

Microscopic studies using mixed ultraviolet, infrared and white light

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The present study presents a quick and inexpensive way to study organic and inorganic rocks and minerals, coal, various types of minerals and crystals, as well as man-made materials, but strong application can be found in biology and study of living organisms such as plant tissues, insects, bacteria, etc. in a laboratory or in the field. The method is no less effective than extremely expensive and available only to some specialists equipment. A laptop, digital microscope, white LED light, ultraviolet light 400 nm and infrared 780 nm light lamps were used for the study. All of them have batteries to be used as on-site mobile devices (in situ). Lamps must be attached to or free of the microscope and must be free from it and must be free to move in all directions of space, i.e. adjust the light to shine at any angle to the sample. A digital USB microscope with a magnification of 1000x1600 with a computer program HiView was also used. The observation was made in an airborne medium with reflected or activating light (fluorescent and infrared). The method helps to quickly and easily petrographically describe coal or organic matter in rocks in situ and evaluate their practical application. It can be used in mineralogy and crystallography, for example, for the study of the mineral magnetite, also in materials science and last but not least in the field of biology. Using all these types of lights, we can recognize the texture faster, the structure, mineral content, coal lithotypes, maceral content and rank of the coal, respectively, and its technological characteristics and the content of its organic constituents.

Keywords – infrared, light, microscopy, petrography, ultraviolet, white.

Микроскопски изследвания с използване на смесени ултравиолетова, инфрачервена и бяла светлини. (Виктор Сотиров, Антон Сотиров). Настоящото изследване представя бърз и евтин начин за изучаване на органични и неорганични скали и минерали, въглища, различни видове минерали и кристали, както и създадени от човека материали, но силно приложение може да намери в биологията и изучаване на живите организми като растителни тъкани, насекоми, бактерии и др. в лаборатория или на терен. Метода е не толкова ефективен от изключително скъпите и достъпни само за някои специалисти апаратури. За изследването са използвани лаптоп, цифров микроскоп, бяла LED светлина, ултравиолетова светлина 400 nm и инфрачервени 780 nm светлинни лампи. Всички те са с батерии, за да бъдат използвани като мобилни устройства на място (in situ). Лампите трябва да бъдат закрепени за микроскопа или свободно от него, като трябва да имат свободата да се преместват във всички посоки на пространството, т.е. светлината да се насочва да свети под всякакъв ъгъл към пробата. Използван е и цифров USB микроскоп с увеличение 1000x1600 с компютърна програма HiView. Наблюдението е направено във въздушна среда с отразена или активизираща светлина (флуоресцентна и инфрачервена). Методът спомага за бързо и лесно петрографско описание на въглищата или органичните вещества в скалите in situ и оценка за практическото им приложение. Може да се използва в минералогията и кристалографията, например за изследване на минерала магнетит, също така в материалознанието и не на последно място в областта на биологията. Използвайки всички тези видове светлини, можем да разпознаем по-бързо текстурата, структурата, минералното съдържание, въглищните литотипове, мацералното съдържание и ранга на въглищата, съответно и технологичните им характеристики и съдържанието на органичните им съставки.

Introduction

This paper presents a fast and inexpensive way to study coal or oil rock in the laboratory, in the field or in the on-site mine (in situ), which is no less effective than extremely expensive methods and equipment available only to some specialists.

Methods for the microscopic examination of coals using single ultraviolet and reflecting white light have been described by Taylor et al. [1], Stach et al. [2] and Sotirov et al. [3]. But in some cases, researchers need more specific information, and for this reason, infrared light is also included, and in different cases, three types of lights are mixed together. The method involves counting illuminated or fluoresced particles and calculating their percentage per sample. The possibility of coal generating natural gas, methane or coal gas is determined by Mastalertz et al. [4] and Hristov et al. [5]. Bell describes briefly about the salts (NaCl) in the soils [6]. Sotirov's reference data (2013, 2007) [7, 8] on the petrographic and mineral composition of coal from nine Bulgarian basins were used for petrographic assessment of coal potential for natural gas, methane formation and for industrial coal gasification. These are the Kyustendil Basin, the Oranovo-Simitli Basin, the Chukurovo Basin, the Sofia Basin, the Pernik Basin, the Dobrudja Basin, the Balkan Basin, the Svoge Basin and the Katrishte deposit.

Methods

For the study, a laptop, a digital microscope, white LED light, ultraviolet light 400 nm and infrared 780nm light lamps were used, with which microcomponent counting and microscopic photographs were made (Fig. 1, 2). All of them have batteries to be used as on-site mobile devices (in situ). Lamps must be attached to or free of the microscope and must be free from it and must be free to move in all directions of space, i.e. adjust the light to shine at any angle to the sample. A digital USB microscope with a magnification of 1000×1600 with a HiView computer program was used. The observation was made in an air environment, and the light was reflected or activating. The method facilitates a quick and easy petrographic description of coal or organics in rocks and an express evaluation of their practical application. Using all these types of lights, we can recognize more briefly the texture, structure, mineral content, coal lithotypes, maceral content, technological characteristics and rank of coal, because different lights are reflected or activated electrons – the phenomenon of fluorescence and luminescence by

the different particles of coal in different colors. The combination of different types of lights, of different wavelengths and of radically different parts of the spectrum allow to see many hidden phenomena and components in the rocks. In order to demonstrate how this method of research can be used, the content of the main groups of macerals and the mineral content of coal from the Donetsk Basin, Ukraine, Bobov Dol and Maritsa East Basin, Bulgaria, were determined.

Discussion

Using combined ultraviolet, infrared and white lights in organic petrology and coal petrography

An example for how it might be used the microscopic study with mixed lights is given below:

Based on the petrographic composition data of the coal from the nine basins investigated [7, 8] the following conclusions were drawn:

1. The prospect for exploring conventional natural gas is the Balkan and Svoge coal basins, as the measured values of their reflectance from coal vitrinite are more than 1.0%, respectively $R_r = 1.12\%$ for Balkan coal and $R_r = 4.89$ for Svoge anthracite, which is higher than 1.4%, but the layers around the basin may be promising. The Dobrudja basin is also of interest as we expect the values of vitrinite reflectance to reach over 1.0% on further study.

In this regard, the coal from the Katrishte field is also of interest, which is rich in - up to 40% petroleum products, coal from the Dobrudja basin with over 20% petroleum products and coal from the Balkan basin with up to 30% petroleum products, represented by migra-bitumen. Migra-bitumen is an indicator of gas or oil condensation (Taylor et al., 1998) [3].

2. The prospect of coal exploration for industrial gasification (not underground – in situ) are lignites from the Sofia Coal Basin, containing macerals from the Liptinite group 15%, Oranovo-Simitli basin 14.76% and Chukurovo basin 14.12%. They also have a relatively low mineral content <10%, except for Sofia coal, which has 13% mineral content.

From the coal basins with a high degree of coalification, suitable for industrial gasification are the coal from the Dobrudja basin, which has a maceral content of the Inertinite group of 24.61% and a very low mineral content of 0.15%, but its coal layers are located at a great depth of more than 1 300 m. Balkan coal is also of interest in this regard. It does not have many macerals of the inertinite group 6.44% and pre-oxidation of the coal will probably be necessary, but their mineral content indicates that they have already been oxidized to some extent as it is represented

mainly by the mineral framboidal pyrite.

Petrographical data of the coals is presented in Table 1, where rank of the studied coal and percentage of different maceral groups were counted under microscope study with mixed lights.

3. The prospect of exploration for natural methane is the Sofia and Kyustendil coal basins, because the depth of their main coal layers is up to 500 m, and the Chukurovo coal layer is about 700 m. The Svoge anthracite basin is also promising in this respect, as most of the methane is formed during the anthracitization stage, and the depth of its layer is 300 m.

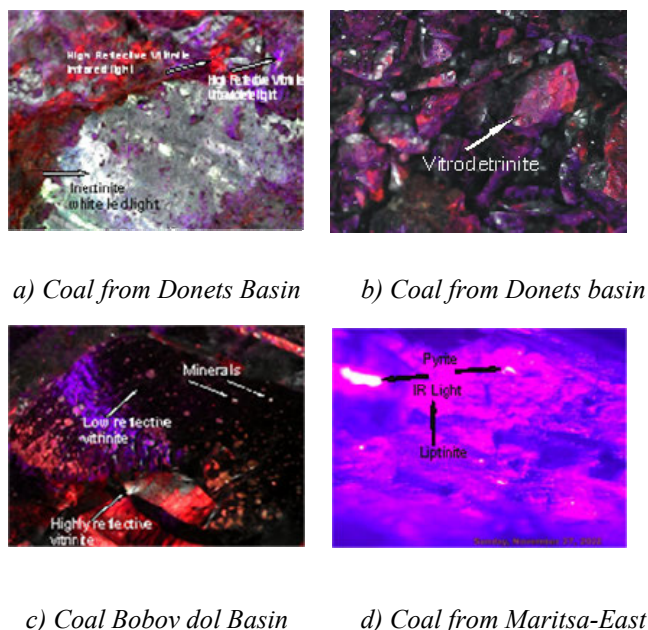


Fig.1. Petrography of coal with different rank, air environment, combined UV, IR, white LED lights, magnification 1000×1600.

Table 1 Petrographical data of the coals

Average, % of total substance	Donets basin 15 samples	Bobov dol basin 18 samples	East Maritsa basin 12 samples
Degree of Coalification - Rank-R	Bituminous	Sub-bituminous	Lignite
High reflective vitrinite, %	50	30	1
Vitrinite macerals, %	70	50	65
Liptinite macerals, %	5	30	15
Inertinite macerals, %	20	10	15
Minerals, %	5	10	5

Study of the minerals (magnetite) with ultraviolet and infrared light

The property of minerals to be attracted to an ordinary handheld magnet is called magnetism. The strongest magnetic is magnetite (Fe_3O_4). Fluorescence is a physical phenomenon, a type of photoluminescence. The explanation of the phenomenon is associated with a radiative transition of atoms or molecules from an excited to a ground state. This is an unstable state, and therefore particles return to their original stable state, emitting a quantum of light (photon).

The mineral magnetite is the only highly magnetic mineral, i.e. it is attracted by a magnet. The orientation of magnetite crystals in rocks indicates the direction of the Earth's magnetic field during their formation. Magnetite is a very common mineral in rocks and sands formed by their destruction, for example in rivers [9 - 11]. Magnetite is known to absorb (absorb) radiation and serve to purify radioactive solutions [12, 13]. It is also known that magnetite is not a radioactive mineral at birth [14 - 16]. So far, there are no fluorescent properties of magnetite described in science [11]. The same applies to halite (salt). More light: enabling the collection of more photons from the sample [17].

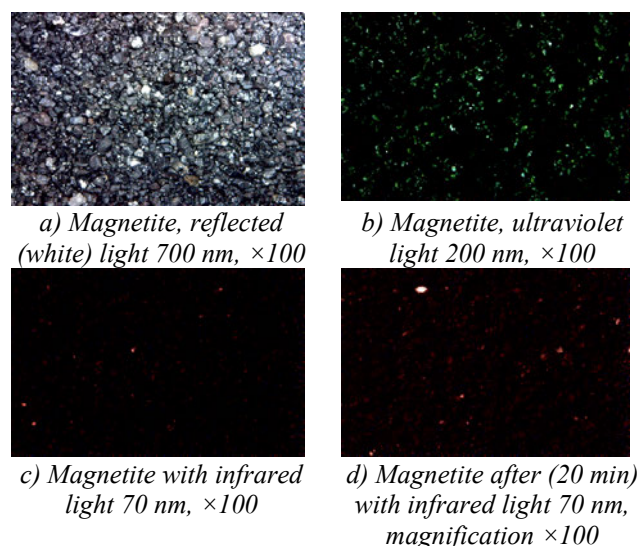


Fig.2. Results of microscope investigations in the field of mineralogy (air environment).

After prolonged irradiation with infrared light, more and more minerals are activated. Such a gradual enhancement of the irradiance is not observed with irradiation with ultraviolet light (Fig. 2). The fluorescence strength of magnetite depends on the wavelength and not on the duration of ultraviolet irradiation.

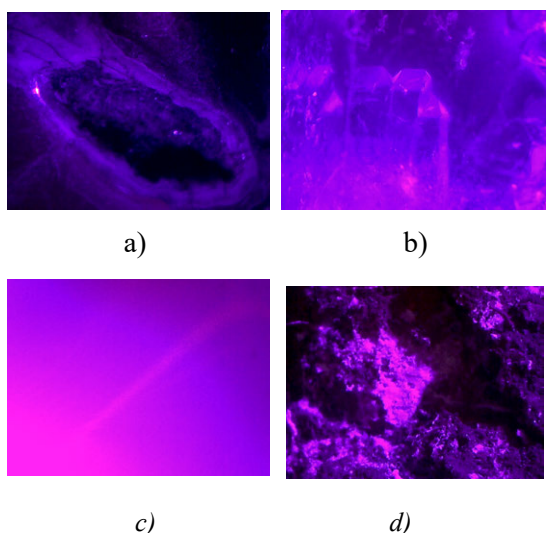


Fig.3. Application of the method in mineralogy – new findings: a) Small crystal inclusions into quartz crystals; b) Fluorescence effects around wholes of amethyst crystal; c) Asterism inside moon stone crystal; d) Fluorescing salts in soil. Combined UV, IR, LED lights, x100.

Application of the method to ecology research

Obtaining information on the quality and possible pollution of the water and its tributaries and influence of water pollution on the distribution of bioindicators for clean water such as fish and zoobenthos. The area has about 100% agricultural and fishing value for the livelihood of the population. Water from the studied rivers is mainly used for irrigation, agriculture, drinking water, fishing and food industry-fruit and vegetable processing. As a result of the study, it was found that the following tributaries Trekljanska River and Dragovishtitsa were not contaminated. Their water is relatively clean and for this reason widespread is the species of freshwater shrimp Branchiopoda are widespread (Fig. 4). The Novoselska River is contaminated with cyanuric acid, copper and high alkalinity around illegal landfills. There are no fish species in the river. Branchiopoda disappears around illegal landfills. The Banshtitsa River is polluted, which is evidenced by the fact that the biological species Branchiopoda disappears

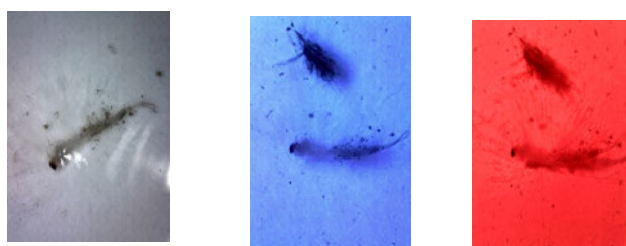


Fig.4. Application of the method in ecology, better recognition of zoobenthos – indicator for clean water: Branchiopoda white light, blue light, IR light, x10.

around places with illegal landfills. Bistritsa is contaminated with washing chemicals, which is evident in the foaming and again the lack of zoobenthos-bio-indicator for clean water [11].

Study of anthropogenic microdetritus, incl. micro-plastics – these are microscopic residues of destroyed or whole detritus of solid waste that has fallen or discharged into the environment – soils, waters, sediments (Fig. 5 and Fig. 6). When examined with a microscope with the application of a combination of bale, ultraviolet and infrared light, it is much more accurate and easier to specify the type of waste, respectively its chemical composition and degree of decomposition of the waste, its harmfulness, as well as its amount in percentage [11].

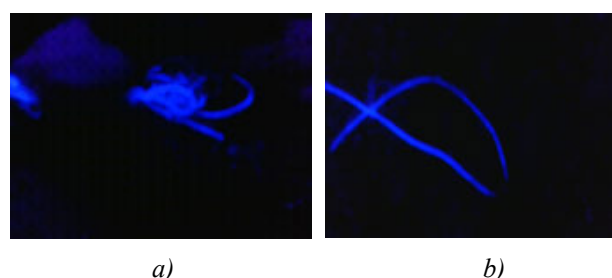


Fig.5. Anthropogenic micro-detritus (polyethylene textile) in the river sediments and soils, fluorescent (blue) light, x100.

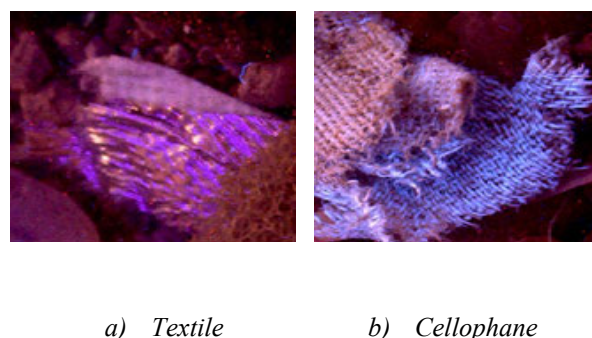


Fig.6. Anthropogenic micro-detritus: textile, cellophane in soils and sediments in river valleys, combined IR, UV, and white LED light, x100.

Conclusion

As a result of the study the following conclusions were drawn:

The application of different types of light in microscopic studies in ecology, water and soil sciences, petrography, organic petrology, mineralogy and crystallography and biology and their simultaneous and combined use reveals many details in microscopic examinations, and they can be used in the field and not only in the laboratory for rapid, reliable diagnosis of macro- and micro-lithotypes,

maceral and mineral composition, waste origin and its decomposition.

Proposed method gives more freedom to multiplex with different light combinations: scientists are no longer limited to working with manipulations that match the fixed filter sets of the microscope. More light: enabling the collection of more photons from the sample. More efficient data generation: The capacity to acquire all events simultaneously and without the need of managing multiple filter sets accelerates the image acquisition process, improving the efficiency of imaging large samples, such as multi-well plates, and enabling the capture of fast events in live samples. More confidence: the use of a Hybrid unmixing approach means it doesn't need to worry about crosstalk anymore. Possibilities for new findings and establishing of new properties of the studied objects are increased.

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