THE GEOPARK POTENTIAL OF THE BURGAS LAKES COMPLEX

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ABSTRACT. Burgas Lake Complex comprising Bourgas, Atanasovsko, Mandra and Pomorie Lakes, is situated on the territory of Burgas and Pomorie municipalities. These ramsar sites are of international importance as habitats of water-living birds. Their interesting geological history, rich biodiversity and balneological importance make them reliable basis for development of a Geopark "Burgas Lakes". Important part of the region's geodiversity are also the old marine terraces outlining the ancient shores of the Black Sea basin: the Nymphean, the Neoeuxinian, the Karangatian, the Early Euxinian and the Chaudinian. They are represented by flattened surfaces or sediments dated on the basis of rich bivalvian fauna. Ramsar sites and dune habitats are subject of intensive research due to the rare and protected inhabiting species. These biotopes are the link between geodiversity and biodiversity within the lake complex and have a high potential for geomorphosites and geo-ecotrails to be developed for geotourism purposes. The area comprises several geosites included in the Register and Cadastre of the Bulgarian geological phenomena like the iridium layer at the Cretaceous-Tertiary boundary near Kozichino village, the pillow-lavas of Bulgarovo (bulgarites), dune sands Alepu, Gradina and Kavatsite as well as several geosites of erosional and abrasional origin like the Dobrovan mushrooms near Sini Rid village, Priest's rock near Fazanovo village, Kolokita Peninsula south of Sozopol, Agalina Cape, and others. An important part of the geological heritage of the area are the residual volcanic craters and calderas, remnants of the Upper Cretaceous volcanic structures and outcrops of Mesozoic and Paleozoic rocks in Strandzha Mountain on the territory of Sredets municipality. The remarkable geodiversity of the area is complemented by the ruins around the ancient towns Anhialo (Pomorie) and Apolonia (Sozopol) testifying to the long history of life on the Black Sea coast. The preview of the geological and cultural arguments for geopark establishment reveals that the Burgas region has a great potential for development of geosites of scientific, aesthetic, ecological and cultural value. The establishment of a Geopark on the Black Sea coast will add this unique sea to the European Geoparks Network's theme and will expand its geography to the lullaby of the ancient European civilization – Pontus Euxinus.

Keywords: Burgas Lakes Geopark, geological and non-geological arguments

ПОТЕНЦИАЛЪТ НА БУРГАСКИЯ ЕЗЕРЕН КОМПЛЕКС КАТО ГЕОПАРК

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РЕЗЮМЕ. Бургаският езерен комплекс, включващ Бургаското, Атанасовското, Мандренското и Поморийското езеро, е разположен на територията на общините Бургас и Поморие. Тези рамсарски места са с международно значение като местообитания на водолюбиви птици. Тяхната интересна геоложка история, богато биоразнообразие и балнеоложко значение ги правят подходяща основа за разработване на геопарк „Бургаски езера". Важна част от георазнообразието в района са и старите морски тераси, очертаващи древните брегови линии на Черноморския басейн: нимфейската, новочерноморската, карангатската, староевксинската и чаудинската. Те са представени от заравнени повърхнини или отложения, датирани с богата бивалвийна фауна. Рамсарските места и дюнните местообитания са обект на интензивни изследвания заради редките и защитени видове, които ги населяват. Тези биотопи са свързващото звено между георазнообразието и биоразнообразието на територията на езерния комплекс и имат висок потенциал за разработване на геоморфосайтове и гео-екопътеки за целите на геотуризма. В площта попадат и някои геотопи, включени в Регистъра и кадастъра на геоложките феномени в България, като иридиевият слой на границата Креда-Терциер при с. Козичино, пилоу лавите при с. Българово (българитите), дюнните пясъци Алепу, Градина и Каваците, както и няколко геотопа с ерозионен и абразионен произход като Доброванските гъби при с. Сини рид, Поповата скала при с. Фазаново, п-в Колокита южно от Созопол, нос Агалина и др. Важна част от георазнообразието на площта са остатъчните кратери и калдери от горнокредните вулкански структури и разкритията на мезозойски и палеозойски скали в Странджа планина на територията на община Средец. Забележителното георазнообразие на територията се допълва от останките на античните градове Анхиало (Поморие) и Аполония (Созопол), свидетелстващи за дългата история на живота по Черноморското крайбрежие. Предварителният преглед на геоложките и културни аргументи за установяване на геопарк показва, че Бургаският регион има голям потенциал за разработване на геотопи с научна, естетическа, екологична и културна стойност. Установяването на геопарк на брега на Черно море ще добави този уникален с геоложката си история морски басейн към тематиката на Европейската мрежа от геопаркове и ще разшири нейната география към люлката на древната европейска цивилизация – Евксински Понт.

Ключови думи: Геопарк „Бургаски езера", геоложки и негеоложки аргументи

Introduction

The Burgas Lakes Complex located in the coastline of the Burgas valley, is a natural extension of the Burgas Bay on land (Fig. 1). It includes the largest Bulgarian lagoon called Pomorie Lake and s.str. Burgas Lakes – Burgas, Atanasovsko and Mandra limans, formed as drowned river valleys in historical time as a result of the subsidence of the Black Sea coast.

The Burgas Lakes Complex is the largest complex of near shore lakes in Bulgaria with an exceptionally rich biodiversity. It is disposed on an area of 95 km^2, 33,3 km^2 of which is declared or proposed for protected territory. Atanasovsko, Pomorie and Burgas Lakes are Ramsar places according to the Ramsar Convention and have an international importance as waterfowl habitats. They are formed after the Würm Ice Age due to the glacier thawing and the sea level rise.

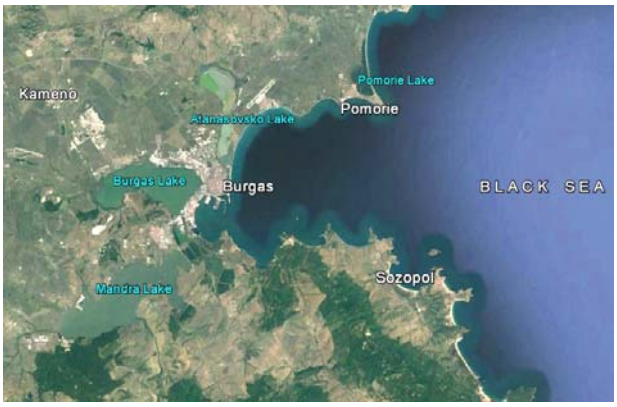

Fig. 1. Satellite image of the Burgas Lakes Complex

Pomorie and Atanasovsko Lakes are unique in the Balkans with the balneo-healing properties of their salty water and anaerobic mud deposits as well as with their endemic plants and animals. On the other side, the various geological structure, remarkable landscapes, rich cultural and historical heritage and well developed coastal tourism are good prerequisites for development of geotourism and other sustainable forms of tourism – ecotourism, rural tourism and mountain tourism that will be a successful complementation to the traditional coastal, spa and balneo-tourism and will provide conditions for all-season engagement of the hotels. Simultaneously geosites and geotrails development inland from the coast will provide a good possibility for the promoting of the geological and cultural-historical heritage of the area through new tourist packets.

Possibility for geopark development

Tourism is a major pillar in the economies of the countries of the Danube Region, part of which is our country. According to the UNESCO Global Geoparks initiative landscapes and geological formations are key witnesses to the evolution of our planet and determinants for our future sustainable development. In the light of the global strategy for better awareness for the Earth's history UNESCO Geoscience and Geoparks Programme encourages the member countries to conserve and enhance the value of areas of geological significance in Earth history and to promote their geological heritage on a global scale. In this aspect development of geosites and their inclusion in the Register and cadastre of the Bulgarian geological phenomena looks ineffective if they are not managed under a holistic concept for protection, education and sustainable development within a modern functioning geopark with the active involvement of the local communities and indigenous people. Burgas region is geologically rather diverse and can provide to the visitors unique geological and geomorphological interpretations. Due to their international prominence and interesting geological history the Burgas Lakes should be in the focus of the future geopark concept. This idea should be discussed in advance with responsible representatives of the local community and disseminated among the local people who can accept or reject it. The preliminary conversations with the mayors of Bourgas and Pomorie municipalities led to a general agreement for geopark development and thematic participation of the two municipalities in the European programmes for funding.

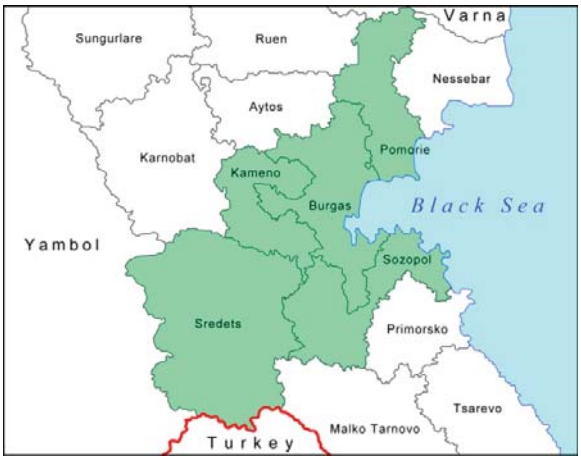

Fig. 2. Burgas District with the composite municipalities of the Burgas Lakes Geopark

However, despite their unique landscapes, Bourgas and Pomorie municipalities do not have the necessary geodiversity to develop a successful geopark. According to the requirements, it must have a sufficiently large territory, which, apart from the sites of the geological heritage of international significance, must also include sites of historical and spiritual value and serve the local economic and cultural development. For this reason the geopark format must include at least two or three adjacent municipalities that can contribute with their geodiversity for the overall geopark concept. From this point of view, the inclusion of the municipalities of Kameno, Sozopol and Sredets will satisfy the requirements for the provision of the necessary geosites of international importance and allow the start of the geopark establishment procedure (Fig. 2).

Geodiversity

In connection with the main theme of the Geopark, the most important geosites must be developed in the context of the coastline proximity and its impact on land. In addition to a clear and accessible concept of the origin of the lakes, the geological and geomorphological interpretations should include data on the development of the ancient sea terraces (paleobeaches) reflecting the high sea levels during the interglacial epochs preserved on the slopes of the Burgas valley. Another important line of geosites should include the localities of the Late Cretaceous volcanic formations - craters, calderas and copper deposits in the Eastern Srednogorie Zone, as well as geological events such as the Cretaceous-Tertiary boundary in the East Balkan Zone, related to the extinction of the dinosaurs and many other Mesozoic animals. Geosites related to the earlier geological history of the area, e. g. Paleozoic, Triassic and Jurassic should be developed in Strandzha Mountain, known for its remarkable geodiversity. The professional identification and description of the geosites associated with the listed geological preconditions combined with the remarkable biodiversity of the protected Ramsar sites and the cultural and historical heritage of the area will be quite enough to develop a modern working geopark with a diverse and attractive themes for the general public.

Historical data for the origin of the lakes

The interpretation of the paleogeographic development during the Late Pliocene and the Quaternary is in direct connection with the modern geomorphological appearance of the region. As early as the beginning of the last century, the first geomorphologists, working on our lands, noted the presence of submerged river valleys along the Bulgarian Black Sea Coast (Cvijić, 1904; Penck, 1925). An interesting interpretation of the origin of the three Bourgas lakes offers Cvijić (1906), according to which they are the result of the dipping of the three sleeves on the so-called "Sub-Balkan River" - the continuation of the modern Tundzha River which at the end of the Pliocene flowed into the Black Sea (Fig. 3). According to this author, the riverbed of the modern Tundzha River has separated from the old riverbed of the Sub-Balkan River (called here Paleo-Tundzha) near the village of Binkos, Sliven district. Now it flows south of it and just before Straldzha Field at the village of Zavoy sharply turns south to Edirne, where it flows into Maritsa River. During the Pliocene Paleo-Tundzha's riverbed was passing through the Sliven field, probably along the 40 km long irrigation channel between Binkos and Gorno Aleksandrovo.

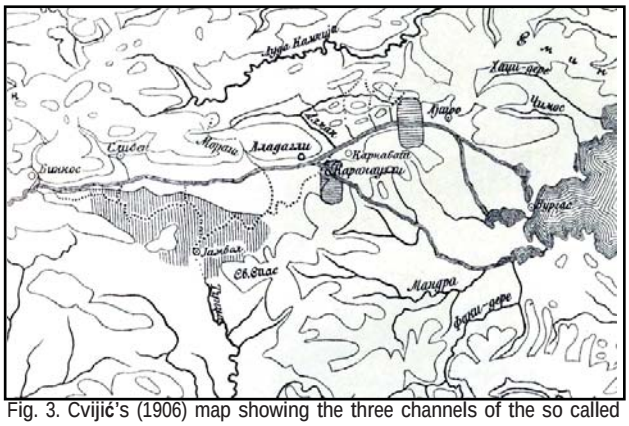

Fig. 3. Cvijić's (1906) map showing the three channels of the so called „Sub-Balkan River" (continuation of Tundzha River to the Black Sea), flowing into the Atanasovsko, Burgas and Mandra Lakes

After another 25 km just before Krumovo gradishte, southwest of the town of Karnobat, the Paleo-Tundzha River was divided into two channels. The right (southern) channel flowed to the southeast where, along the riverbeds of Karaorman, Papazlaka and Rusokastro Rivers, flowed into the Mandra Lake. The left (northern) channel passed through the gorge of the Mochuritsa River through the Hissar Hill, the irrigation channel Azmaka (the old river name of Mochuritsa) between Karnobat and Sigmen, the Topalaka River between Chernograd and Topolitsa villages and the drainage channel south of the town of Aitos along Aitos river. Here it was divided into two more channels, the southern one flowing into the Burgas lake along the Aitos River, and the northern one between the villages of Sadievo and Bulgarovo, through Kandzhikdere and Vetren, flowing into the Atanasovsko Lake.

Burgas Lakes Complex

Pomorie Lake is a super-saline lagoon about 6 km long, with a maximum width up to 1.6 km and an area of about 8.5 km^2. Its depth does not exceed 1.4 m. It is situated NW of Pomorie in the northern part of the Burgas Plain. The mechanism of lagoon formation has been known since the mid-19th century. Lagoons are isolated from the sea basin by sandy bars formed by the waves in the underwater sandy beach as a sandy shaft, which is gradually pushed from the surf to the shoreline as it rises above the water and completely isolates the lagoon from the sea (Fig. 4). The Pomorie lagoon is formed as a double tombolo (Popov, Mishev, 1974) by two sandy bars connecting the island of Pomorie with the land. It was formed in historical times and is associated with the Nymphean transgression that submerged the Black Sea coastline 1000-1500 years ago. The recent researches confirm the tendency for continuing subsidence of the coast. Citing a study of the last century Kanev (1988) concluded that the old road between Anhialo (Pomorie) and Mesemvria (Nessebar) is situated below the Pomorie Lake where a stone pavement was discovered 50 m away from the coastline and 1 m below the lake's surface.

Fig. 4. The sandy bar between the Black Sea and the Pomorie lagoon

Burgas Lake is the largest natural lake in Bulgaria with a length of 9.6 km, a width of 5 km and an area of about 28 km^2, with a depth up to 1.3 m. It represents a liman, separated from the Black Sea by the sandy bar "Kumluka" and connected to it by a narrow channel.

Fig. 5. The Nymphean terrace east of the Atanasovsko Lake

Atanasovsko Lake is a super-salty liman, situated within Burgas between the districts of Izgrev and Sarafovo. To the east it borders the Black Sea with Atanasovska sandy strip, which is about 1 km long sandy bar. Its total area is about 7.2 km^2 with a length of 9 km and a width of 4.3 km with a maximum depth of 0.9 m. It is divided into two halves from the Burgas-Pomorie road. Around the lake the Nymphean marine terrace is well exposed (Fig. 5). The northern half has the status of a protected reserve, and the southern is a protected area. The whole lake falls into the European Network Natura 2000.

Pleistocene-Holocene marine terraces

The marine terraces and their accumulation cover outline the ancient shores of the Black Sea basin. High sea levels during the interglacial epochs are fixed along the coast from ancient

marine terraces. Petrbok (1952) first in Bulgaria proved stratigraphically and paleontologically Pleistocene marine terrace with a length of 1 km and a width of 20 m at Tuzlata near Balchik, which is considered to be probably Karangatian. In the sixties and seventies they were characterized in the works of Fedorov et al. (1962), Lilienberg et al. . (1965), Lilienberg (1966), Boshev et al. (1967), Hristov (1967), Mishev et al. (1969) and summarized later in the monograph of Popov, Mishev (1974). For these terraces were adopted the established Russian names of the Black Sea stratigraphic divisions, which are well correlated with the corresponding terraces of the Crimean and Caucasian coast: Lower Pleistocene – Early Chaudinian at 110-120 m and Late Chaudinian at 85-100 m; Middle Pleistocene – Early Euxinian at 50-60 m and Euxinian-Uzunlarian at 35-40 m; Upper Pleistocene – Early Karangatian at 20-25 m and Lale Karangatian at 8-15 m and Holocene - Neoeuxinian at 4-5 m and Nymphean at 1,5-2 m (Fig. 3). In many places along the Black Sea coast the terraces are paleontologically dated with mollusc (mainly bivalvian) fauna. The scientific development of ancient erosional and accumulation terraces should be made on accessible and representative outcrops appropriate for meditation places, where not only the outcome of the geological activity of the sea but also the paleontological evidence of their age with the characteristic species can be demonstrated.

Erosional and abrasional landforms

Attractive geosites can also be developed in places where current processes of sand-beach formation occur. Most suitable for this purpose are the dunes, which have been developed in many places along the southern Black Sea coast but a small part of them are preserved in a form suitable for demonstration. Geosites with sand dunes "Alepu", "Gradina" and "Kavatsite", included in the Register and Cadastre of the geological phenomena in Bulgaria, fall within the project area of the Geopark. It also includes other erosional and abrasional landforms such as the "Dobrovian mushrooms" near the village of Sini Rid, Priest's Rock at the village of Fazanovo, the Kolokita peninsula south of Sozopol, Cape Agalina and others.

Geosites of scientific and educational value

Two geosites of extraordinary scientific value of the area are described and included in the Register and Cadastre of the Bulgarian geological phenomena. The Iridium layer at the Cretaceous-Terciery boundary, formed as a result of the global catastrophe caused by the asteroide impact 65 million-years ago, known as "the asteroide that killed the dinosaurs" is fixed in a turbidite sequence near Kozichino village. The pillow-lavas near Bulgarovo village is the type locality of the rock "bulgarite" defined as a separate rock type by Stanisheva-Vassileva, Yanev and Harkovska (in Dabovski et al., 1991) (Fig. 6).

Geosites of research and educational value can be selected among the numerous outcrops of the rocks of the Upper Cretaceous Srednogorie Volcanic Complex, such as the preserved crater of the Zidarovo Volcano, which is petrographically well-studied, morphologically well expressed and extremely suitable for demonstration (Fig. 7). On the other hand, the rock formations in Strandzha are crucial for meeting the criteria of the International Union of Geological Sciences in terms of the geodiversity of the proposed territory. Mesozoic rocks with Triassic, Jurassic and Cretaceous age, as well as Paleozoic and Precambrian rocks crop out in Strandzha Mountain on the territory of Sredets Municipality.

Fig. 6. The type locality of Upper Cretaceous pillow lavas defined as a separate rock type "bulgarite" near Bulgarovo village

The oldest rocks in the area are the high-grade metamorphic rocks of the so called "Undivided Precambrian". According to Kozhoukharov and Kozhoukharova (1978) they are formed as a result of progressive metamorphism manifested in amphibolite facies in places revealed as ultrametamorphism. The Paleozoic is represented by metasedimentary and igneous rocks. The oldest Paleozoic rocks are associated with the formation of the phyllitoid argillites, metasandstones and marbleized limestones which are considered as Early Paleozoic. The overlying formation of the marbleized limestones and marbles, which follows with a gradual transition, is also of Early Paleozoic age. These formations are composed of grauwacke-like and arkose-like metasandstones in several places with conglomerate appearance, thin-bedded marbleized limestones and marbles. They are exposed north of Fakia village and between Slivovo and Golyamo Bukovo villages. These rocks are intersected by Late Paleozoic granites and their contacts with the other rock formations in the area are tectonized. Very interesting outcrops of Paleozoic metagabbroids are described in the surroundings of Zhelyazkovo village. These are metamorphosed ultrabasic and basic rocks first described by Yanishevski (1946) as "old gabbro". The ultrabasic rocks are determined as antigorite-tremolite-talk schists and the basic rocks form a large body of gabbro-amphibolites (Kamenov, 1976). The Upper Paleozoic (Hercynian) granitoids of the so called "Central Strandzha Batholith" (Yanishevski, 1946) form a large body between Fakia and Zvezdets villages. The granite body intersects and alters the older Precambrian and Paleozoic rocks and possess xenoliths of them. In turn the granite is intersected by subvolcanic quartz-porphyry and felsite bodies. The Permian is represented by metabreccia-conglomerates, metasandstones and quartz schists of the Sveti Iliya Formation (Chatalov, 1985c) and acid metavolcanics.

Triassic is represented by Sub-Balkan and Strandzha facial types. The former is composed of several formations characreristic for the platform carbonate environment. The underlying unit – the Pitovo Formation of the Tundzha Group, is composed of white arkose sandstones. The rest of the units belonging to the Iskar Carbonate Group, are composed of carbonates – limestones and dolomites with shales and sandstones. The Strandzha facial type united in Veleka Group presents greater diversity of rocks, belonging to several

formations within Bosna and Grahilovo Sub Groups (Chatalov, 19856, 1990).

Jurassic is represented by several formations of the East Thracian Group (Chatalov, 1985a, 1995). The underlying sediments of the Kubarelov Formation (Hettangian-Sinemurian) are represented of quartzitized sandstones and quartzites cropping out as a long strip between Golyamo Bukovo and Zvezdets villages. The younger Kraynovo Formation (Pliensbachian) is composed of different types of marbles and recrystallized limestones cropping out south of Zvezdets village. The Varovnik Formation (Pliensbachian-Bajocian) represents an alternation of biodetritic limestones and fine-grained ferritized sandstones. It crops out only between the villages of Varovnik and Golyamo Bukovo. The Bliznak Formation (Sinemurian-Toarsian) is composed of quartz sandstones. It crops out as a long strip between the villages of Zvezdets and Bliznak. The Zvezdets Formation (Bajocian) cropping out between Zvezdets and Golyamo Bukovo villages is represented by black shales quartzitized sandstones and rare limestone beds.

Fig. 7. The caldera of the Zidarovo volcano with bottom covered by deposits of the Nymphean marine terrace

Cretaceous is represented by widely exposed various sedimentary, volcanic-sedimentary and volcanic rocks grouped into four lithostratigraphic units: Varshilo, Grudovo, Michurin and Burgass Groups (Coniacian-Lower Campanian) as well as intrusive bodies intruded into the older rocks. They are in the core of East Srednogorie structural zone. Fossil volcanic structures like calderas, necks, lava flows, sills, dikes, and volcanic rocks of various composition can be demonstrated in many places in the area, including the Black Sea coast (Fig. 6).

Cenozoic sediments are also well represented in the area. The Burgas Lakes are surrounded by outcrops of Paleogene terrigenous sediments. Well studied deposits of Crimean-Caucasian type Miocene (Tarkhanian-Konkian) are widely exposed on the Black Sea coast with abundant mollusc fauna.

Geosites of cultural-historical value

Geosites of cultural-historical value are related to the many-thousand-year history of the ancient towns Anhialo (Pomorie) and Apolonia (Sozopol). The ancient Thracian tomb in Pomorie, which is the largest antic tomb in Bulgaria built in 1st - 2nd century AD, has recently been open to public access (Fig. 8). The old fortress city wall of Anhialo called by the local people “Rehata”, situated below the present sea level, is an attractive ancient testimony for the subsidence rate from antiquity to recent days. This is an excellent example about the relation between human history and geology that can be demonstrated to the visitors. Another cultural landmark of Pomorie is the Museum of salt which is the only museum in Bulgaria and Eastern Europe specialized in the production of salt through the natural evaporation of sea water by the sun’s heat. It is an original complex of water basins, channels, and other attributes of the ancient Anhialo’s technology for the extraction of sea salt, representing an intangible heritage for the area (Fig. 9).

Fig. 8. The ancient Thracian tomb in Pomorie built in 1st -2nd century AD

Fig. 9. The Museum of salt in Pomorie is a complex of water basins, channels, and other attributes of the ancient Anhialo’s technology for the extraction of sea salt

Apolonia is the most ancient town in Bulgaria founded in 610 BC. The surrounding shallows keep the secrets of the thriving civilization on the western Black Sea coast submerged under sea level. Ancient Greek vases from VII-II century BC, Roman amphorae, coins, ceramic and glassware from I-VI century AD and many artifacts of the many-thousand-year history of the town are saved in the municipal Archaeological museum.

Conclusions

The preliminary analysis of the potentially valuable geosites in the area of the Burgas Lakes Complex reveals a remarkable geodiversity which is a reliable basis for geopark establishment. Obviously, in the focus of the geopark concept will be the development of geomorphosites related to the origin of the lakes and their Quaternary history. Further topics should be related to Black Sea level fluctuations and their relationship to the Quaternary glacial and interglacial epochs, resulting in the formation of marine terraces correlated with the “standard” Black Sea terraces. Another type of Quaternary geological phenomena are the dunes along the sandy beach. Geological phenomena s. str. related to the geological history of the area will be developed on the basis of the rock variety and geological events in the area. The Upper Cretaceous volcanic complex offers various volcanic structures and rocks in perfect condition for demonstration of the volcanic processes. Among the pillow lavas of this complex is situated the type locality of the rock type “bulgarite”. An important outcrop related to one of the most dramatic events in geological history of the planet is the Cretaceous-Tertiary boundary layer preserved in the East

Balkan. With the remarkable geodiversity of Strandzha Mountain, including rocks of different types and ages from Precambrian to Cenozoic, the future geopark has a chance to meet all the requirements of the European Geoparks Network.

References

Бошев, С., Б. Страшимиров, С. Зафиров, Р. Христов, М. Моев. Геология на приморската част на Източна Стара планина. – *Год. ВМГИ, 12,* Св. 2, 1967. – 7-62. (Boshev, S., B. Strashimirov, S. Zafirov, R. Hristov, M. Moev. Geologiya na primorskata chast na Iztochna Stara Planina. – God. VMGI, 12, Sv. 2, 1967. – 7-62.

Каменов, Б. Петрология на Желязковския плутон. – Год. Соф. Унив., Геол.-геогр. фак., 67, 1 – геол., 1976. - 179-212. (Kamenov, B. Petrologiya na Jelyazkovskiya pluton. – God. Sof. Univ., Geol.-geogr. fac., 67, 1 – geol., 1976. – 179-212.

Канев, Д. Към тайните на релефа в България. С., Народна просвета, 1988. - 150 с. (Kanev, D. Kam taynite na relefa v Bulgaria. S., Narodna prosveta, 1988. – 150 s.)

Лилиенберг, Д. А. Опит за морфоложко райониране на Българското Черноморско крайбрежие. – Изв. Бълг. геогр. д-во, 6, 1966. – 23-45. (Lilienberg, D. A. Opit za morfolozhko rayonirane na Bulgarskoto Chernomorsko krajbrezhie. – Izv. Bulg. geogr. d-vo, 6, 1966. – 23-45.)

Лилиенберг, Д. А., В. Попов, К. Мишев. Морфология на терасите по Странджанското Черноморско крайбрежие между Созополския залив и устието на река Велека. – Изв. Геогр. инст. на БАН, 9, 1965. -25-43. (Lilienberg, D. A., V. Popov, K. Mishev. Morfologiya na terasite po Strandzhanskoto Chernomorsko krajbrezhie mezhdu Sozopolskiya zaliv i ustieto na reka Veleka. – Izv. Geogr. Inst. Na BAN, 9, 1965. -25-43.)

Мишев, К., В. Попов, Д. Лилиенберг. Досегашни резултати от геоморфоложките изследвания на Българското Черноморско крайбрежие. - Изв. Бълг. геогр. д-во, 9, 1969. – 37-55. (Mishev, K., V. Popov, D. A. Lilienberg. Dosegashni rezultati ot geomorfolozhkite izsledvaniya na Bulgarskoto Chernomorsko krajbrezhie. – Izv. Bulg. geogr. d-vo, 9, 1969. – 37-55.)

Попов, В., К. Мишев. Геоморфология на Българското Черноморско крайбрежие и шелф. С., Изд. БАН, 1974. – 267 с. (Popov, V., K. Mishev. Geomorfologiya na Bulgarskoto Chernomorsko krajbrezhie i shelf. S., Izd. BAN, 1974. – 267 s.)

Федоров, П. В., Д. А. Лилиенберг, В. И. Попов. Новые данные о террасах черноморского побережья Болгарии. – Докл. Акад. Наук СССР, 144, 2, 1962. – 431-434. (Fedorov, P. V., D. A. Lilienberg, V. I. Popov. Novie dannie o terrasah chernomorskogo poberezhiya Bulgarii. – Dokl. Akad. Nauk SSSR, 144, 2, 1962. - 431-434.)

Христов, Р. Морски тераси по крайбрежието на Черно море в района Бургас-Несебър. – Год. ВМГИ, 12, Св. 2, 1967. – 75-88. (Hristov, R. Morski terasi po krajbrezhieto na Cherno more v rayona Burgas-Nesebar. – God. VMGI, 12, Sv. 2, 1967. – 75-88.

Цвијић, Ј. Основе за географију и геологију Македоније и Старе Србије с проматрањима у Јужној Бугарској, Тракији, суседним деловима Мале Азије,Тесалији, Епиру и Северној Арбанији. – Београд, Српска Краљевска Академија, Књига друга, 1906. - 548-630. (Cvijich, J. Osnove za geogrfiyu i geologiyu Makedonije i Stare Srbije s promatranjima u Yuzhnoj Bugarskoj, Trakii, Epiru I Severnoj Arbaniji. – Reograd, Srpska Kraljevska Akademia, knjiga Druga, 1906. - 548-630.)

Чаталов, Г. Стратиграфия юрской системы в Странджанской области в Болгарии. - Geologica Balc., 15, 4, 1985а. - 3-39. (Chatalov, G. Stratigrafiya jurskoy sistemi v Strandzhanskoj oblasti v Bulgarii. - Geologica Balc., 15, 4, 1985a. - 3-39.)

Чаталов, Г. Стратиграфия триасовых отложении Странджанского типа (Странджанские горы, Юго-Восточная Болгария). - Geologica Balc., 15, 6, 1985б. - 3-38. (Chatalov, G. Stratigrafiya triasovih otlozhenii Strandzhanskogo tipa (Strandzhanskie gori, Yugozapadnoj Bolgarii. - Geologica Balc., 15, 6, 1985b. - 3-38.)

Чаталов, Г. Принос към стратиграфията и литологията на палеозойските и триаски скали в Светиилийските височини. – Сп. Бълг. геол. д-во, 46, 1, 1985в. - 53-70. (Chatalov, G. Prinos kam stratigrafiyata i litologiyata na paleozojskite i triaski skali v Svetiilijskite visochini. – Sp. Bulg. geol. d-vo, 46, 1, 1985v. - 53-70.)

Чаталов, Г. Геология на Странджанската зона в България. Изд. БАН, 1990. – 263 с. (Chatalov, G. Geologiya na Strandzhanskata zona v Bulgaria. Izd. BAN, 1990. – 263 s.)

Чаталов, Г. Триас. Юра. - В: Дабовски (Ред.) Обяснителна записка към Геоложка карта на България М 1:100 000. Картни листове Желязково и Кърклареli. С., КГМР, „Геология и геофизика" - АД, 1995. -15-30. (Chatalov, G. Trias. Jura. V: Dabovski, H. (Red.) Obyasnitelna zapiska kam Geolozhka karta na Bulgaria M 1:100 000. Kartni listove Zhelyazkovo i Karklareli. S., KGMR, "Geologiy ai geofizika" AD, 1995. – 15-30.

Янишевски, А. Кратко изложение върху геологията на Странджа. В: Основи на геологията на България. – Год. Дир. геол. и минни проучв., А, 4, 1946. – 380-388. (Yanishevski, A. Kratko izlozhenie varhu geologiyata na Strandzha. V: Osnovi na geologiyata na Bulgaria. – God. Dir. geol. i minni prouchv., A, 4, 1946. - 380-388.)

Cvijić, J. Die Tektonik der Balkanhalbinsel mit besonderer Berücksichtigung der neueren Fortschritte in der Kenntnis der Geologie von Bulgarien, Serbien und Makedonien. – Compt. Rend. IX Session Congr. Geol. Intern., Vienne 1903, Premier Fasc., Sixième Partie, 1904. -347-370.

Dabovski, Ch., D. Harkovska, B. Kamenov, B. Mavrudchiev, G. Stanisheva-Vassileva, Y. Yanev. 1991. A geodynamic model of the Alpine magmatism in Bulgaria. – Geologica Balc., 21; 3-15.

Kozhoukharov, D., E. Kozhoukharova. Precambrian metamorphic rocks in the Sakar-Strandža Zone. – In: The Precambrian in Bulgaria. - Precambrian in younger fold belts, Materials to the IGCP Project 22, Geogr. Inst. ČAS, Brno. 1978. - 41-47.

Penck, A. Geologische und Geomorphologische Probleme in Bulgarien. – *Der Geologe, 38,* 1925. – 849-873.

Petrbok, J. Měkkýši plistocenní a holocenní marinní terasy Černého moře u Balčíku v Bulharsku a marinní měkkýši bulharského plistocenu. – Acta Musei Nationalis Pragae, series B 8B(2), 1952. –1-21.

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