

## MAJOR ELEMENTS IN COALS FROM GOTSE DELCHEV BASIN, BULGARIA

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**ABSTRACT.** Lignite seams from Gotse Delchev Basin, which belongs to the Struma-Mesta Coal Province from south-western Bulgaria, were sampled. With the exception of Ti and P, the concentration of the other major elements in the studied samples is higher than the World average values (Valkovic, 1983). Within the carbonaceous shale samples S, Ca, Mg and Al contents are higher than the Clarke values. Moreover, Ca, Mg and Al show the highest concentrations among the coals from the whole Struma-Mesta Province. This is interpreted as a result of the active groundwater supply of Ca and Mg from the marbles and dolomitic marbles of the Dobrostan Formation, which occupy significant areas from the Basin's western margin. In addition, intensive siliciclastic supply from the Boikovo and Bachkovo Formations gneisses, which compose parts of the eastern margin of the coal basin, is the most probable reason for the significantly elevated Al concentrations. Calcium, S, Fe, Mg, Mn, Na and P show predominantly organic affinity, whereas Si, Al, Ti and K are mostly inorganically bound. The environmental acidity (pH) during peat formation is determined on a pH diagram. The results indicate that peat accumulation processed in acidic settings with pH in the range between 3.5 and 6.5 (average ~5). The calculated Supply Index (SI) indicates mixed groundwater/surface inorganic supply, with the former or latter predominating in particular stages of basin development.

**Keywords:** lignites, major elements, organic and inorganic affinity, environmental acidity, supply index, Gotse Delchev basin.

## LASER "RAMAN" SPECTROSCOPY AND LA-ICP-MS ANALYSIS OF COPPER-BEARING PYRITE AND SPHALERITE FROM GOLD-COPPER DEPOSIT CHELOPECH

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**ABSTRACT.** The presences of copper-bearing pyrite and sphalerite from the gold-copper deposit Chelopech are determined, by LA-ICP-MS analysis and  $\mu$ -laser „Raman” spectroscopy. In polished sections of Western sector of the deposit, the quantitative LA-ICP-MS analysis are performed on zonal pyrite, which shows a varying contents of Cu, with values up to 37,000 ppm. Two types of zonal pyrite with idiomorphic octahedral and colloform texture are observed, in which the copper is a structurally bound and in the form of sub-microscopic inclusions of chalcopyrite. The studied sphalerite grain with a darker section also contains copper in the form of mineral inclusions of chalcopyrite.

**Key words:** „Raman”  $\mu$ -spectroscopy, LA-ICP-MS analysis, element-impurities, ore minerals, Chelopech deposit

## NATIVE GOLD AND TELLURIDE MINERALS FROM A DEEP SUPERGENE ZONE IN THE AU-CU DEPOSIT CHELOPECH

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**ABSTRACT.** In the present study, a new data for mineral composition of Western sector in ore bodies in block 149, found about 700 m below the surface, are shortly discussed. In polished sections of the ore bodies are observed and analyzed with  $\mu$ -laser "Raman" spectroscopy a native gold and tellurium minerals (hessite and altaite), established in association with pyrite, chalcopyrite, bornite and anglesite. Their typical features and relationships are described. This complex mineralization is likely due to the later deep supergene processes, associated with open fault structures that have changed the character of mineralization in the deeper parts of the deposit. The analyses of the results obtained by present work will complement previous studies of the typical mineralogical and chemical zoning of this type of epithermal deposits.

**Key words:** „Raman”  $\mu$ -spectroscopy, ore minerals, deep supergene processes, Chelopech deposit

## TRACE-ELEMENTS IN COLLOMORPH MARCASITE AND CHALCOPYRITE FROM SILVER-GOLD DEPOSIT SEDEFICHE, EASTERN RHODOPE

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**ABSTRACT.** Sedefche is an epithermal type Ag-Au deposit, part of the Zvezdel-Pcheloyad ore field in the Eastern Rhodopes. The ore mineralization is hosted in volcanic tuffs, affected by intensive hydrothermal alteration. The deposit is located near the ground surface hence its upper parts are subject to supergene changes. The primary ore minerals are sulfides and sulfosalts. The supergene minerals are typically hydroxides, sulfates, carbonates and arsenates. Samples from drill cores and trenches have been studied through optical microscopy, X-ray spectral micro-analyses and LA-ICP-MS (Laser Ablation-Inductively Coupled Plasma-Mass Spectroscopy) in order to determine trace elements (particularly rare and precious), their content and distribution in colomorph marcasite and chalcopyrite from deposit Sedefche. The studies that were carried out, established that the presence of Au in marcasite is relatively low and unevenly distributed. Silver is more abundant, but its content and distribution are even more variable than these of Au. The studies established that Au and Ag contents increase somewhat towards the cores of colomorph marcasite aggregates. Brighter concentric circles in the colomorph marcasite are due to admixtures of Sb and As. Marcasite also hosts significant amounts of Tl. Chalcopyrite exhibits very low Au content and some Ag with very erratic distribution. The only other trace element with somewhat higher content in chalcopyrite is Ni.

**Key words:** *trace elements, silver-gold deposit, sulfide minerals, Sedefche deposit*

## TRACE-ELEMENTS IN SPHALERITE, PYRRARGYRITE, PYRITE AND ARSENOPYRITE FROM SILVER-GOLD DEPOSIT SEDEFICHE, EASTERN RHODOPE

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**ABSTRACT.** Sedefche is an epithermal type Ag-Au deposit, part of the Zvezdel-Pcheloyad ore field in the Eastern Rhodopes. The ore mineralization is hosted in volcanic tuffs, affected by intensive hydrothermal alteration. The deposit is located near the ground surface, hence its upper parts are subject to supergene changes. The primary ore minerals are sulfides and sulfosalts. The supergene minerals are typically hydroxides, sulfates, carbonates and arsenates. Samples from drill cores have been studied through optical microscopy, X-ray spectral micro-analyses and LA-ICP-MS in order to determine trace elements (particularly rare and precious), their content and distribution in various sulfide and sulfosalts minerals from deposit Sedefche. The analyses established that Au and Ag content in pyrite is somewhat higher than in marcasite. Analysis of arsenopyrite showed that its gold content is the highest among all studied minerals – about 100 times higher than Au content in pyrite. Sphalerite contains significant amounts of Cd and some admixtures of Ga, In and Ag. The distribution of Ag and In in sphalerite is very irregular, while the Ga content is much more consistent. The quantity of Au in sphalerite is low. Pyrrargyrite contains some admixtures of Au and more significant amounts of Tl and Se.

**Key words:** *trace elements, silver-gold deposit, sulfide minerals, sulfosalts, deposit Sedefche*

## PETAR (PETRA, PETRANITSA) RIVER CANYON BETWEEN THE VILLAGES GUBISLAV AND MILANOVO (WESTERN STARA PLANINA MOUNTAIN)

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**ABSTRACT.** Petar River (Petra, Petranitsa), separating the Lakatnik Rocks massive from Koznitsa Mountain, forms typical canyon-like valley from its mouth near Samotvor neighborhood of the village of Gubislav to the village of Milanovo. It gives an excellent opportunity for field observation and examination of the diversity of geomorphological sites formed in the Triassic carbonate rocks. The present article aims to describe some of the most typical geological phenomena exposed in the geotope, such as the widely distributed rockcliffs, formed in the rocks of the Mogilska Fm (Olenekian-Anisian) as well as the rock pinnacles and dolls in the Babino Fm (Anisian). According to the classification of the geological phenomena, the geomorphological sites described here are referred to the geosites of aesthetic value, and according to the original Bulgarian methodology for estimation of geological phenomena they correspond to the criteria for geosites of local importance.

**Key words:** *Petar River, Western Stara Planina Mountain, geological phenomena.*

## MINERAL COMPOSITION OF JASPER FROM THE EASTERN RHODOPE

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**ABSTRACT.** Listed with their respective mineral composition are 8 occurrences of jasper, as well as over 20 alluvial and diluvial jasper and jasper-like bearing placers in different parts of the Eastern Rhodopes. According to their composition and colour the jaspers are separated in three main groups: red jasper with an admixture of hematite, yellow (pale brown) jasper with an admixture of goethite and green jasper with an admixture of celadonite. Based on certain ratios of the intensity of some X-ray reflections in the quartz, two groups of specimens are separated: substantially microcrystalline quartz-bearing and substantially chalcedony-bearing jaspers. In terms of geological position and age, the findings are related to the first, second and third stage of the medium acid volcanism in the Eastern Rhodopes with corresponding Upper Eocene and Oligocene ages.

**Key words:** *jasper, quartz, mineralogy, Eastern Rhodopes*

## CHEMICO-MINERALOGICAL CHARACTERISATION OF ANCIENT SLAGS FROM ROSEN ORE FIELD

### PART 1 – PROPADNALA VODA DEPOSIT

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**ABSTRACT.** The objects of this study are ancient slags from the vicinity of Propadnala voda deposit, Rosen ore field. With the methods of optical microscopy in transmitted and reflected light, X-ray powder diffraction, chemical analyses by ICP-OES, CEM and X-ray microanalyses, it was found that the slags consist mainly of iron-siliceous and iron-oxide phases. The analyzed samples are with high iron content, the presence of copper, sulphur, sulfide aggregates, impurities of phosphorus, cerium and lanthanum. Macroscopically and microscopically spherical drops of copper are observed in all studied samples. The analyzed slags are evidence of ancient metal production in the area around Propadnala voda deposit and represent a by-product product of copper mining activity in which the copper sulfide ore was processed.

**Key words:** archaeometallurgy, ancient slags, copper, copper-sulfide aggregates, copper-oxide phases, iron-siliceous and iron-oxide phases

## CHEMICO-MINERALOGICAL CHARACTERISATION OF ANCIENT SLAGS FROM ROSEN ORE FIELD

### PART 2 – KORUCHESHME AND ROSEN DEPOSITS, METALLURGICAL CENTER "ATIYA"

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**ABSTRACT.** The ancient slags, found in the Rosen ore field were researched. They were collected from the surface of several ancient metal production centers located near the ancient mines in Medni rid. The mining of copper there is referred to the period 6<sup>th</sup> century B.C. – 4-5<sup>th</sup> century A.D. The chemical composition of the samples was determined based on data from ICP-OES. The slags have high Fe<sub>2</sub>O<sub>3</sub> and SiO<sub>2</sub> content. Their mineral composition was studied with the help of optical microscope in transmitted and reflected light, with the methods of X-ray powder diffraction and with electron probe microanalyses. It was found that the slags consist mainly of iron-containing phases such as fayalite, magnetite, maghemite, wustite, kirschsteinite, presence of copper drops and copper-sulfide aggregates. The studied materials are defined as by-products, produced from the heat treatment of copper-iron sulphide ore for copper mining in ancient times.

**Key words:** archaeometallurgy, ancient slags, copper, copper-sulfide aggregates, copper-oxide phases, iron-siliceous and iron-oxide phases

## CARTOGRAPHIC SUPPORT OF ASPIRING GEOPARK BELOGRADCHIK ROCKS

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**ABSTRACT.** The new territory of the first Aspiring UNESCO Geopark in Bulgaria, Belogradchik rocks, comprises three municipalities in Northwest Bulgaria in Vidin region between Bulgarian-Serbian border and the Danube. The new concept of geopark emphasizes the importance of geotourism and other alternative forms of sustainable tourism. Tourism activities can actively promote to get acquainted with geologic and landscape features of the region. In relation to the main objectives of the proposed geopark we have elaborated a new informational support based on geospatial data and thematic maps. These data can be organized in three blocks: base geospatial data, thematic data and tourism data. Base data include digital elevation model, hydrography, populated places, road network and so on. Thematic maps relate to geologic and landscape diversity and reflect geologic structure, locations of geosites, landscape types, land cover classes according to CORINE landcover 2012 and areas of high nature value. Tourism data comprise georeferenced bicycle routes, pedestrian tracks and ecological tracks. All these geospatial data have been compiled in the single geodatabase and visualized at a scale 1:300 000.

**Key words:** aspiring geopark Belogradchik rocks, geospatial data, thematic maps, natural landscape, land use, tourist routes, tourist attraction

## INTERNATIONAL PROSPECTS OF THE ASPIRING GEOPARK BELOGRADCHIK ROCKS

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**ABSTRACT.** Geopark Belogradchik rocks passed through another unsuccessful application for Global Geoparks, although all instructions of the previous UNESCO mission were implemented. According to these recommendations a new concept of the geopark was developed including establishment of a management body, expanding of the geopark area, and scientific description of at least 50 geosites of aesthetic, scientific and cultural value. Since then geopark has come a long way to its present state of Aspiring UNESCO Geopark. First of all geopark area was enlarged to the territory of 1373 sq. km between Bulgarian-Serbian border and Danube including four municipalities Belogradchik, Dimovo, Chuprene and Ruzhintsi. A new management body of the geopark was established - nongovernmental organization Association for Development of North-West (ADNW) registered by three municipalities Belogradchik, Dimovo and Makresh. Over the past four years the geopark area has undergone significant scientific investigations. First of all a solid geodatabase was developed, including geodiversity description, scientific dossiers of 72 geosites, and geological map of the area. The application dossier was applied in November 2014 and the mission of UNESCO was conducted at the end of June and the beginning of July, 2015. On 30 September 2015 the Global Geoparks Network Bureau inform us that at its meeting on 18 September has discussed the evaluation of our application and decided that at this stage Geopark Belogradchik rocks has not yet reached sufficient maturity to be declared a Global Geopark, and asked all stakeholders at Belogradchik to work for at least two more years on establishing a strong Global Geopark. The main reasons for the unsuccessful application could be summarized as follows: increasing requirements of the Global Geoparks Network, missing action plan, refusal of Chuprene and Ruzhintsi municipalities to participate in the ADNW, and refusal of the Ministry of Environment and Water to support preliminary activities prior to the UNESCO mission concerning geopark infrastructure: information panels with interpretation of the geological history for the general public, geotrails, information centres. The new concept of the geopark will be developed on a strong agreement between the participating municipalities, state support of the geopark activities, clear geopark funding, management plan for development of the geopark area, sustainable regional development policy strategy and importance of geotourism and other alternative forms of tourism – ecotourism, rural tourism, cultural tourism. It will be also developed considering the common requirements for conservation, protection and promotion of natural and cultural heritage sites and monuments, in areas hosting significant natural heritage of international importance through the establishment of aspiring UNESCO Global Geoparks in the light of the new International Geoscience and Geoparks Programme (IGGP) of UNESCO.

**Key words:** Aspiring Geopark Belogradchik rocks, UNESCO Global Geoparks

## BRIDGE MODELING AND HYDRAULIC ANALYSIS WITH HEC-RAS AT THE TUNDZHA STRUCTURAL DECLINE, IN ELHOVO TOWN AREA

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**ABSTRACT.** Bridges are main units of the road infrastructure. In terms of global warming and climate change, the fallen extreme rainfall threaten these facilities with damage. The most common cause of bridge failure is the phenomenon of pier scour at bridge foundations. In order to avoid possible damage to road infrastructure, should be taken adequate and timely measures to assess and anticipate such potential adverse events. This study used a one dimensional steady flow HEC-RAS analyses, for modeling pier scour and abutments scour of the bridge in Elhovo town. The bridge connects Elhovo town and Izgrev village. The main parameters affecting scour depth are water speed and water depth of the flow, bed sediment characteristic, and pier width. The aim of this study is forecasting, assessment and analysis of potential future scour events at the bridge foundations as a result of the impact of flash floods in the research area and determine the location of the most vulnerable areas in the foundations of the bridge facility.

**Key words:** GIS, HEC-RAS, hydraulic analysis.

## PETROGRAPHY, MINERALOGY AND GEOCHEMISTRY OF COAL FROM PCHELAROVO DEPOSIT, THE EASTERN RHODOPEs

### PART I. PETROGRAPHICAL AND MINERALOGICAL CHARACTERIZATION

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**ABSTRACT.** Samples from Pchelarovo deposit were studied. The coals are subbituminous, with high ash and high sulfur content. The goal of the investigation is to perform detailed petrographical and mineralogical coal characterization. The following methods have been applied – proximate analysis, sulfur forms determinations, Rock Eval pyrolysis, ulminite reflectance measurement, optical and scanning electron microscopy, equipped with an appliance for microelemental analyses. The quantitative maceral analysis reveals that ulminite totally predominates and textinite also presents in smaller amount. Sporinite, cutinite, resinite and sometimes alginite and liptodetrinite were observed from the group of the liptinite macerals. The macerals from inertinite group are present from funginite, and rarely from semifusinite and inertodetrinite. The mineral coal composition shows that pyrite, quartz and illite are the main minerals in studied coals. The kaolinite, K feldspar, gypsum, calcite and siderite are present in lower amount. The numbers of accessory minerals, lower than 1%, have been also determined. The variety of mineral composition and the increased content of inorganic matter in studied coals is strongly influenced by the volcanic and hydrothermal activity, simultaneous with the peat formation and coalification process, and with the presence of Pb-Zn, Cu and polymetallic mineralization in the region of the Pchelarovo deposit.

**Keywords:** Pchelarovo coal deposit, maceral composition, mineral composition.

## PETROGRAPHY, MINERALOGY AND GEOCHEMISTRY OF COAL FROM PCHELAROVO DEPOSIT, THE EASTERN RHODOPES

### PART II. GEOCHEMICAL CHARACTERIZATION

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**ABSTRACT.** Coal samples from Pchelarovo deposit were studied. The coals are subbituminous, with high ash and high sulfur content. The goal of the investigation is to perform detailed geochemical characteristics of bulk coals and to determine the trace elements in pyrite structures. For the purpose of the present study the following methods have been applied – ultimate analysis (ICP-AES), sulfur forms determination, ICP-MS and EPMA-WDX analysis. Seven major and 47 trace elements, including 15 REE were determined. The data show that there is a high concentration of number elements. The amount of U in coals is about 30 times higher and that of Cs is about 25 times higher than the average content for coals. The concentration of Mg, Cr, Ni and As is from 10 to 12 times higher and Mo, Sb, K, W, Rb, V and Na is from 5 to 8 times higher than average for coal. The elements Mn, Co, Ni, Cu, Zn, Cd, As, Se and Pb have been established in pyrite. The amount of these elements is compared with the amount of the same elements in other Bulgarian and worldwide coals. The data show an increased content of Zn, Ni, Pb and Cd in the Pchelarovo coals. The factors which controlled the higher concentrations of the elements in bulk coals and in pyrite are the presence of a hydrothermal and volcanic activity in the deposit's area, the presence of the Pb-Zn, Cu and polymetallic mineralizations in the region, the availability of molasse-type surrounding sediments which are permeable to circulating post-volcanic solutions and nearby situated fault zone.

**Keywords:** Pchelarovo coal deposit, geochemistry, trace elements in pyrite.

## INTEGRATED GEO-DATABASE OF SEABED DATA IN FRONT OF AVREN COAST, BULGARIAN BLACK SEA (CAPE GALATA – CAPE ILANDZHIK)

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**ABSTRACT.** An integrated geo-database for the continental shelf in front of Avren coast (between cape Galata and cape Ilandzhik) was created to facilitate contemporary and complex interpretation of geological and geomorphological settings of the area. It comprises seabed data gathered by innovative methods like Multibeam Echosounder System (MBES SeaBat 7111) data with 100% coverage, side scan and satellite imaging and sediment profiling. Data from 231 geological stations are analyzed by standard sedimentological procedures and results are combined into a single classification system. Thicknesses of contemporary seabed deposits are determined based on sub bottom sediment profiler data. Up to date coastline was digitized using orthophoto mosaics with 0.5 m accuracy. Based on seabed digital terrain model (DTM) with 2 m resolution a high accuracy bathymetric map with 0.5 m isobaths spacing was built, serving to determine different morphological zones within the continental shelf. All aforementioned data are combined into a geospatial database, analyzed by Geographic Information Systems (GIS) and are separated into two main categories of data models: raster and vector. Combining results of contemporary shelf explorations and archive materials from the Institute of Oceanology "Fridtjof Nansen" allows detailed update of seabed relief of the shelf in front of Avren coast with respect to morphological zonation. Similar morphological zoning of the coastal zone between c. Galata and c. Ilandzhik is proposed on the ground of morphodynamic activity. The spatial distribution of seabed lithological varieties and thickness of Holocene sediments up to continental slope are also defined.

**Key words:** Geo-database, Avren plateau coastal zone, continental shelf, morphological zonation, Multibeam echosounder system, Geographic information systems (GIS)

## CHARACTERIZATION OF ZEOLITIC TUFF FROM NORTHEAST JORDAN USING BOREHOLES DATA

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**Abstract.** Zeolite, the hydrate tectosilicate minerals, composed of various minerals such as phillipsite, chabazite, faujasite and analcime. Zeolites have been used for many applications such as drying and purification. Zeolites are distributed throughout Jordan in volcanoclastic and tuff volcanic centers. Several zeolitic deposits were located in northeast areas, mainly in Al-Aritayn, Tlul Al-Shahba, Jibal Hmelan, Tal Rimah, Tell Hasna and other places. These deposits are associated with the Harrat-Asham volcanic activity. The zeolitic tuff is composed of different assemblages of minerals such as phillipsite, faujasite, chabazite and analcime with high amount of iron oxide as hematite, fresh sideromelane, palagonite and smectite. They can be associated mainly with the black and red scoria. For the purpose of this study many boreholes have been drilled for examination of main characteristics of the zeolitic tuff, with aim to get a better understanding about vertical and lateral distribution of these minerals below the surface. To achieved that, many samples from different boreholes have been investigated using XRF, XRD and thin sections. The results revealed huge reserves that can be approved for future detailed exploration and extraction. The Jordanian zeolites are considered to have many important applications such as: ion-exchange (water softening and purification), and in the separation and removal of gases and solvents, in agriculture, and in animal husbandry.

**Keywords:** Jordan, zeolites, tuff, deposits, reserves.

## TIMOK FAULT AND TERTIARY STRIKE-SLIP TECTONICS IN PART OF WESTERN BULGARIA

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**ABSTRACT.** The existence of NW-SE and NNW-SSE trending, regional-scale faults is well-known feature in the area of Tran and Breznik (West Bulgaria). Despite the numerous studies in the area, there is a lack of direct data about the kinematics of the main fault zones. Our investigations allow to define three groups of faults and also demonstrate the dominant dextral strike-slip kinematics of the faults from Pernik fault zone, as well as of several segments of Tran-Kosharevo fault. The field data, together with analysis of the existing maps, suggest the existence of another main strike-slip fault zone with almost N-S strike – the Timok fault. This fault is well-documented in Eastern Serbia, as its continuation in the area of Tran (Kraishte zone) was already suggested by Karaguleva et al. (1980) and Krautner and Krstic (2003). In the westernmost parts of Bulgaria, the Timok fault is traced along the fault segments, previously interpreted as parts of Tran-Kosharevo fault. To the Southward the zone is following the Serkima fault. Unlike the northeast Serbia the translations along the Timok fault in western Bulgaria are much smaller – probably of not more than few kilometers. Additionally, our new data do not support the idea that these fault zones are part of Maritsa fault zone, well-defined southeast from Sofia.

**Key words:** Timok fault, strike-slip tectonics, western Bulgaria

## PLACER GOLD IN EOCENE SEDIMENTS OF EASTERN BALKAN AND FOREBALKAN

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**ABSTRACT.** Placer gold is found in several samples taken from two localities: from Chekeleza area (west of Obzor town) and from Nemoi Dere area (Rish Pass). In the first locality it is established in heavy mineral fraction from the sediments of the Obzor Conglomerate Formation (Middle-Upper Eocene), while in the second one – in heavy mineral fraction of the Armera Conglomerate Member of Dvoinitza Formation (Lower-Middle Eocene). Characteristic feature of both lithostratigraphic units is the presence of extraclasts of volcanic and intrusive rocks, cropping out in autochthonous position in Srednogorie Zone, which are the most probable gold source. Its presence among Eocene sediments is explained by Illyrian (post-Lutetian) orogeny, resulting in formation of Eastern Balkanides. Despite their lithological similarities and close ages, both units differ in their tectonic position - the Armera Member is syn-tectonic while the Obzor Formation is post-tectonic.

**Key words:** Eocene, Eastern Balkan and Fore-Balkan, placer gold

## FIRST DIGITAL TERRAIN MODEL OF THE SEABED OF SOUTH BULGARIAN BLACK SEA COAST - BROAD BOURGAS BAY

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**ABSTRACT.** Composite digital terrain model of the seabed in the waters of the southern Bulgarian Black Sea coast - broad Burgas Bay (from Cape Emine to Cape Maslen nos) is the result of processing and assembling data from single beam echosounder and multibeam sonar systems derived from the Institute of Oceanology-BAS, bathymetric LiDAR data, data provided by the port authorities and data from digitizing water lines from marine navigational charts. Data from single beam echosounder and multibeam sonar systems were acquired during the implementation of various national and international projects of IO-BAS. Areas for which no data are available were completed by manually drawn isobaths built on the grounds of the surrounding terrain and circular interpolation with step of 55 m. By combining all the data a comprehensive 3D digital terrain model of the topography of the seabed with resolution of 1/64 arc minute or cell size of 29 m was created. The digital terrain model allows detailed understanding of the seafloor morphology and with success can be used in the compilation of highly accurate, small-scale navigational charts and study of the geomorphology of the seabed. The digital model was made under implementing the project EMODNet Bathymetry funded by the EU and is included in the European hydrographic data base.

**Keywords:** Digital model, sea bottom, Burgas bay, continental shelf, morphological zones, multibeam echo sounder systems

## A GEOELECTRICAL APPROACH FOR SEARCHING KARST AREAS AND PROMISING SITES FOR CONSTRUCTION OF WATER WELLS

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**ABSTRACT.** The proposed geoelectrical approach for localization of karst areas is based on the different electrical resistivity properties of these zones in comparison to those of the unchanged parts of the rock massif. The same characteristic can be applied with high credibility for the differentiation of sub-surface areas with different water saturation and water abundance, which is a very important benchmark in the search for promising sites for construction of water wells. The high efficiency of the proposed approach for mapping karst and more prominent zones is illustrated by the results of the performed electrical tomography study in the area of Arbanasi, Veliko Tarnovo region. The presented results confirm the applicability of the proposed methodology for measurement, data analysis and interpretation.

## HIGH RESOLUTION VELOCITY ANALYSIS IN SEISMIC DATA PROCESSING

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**ABSTRACT.** In reflection seismology seismic data are usually contaminated with noise, which refers to any unwanted features in the data. One of the most important criteria for data quality is visibility of primary reflections, often quantified as signal-to-noise ratio. For achieving this goal one possible solution is to perform high resolution velocity analysis. Building adequate, high resolution velocity analysis is basic step for creating realistic and reliable geological section. Creating correct velocity model requires good differentiation between primary reflections and seismic noise. For achieving better velocity model resolution it is sometimes suitable to perform linear noise attenuation procedures before to perform velocity analysis.

**Keywords:** velocity model, filtration, resolution

## PASSIVE SEISMIC IN HYDROCARBON EXPLORATION

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**ABSTRACT.** Passive seismic is the detection of natural low frequency earth movements, usually to recognize geological structure and locate underground oil, gas, or other resources. Most of all passive seismic method is used in hydrocarbon exploration to support exploration efforts and minimize risk. In recent years, the technique has been applied to many oil and gas fields throughout the world and proof itself as a potentially powerful tool in the exploration of hydrocarbon resources. Passive seismic proof itself as a cost effective way to image a large area, where the terrain is difficult and consequently, conventional seismic is expensive and can be of poor quality due to seismic penetration problems.

**Keywords:** passive seismic, low frequency signal, oil and gas

## HYDROGEOLOGICAL MODEL OF THE DANUBE RIVER INFLUENCE OVER THE GROUNDWATER LEVEL AND THE POSSIBLE FLOODING OF THE SUGGESTED FOR CONSTRUCTION BLOCK 7 OF NPP "KOZLODUY"

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**ABSTRACT.** A general conceptual model of the hydrogeological conditions within the proposed alternative sites for the construction of a new nuclear power facility - Block 7 of NPP "Kozloduy" is presented. The model is developed after a systematization of the collected climatic, geological, tectonic, hydrological, hydrogeological, and technogenic information about the nuclear plant area and a detailed analysis of the conducted detailed borehole, geophysical and experimental filtration tests on the proposed alternative sites. Applying the computer program Modflow, a three-dimensional (3D) non-stabilized filtration model, based on an accepted general conception, is developed. This model is used for simulating the changes in the filtration field after taking into account the specific hydrogeological conditions and the continuous fluctuations of the water level in the Danube River. Based on the obtained model solutions, is developed a quantitative estimation for the rise and the drop of groundwater levels in the range of the proposed alternative sites and in the areas adjacent to the Danube River, and that is used for predicting the possibilities and the dimensions of their possible flooding.

## MODELS OF CONTAMINATION IN THE KARST AQUIFER CAUSED BY THE OLD AND THE NEW LANDFILL OF PAZARDZHIK

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**ABSTRACT.** A comprehensive approach for modeling the subsurface space and groundwater pollution caused by landfills in karst areas is applied. An electrical tomography surveying was performed in order to study the karst areas and to obtain a detailed picture of the hydrogeological conditions in the area of the old and the new landfill of Pazardzhik. Two-dimensional (2D) models of the hydrogeological conditions for the landfill leachate passage through the unsaturated zone and its spread into groundwater are developed. Different model variants are used in order to study the behavior of contaminants characterized by high and by low mobility on the example of chloride and ammonium ions (Cl and NH<sub>4</sub>). An evaluation of the current contamination caused by the old landfill was performed and a forecast for the development of possible negative processes after its recultivation was done taking into account the role of the upper insulating screen. The potential contamination of the karst reservoir caused by the new landfill is predicted after assessing the protective effect of the clay layer in the bottom insulating screen and the retention capacity of the geological base.

## **KINEMATIC MODELS AND EARLY WARNING SYSTEMS (EARTHQUAKES AND TSUNAMIS) FOR AZERBAIDJAN (BAKU CASE)**

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**ABSTRACT.** The fundamental relationship of the velocities of P- and S-seismic waves is used to calculate the travel times between the well known seismic sources of Azerbaijan to Baku (capital and the most populated city). The time differences between the P and S waves' arrivals are used for signalization and some preventive measures (gas and fuel pipelines switch off, electrical lines disconnection, dangerous production factories stop, etc). It is well known that the seismic waves are tens to thousands faster then the tsunami waves. On the same principle the seismic waves travel times from the tsunmiagenic zones as well as the travel times of tsunamis to Baku are calculated for practical purposes.

## **MAIN ACTIVITIES APPLIED IN THE PROCESS OF PATTERN RECOGNITION USED FOR SOLVING PROGNOSTICATION GEOLOGICAL TASKS**

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**ABSTRACT.** The theory of pattern recognition in geology and in particular for classification of objects in a set of different characteristics (geophysical, geological, geochemical, etc.) is developing intensively and is having a wide-ranging practical implementation. The pattern recognition is a machine-oriented methodology providing a rapid and repetitive analysis of diverse information and ensuring acquirement of quantitative results. The application of pattern recognition in geological prognostication requires a sequence of some major activities related to the selection of the territory and the subject of estimation, to the collection and classification of the characteristics used for description of the studied sites and to the definition of reference sites that can be used in the classification process.

## **GEOPHYSICAL APPROACH FOR MONITORING SALTWATER INTRUSION IN COASTAL AQUIFERS**

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**ABSTRACT.** In many places around the world groundwater is used as a main source of fresh water. The alarming rate of increasing the world's population makes its monitoring and managing of great importance. Both anthropogenic activities and natural phenomena lead to displacement of fresh groundwater by saline water. Electrical Resistivity Tomography (ERT) performed with various electrode configurations is widely used geophysical technique for high resolution illustrations of sites with complex geology. 2D electrical resistivity surveys were conducted near Yovanitsa port on Mount Athos in Northern Greece. The obtained results suggest that the ERT can be a powerful tool for delineating aquifers, reconstructing saltwater wedge geometry and contouring the zones with higher level of salinization which are necessary for the process of prevention.

## **LONG-STANDING GRAVIMETRIC MEASUREMENTS OF THE KRUPNIK POLYGON**

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**ABSTRACT.** The paper presents the long term results of gravity measurements of the Krupnik polygon performed on the one hand by a single step methodic comprising larger number of control points and on the other triple step methodic (double knot) with different types of gravimeters. During four epochs the gravimeters were calibrated on Sofia's gravimetric polygon and BAS's Calibration profile. While in another two epochs they were calibrated on the National Reference Gravimetric Polygon (NRGP). The results from the NRGF calibration show that its reference values have changed after 2003, probably under the influence of influence of various geodynamic processes. Therefore, it is necessary the reference polygons to be partly or fully re-measured by using absolute gravimeters every five years. The results from the long-standing gravity measurements around Krupnik region also show us in what condition part of the available in Bulgaria gravimetrical equipment is.

**Keywords:** Krupnik fault, gravimetry, geodesy, geodynamics, geophysics

## **HISTORICAL OVERVIEW OF THE METROLOGICAL MAINTENANCE OF STATIC GRAVIMETERS USED BY THE BULGARIAN GEOPHYSICISTS AND GEODESISTS**

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**ABSTRACT.** The report provides detailed historical reference about the establishment of the Gravimetric Laboratory for Servicing Gravimeters – Burgas, as well as its activities. Also, detailed description of the establishment of the Laboratory for Testing and Calibration of Gravimeters at the Research Institute of Geodesy and Photogrammetry – Sofia is included too. The full facts concerning the research and calibration of gravimeters in Bulgaria are presented, including closed polygon and slope-change techniques, which are used for calibration of the instruments for geophysical or surveying purposes.

**Keywords:** Gravimetry, geodesy, gravimeters, geophysics

## **APPLICATION OF NON-PROFESSIONAL REMOTELY PILOTED AIRCRAFT SYSTEMS (RPAS) FOR SOLVING PRACTICAL PROBLEMS**

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**ABSTRACT.** The use of RPAS for solving different practical problems is a new approach which is actively developed and should be enhanced and affirmed in solving number of problems related to monitoring and studying Earth's surface, as well as currently ongoing processes or phenomena. A typical application is the ability to generate detailed digital terrain models, which is critical in planning, design and monitoring of engineering and others activities.

The modern technologies and the increasing popularity of the drones contributed the emergence of relatively inexpensive multicopter systems. Combined with standard high-resolution camera (or different type of sensor) they are converting into powerful tool for remote sensing. Additionally, there are a number of budget software solutions for further processing the data gathered during the flight missions.

The current paper presents case studies conducted with DJI Phantom 3 Professional (P3P) quadcopter. The P3P is a fully ready to fly intelligent system designed primarily for non-professional purposes.

**Keywords:** Remote sensing, drones, geophysics, photogrammetry, cartography

## **ESTABLISHMENT THE IMPACT OF ANODIC TYPE ON THE PERFORMANCE OF MFC WITH H<sub>2</sub>S AS A MEDIATOR**

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**ABSTRACT.** In order to establish the impact of the type of electrode in the anodic chamber of an MFC, based on microbial sulfate reduction, a series of laboratory experiments is performed with the same U-shaped design of the fuel element and identical experimental conditions. Each time the anodic surface area is the same. The cathode at the five variants is a graphite rod. It was found that the aluminium anode allows a transfer of a larger electron flow and the generation of higher maximum power density rates - more than three times higher than those obtained with the graphite. The lowest value of coulombic efficiency is that of the lead anode.

**Keywords:** Microbial Fuel Cell, Wastewater Treatment, Alternative energy

## **IDENTIFICATION OF EXPOSED ROCKS IN OPEN PIT MINES USING INFRARED SPECTRAL DATA**

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**ABSTRACT.** In this study satellite data from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) in the wavelength range (1.6-2.5  $\mu\text{m}$ ) of bare rocks and soils in the region of open pit mines "Elshitsa" and "Tsar Asen" in Bulgaria were used. The spectral reflectance of exposed rocks was compared with the spectral reflectance of the same rocks taken from different spectral libraries. The analysis of the spectral characteristics in the specified range indicates maintain their specific features. In the obtained curves were observed distinctive extrema that be able to be used to identify the type of rocks. The results show that the suggested methods for analyzing the spectral data could be used to identify exposed rocks. Theoretical and analytical techniques that have been developed for the analysis of the laboratory spectral data also could be applied to field spectral data.

## SPECTROMETRIC MEASUREMENTS OF REFLECTED RADIATION IN ECOLOGY RESEARCH

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**ABSTRACT.** In recent years, remote sensing proved to be very effective for ecological and conservation biological applications. Spectral remote sensing generates a remarkable array of ecologically valuable measurements for detecting natural and human-induced changes in the terrestrial ecosystems. In this study hyperspectral remote sensing method based on reflectance measurements in the visible and near infrared spectral ranges was applied for assessing the influence of some adverse natural changes in the environment (enhanced UV-B radiation and acid rain) on the physiological state of deciduous trees (species *Paulownia tomentosa*). Reflected radiation from the leaves was recorded on the seventh and fourteenth days after the adverse treatments by means of a portable fiber-optics spectrometer in the spectral range 350-1100 nm with a spectral resolution of 1.5 nm. Statistical and first derivative analyses and five narrow-band vegetation indices (mNDVI – modified Normalized Difference Vegetation Index, f<sub>D</sub> - Disease index, SR – Simple Ratio, PRI – Photochemical Reflectance Index, TCARI - Transformed Chlorophyll Absorption Reflectance Index) were used to evaluate the changes in the spectral reflectance of the investigated tree groups. Indices mNDVI and SR performed best for discrimination between different treatments. Shift of the first derivative maxima on the reflected spectra to the lower wavelengths was observed for all treatments which indicated the presence of the changes in the physiological state of the paulownia trees against the control.

**Keywords:** Remote sensing, hyperspectral leaf reflectance, vegetation indices, ecology

## REVIEW OF THE MODERN APPROACHES FOR LABORATORY ASSESSMENT OF THE RESERVOIR PROPERTIES OF SOLID ROCKS-COLLECTORS

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**ABSTRACT.** The suggested article concerns issues related to the review of modern approaches to laboratory determination of the reservoir properties of dense rock-collectors. The interest in these formations is extremely high, in view of the fact that globally established formations with very low permeability values contain significant amounts of hydrocarbons. For purposes of determination of their resources / reserves and forecasting of technological parameters output of their development as quantitative values capacity-filtration parameters on concrete, real samples, is important. The study of their physical properties is a challenge to researchers as traditional laboratory methods and methods do not yield satisfactory results and are not applicable. Regarding to this significant research and financial efforts to develop innovative methods are made. Leading centers as Gas Research Institute Inc. and Agros Ltd., create modern devices that allow determination with a high degree of credibility of the solid rocks main petrophysical parameters. The analysis of proposed methodologies and methods indicates their applicability in a wide scale, including the conditions of Bulgaria, where they found interesting and promising oil and gas formations.

**Keywords:** solid rocks-collectors, laboratory assessment

## EVALUATION OF THE EFFECTIVENESS OF CORROSION INHIBITORS IN CONDITIONS OF JOINT USE OF INHIBITORS OF SCALING

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**ABSTRACT.** The article presents the results of laboratory studies to assess the effectiveness of corrosion inhibitors in conditions of joint use of a scale inhibitor. Analysis of the results of these studies have shown that the protective properties of corrosion inhibitors, adding scale inhibitors might change for the better or for the worse.

**Keywords:** Inhibitors, evaluation of compatibility, effectiveness, protective effect, polarization impedance, current density.

## GEOTECHNICAL CONDITIONS OF JELEZNICA TUNNEL FROM STRUMA HIGHWAY

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**ABSTRACT.** A review of the geological and tectonic structure, the seismic hydrogeological and engineering geological conditions of the rockmass was carried out as elements of the geotechnical conditions of the Jeleznica tunnel from the Struma Highway. More detailed characteristics are made to the engineering properties of the identified rock types. It is based on qualitative parameters as RQD and GSI and quantitative parameters based on the results from the laboratory and field (geophysical and elastometric) tests. General description of the hydrogeological conditions and the estimated in-flow in the tunnel is presented. General conclusions for the design and construction are presented.

## GEOTECHNICAL CONDITIONS OF THE LANDSLIDE IN PLETENA VILLAGE, SATOVCHA MUNICIPALITY, BULGARIA

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**ABSTRACT.** The landslides are one of the most common geological hazards in the West Rhodopa Mountain. They had affected mostly the mountain steps and slopes and are with ancient origin. In many areas they are currently re-activated and impact the local infrastructure, civil buildings and structures. One of the most recent and active landslide is that in the area of Pletena village. It is formed in the down-slopes of an ancient slope body and has affected the streets, houses and outbuildings. This article presents the results from its geotechnical investigation, analyses its actual condition, mechanism and dynamics of development. The slope stability analyses are used for defining the type of the stabilization structures.