburg). Poltavo-Bredinsk district and Dombarovsk deposits are located in the south of eastern slope of the Urals. The Lower Carboniferous coal-bearing formations vary in thickness averaging 700–900 m. Coal rank increases from north to south, according to vitrinite reflectance values (R_o). High volatile matter bituminous coals were recovered in the Man'in coal occurrence ($R_o=0.75$ – 1.0%). There are low volatile matter bituminous coals and anthracites in the Egorshin-Kamensk coal district ($R_o=2.2$ – 3.5%) and anthracites of higher rank in the Dombarovsk deposits ($R_o=4.7$ – 5.3%).

The key study concerns the Dombarovsk Lower Carboniferous series as the extreme southern manifestation in the Ural eastern slope.

The fieldwork carried out in the Orenburg region (South Urals) enabled us to collect abundant data. The Lower Carboniferous rock samples of different lithological varieties were collected in two Dombarovsk quarries. Abundant occurrence of ore mineralization permitted us to attribute the local Lower Carboniferous rock outcrops to both anthracitic and haematitic conditions.

The Dombarovsk deposits were described in detail by L. D. Basharkevich, O. V. Zhukov and A. N. Sukhorukov (BASHARKEVITCH 1967; Coal base... 2000). The Dombarovsk deposits are located in the Orenburg district, 100 km east of the town of Orsk. They are confined to the Dombarovsk fault graben, located in the joint zone of the Magnitogorsk depression and the East Urals rise. The structure is filled with Paleozoic sediments. The strongly dislocated Lower Carboniferous Tournaisian (C_1) coal-bearing sequence reaches a thickness of 900 m. The productive Dombarovsk deposits comprise highly metamorphosed sandstones, siltstones, claystones, shales, and coaly rocks affected by different cleavage types, with coal interlayers and coal seams of paralic origin with thickness varying from 0.5 m to 1.2 m. Anthracite with various textures is often folded and smashed into pieces, with a carbon content (C^{daf}) of 91.0–94.6%. The vitrinite reflectance (R_o) is high (4.7–5.3%). In rock and coal polished sections, the coal shows a

strong anisotropy in polarized reflected light and a heterogeneous structure, typical of anthracites of high rank. The peak reflectance value (R_0) is equal to or above 5.3–5.5%.

The polished sections of coal studied in reflected light at high magnification show fragments of vegetable tissue, sometimes with a distinct cellular structure. These fragments are composed of different microcomponents, including vitrinite (telinite and collinite) and inertinite. Strong anisotropy and distinct heterogeneous structure, as observed under crossed nicols, exhibit rare remains of cellular cavities. Coarse and fine haematite inclusions are present. Curved, elongated vitrinite lenticles occur in coaly siltstones. Their heterogeneous, inner structure is distinct and is recognized under crossed nicols in several highly altered areas. Vitrinite (anthracite) lenses show numerous fissures, developed either as voids or as mineral infilling. Highly elongated anthracite lenticles with plication (assumably due to tectonic stress) demonstrate the rock alteration when in a consolidated state.

Results of X-ray analyses of the pelitic fraction of coaly claystones and siltstones sampled from coal-bearing Lower Carboniferous Dombarovsk series are provided. Oriented aggregates of the pelitic fraction (1–2 μm) were extracted for X-ray examination from clay suspension in water. The X-ray analyses show dioctahedral mica as the dominant mineral in all samples, associated with pyrophyllite and chlorite. Some samples contain kaolinite and a mixed-layer mineral, with minor amounts of quartz and feldspar. Na-mica was assumed to be present.

The pelitic fraction chiefly contained a mica belonging to the $2M_1$ polytype with typical reflections at 4.99; 4.98; 3.38; 3.34; 1.99 Å. The light-colored dioctahedral potassium micas (K-micas) occurred in most samples without hydrated states. The first reflection $d_{(001)}$ was as 9.89–9.96 Å. K-mica showed a rather high range of crystallinities. The crystallinity index after K. Weber (WEBER, 1972) was from 105 to 120. Such values are typical of high-temperature, well structured non-hydrated micas.

The pelitic fraction also contained chlorite (with $d_{(001)}$ varying from 13.8 to 14.0 Å and its $d_{(003)}$ from 4.72 to 4.69 Å), and pyrophyllite (9.21; 4.60 and 3.06 Å). Haematite was identified by its typical reflections at 3.68; 2.698; 2.515; 2.209; 1.841 and 1.693 Å.

The Dombarovsk deposits were formed in complex geological conditions. The diagenetic rock alteration and the organic matter metamorphism observed in Lower Carboniferous rocks are assumed to be due to repeated tectonic stresses developed along different trends. Due to the high degree of metamorphism the coal has been transformed into anthracite with a graphite-like composition in most altered occurrences. The primary host rock minerals became structurally altered into $2M_1$ micas typical for high-temperature conditions. The structural properties of the Dombarovsk deposits anthracite — its fractionation nature, goffering and strong anisotropic properties indicated that the coal deposits endured stresses. Besides, these rocks have also been affected by hydrothermal solutions, including ore mineralization. Thanks to fractures, these hydrothermal fluids penetrated into the organic matter of the coal seams. The organic matter was then cemented and transformed into hydrocarbon-ore aggregates.


Intensive P–T conditions have affected both the mineral matter and the composition of the pelitic fraction. These conditions triggered the clay mineral transformation, in particular, the appearance of $2M_1$ polytype at temperatures of 200–250 °C.

Provided other conditions are alike, a direct relationship exists between the regional tectonic stress and coal rank in particular coal fields. Besides, clay diagenesis in the

pelitic fraction in the host rock changes from mixed-layer smectite-mica varieties to micas of $2M_1$ polytype modification, stable at high pressure and temperature values.

The transformation of humic organic matter in Lower Carboniferous coal deposits of the Urals eastern slope is controlled by: 1) the extent of diagenetic alteration of organic matter, resulting from the sedimentary basin subsidence and 2) subsequent geologic processes, imposed on the already-formed coals (stresses related to the formation of collision belts in Urals).

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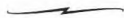
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Organomaceral Composition of Organic Matter in Maikop rocks and their oil potential

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Forecasting of petroleum fluid composition is based, firstly, on the initial composition of the source organic matter (OM). Characteristics of remains of precursor organisms, conditions of their accumulation and transformation during burial are traced in petrographic and chemical composition, characterizing certain types of kerogen.

Integrated petrographical and geochemical investigations were carried out on Maikop Formation (MF, Oligocene-Lower Miocene) source rocks.

The Maikop deposits are widely distributed in the basins of the Eastern Paratethys. High amount of clay minerals, great thickness, and optimal temperature and pressure conditions allow us for considering the MF as one of the major oil-generating suites in the Caucasus region.

According to maceral composition of the OM, the MF is divided into two types characterized by predominance of detrital components and amorphous organic material (up to 90–100%), respectively. Detrital OM contains different remains of marine (dinocysts, algae, foraminifera and crustaceans) and terrestrial (spores, pollen, particles of the vitrinite and fusinite groups) origin. Such type of kerogen is typical for deposits of all stratigraphic units of MF formed under strong input of terrestrial OM (outlying parts of Paratethys — Crimea, NE of the Scythian plate).

OM composed of amorphous material is characteristic of the major part of the MF. According to palynological data, the bulk of OM is of mostly marine, phytoplanktonic (dinoflagellates, rare green alga, acritarchs and diatoms) origin. However its chemical composition and, therefore, its oil-generation potential vary in a wide range from type I to type III kerogen. Type I–II and II–III kerogens consist of fluorescing amorphous yellow mass and non-fluorescing brown mass, respectively. Such changes in petrographic characteristics are accompanied by changes in chemical composition; the transition from fluorescing to non-fluorescing kerogen corresponds to degradation of oil-source properties, which is obviously provoked by several reasons. Formation of the Pre-Caucasus foredeep began in Late Oligocene and continued during Miocene. Rapid subsidence and high rates of sedimentation and deposition of terrestrial OM characterize this stage. These conditions resulted in dilution of OM by sedimentary material and its bacterial degradation. Both processes led to a decrease of oil-source potential of the sediments. Inflow of fresh waters led to water stratification up to appearance of anoxic environments. Bacterial degradation of OM develops in such conditions. This assumption is based on negative correlations observed between TOC, elemental composition of kero-

gen (C, H, N, O) and coefficient of stagnation (Mo/Mn ratio) (KHOLODOV and NEDUMOV, 1991). The use of the Mo/Mn ratio is based on opposite behavior of the two metals in sulfidic environment. Mo/Mn ratio close to 0.00n gives evidence of oxic conditions; its increase up to 0.0n–0.n gives evidence of anoxic conditions. In case of anoxia all components of OM are intensively destroyed resulting in a decrease of TOC content from 3.6% (Lower Oligocene) to 0.5–1.4% (Upper Oligocene – Miocene). This drop in organic richness is accompanied by decreases of kerogen hydrogen content (from 7–9.4% up to 6.3%), H/C ratio (from 1.1–1.52 up to 0.9–1.1) and HI (from 515–776 to 308–462 mg HC/g TOC), increase of kerogen $\delta^{13}\text{C}$ (from -27.4‰ to -26.56‰), and optical changes of amorphous organic mass dominating the kerogen (it becomes more brownish and weakly/or non-fluorescing). These changes correspond to a decrease of oil potential (from 24 to 2.7 kg HC/t of rock). Moreover, contribution of terrestrial OM that likely entered the Paratethys in form of humic acids (their amount sometimes reaches 30% in the Miocene OM) reduces oil-source potential. Miocene rocks and their OM are characterized by very low values of oil potential (1.5 kg HC/t of rock), kerogen H content (3.2–5.6%), H/C ratio (0.54–0.98), and HI (199 mg HC/g TOC).

According to positive correlation found between Mo/Mn and sulfur content, the kerogen is relatively enriched in sulfur. However, positive correlation between Sorg and H/C ratio (and HI) is observed at Mo/Mn ratios as low as <0.001 . It attests that an increase of oil-potential takes place at an aerobic stage of sedimentogenesis as a result of a more intensive degradation of proteins and carbohydrates.

Due to transformation of OM during early burial carbonate-clayey deposits of Lower-Middle Oligocene possess high oil-source potential in shelf (Northern Azerbaijan) as well in deep-sea (Pre-Caucasus) facies. Upper Oligocene – Lower Miocene rocks are predominantly gas-source rocks.

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Organic-rich sediments of the Dnieper-Donets Basin and Fold Donbass

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Key words: organic-rich sediments, Carboniferous, Devonian


The Dnieper-Donets depression (or basin, DDb) and Hercinides of the Fold Donbass (or Donbass) represents the general large structure — megarift. It is the unique geological region, which is situated on the East-European craton between the Voronezh anticline and Ukrainian shield and extends from Pripyat graben (Byelorussian region) to the Caspian Sea (including Karpinskyi ridge). The megarift has NW trend, 70 to 140 km width and is bordered by marginal deep faults zones. Depth of the basement ranges from 5 to 20 km (CHEKUNOV et al. 1993). Late Paleozoic, Mesozoic and Cenozoic rocks compose the overlying sediments of the megarift. In the DDb the Late Paleozoic sediments have a special interest because significant source-rocks of oil-gas resources are concentrated only in the Devonian and Carboniferous sediments. In the Donbass —Middle Carboniferous sediments contain economic coal seams. The Lower Carboniferous sediments are the horizons of the marine black shales (source-rocks), which we consider a certain prospects for petroleum. The Devonian marine facies in the Donbass is absent.

The Late Devonian and the Early Carboniferous history of the development of the DDb is characterized by periodical accumulation of the black shales sediments containing high concentrations of organic matter of humic-sapropel type. They accumulated in shallow-water paleodepressions. The black shale organic-rich sediments consist of siliciclastic-argillaceous or carbonate-argillaceous rocks. They also have rhythmical internal structure. To the direction to the carbonate platform the Lower Carboniferous black shales are replaced by reef facies. The Devonian black shales are characterized by TOC 1–4%, but Tournaisian and Visean black shales has TOC 3–10%, average — 4–6%. Their thickness vary from 40–65 m up to 600–700m. In the Donbass, the horizons of the black shales are determined in the Tournaisian and in the Visean carbonate formations. Their thickness has 0,40–5,0 m and 5–40 m accordingly. Their TOC — 1,15–6%. Now the structure and genesis of the bitumens of these rocks are studied in the laboratories of MÁFI (Budapest, Hungary) and VNIGNI (Moscow, Russia).

The Devonian bituminous black shales have similarity with the equivalent age Domanic suite in the Volga-Uralian oil-bearing regions (STRAKHOV N. M. 1939). The Visean bituminous black shales are similar to the Woodford Shale in the Anadarko Basin (HESTER T. C. and SCHMOKER J. W. 1994). The organic-rich sediments of the DDb and the Donbass have high content of uranium and other chemical elements: Mo, S, V, Zn, Ti, Ni, Pb, Co, P, Sr, and Zn etc. The porosity of the highly bituminous of argillaceous shales ranges from 3% to 18%. The formation of the organic-rich sediments in the DDb and in

the Fold Donbass Basins occurred in hot humid climate and developed due to marine transgression and uncompensated sinking of the basin's bottom. The fact is that the basins with "black shale" accumulation (Pripyat Trough, DDb, Donbass, Karpinskyi Ridge, Pre-Caspian Region etc.) are located in the active fault zone of the global Sarmathian-Turonian Lineament. This allows assuming that accumulation and distribution of organic-rich sediments with elevated concentration of uranium were the results not only climatic factors, but also the influence of deep-seated tectonic and geodynamic processes of the crust.

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Organic maturation of shales from Toca da Moura Volcano-Sedimentary Complex (Ossa Morena Zone, Portugal)

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Key words: peperite, vitrinite reflectance, Toca da Moura Complex, Beja Massif

The Ossa Morena Zone (OMZ) is a major geotectonic unit located at the southern sector of the Iberian Massif. During Middle Devonian to Lower Carboniferous times, the OMZ underwent igneous activity related to the convergence and collision with the South Portuguese Zone. The Beja Massif, a large calc-alkaline suite, testifies this activity, outcropping at the Portuguese part of the OMZ, near its southwestern border. It is composed of basic to felsic intrusions and a main volcano-sedimentary complex named Toca da Moura, which dates from Late Tournaisian to Late Visean (Pereira et al., in press). This volcano-plutonic suite has been interpreted as corresponding to a volcanic arc (or arcs) associated with the development of a subduction zone dipping northwards, at the southwestern edge of OMZ (MUNHÁ et al., 1986; SANTOS et al. 1987; SANTOS et al. 1990).

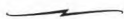
Our study focuses on thermal maturation of organoclasts dispersed in metric thick intercalations of shales, caused by the intrusion of basic to intermediate sills belonging to the Toca da Moura Complex (TMC).

The occurrence of dispersed peperite in one (Corte Pereiro quarry) of the four sampled sections demonstrates that it is contemporaneous of volcanism and sedimentation and indicates that, when magma injection occurred, the host sediment was unconsolidated or poorly consolidated, and probably wet. However, further south, along the TMC, the absence of any evidence of magma and sediment mingling together with the observation of sharp contacts between sills and shales, suggests a different setting, probably deeper, better consolidated and with minor fluid circulation. To test this hypothesis, we collected four sets of samples at regular intervals at each site, both above and/or below decimetric sills exposed in the TMC, which were thoroughly brushed before fine grinding of the shales (to pass 212 µm). After centrifugation, the organic constituents (mostly vitrinite and inertinite) floating in a mixture of bromoform and alcohol were concentrated on a millipore screen, mounted on a plexiglass slide and polished. Whole rock blocks (grains diameter ~1mm) were also prepared. Random reflectance was measured on adequately polished vitrinite particles. The organic concentrates were analysed by Micro-Raman spectroscopy and X-ray diffraction, as a complement to petrographic analysis. Micro-Raman spectroscopy is a very sensitive analytical technique for the detection of crystallinity/graphitisation degree (GUEDES et al. 2002). We used it in order to identify possible variations in molecular ordering within apparently homogeneous vitrinite particles, probably responsible for the observed increase in standard deviation near the intrusions. Reflectance measurements, on samples collected at approximately 1m from the sills,

were around 3%, probably imposed by regional metamorphism. In the immediate proximity to the sills, where thermal influence often causes the appearance of devolatilization pores, mean random reflectance values are relatively higher. In the Corte Pereiro section, these structures do not occur and the thermal effects due to igneous activity seem to be of minor importance.

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Conodont colour alteration and vitrinite reflectance data related to a half-graben structure in the Mesozoic of the Mecsek and Villány Mountains, southern Hungary

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Keywords: Conodont colour alteration (CAI), vitrinite reflectance, microfacies, palynology, Mesozoic


The colour alteration of conodonts (CAI) and vitrinite reflectance data are good indicators of the temperature increase with increasing burial depth. A characteristic example is described herein from the Mecsek and Villány Zones of the Tisza Megaunit (or Tisia Terrane), South Hungary. Middle Triassic conodont-bearing carbonates are well recorded by surface geological and borehole data in the area of Mecsek and Villány mountains. They were buried in very different depths during the formation of a large half-graben structure from the Late Triassic to Early Cretaceous. In the Mecsek half-graben zone up to 4300 m thick sediments were deposited until the end of the Bajocian (Upper Triassic atypical, „grey Keuper”, Lower Liassic coal-bearing Gresten Facies, Middle Liassic to Lower Dogger „*Fleckenmergel*” or Allgau Facies). On the other hand, coeval strata on the adjacent Villány ridge zone are missing or reach no more than 90 m thickness (Upper Triassic Carpathian Keuper, Pliensbachian sandy, belemnitic limestone). The siliciclastic input ceased after the Bajocian, in the Mecsek Zone: Bathonian to Berriasian pelagic carbonates and some chert, Berriasian to Barremian/Aptian alkaline rift-type basalts and associated volcanoclastic conglomerates with some carbonate; in the Villány Zone: shallow water carbonates up to early Albian, flysh type sediments in the late Albian were formed. The Bathonian to Albian sedimentation and magmatism essentially did not result in the further difference between the overburden of the two zones.

The investigated Middle Triassic conodonts of the Mecsek Zone (deriving from the depocentre of the half-graben zone) were altered to dark grey, black colour (CAI=4) whereas those of the Villány Zone preserved their original yellowish white colour (KOVÁCS et al. in press). Neither the Early Cretaceous volcanism in the Mecsek Zone, nor the additional tectonic overburden resulting from Middle-Late Cretaceous northward thrusting in the Villány Zone influenced the colour of conodonts. Vitrinite reflectance data ranges between 0.81–2.00%. It shows similar values in the two zones (LACZÓ 1984) for the same sequences, which is confirmed by palynology and microfacies data as well.

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Post mortem 2D-simulation study of the hydrocarbon generation and migration of a N₂-rich gas field on the inverted south-western rim of the Lower Saxony Basin

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Key words: Lower Saxony Basin, basin modelling, vitrinite reflectance, burial, Upper Cretaceous inversion, natural gas, nitrogen

Palaeozoic petroleum system of gas field A was reconstructed using a 2-D forward basin modelling software. The gas field is located on an inverted western rim of the Lower Saxony Basin (LSB) (Fig. 1) and belongs, with its relatively anomalous nitrogen content of 73.9 vol.% and its cumulative production of 4,27 G.m³, to one of the most unique gas accumulations in North Germany. According to the modelling results, the key charge of the present gas field began in the Tithonian (late Upper Jurassic) during the

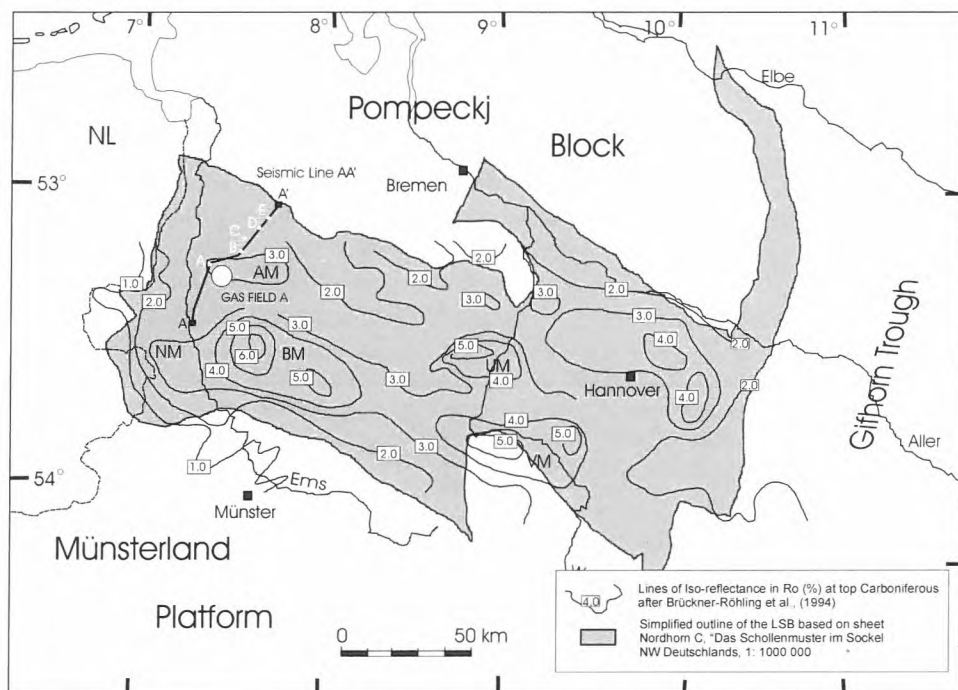


Fig. 1. Location of the study area marked by the seismic line AA' in Emsland region, Western Germany together with the extent of the Lower Saxony Basin (modified after Baldschuhn, 1996) and the geographic extent of the Middle-Upper Cretaceous Massifs with the associated high maturity areas as indicated by the lines of iso-reflectance or top pre-Permian basement. BM-Bramsche Massif, VM-Vlotho Massif, NW-Nordhorn Massif, AM-Apeldorn Massif, UM-Uchte Massif. Wells A, B, C, D & E were used for calibration

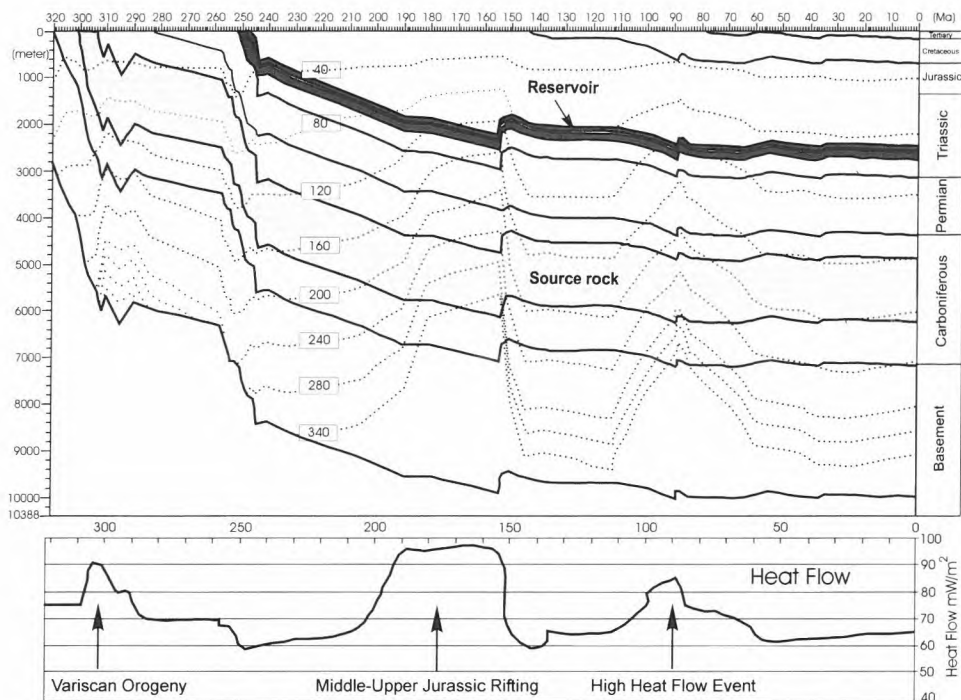


Fig. 2. Burial history diagram, vertical temperature distribution and heat flow history (High heat flow model, scenario1) at well A

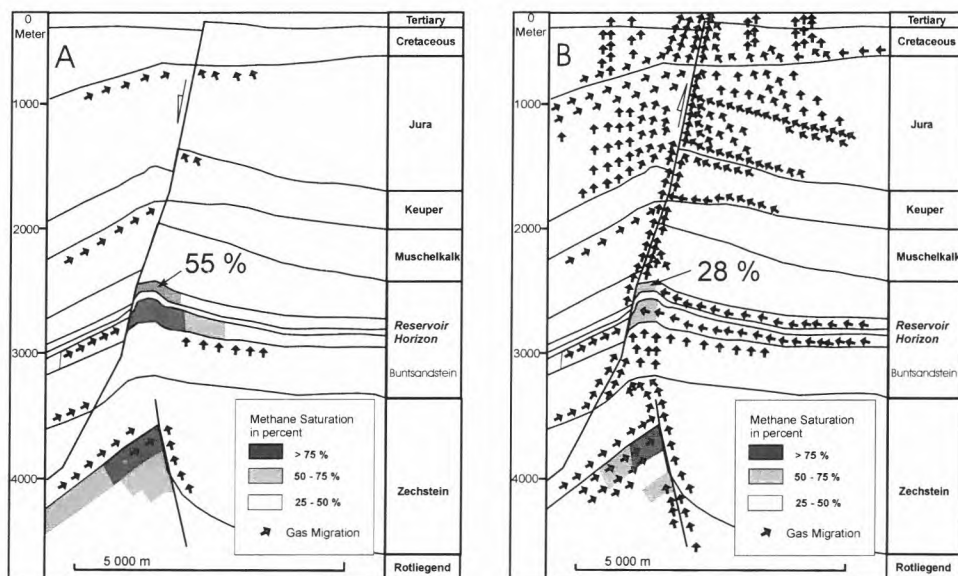
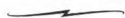



Fig. 3. Migration of methane and saturation of the pore space with methane (in percent of total volume) at gas field A preceding (A) and during (B) the Coniacian-Santonian inversion

major rifting-phase in the Lower Saxony Basin. The present Westphalian coal-derived gas accumulations of the Lower Triassic Buntsandstein reservoir were sourced directly from methane pools at the top Rotliegend level. The hydrocarbon potential of the Westphalian source rocks became exhausted in the Oxfordian (early Upper Jurassic). Based on thermal calibration studies utilising both vitrinite reflectance data and corrected bottom hole temperatures as calibration parameters, an anomalous event of elevated heat flow of 80 to 120 mW/m² during the Coniacian was modelled (Fig. 2). A high temperature increase during the Coniacian high heat flow event, together with an uplift during the Coniacian-Santonian inversion, led to an extensive free gas exsolution. The resulting gas mixture between the exsolved free gas and the Westphalian coal-derived gas reached and saturated the Buntsandstein reservoir. The structural trap was destroyed in course of the inversion, leading to a sharp decrease of methane and nitrogen saturation (Fig. 3). Tertiary northeasterly directed tilting did not affect the hydrocarbon accumulation in gas field A.



The origin of gases explored within the Inert Gas Zone, Hungarian Great Plain, Hungary

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The purpose of this study was to find an answer to the origin of high “inert-content” (CO_2 , N_2) gases, explored in the “Szolnok Flis Area” and its direct geological surroundings. Since the carbon isotope ratio of methane homologues is unknown, the origin of these gases can be only estimated indirectly. During the development of the project several problems occurred concerning the maturity of the organic matter and, related to this, the vertical migration of the gases, the composition - in-homogeneity of the gas-pools and the relationships between them. The solution of these problems effectively contributed to the revelation of the origin of the gases within the area.

The most accurate evaluation of the maturity of organic matter is essential to the calculation of both the role of the organic matter content of the source rock in the hydrocarbon generation and the minimum and maximum depth of hydrocarbon generation. The thesis is focused on minimising the uncertainty of two parameters: vitrinite reflectance (R_o) and TTI. Based on the statistical analysis of the R_o parameter, it could be stated that the standard parameter calculation (ISO, ASTM) needs to be corrected as outliers can be expected in almost every case resulting from the uncertainty of the measurement. This can be a significant source of errors, especially in the case of small sample sized dispersed organic matter (DOM), due to the un-robust and un-resistant character of mean calculation. Based on these, it seems to be more advisable to use the median during the examination of small sample sized DOM samples.

In some cases the maturity of the organic matter needs to be estimated in areas where the vitrinite reflectance has not been measured. There are two ways to do this: either to find an experimental formula, which gets closest to the measured R_o values (R_{o-sz}), or to find a maturity parameter which can be calculated at any point of the given area (TTI). Both methods raise several questions concerning the given parameters' dependence on depth, temperature and time. The area's map of inverse geothermal gradient (gg) can be drawn based on the available data of temperature and depth acceptable in industrial practices. Also, the sedimentation period of each layer can be calculated considering the “almost regular” sedimentation of the deeper areas of the Pannonian-basin and the estimated time frames of the ages.

Although these calculations will need to be corrected at a later stage, and the uncertainty of the data gained this way might also be significant, the values of R_o measured in the organic matter samples from the area — concerning the sediments from the Jászág basin of the Pannonian age:

$$R_{o-sz} = 0.0387 \cdot e^{0.1572 \cdot \lg(t) \cdot g_l} \text{ (if } R_o \leq 0.7\% \text{) and}$$

$$R_{o-sz} = 10^{1.469 \cdot 10^{-9} \cdot z^2 \cdot T^{0.5} - 0.1862} \text{ (if } R_o > 0.7\% \text{)}$$

can be estimated significantly more accurate according to these calculations, than according to the linear relations between R_o and the depth, which had been assumed earlier. Based on the more recent research results (KONCZ and LOPATIN) regarding TTI calculations, if the activation energy is regarded as constant, the speed of reaction decreases with the growth of the temperature. Given this, it was advisable to modify Lopatin's TTI calculation:

$$TTI_{Pa-mi} = \sum_{i=n_{min}}^{n_{max}} \left(\left(10^{c-1} \int_{T_i}^{T_{i+1}} T^{1.746 \cdot \lg T - 3.4048} dT \right) \cdot \Delta t_i \right)$$

to a general formula, where "c" is a constant of $n = 0$ point, and if $T = 105^\circ\text{C}$, then its value is -0.25104.

Based on the calculations above, it has become possible to calculate the values of R_{o-sz} and TTI_{Pa-mi} for the Pannonian basement of Jászság sedimentary basin. Considering these values and the other information available from earlier researches, it can be stated that the organic matter of the Pannonian Basin?, even in the deepest parts of the basin, was suitable to generate only early catagenetic and catagenetic hydrocarbons, mainly gases. However, gases of such maturity could not cause the in-homogeneity of composition to such a great extent in the explored area. Considering those gases of the area, that are probably homogeneous and are more matured than catagenetic, the migration distance of these gases could be estimated, using the relations between $\delta^{13}\text{C}_{\text{CH}_4}$ and R_o coming from other fields and the relation between R_o and Z that had been supposed within the area.

$$Z = \left(\frac{\lg(10^b \cdot R_{o-sz})}{c} \right)^{0.4}$$

These calculated vertical migration distances confirmed the earlier assumption about the presence of late-catagenetic and metagenetic gases within the area. By examining the relations between the gas compositions claimed reliable, it could be stated that the gases of the gas-pools of the area originates from the mixing of three basic gases:

— late-catagenetic, metagenetic gas, originating from coal-type organic matter, with high N_2 and probably high CO_2 content, and a CH_4 content that is supposedly below its N_2 (gas "A"), which had come from the so far unexplored, but supposedly existing, Liassic coal seam inside the basement of the Jászság basin;

— early-catagenetic, catagenetic and liquid hydrocarbon-assimilated gas with an origin of mainly coal-type organic matter (gas "B"), which has come from a source rock of the Miocene and Lower Pannonian ages, lying South of the area;

— CO_2 (gas "C") released during the thermal degradation of Triassic and Jurassic carbonates in great depths.

The late catagenetic, metagenetic gas and the CO_2 of non-organic origin have probably mixed through migration, and following this, the early-catagenetic, catagenetic gas has displaced CO_2 from the pools. The composition of the gas-pools could also be influenced by the bacterial degradation of the liquid hydrocarbons within them.

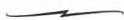
Aliphatic and aromatic biomarkers in Amynteo lignites, northern Greece

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Key words: biomarker, Greece, lignite, GC-MS

The recognition of the biomarkers in coal provides valuable information about the original organic matter and the transformation processes that took place during sedimentation. Although coal biomarkers have widely used worldwide, only a few publications are known to deal with biomarkers in Greece lignites.

Most of the greek lignite deposits are located in the Florina Ptolemais Kozani basin, a large intensively exploited area, in northern Greece. In the present study, a lignite sample was collected from a borehole, in the Amynteo mine, northern Greece. The sample was finely ground and processed for Soxhlet extraction with dichloromethane. The extract was separated into three fractions (saturated, aromatic and polar hydrocarbons) by Medium Pressure Liquid Chromatography (MPLC). Gas chromatographical analyses (GC) were carried out on a Carlo Erba HRGC 5160 device, equipped with 25 m fused silica column SE54 (0.25 mm i.d., 0.25 µm film thickness). The identification of biomarkers was performed by GC-MS analysis using a Hewlett Packard 5890 Series II gas chromatograph coupled directly to a Finnigan MAT 8222 mass spectrometer. The operating parameters were: EI mode, electron energy 70 eV, scan range 35–500 amu and helium (He) as a carrier gas.

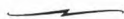
Terpenoid and sesquiterpenoid compounds were detected by GC-MS analysis. In particular, gymnosperm biomarkers such as isopimarane, abietane, phyllocladane and sandaracopimarane (MIRANDA et al. 1999), as well as angiosperm indicators such as lupane (STEFANOVA et al. 1995) and hopanoid compounds with bacterial

Peak ID	Compound designation
Aliphatic fraction	
is1	n-hexadecane d34D internal standard
A	terpenes
B	sesquiterpenes
C	phyllocladane
D	sandaracopimarane
E	isopimarane
F	abietane
G	des-A-lupane
H	squalane
I	trisnorhopane
J	lupane or hop-17(21)-ane
Aromatic fraction	
is ₂	d10-anthracene internal standard
K	naphthalene
L	cadalene
M	alkyl phenols
N	alkylbenzenes and cadinene
O	dibenzofuran
P	alkylbenzenes
Q	fluoranthene
R	pyrene
S	cholesteren
T	triaromatic steroid

origin were identified (DEHMER 1995; RAYMOND et al. 1997). GC-MS analyses applied to the aromatic fraction revealed the presence of the following compounds: naphthalene, alkyl benzenes and phenols, which are mainly related to liptinite maceral (STANKIEWITZ et al. 1996); pyrene, which could indicate natural fires in the forests (MIRANDA et al. 2000); cadalene and cadinane, which have an angiosperm origin (NORGATE et al. 1999); fluoranthene and dibenzofuran, typical of terrestrial plants (KRUGE 2000). Similar biomarkers were found by PAPANICOLAOU et al. (2000) in other Greek lignites.

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Studies on the matrix effect in Pyrolysates of pre-treated organic rich sediments

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Key words: pyrolysis-gas chromatography, matrix effect

11 samples have been chosen for this study on the basis of their Rock Eval data. 11 oil shales, and one organic rich lignites come from Hungary. The samples are immature ($R_o < 0.4\%$). The age: is Tertiary (Miocene: 1, and 11 Pliocene samples). Distribution of samples on type: Type I: 4, Type II: 6 and Type III: 1 samples.

Kerogen samples (common organic solvent and non-oxidising mineral acid insoluble organic fraction of rocks) were prepared, and their C, H, N, S and Fe contents were determined, and pyrolysed. The elemental analyses gave information of gross composition of kerogen (kerogen types are determined by the atomic ratios: H/C, O/C), but without any estimation of the hydrocarbon product distribution. Pyrolysis-gas chromatography (Py-GC) provides a direct compositional link with products expected to be formed from kerogens offering a more detailed insight into kerogen structure. Numerous homologue series have been found in pyrolysates and both their relative and absolute abundances have been exploited to infer precursors, extent and type of diagenetic processes and level of early catagenesis.

We focused on the role of inorganic minerals in flash pyrolysis processes and the relationship between elemental composition of kerogens and their pyrolytic products. In Table 1, the partial effect of mineral matrix are shown in the case of *n*-alkene/alkane

Table 1. The range observed of *n*-alkene/alkane doublets and the upper limit of *n*-alk-1-ene predominance over *n*-alkane in the different pyrolysate

sample	TOC (%)	HI	1*or1	1*ir2	1*k3	2#or1	2#ir2	2#k3
P1	10.8	571	2-39	2-36	2-39	12	8?	12
P2	16.2	609	2-39	2-37	2-38	20	16	11
P3	27.7	722	2-39	2-38	2-38	22	20	12
P4	13.0	575	2-39	2-39	2-38	22	16	12
P5	17.5	747	2-39	2-39	2-39	22	16	12
P6	18.9	717	2-38	2-39	2-39	8	12	14
Ge	9.8	748	2-39	2-38	2-39	16	12	16
Ek	12.4	525	2-39	2-39	2-39	22	12	15
Vk1	10.4	416	2-35	2-38	2-39	13	8?	17
Vk2	11.4	635	2-36	2-39	2-39	13	8?	12
Vk3	12.3	491	2-39	2-39	2-39	18	7?	11
Ba	37.1	84	2-37	2-38	2-35	?	16	16

1*: the range of occurrence *n*-alk-1-ene/*n*-alkanes in pyrolysates; 2#: the last doublets where *n*-alk-1-ene/*n*-alkane >1 i.e. the highest C number for the statement is true; or¹: in original rock, ir²: insoluble residue in cc. HCl; k³: in kerogen concentrate (further data in HETÉNYI, 1996)

Table 2. The effect of matrix on pyrolysates in the case of original samples and HCl insoluble residues comparing with yields of kerogens

sample	o/x^{*or^1}	o/x^{*ir^2}	o/x^{*k^3}	$2\#or^1$	$2\#ir^2$	$2\#k^3$	$3^{\wedge}or^1$	$3^{\wedge}ir^2$	$3^{\wedge}k^3$
P1	1.28	0.43	2.54	1.4	—	1.8	0.17	—	0.24
P2	1.55	2.08	2.18	3.6	1.5	4.8	0.35	0.80	0.32
P3	3.41	5.64	4.18	3.7	2.2	2.1	0.37	0.36	0.36
P4	1.69	1.99	2.26	3.9	1.4	3.9	0.34	0.39	0.31
P5	2.92	2.81	3.78	5.1	1.6	3.8	0.36	0.40	0.27
P6	0.55	1.41	2.75	0.8	0.6	9.0	0.44	0.28	0.35
Ge	0.91	1.26	2.16	0.8	0.7	4.2	0.26	0.24	0.22
Ek	1.20	1.11	1.62	2.1	0.8	2.8	0.61	0.32	0.37
Vk1	0.74	0.43	1.83	0.8	1.0	4.5	0.30	0.38	0.32
Vk2	1.23	0.89	2.78	0.6	—	7.1	0.47	—	0.32
Vk3	0.50	0.32	0.94	1.9	0.5	6.4	0.63	0.38	0.53
Ba	0.08	0.19	0.24	1.4	0.6	2.9	1.2	0.52	1.35

o/x^{*} : n-okt-1-ene/m+p-xylene; $2\#$: prist-1-ene/prist-2-ene; 3^{\wedge} : prist-1-ene+prist-2-ene/n-C₁₇-ane+C₁₇-1-ene, measured in or^1 : in original rocks, in om^2 : insoluble residues in cc. HCl; in k^3 : in kerogen concentrates;

yields of pyrolyses comparing the composition of pyrolysates of kerogen, that of their original rock and that of their insoluble reidues in HCl.

In Table 2 the variation of parameters frequently used in Py–GC are exhibited demonstrating a very considerable matrix effect. The observed trends are only partly similar to that of similar studies (MUKHOPADHYAY 1989; REGTOP et al. 1986 and SOLLY et al. 1984). In the case of different samples, different matrix effect trends were observed. The variations are governed by precursors of organic matter, by depositional environment and by diagenetic processes. The order of formation of diagenetic minerals is the determinant factor in the effect of mineral matrices.

Several relationships were found between the bulk composition of kerogens and the different components of pyrolysates: e.g. a considerable part of the O-content of kerogens is phenolic; the S_{org} -content of kerogens is only partly thiophenic and the H/C value of kerogens partly reflects the depositional and diagenetic oxidation.

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