PALEONTOLOGICAL HERITAGE IN DOBROGEA: PROTECTION, GEOCONSERVATION, EDUCATION AND PROMOTION

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Abstract: Natural diversity, in its inner structure, has two major components: biological diversity (biodiversity) and geological diversity (geodiversity). However, while the former has already gained a clear status, being used and accepted worldwide, we cannot say the same about the latter, the geodiversity. This paper tries to highlight the defining elements, values, vulnerabilities and threats to geodiversity applied to five geological reserves from Dobrogea, by referring to the legislation, using existing scientific and public information and discussing the utility of such an initiative, aiming to contribute to the protection and conservation of the geological heritage in Romania.

Key words: natural protected areas, Fossil Site, site of community interest – SCI, special protection area – SPA, geodiversity, geoheritage

1. INTRODUCTION

Nature conservation, as activity supported by authorities of a State, debuted in the United States in the third decade of the XIXth century, when George Catlin, an artist and naturalist of that times, expressing his concern about the future of American bison, had proposed the establishment of a protected area in the Great Plains, where American Indians could live peacefully in harmony with the wild nature (Gray, 2004). Although the idea was greeted with enthusiasm, it was put into practice 20 years later. In his book "Man and Nature", Perkins (1864) provided the first description of the impact of human activities upon nature. The Scottish immigrant John Muir was one of the most fervent supporters of the idea of conservation and, as a result of his intervention, the first nature reserve – Yosemite Valley, California – was founded in 1864 (Gray, 2004); this was followed, in 1872, by the establishment of the first national park, Yellowstone.

The first naturalist who used and imposed the notion of nature conservation was the 26th U.S. President, Theodore Roosevelt (Dasmann, 1984). In 1883, Roosevelt moved from New York to North Dakota with the intention of becoming a farmer. The timing coincided with the extinction of large herds of buffalo, killed by intensive hunting and disease. This led Roosevelt to become, in time, a convinced environmentalist and to establish, during his presidency, the U.S. Forest Service, stating also, by law, the establishment of 18 nature monuments and obtaining approval from the North American Congress to establish 5 national parks and 55 reserves.

In Europe, the UK is the one that started the conservation and protection of nature in the nineteenth century, through the romantic poets gathered under the beauty of the Lake District landscape. One of them, William Wordsworth, was publicly expressing his concern about the impact that would have what he called "the masses" that could ruin the natural beauty of the Lake District region. The fear he shared with other artists and writers was concluded in 1883, by establishing the Lake District Defense Society, which was later included in the National Trust (The Conserving Geodiversity: The Protected Area and Legislative Approaches National Trust for Places and Historical Interest and Natural Beauty). In the fourth decade of the XX-th century, the National Park and Access to the Countryside Act was published in UK. However, the first national park in Scotland was established only in 2002, while in 2003 there was none yet in Northern Ireland (Gray, 2004).

In Romania, in the early twentieth century, among the pioneers of nature protection was Nicolae Grigorescu, the painter, along with Alfred Nicolaus Bernath-Lendway, Romanian pharmacist and doctor in chemistry of Austrian origin, Calistrat Hogas, writer and naturalist, Demetrius Grecescu and Ion P. Licherdopol, botanists and ornithologists. In 1907, Petre Antonescu, a forest engineer, the Romanian representative at the International Congress of Agriculture in Vienna, established the first laws on nature protection (http://www.rosilva.ro/articole/istoric_arii_naturale_protejate__p_185.htm). In the same year, the centennial forests of Slătioara and Putna were proposed as first nature reserves. The implementation of these proposals took place only in 1925, when the Slătioara forest was declared nature reserve, with an area of 671.11 ha (http://www.inffo.ro/Enciclopedie/ Rezervatii_naturale_din_ Romania_protejate.html). The first national park in Romania, the Retezat National Park, was established in 1935, at the initiative of two personalities: Alexandru Borza, the professor who founded the Botanic Garden in Cluj-Napoca and Emil Racoviță, the famous biologist, explorer, and father of the speleology in Romania (http://www.infoghidromania.com/parcul-national-retezat.html). The park was recognized as a Biosphere Reserve in 1979 (http://retezat.ro/index.php/romana/despre-parc/istoric.html).

In 2000, the Law 5 on National Spatial Plan established about 800 Natural Reserves (including Natural Monuments), 16 National Parks and 1 Biosphere Reserve (Danube Delta).

This paper highlights the defining elements of geodiversity, its values and vulnerabilities, applied to five geological reserves from Dobrogea, citing the current legislation and using the existing scientific and public information and following the usefulness of such an initiative for protection and conservation of the Romanian geological heritage.

2. CONCEPT OF GEODIVERSITY

Introduced at the end of the XXth century from the necessity to create a management tool for the abiotic natural elements, or the so-called "forgotten diversity" (Sharples, 2002), the concept of geodiversity is still in the phase of understanding and adopting worldwide. According to the cited author, it is difficult to specify the location in which the term has appeared, but one thing is certain, in Tasmania, in the 8-th decade of the last century, the geomorphologist Kevin Kiernan was talking about "geomorphic diversity", referring to what later was to be called "geodiversity".

In 1993, still in Australia, Sharples used the term "geodiversity" to define "the diversity of systems and features of the Earth", while in 2002, the Australian Heritage Commission was using the following definition for geodiversity: "the diversity of processes, systems, assemblies and features, both geological (rocks), as well as geomorphological (landforms) and pedological (soils)".

Currently, the term geodiversity is well known in Tasmania. Moreover, Sharples (2002) stated that it is absolutely necessary to distinguish between "geodiversity", "geoconservation" and "geoheritage", defining them as follows:

"Geodiversity" – the natural quality that we want to protect;

"Geoconservation" – our endeavor to try to protect "geodiversity";

"Geoheritage" – includes concrete examples of the significance of our efforts to preserve geodiversity.

Although up to now a lot has been written about geodiversity, we still cannot say that there is a very clear definition of the term, given the fact that geology is an evolving science. Using the Australian model, Gray (2001) redefines geodiversity as follows: "... the geological diversity of natural elements (rocks, fossils, minerals), geomorphological (landforms), soils, including also their properties and relationships between them."

What is new about this concept? Taking over and adapting models applied in biodiversity, geodiversity concept comes to assign value to geological features, in fact a whole set of values.

Thus, geological diversity certainly has an *intrinsic value*. Of all values of geodiversity, this is the one that arises the most ethical and philosophical controversies. By definition, intrinsic value refers to value something (in this case geological diversity) for its mere existence, without any connection with its possible uses or benefits obtained from it.

The geodiversity concept is completed with the *scientific value*, which represents, for geologists, one of the most important features. Nature is the best-equipped laboratory (Bennett and Doyle, 1997). For this reason, protection and conservation of geological heritage is necessary in order to ensure that future students or scientists can further investigate nature... within nature. The *cultural value* is the value attributed by society to physical elements, in terms of their significance to the community. Artistic events of any nature, inspired by the topic of geological diversity, are an integral part of that value. The *aesthetic value*, although depends rather on the mood it creates, is extremely important for the impact that the environment, with all its elements, has upon the viewer. The *economic and functional value* is the theoretical value attributed by economists to geodiversity elements, depending on its role in supporting life. In reality, the economic value of these elements depends heavily on their rarity, usability and degree of regeneration. An important economic resource is geological tourism (geotourism). *Geotourism* essentially means geological tourism, rather than geographical tourism or a part of natural area tourism and ecotourism; it is a specialized form of tourism, as it is focused on geosites (Newsome and Dowling, 2006). The alternative definition of geotourism belongs to National Geographic Society: „Tourism that sustains or enhances the geographical character of a place – its environment, heritage, aesthetics, culture, and the well-being of its residents" (www.nationalgeographic.com/

travel/sustainable). These two definitions have in common the concept that geotourism involves the community that, based on the knowledge, valuation and promotion of the local geological (or natural and cultural) elements, can develop flourishing small family business, very important in boosting the local economy.

Besides its values, the concept of geodiversity involves also vulnerabilities and threats addressed to its elements. Although almost unconscious, threats to geodiversity are numerous, the most serious consequences resulting from human impact. Unfortunately, the geodiversity values outlined above are also the main cause of its threats, due to their poor management at the community level, to the reckless consumption of non-renewable natural resources, or by the destruction of landforms for various human needs related to infrastructure and agriculture. The main types of threats to geodiversity are: extraction of mineral resources, urban development, coastal erosion, river management, deforestation, intensive agriculture, tourism activities, removal of geological specimens, climate and sea level changes, forest fires, military activity, lack of education (Gray, 2004).

3. GEODIVERSITY ELEMENTS OF THE GEOLOGICAL SITES OR RESERVES INCLUDED IN THE PROTECTED AREAS OF AGIGHIOL HILLS, DOBROGEA GORGES, CANARALELE DUNĂRII AND VEDEROASA LAKE

Presented in detail for the first time in the literature by Bleahu *et al.* (1976), such types of reserves currently raise a particular interest due to the set of values (scientific, aesthetic, cultural or economic, etc.) represented by the natural geological elements.

Part of the natural heritage of Romania, most geological reserves and monuments from Dobrogea (currently 13 according to Law 5/2000 and to Government Decision 2151/2004) are included within larger protected areas of national interest, part of the Natura 2000 network in Romania (according to the Order of the Ministry of Environment and Sustainable Development nr. 1964 /2007 regarding the establishment of the natural protected area of sites of community interest as integral part of the Natura 2000 European ecological network in Romania).

This paper addresses five of these reserves in terms of the concepts of geodiversity, geoheritage and geoconservation, concepts almost nonexistent today in the Romanian legal framework dedicated to natural protected areas. The location of the geological reserves presented in this paper is shown in Fig. 1.

3.1. Agighiol Fossil Site

Described in the classical monographs of the Viennese geologist and paleontologist Kittl (1908) and of the Romanian paleontologist Simionescu (1913 a), the Fossil Site from Dealul Pietros at Agighiol, discovered in 1895 by Gregoriu Ştefănescu, proves to be an exceptional value for the European and international Alpine Triassic (Bleahu *et al.*, 1976), due to its rich fauna of ammonoids, bivalves brachiopods and gastropods.

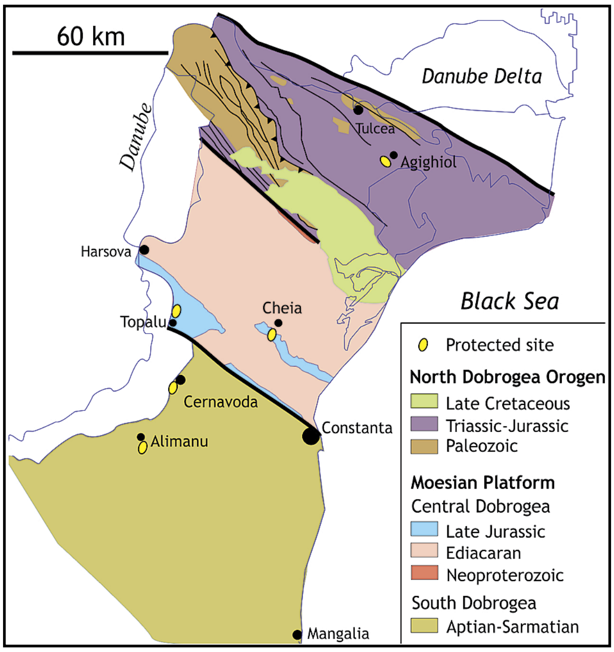

Figure 1. Location map of the fossil sites from Dobrogea presented in this paper, on the simplified geological map of Dobrogea (modified after Seghedi, 1999).

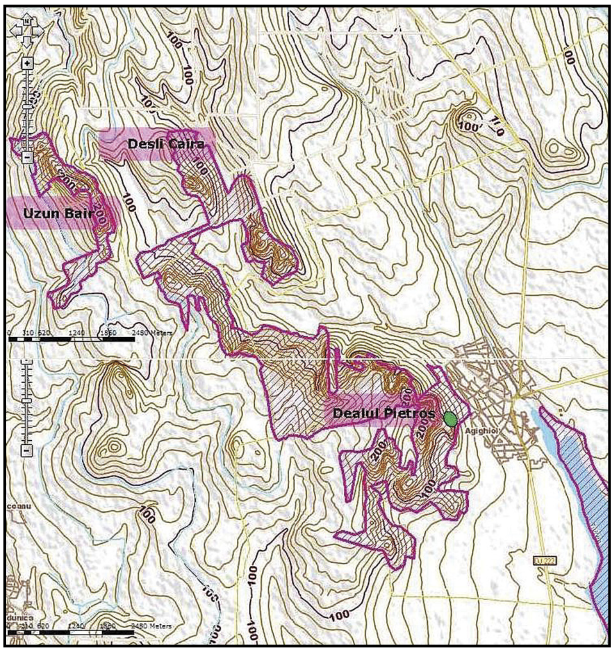

Figure 2. Location of Agighiol Fossil site on the Agighiol Hills SCI map (modified from the website www.dealurileagighiolului.ro).

3.1.1. General geographic and geologic data

The Agighiol Fossil Site became the object of protection according to the Ministerial Order 43/1990 and law 5/2000 and was included in the Natura 2000 network of protected areas according to the Ministerial Order 1964/2007. In 2007, the Agighiol Fossil site was included in the Agighiol Hills Site of Community Interest (SCI) – RO SCI 0060 (Fig. 2). Since February 2010, the site is in custody of Association *GeoD* for Promoting Geodiversity (www.ageod.org).

Geographically, the Agighiol Hills SCI is located north of Lake Razelm (Tulcea County), west and north of the village of Agighiol (N 45° 02′ 39″, E 28° 48′ 41″), in the steppe biogeographic region. The surface of the site, according to the Nature 2000 Standard Forms, published in the Official Monitor no.98bis /2008, is 1479 ha, the maximum altitude being of 218 m. In this area, the Fossil site occupies 9.7 ha.

From geological point of view, the Agighiol Hills belong to the Tulcea Unit of the Cimmerian Orogen of North Dobrogea (Săndulescu, 1984). The Triassic deposits overlie a Hercynian basement, exposed largely in the western part of the site. In Kazalgic Bair, east of Rândunica village, the basement consists of Paleozoic granitoids, known from outcrops and boreholes (Mirăuță, 1966; Ştefan and Popovici, 1970; Patrulius *et al.*, 1973; Seghedi, in Baltres *et al*., 1990), while in the Uzun Bair Hill micaschists are cropping out (Mirăuță, 1966; Patrulius *et al*., 1973). In Dealul Pietros only Triassic limestones are exposed, in a succession from Scythian to Lower Carnian (Patrulius *et al*., 1974).

3.1.2. Quality and importance

According to the Natura 2000 Standard Form, the biodiversity of the Agighiol Hills SCI includes endemic plants for the territory of Dobrogea of a remarkable value. Such an endemic association is *Agropyron brandzae - Thymus zygoides*, with large populations of the taxon *Euphorbia myrsinites*, found on the national Red List (Oltean *et al*., 1994). This is the main association found in the area of the Fossil site, belonging to the priority habitat of Ponto-Sarmatic steppe. Another priority habitat, the Ponto-Sarmatic deciduous thickets, develops sparsely along the borders of the Fossil site. The species of community interest are represented by reptiles like the turtle – *Testudo graeca* and mammals such as the hamster of Dobrogea (*Mesocricetus newtoni*) and the ground squirrel (*Spermophilus citellus*).

The information on Agighiol Fossil site is included in the SCI datasheet, Section 4.4 „Site Designation", where it is stated: „The site includes a natural reserve enacted nationwide (Law 5/2000), respectively Agighiol Fossil site"; in section 5 of the SCI dataset, the Agighiol fossil site is listed as IUCN Category III, Natural Monument (http://natura2000.mmediu.ro/site/49/rosci0060.html).

3.1.3. Geodiversity values of the Agighiol Fossil Site

Intrinsic value. From this point of view, the mere discovery of the rich Fossil Site in Dealul Pietros at Agighiol, with its very rich and diverse paleontological content, represents the reason for its protection. The Triassic deposits from Agighiol are classic for the development of the Triassic System in North Dobrogea.

The lithological succession of Dealul Pietros is dominated by limestones, separated as the Agighiol Formation (Grădinaru, 1997) (Fig. 3). The succession starts with light coloured dolomites, grading upwards to massive-bedded Hallstatt-type limestones. The Hallstatt-type facies extends uninterruptedly on the whole time interval from Late Spathian to Early Carnian. Microfacies studies indicate various types of nodular biomicrites, microbial-sponge biomicrites, either burrowed, or with Stromatactis or geopetal shaped vugs, interbedded with biomicrite wackestones or coquina tempestites containing brachiopds, crinoids, microbivalves, etc. The limestone microfacies shows a progressive transition from wackestones (in the Upper Spathian - Lower Ladinian interval) to packstones in the Upper Ladinian - Middle Carnian sequence. Spectacular laminations, indurated surfaces, neptunian dykes (filled with sediments or epigenetic calcite), yield evidence of condensed sedimentation (especially in the Anisian). Mottling structures are also commonly seen in the most part of the Hallstatt-type sequence.

The paleobiodiversity of the site is dominated by ammonoid associations, with subordinate pelecypods, brachiopods or crinoids. The ammonoid faunas are not uniformly distributed in the whole Hallstatt type sequence, but are concentrated in some levels in the Lower Middle Anisian sequence and rather uniformly distributed in the Upper Anisian to Middle Carnian sequence. The microfauna is represented by conodonts (for the whole Hallstatt sequence) and foraminifers (for the Upper Ladinian - Middle Carnian interval). The depositional environment of these formations is represented by the deep water area of a pelagic carbonate ramp, evolving from a pelagic microbial bank on deep submerged plateau in the Middle-Upper Anisian to a mixed pelagic-benthic microbial-sponges bank on a submerged plateau above fairweather wave base (or distal coquina tempestite) from the Uppermost Anisian to Lower Carnian (Grădinaru, 1997).

Simionescu (1911, 1913 a) described 89 species of ammonoids from Hagighiol (Agighiol), from a total of 680 of specimens collected. The most numerous are presented in Table 1.

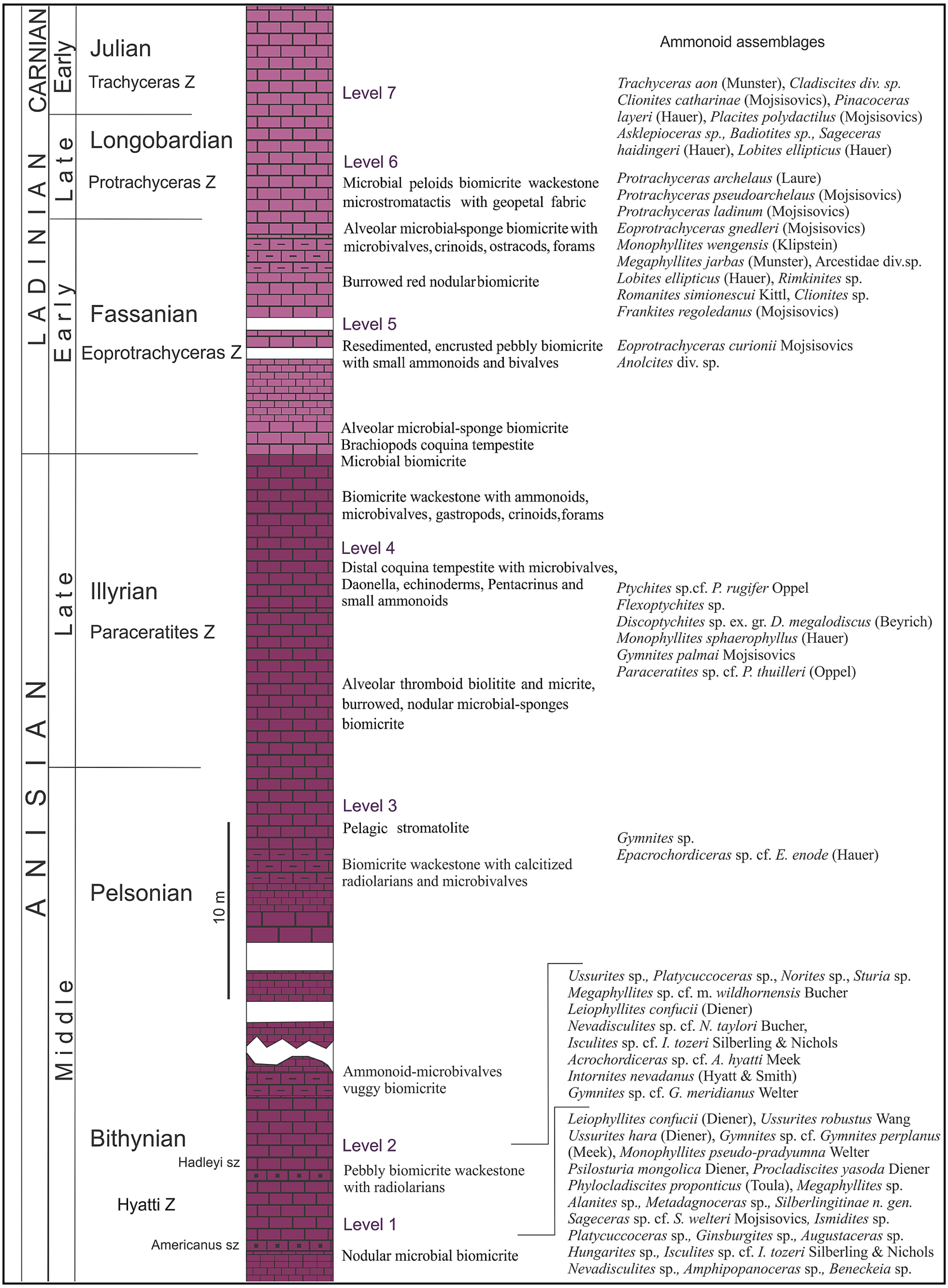

Figure 3. Litological column in Dealul Pietros, showing the age, microfacies and ammonoid zones of the Agighiol Formation limestones (after Grădinaru, 1997).

Table 1. The most abundant ammonoid species reported by Simionescu (1913 a) at Agighiol

Nr.	Ammonoid species	Number of specimens
1	*Romanites simionescui* Kittl.	> 100
2	*Monophyllites aonis* Mojs.	60
3	*Sageceras heidingeri* Hauer	33
4	*Megaphyllites jarbas* Münst.	27
5	*Pinacoceras (Pompeckyites) layeri* Hauer	24
6	*Ioannites stefanescui* Kittl	20
7	*Atractites boeckhi* Strb.	14
8	*Arcestes (Proarcestes) ausseeanus* Münst.	14
9	*Protrachyceras furcatum* Münst.	13
10	*Cladiscites primitivus* Kittl	12
11	*Orthoceras dubium* var increscens	12
12	*Orthoceras campanille* Mojs.	10
13	*Sturia sansovinii* Mojs.	10

Seven fossil levels are identified in Dealul Pietros (Grădinaru, 1997) (Fig. 3), within the syncline forming the eastern and western flanks of Dealul Pietros and covering the biochronological interval from the Middle Anisian to Lower Carnian.

The first fossil level contains ammonoids correlative to the *Ismidicus* Subzone of the *Kocaelia* Zone in the Early Middle Anisian (Bithynian) (in the Middle Triassic ammonoid standard scale of the Mediterranean Triassic) or to *Americanus* subzone of the *Hyatti* Zone (from the Middle Anisian of the Western Nevada): *Leiophyllites confucii* (Diener), *Ussurites robustus* Wang, *Ussurites hara* (Diener), *Gymnites* sp. cf. *Gymnites perplanus* (Meek), *Monophyllites pseudo-pradyumna* Welter, *Psilosturia mongolica* Diener, *Procladiscites yasoda* Diener, *Phylocladiscites proponticus* (Toula), *Megaphyllites* sp., *Alanites* sp., *Metadagnoceras* sp., *Silberlingitinae n. gen., Sageceras* sp. cf. *S. welteri* Mojsisovics*, Ismidites* sp., *Platycuccoceras* sp., *Ginsburgites* sp., *Augustaceras* sp.*, Hungarites* sp., *Isculites* sp. cf. *I. tozeri* Silberling and Nichols*, Nevadisculites* sp., *Amphipopanoceras* sp.*, Beneckeia* sp.

The second fossil level yielded ammonoids correlative to Subzone 2 of the *Kocaelia* Zone of the Early Middle Anisian (Bithynian) (in the ammonoid standard scale of the Mediterranean Tethyan Triassic), or with the *Hadleyi* Subzone, the latest subzone of the *Hyatti* Zone in the Middle Anisian: *Ussurites* sp., *Megaphyllites* sp. cf. m. *wildhornensis* Bucher, *Norites* sp., *Leiophyllites confucii* (Diener), *Nevadisculites* sp. cf. *N. taylori* Bucher, *Isculites* sp. cf. *I. tozeri* Silberling and Nichols, *Acrochordiceras* sp. cf. *A. hyatti* Meek, *Platycuccoceras* sp.*, Sturia* sp., *Intornites nevadanus* (Hyatt and Smith), *Gymnites* sp. cf. *G. meridianus* Welter.

The third fossil level is poorer and includes large-sized specimens, indicating the Late Middle Anisian (Pelsonian): *Gymnites* and *Epacrochordiceras* sp. cf. *E. enode* (Hauer).

The fourth fossil level, indicative of the *Paraceratites* Zone of the Early Illyrian (Late Anisian), includes: *Ptychites* sp. cf. *P. rugifer* Oppel, *Flexoptychites* sp., *Discopthychites* sp. ex. gr. *D. Megalodiscus* (Beyrich), *Monophyllites sphaerophyllus* (Hauer), *Gymnites palmai* Mojsisovics, *Paraceratites* sp. cf. *P. thuilleri* (Oppel).

The fifth fossil level yielded elements correlative to the *Eoprotrachyceras* Zone of the Early Ladinian (Late Fassanian), as suggested by the zonal and subzonal index species, e.g. *Eoprotrachyceras curionii* Mojsisovics and *Anolcites* div. sp. The taxa described by Kittl (1908) and Simionescu (1913 a) come from this level.

The sixth fossil level, correlative to the Protrachyceras Zone of the Upper Ladinian (Longobardian), includes: *Protrachyceras archelaus* (Laure), *Protrachyceras pseudoarchelaus* (Mojsisovics), *Protrachyceras ladinum* (Mojsisovics), *Eoprotrachyceras gnedleri* (Mojsisovics), *Monophyllites wengensis* (Klipstein), *Megaphyllites jarbas* (Münster), *Lobites ellipticus* (Hauer), *Rimkinites* sp., *Romanites simionescui* Kittl, *Frankites regoledanus* (Mojsisovics), *Clionites* sp., Arcestidae div.sp.

The seventh fossil level that yielded a rich ammonoid assemblage is correlative to the *Trachyceras* Zone of the Early Carnian (Julian): *Trachyceras aon* (Munster), *Clionites catharinae* (Mojsisovics), *Cladiscites* div. sp., *Pinacoceras layeri* (Hauer), *Placites polydactilus* (Mojsisovics), *Sageceras haidingeri* (Hauer), *Asklepioceras* sp., *Badiotites* sp., *Lobites ellipticus* (Hauer).

Other macrofaunas are represented by the brachiopods *Decurtella decurtata* (Girard) (formerly *Rhynchonella decurtata*) in the Middle Anisian (Pelsonian), *Homoerhynchia subacuta* (Bittn.) in the Lower Ladinian (Fassanian) and "*Rhynchonella*" *linguligera* Bittn., along with the bivalve species *Daonella lommeli* Wissm. and *D. pickleri* Gümbel, for the Upper Ladinian (Longobardian) (Iordan, in Patrulius *et al*., 1974).

Conodonts identified in Dealul Pietros (Mirăuţă and Atudorei, 1997), include the following taxa corresponding to the Upper Anisian (Early Illyrian Trinodosus Zone): *Gondolella constricta*, *Gondolella constricta constricta* (abundant), *Gondolella constricta cornuta, Gondolella bulgarica* (Budurov and Stefanov), *Gondolella bifurcata* (Budurov and Stefanov), *Gladigondolella malayensis* budurovi, *Gondolella cornuta* (Budurov and Stefanov), *Gondolella excelsa* (Mosher), *Gondolella liebermani* Kovacs and Krystyn, *Gondolella excelsa* (Mosher), *Gladigondolella tethydis* (Huckriede).

Three ichtyosaurian dorsal vertebrae were found by Simionescu (1913 b) in the area (two of them currently hosted at the Paleontological Museum of the "Al. I. Cuza" University of Iaşi) (Fig. 4). At the time of their recovery, Agighiol (Hagighiol) was the third locality in the Alpine Triassic of Europe with ichtyosaurian remains, after Grossreifling (Germany) and

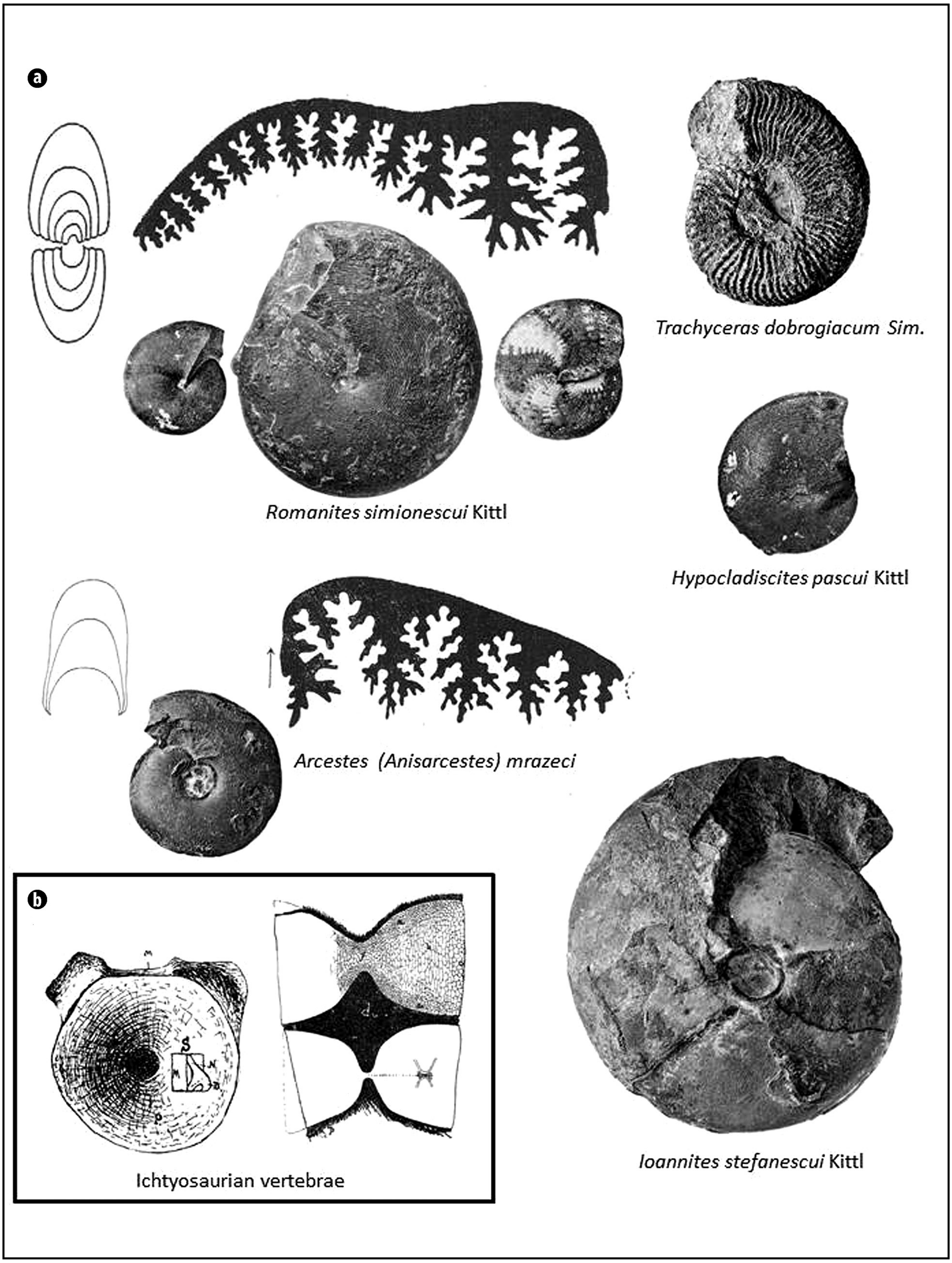

Figure 4. Ammonoids (**a**) and ichtyosaur vertebrae (**b**) from the collection of Simionescu (selected images and original drawings from Simionescu, 1913a, b).

Bessano (Italy). Of the two taxa the vertebrae showed more resemblances with, *Cymbospondylus* Leyde and *Shastasaurus* Merriam, Simionescu (1913 b) accepted the latter. Grădinaru (personal communication) has found other vertebrae in a hill to the north of Dealul Pietros and their study is in progress.

Scientific value. The Agighiol region, where the Fossil site from Dealul Pietros is located, represents a reference point for the Triassic stratigraphy of the North Dobrogea Orogen, due to the richness of fauna and its well established biostratigraphy. The typical features of the Hallstatt and Schreyeralm facies can be studied in these easily accessible hills. Many ammonoids are found in juvenile stage, which allows correlation to the adult forms, thus contributing to a complete knowledge of certain taxa of the Alpine Triassic facies (Simionescu, 1913 a). Abundance of fossils allowed the discovery of new taxa and species in Agighiol Hills: *Romanites simionescui* Kittl, *Joannites stefanescui* Kittl, *Trachyceras dobrogiacum* Sim., *Arcestes (Anisarcestes) mrazeci* Sim., *Hypocladiscites pascui* Kittl, *Ptychites stefanescui* Sim., *Japonites dobrogiacus* Sim., *Lobites euxinus* Kittl.

The ammonites from Agighiol described in the classic monographs of Kittl (1908) and Simionescu (1913 a) are famous in the literature relevant for the Mediterranean Triassic. Several chronostratigraphic intervals (Spathian-Middle Anisian, Middle and Late Carnian) are well-documented by rich and taxonomically diversified ammonoid faunas recovered due to detailed macropaleontological and micropaleontological studies, starting with the synthesis of Patrulius *et al*. (1974). The importance of these faunas is twofold: they show a chrono- and biostratigraphic significance for improving the ammonoid standard scale of the Tethyan Triassic, as in the Mediterranean area the time interval of Early Anisian to Early Middle Triassic (Aegean to Bithynian) is generally poorly recorded by ammonoids; they are also important for paleogeographic correlations of the Triassic sequences of the Tethyan area with the Triassic facies of Asia and North America (Grădinaru, 1997). Already in 1913, Simionescu suggested that the ammonite fauna in Deşli Caira, a hill north-east of Dealul Pietros, showed affinities with the Oriental Triassic (Indian and Circum-Pacific), based on *Monophyllites* and *Japonites*, taxa also found in the Balkans. Early and Middle Anisian ammonoid assemblages from Agighiol area show common elements with coeval ammonoids faunas from Nevada, while in the time equivalent Tethyan ammonoid faunas of the Mediterranean area they are poorly represented. Moreover, the discovery in the Early and Early Middle Anisian ammonoid assemblages of the Tulcea unit of ammonoid genera known only in the Boreal realm (Grădinaru, 1997) is extremely important for its potential for refining the correlation of the Anisian chronostratigraphic divisions recognized in the Arctics with those of the Tethys.

The rich ammonoid assemblages of the Agighiol in the interval of Late Ladinian (Longobardian) to Early Carnian (Julian) allows studies on the Ladinian/Carnian boundary. Moreover, the Deşli Caira Hill from the Agighiol Hills SCI, is the most important candidate for the international GSSP of the Olenekian-Anisian boundary (Grădinaru, 1997; Ogg, 2004; Grădinaru *et al.*, 2007). The presence of the ichtyosaur vertebrae considerably increases the importance of the Agighiol Hills, as this is the only place in Romania where Ichtyosaurian remains have been found so far.

Cultural value. The locality of the protected fossil site from Agighiol, Dealul Pietros (Stony Hill in Romanian), has a denomination with geological connotations. The names Deşli Caira (in Simionescu, 1911), or Berge Taşli (in Kittl, 1908), are of Turkish origin, the current name in the Romanian toponymy being Stânca Mare (Big Cliff) or Muchea Ascuțită (Sharp Edge).

Stones have always played a key role in the evolution of human society, from the first tools manufactured by prehistoric people, to building material or means of defense. The cultural value of geodiversity also includes ways of artistic expression, with the topic of inspiration in the geological diversity. Nature has always been a very important source of inspiration for painters, musicians, poets and writers. For an NGO event in 2010, a pencil sketch was drawn by the author of this paper to recreate the lost Triassic seascape of Agighiol area, with ammonites and ichtyosaurians; the sketch was included in 2012 in a travelling exhibition dedicated to Dobrogea.

Aesthetic value. In the perception of viewers, the dominant geomorphological aspect in Dobrogea is given by the succession of gently sloping hills, alternating with areas of flat fields. Dealul Pietros is no exception to this description. The Agighiol Hills make a beautiful landscape of small rounded hills covered with steppe herbs, with forests or bushes, in an area which is otherwise quite flat. From the hills of Agighiol the viewer can enjoy not only beautiful scenery over the Lake Razelm and the Popina Island situated to the south, but also a feeling of serenity and calm, as described by Simionescu (1939) in his publications for the general public grouped under the title of „The picturesque Romania. Between the Danube and the Sea". In its turn, the geological protected site leaves a strong impression upon all who have the opportunity to visit it, due to the density of fossils scattered on the rock surfaces (Fig. 5 a, b). The grey or reddish limestone blocks, „printed" with numerous Triassic cephalopods, reveal a vivid page in the geological history of the Agighiol area, as it was 240 million years ago, at the beginning of the Mesozoic.

Economic and functional value. Economic classifications of the mineral resources include limestone in the category of minerals and construction aggregates. Even its domestic exploitation as building stone represents a real economic resource for the local people in the area of Aghighiol Hills. Fossils *in situ* in the geological site of Dealul Pietros are also a potential source of income, if collected and sold on the black market. Soils (lithosoils and rendzines) developed on limestones also play a very important functional role in supporting the local food chain, and both vineyards and various

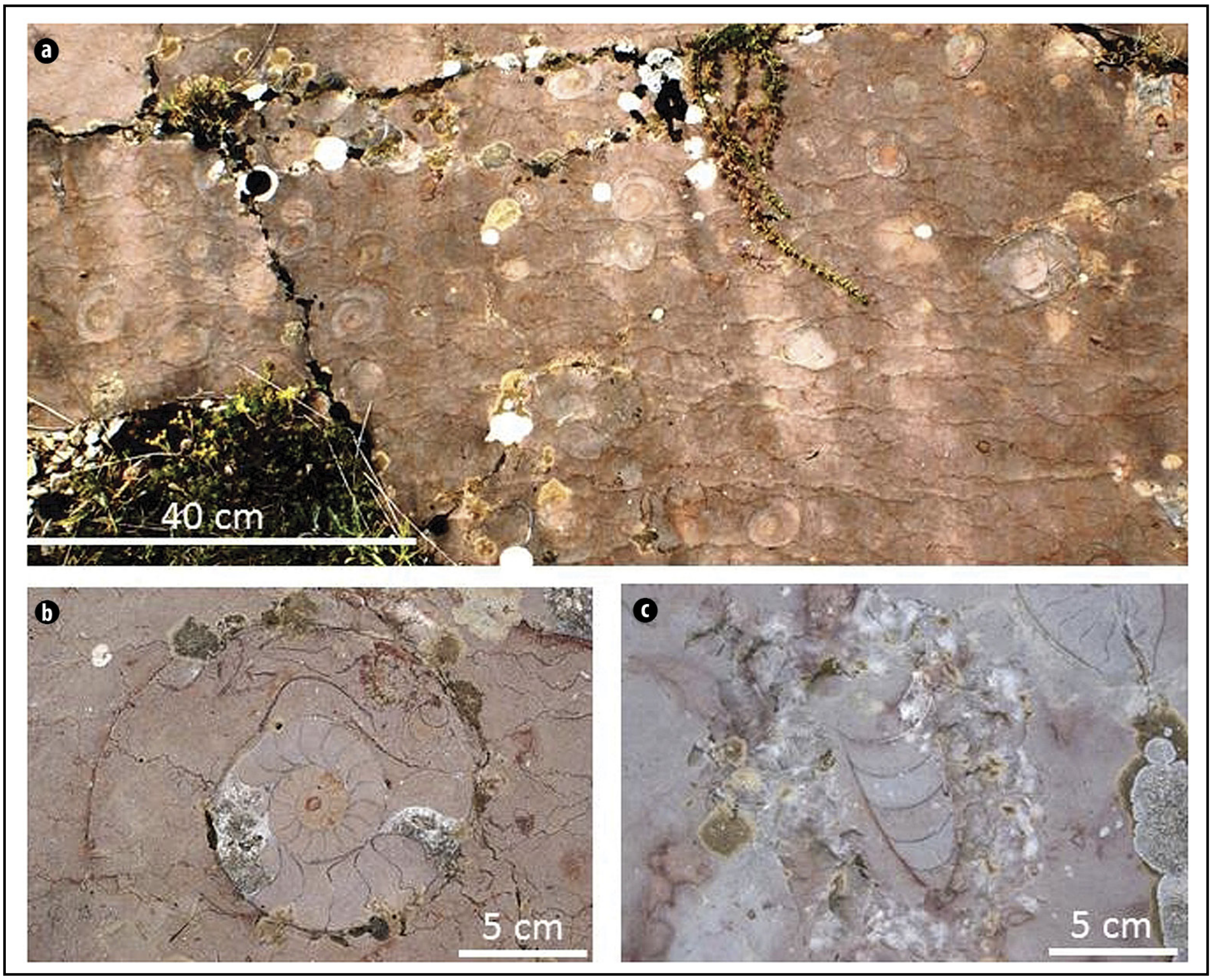

Figure 5. Aesthetic value and threats to the Agighiol Fossil site. **a**, photograph of a rock surface with ammonoids; **b**, detail of a ceratitid seen on the rock surface; **c**, hammering marks around an orthocerathid.

agricultural plants are cultivated in the neighbouring areas. The main activity in the fossil site is grazing. Every year, scientific and educational activities are also performed: studies of the ammonnoids and microfauna by specialists from the University of Bucharest and PhD students, field excursions connected to various scientific meetings. Field trips organized for undergraduate students from the Universities of Bucharest and Iaşi as part of the academic curricula always include a visit to Agighiol outcrops, in order to understand the facies, lithology, stratigraphy and paleontology of the Alpine Triassic.

The limestone bedrock supports the biodiversity of the Agighol Hills protected site, as it is the base of the ecosystems developed here. The beautiful landscape and vegetation make the Agighiol Hills very attractive to the local communities, and locals come for picnics on top of the hills. Geotourism, triggered by the aesthetic and scientific value of the site, can generate income for the local economy.

3.1.4. Vulnerabilities and threats to geodiversity of the Agighiol Fossil Site

Although almost unintended, threats to geodiversity are numerous, the most serious resulting from human impact. Unfortunately, the above mentioned geodiversity values of the geological reserve in Dealul Pietros presented above are also the main cause of its threats, due to their poor management at the community level, to reckless consumption of natural resources, or to the destruction of landforms for various human needs related to infrastructure and agriculture. The main types of threats to geodiversity are presented further.

Constructions of any kind and anthropogenic intervention. Under environmental legislation in force, especially GEO 154/2008 (which amends Ordinance 57/2007) regarding the natural protected areas, Article 52 (1), letter i, states the prohibition of construction works and investments outside the areas of sustainable development in natural protected areas. Moreover, art. 28, point 1, states: „It is forbidden any activity within the perimeter of protected natural areas of community interest that may generate pollution or deterioration of habitats and disturbance of species for which these areas were designated ...". In 2011, the custodian of the Agighiol Hills SCI faced such human pressure when it was asked to issue a point of view on the new General Urbanism Plan (GUP) for the development of the Agighiol area (Seghedi *et al*., 2012). Aiming to modernize and ensure a harmonious development for the Agighiol village, the architectural firm that elaborated the GUP proposed to expand the village by new buildings within the eastern part of the SCI and perform several construction works to stabilize the slope in the western part of the village. The area where the slope stabilizing construction works were intended was the rocky area of the Agighiol Fossil site and it seemed that the firm did not know about the existence of the SCI. Moreover, the very integrity of the Agighiol Fossil site was in great danger, as the construction works would have destroyed the Fossil site forever. The custodian of the SCI refused to agree with the proposal of expanding the village within the SCI limits, as diminishing the surface of a protected site means breaching the law. The custodian released a favorable point of view only subsequently to drastic modifications of the GUP.

Another threat is *the existing wind farm* in the ROSCI 0060 Agighiol Hills, one of the 17 wind turbines within the site perimeter being emplaced on top of Dealul Pietros, fortunately outside the limits of the Fossil Site (Seghedi *et al.*, 2010). The wind park owner, ENEL Green Power, obtained the concession of about 350 ha of the SCI area from the local administration, as well as the approval of the Tulcea Environmental Protection Agency to install the wind turbine park prior to the Agighiol Hills SCI was given into custody. By building roads and platforms for the 17 turbines, the wind park also diminished the surface of the SCI, which again is breaching the law (Seghedi *et al*., 2012).

Tourism, geotourism or ecotourism. Any type of sustainable tourism may be an important economic resource for the Agighiol community and thus can promote national geological values also worldwide. At the same time, if uncontrolled, touristic activities may represent a real threat to geodiversity of the Dealul Pietros geological reserve. The lack of thematic paths, special indicators, ecologic garbage storage areas or specific locations for setting fires may, in time, damage to site.

Harvesting geological specimens. According to the Ministerial Order no. 410/2008 on domestic and intra-Community market trade with minerals and fossils, art. 13, letter d, harvesting, buying and selling gems, fossil plants and vertebrate and invertebrate fossils is prohibited within protected areas. However, the lack of constant monitoring of the site, correlated with a poor economic situation of locals and relatively easy access to the site could make harvesting and selling fossils on the black market to become an attractive business. However, although illegal attempts to collect fossils leave their marks on rocks within the Fossil site (Fig. 5 c), this activity is not constant and it is prevented by the difficulty to extract the fossils from the hard limestones enclosing them.

3.2. Cheia Jurassic Reefs Geological Reserve (ROSCI0215)

Due to its valuable geological, geomorphological and botanical features, the Cheia geological reserve was proposed for protection as a landscape reserve (Bleahu *et al*., 1976). According to the Natura 2000 Standard Form, the Cheia Jurassic Reefs Site protects an area of 5.134 hectares, which is included in the Dobrogea Gorges SPA (site for protection of avifauna) (http://natura2000.mmediu.ro/site/35/ rospa0019.html). Jurassic reefal limestones, which are the crucial element of the site, preserve former atoll shapes formed by reef building organisms such as sponges and corals, which inhabited the shallow Jurassic sea from the Cheia region.

3.2.1. General information

The Cheia Jurassic Reef is part of the Dobrogea Gorges SPA (RO SPA 0019), a larger protected area located on the right side of the Casimcea Valley, about 50 km northwest of the city of Constanța (N 44º 31′ 14", E 28° 24′ 32"), in the steppe biogeographic region of Central Dobrogea, Constanța county. According to the Natura 2000 Standard Form, the SPA area is 10,929 ha, with a maximum altitude of 200 m (Fig. 6). The site is in custody of Constanța Forestry Department, Hârşova Forestry District.

Central Dobrogea belongs to the eastern part of the Moesian Platform (or East Moesia), and exposes the Ediacaran (Late Neoproterozoic) basement of the platform with remnants of its Late Jurassic platform cover, preserved mainly in the Casimcea syncline (Săndulescu, 1984; Seghedi *et al*., 2005). A geological cross section through the Casimcea syncline is well exposed along the Cheia Valley.

3.2.2. Quality and importance

The biodiversity of Dobrogea Gorges SPA includes a number of highly valuable species of birds that nest in the area of the site (like *Accipiter brevipes, Circus pygargus, Aquila pomarina*), reptiles, such as turtles (*Testudo graeca*), or mammals, such as the ground squirrels (*Spermophilus citellus*). In the Natura 2000 Standard Form, the „site description" states that „in paleontological terms, the limestones from Dobrogea Gorges area are home of the richest Middle Jurassic fossil fauna site from the entire Casimcea syncline".

In what concerns the existence of the Cheia Massif, or the Cheia Jurassic Reefs geological reserve within the Dobrogea Gorges Site, the datasheet specifies:"The Cheia Massif or Cheia Jurassic Reefs reserve was initially designated as protected area by the Decision 425/1970 of the Constanța County Council. It was designated a nature reserve of national interest by Law 5/2000 on National Spatial Plan.

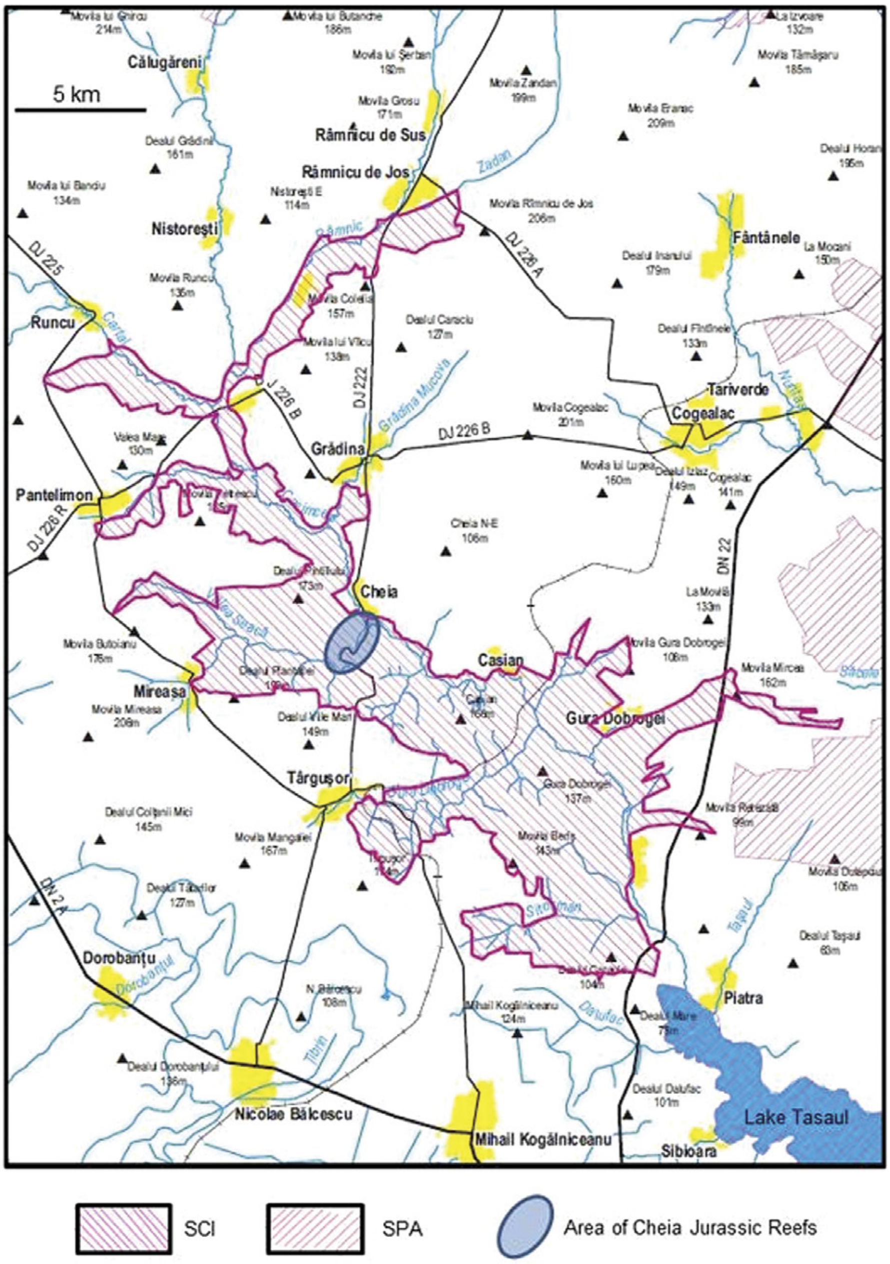

Figure 6. Location of the Cheia Jurassic Reefs on the RO SCI 0215 map, modified after the website of the Ministry of Environment (http://natura2000.mmediu.ro/site/35/ rospa0019.html).

3.2.3. Geodiversity values of the Cheia Jurassic Reefs Site

Intrinsic value. The existence of reef buildups in the Cheia valley is a good reason for valuing and protecting this geological site. Located in the southern part of East Moesia, in the Casimcea Syncline, the Cheia geological site belongs, from a lithostratigraphic point of view, to the Casimcea Carbonate Formation (Middle – Late Oxfordian) (Drăgănescu, 1976 a). The Casimcea Formation is part of the Jurassic sedimentary cover from Central Dobrogea, unconformably overlying the basement rocks represented by green clastics of the Ediacaran Histria Formation.

The Casimcea Formation was separated into 7 distinct lithological facies (Drăgănescu, 1976 a), also refered to as sedimentary series or members (Bărbulescu, in Dragastan *et al*., 1998). The Cheia Fossil Site is located in the Visterna Member or the bioconstructed Spong-Algal Series, with its type section on the middle course of the Visterna Valley and on the Cheia Valley. Two bioconstructed complexes are distinguished within the Visterna Member: the lower, biostromal complex and the upper, biohermal complex (Drăgănescu, 1976 a).

The biostromal complex consists of layered bodies of sponges and pseudostromata calcareous crusts, interlocked with lens-shaped bodies of spong-algal limestone. The biohermal complex includes biostromal limestones with siliceous sponge reefs and microbialitic crusts (Herrmann, in Leinfelder *et al*., 1994) (Fig. 7).

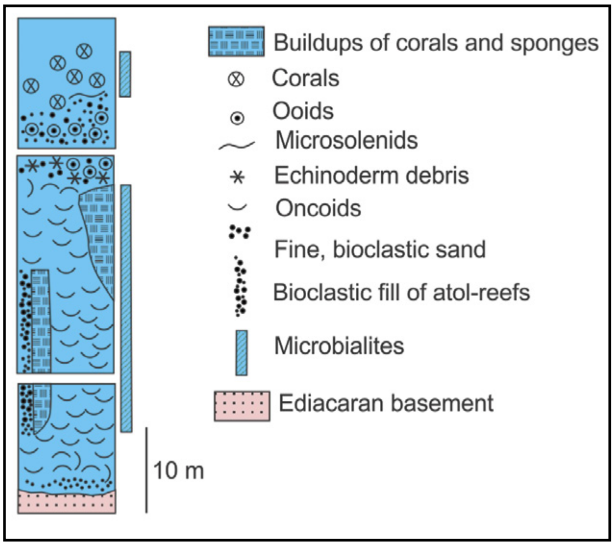

Figure 7. Lithological column in the Late Jurassic deposits of the Cheia valley (after Herrmann, in Leinfelder *et al.*, 1994).

The reefs show various shapes (cylindrical, horseshoe, globular), the most famous of them being the microatols, initially considered coral atolls (Orghidan, 1963) and subsequently demonstrated to be sponge buildups (Bărbulescu, 1974; Drăgănescu, 1976 a; Herrmann, 1996) (Fig. 8). The depositional environment of the reefs corresponds to a monoclinal carbonate platform (ramp), with the bioconstructed facies accumulated at about 10 – 20 m deposition depth in the offshore shelf area below the wave base, with a low-moderate rate of sedimentation and basin energy (Drăgănescu, 1976 b).

Scientific value. The Jurassic sponges from Dobrogea are part of the great European limestone belt bioconstructed by sponges 160 Ma ago on the northern margin of the Tethys. This European limestone belt, referred to as the „Upper Jurassic Sponges Megafacies" (Matyja, 1976), discontinuously developed in the southern and central part of Europe, is extending from West to East, from Portugal and Spain, through France, Switzerland and Germany, to Poland and Romania. The remnants of this belt in Romania enable to refine the paleogeographic reconstructions of the northern margin of the Tethys Ocean during the Late Jurassic.

Cultural value. The Dobrogea Gorges and the Cheia Jurassic Reefs represent toponyms with a geomorphological and geological feature which clearly refer either to natural processes leading to the formation of certain geomorphological elements such as gorges, or to Jurassic bioconstructing organisms. The picturesque natural scenery of the Dobrogea Gorges inspired contemporary artists such as Simina Mureşan, Ioan Orătie or Cornelia Gherlan to dedicate landscape paintings embodying the Dobrogea area (Fig. 9).

Aesthetic value. The beauty of a country is largely based on the value of its landscape (Daly *et al.*, 1994). An attraction for Central Dobrogea, the Cheia Jurassic Reefs Geological Reserve has a great aesthetic value, primarily for its contribution to the local geomorphology (Fig. 8). Among the flat hills of Central Dobrogea, the Casimcea syncline offers a scenic landscape of forested flat hills where the white limestones, often showing the rounded towers of bioherms, contrast with the green colour of trees and bushes. The age of the reef formations is another reason for admiration, the visitor's imagination being stirred by the "Jurassic" term and its Hollywoodian connotations. It is indeed a marine Jurassic Park.

Economic and functional value. Local communities use the Cheia Gorges for grazing. Economically, the geologically-controlled landscape from Cheia is obviously a tourist attraction. People come here on holidays or weekends, mainly for a picnic or a barbecue. In the spring of 2013, camping was still allowed by the village council and an unfortunate metal plate announcing the camping fees was fixed on one of the atoll's walls. Local tourism development is favored by the national road network which allows direct access to the site, which is extremely important in the development of local and national economies. Geotourism, producing and selling souvenirs related to both geology and biodiversity of the site could be a source of income. Wrong as it is, removing fossils from the site and selling them also has an economic value.

3.2.4. Vulnerabilities and threats to Geodiversity of the Cheia Jurassic Reefs Site

Site popularity and easy access represents, undoubtedly, one of the main threats to its integrity. Non-ecological tourism practiced in the Dobrogea Gorges is most often absurd. The so-called weekend or mini-vacation tourism seems the most destructive, when hundreds of cars park illegally in the perimeter of the site, fires burning, bikes circling, rocks painted with graffiti and garbage spread all around (Mihaela Dragomir, www.telegrafonline.ro) (Fig. 10). This generates pollution, damaging habitats and geodiversity elements and it is against the provisions of GEO 195/2005, paragraph 26, stating: „ecotourism is a form of tourism in which the main objective is observation and awareness of the nature and value of local traditions and must meet the following requirements:

1. to contribute to the conservation and protection of nature;
2. to use local human resources;
3. to have an educational, respect for nature - awareness of tourists and local communities;
4. to have insignificant negative impact on the natural and socio-cultural environment"

Maintaining and opening new quarries in the site. This type of activity represents another threat to natural diversity within RO SPA 0019, especially to RO SCI 0215. Active or reopened abandoned quarries extracting green siltstones (Pantelimon, Izvorul Mic) are beyond the limits of the protected area, but the limestone quarry from Cheia means mining activities within a protected area. The impact this kind of activity has

Figure 8. Photograph of the bioherms (microatolls) and biostromes in the Cheia valley.

Figure 9. Painting of Cheile Dobrogei, artwork by painter Simina Mureşan (http://www.tablouri-de-vis.ro/tablouri_cu_peisaje/muresan_simina/cheile_dobrogei/)

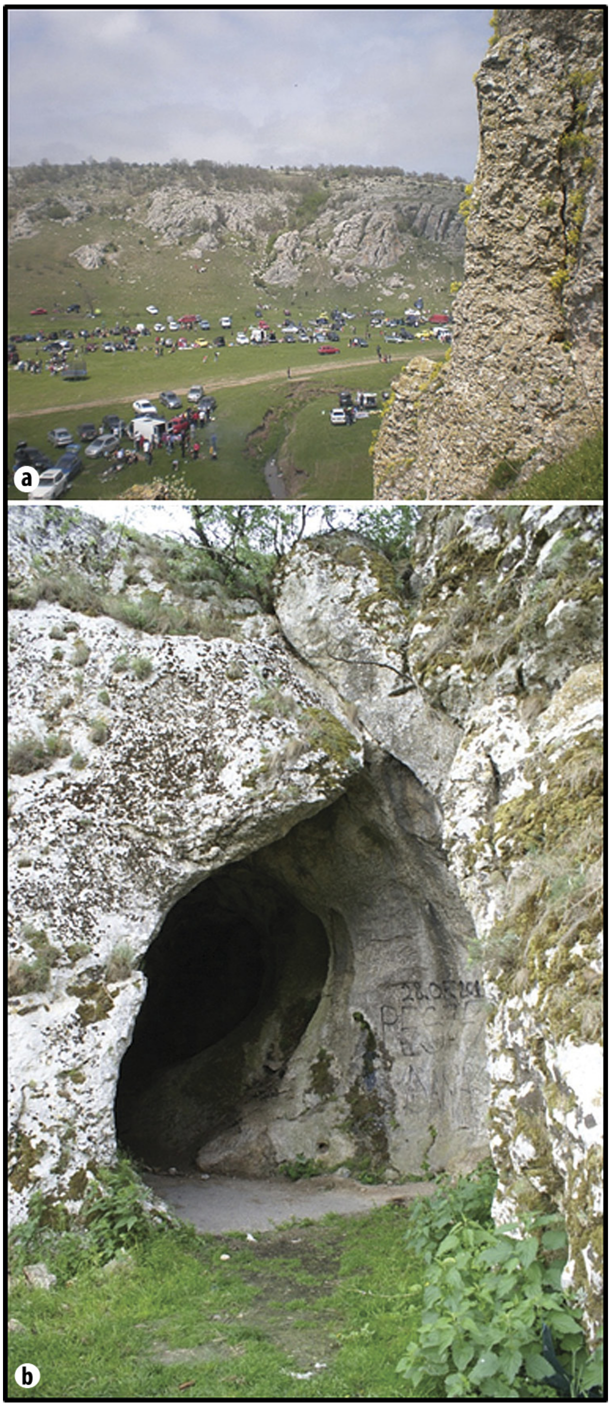

Figure 10. Threats to the Cheia Jurassic Reefs. **a**, Weekend tourism in Dobrogea Gorges, a real threat to the site integrity (http://vizitam.blogspot.ro/2011/05/cheile-dobrogei.html); **b**, Graffiti at a small cave entrance in Dobrogea Gorges.

on geomorphology and landscape is irreversible, resulting in local or regional landscape change, regardless of the subsequent ecological operation programs (if any). Moreover, under Law 49/2011, Article 28, „It is forbidden to deploy any activities in the perimeters of natural protected areas of community interest that can generate pollution or deterioration of habitats and disturbance of species for which these areas were designated ...". A visit of the Environmental Protection Agency from Constanţa in the Pantelimon Quarry, opened in 2009, identified many galleries of rodents and detected the protected species *Mesocricetus newtoni* (hamster of Dobrogea) on land still unaffected by mining works (Anca-Alina Jitaru, telegrafonline.ro). The hamster is a mammal species listed on the national Red List, representing a vulnerable, threatened species.

Harvesting fossils. Although prohibited by law (Ministerial Order 410/2008), harvesting fossils from the geological reserve for marketing or collection purposes is a type of threat that hovers over all fossil sites, the Cheia Jurassic Reefs being no exception.

3.3. Topalu Neo-Jurassic Reef Geological Reserve

Located in the Central Dobrogea tectonic block of the Moesian Platform, between Cernavodă and Hârşova, the Topalu Neo-Jurassic Reef is the third geological reserve from Dobrogea protecting Jurassic limestones. The aim for establishing a protection status was to preserve this rich fossil site from destruction by quarrying, considering that several quarries were opened on the right bank of the Danube (Bleahu *et al.*, 1976).

3.3.1. General information

The Topalu Neo-Jurassic Reef is included within the Canaralele Dunării (or Danube Rocks) Site of Community Interest (RO SCI 0022). The SCI is located on the right bank of the Danube, south of Hârşova (N 44 °24 ,43", E 28°04'48"), in the county of Constanţa, in the steppe biogeographic region between Central and South Dobrogea. The site is in custody of Constanţa Forestry Department, Hârşova Forestry District.

According to the Natura 2000 Standard Form, the SCI area is 26,064 ha, with a maximum altitude of 133 m (http //natura2000.mmediu.ro). Within the SCI, the Topalu Neo-Jurassic Reef occupies an area of 20,74 ha, being designated a nature monument of mixt type, both geological and paleontological (Fig. 11).

The site is situated in the south-western part of Central Dobrogea, in the Casimcea Syncline. Geologically, the nature monument belongs to the Late Jurasssic carbonate platform cover of the Ediacaran basement of Central Dobrogea.

3.3.2. Quality and importance

According to the Natura 2000 Standard Form, the Canaralele Dunării SCI presents a variety of protected habitats, from hydrophilic to those xerophilic, including meadows, shrubs, forests, etc. The site is a vital area for reproduction and migration of sturgeon and other fish species. Including the river Danube in the site is essential for the continuity and transportation of the reproductive organs of various plant species (seeds, sprouts), favoring their dispersal to northern Dobrogea and to the Danube Delta (http//Natura2000.mmediu.ro).

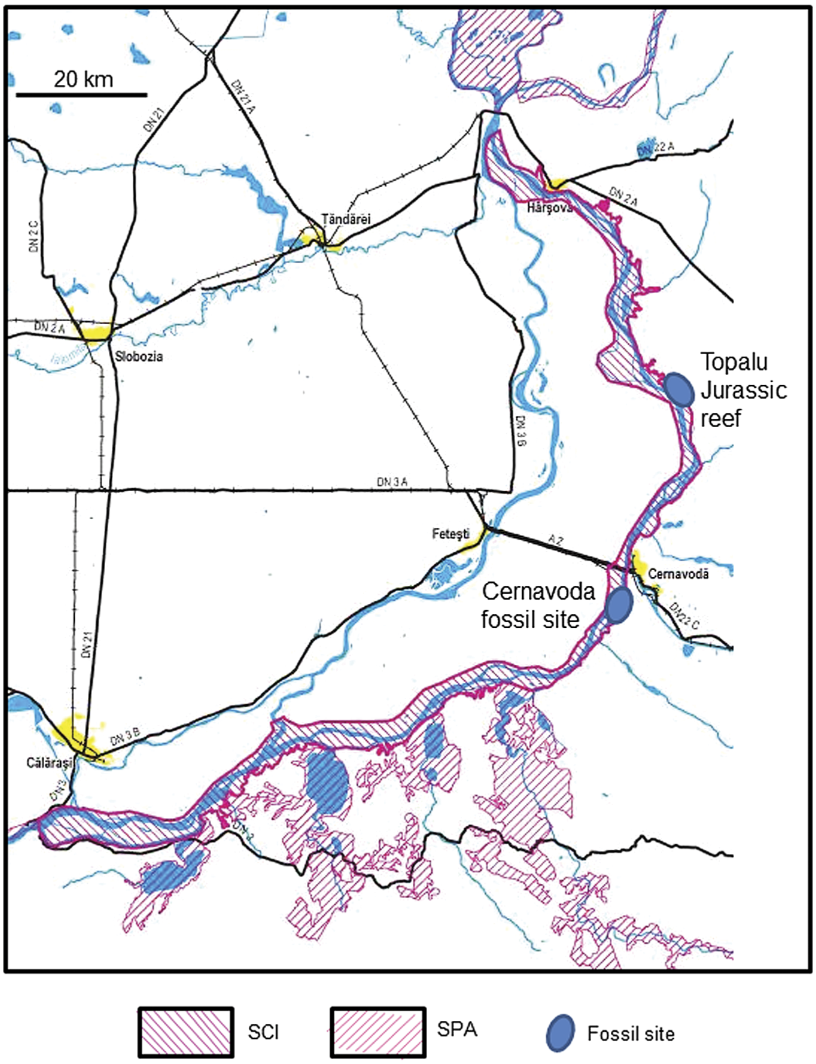

Figure 11. Location of the Topalu Jurassic reef and of Cernavodă Fossil Site on the map of RO SCI 0022 Canaralele Dunării, modifed after the site of the Ministry of the Environment (http://natura2000.mmediu.ro/site/35/ rosci0022.html).

Among others, the Standard Form specifies the existence, in RO SCI 0022, of two geological reserves: the geological reserve of Cernavodă, known as the Cernavodă Fossil Site, protected by the Decision 425/1970 of the Constanța County Council and, subsequently, by Law 5/2000, and the geological and paleontological Topalu Neo-Jurassic Reef Site, protected since 1980, by DCCC 31 and by the National Spatial Plan (Law 5/2000). Beyond the reference to the legal framework, the data sheet also specifies that the two reserves are listed as IUCN Category III, Natural Monuments.

3.3.3. Geodiversity values of Topalu Neo-Jurassic Reef, Geological and Paleontological Site

Intrinsic value. As a natural monument, the Topalu site illustrates the Neo-Jurassic reef platform facies (Bleahu *et al*., 1976). Lithostratigraphically, the reef belongs to the Casimcea Formation (Lower Oxfordian - Lower Kimmeridgian), namely to the Upper bioconstructed Coral-Algal Series or Topalu Member (Upper Oxfordian - Lower Kimmeridgian coral-pseudostromata complex) (Drăgănescu, 1976 a).

The limestone deposits which include the Topalu Reef crop out in the perimeter of the Privalul Veriga, a secondary arm of the Danube. The reef, 12-20 m thick, is exposed on a length of almost 1 km. Here is the type section of the Topalu Member (Fig. 12). According to Drăgănescu (1976 a), the reefal limestones outcropping in Topalu are microgranular, organogenic (often micritic), with fine detrital fragments. The site is dominated by tree-like coral colonies, but subordinately sub-massive lamellar colonies and conical or cylindrical sub-spherical or solitary polyps can be seen.

Intercalicinal spaces are filled with micritic pseudostromatic biolithite. The coral fauna is displayed within 4 levels, the first three being stromatolitic, with varied coral associations, but the representative richness and variety of this biostrome is in its fourth level, also known as the coral-pseudostromata complex. In this complex (known also as the Topalu Biostrome) 69 species of corals from a total of 74 in all the levels were identified by Roniewicz (1976) (who studied both the macro and microscopic morphology of the corals). According to this author, the Upper Oxfordian is represented by species such as *Clausastraea parva* Milne-Edwards, *Comoseris interrupta* Koby, *Dimorphastrea dubia* and *Dimorphomeandra concentrica* Roniewicz. In the scale based on the coral species, the species *Epistreptophyllum giganteum*, identified in

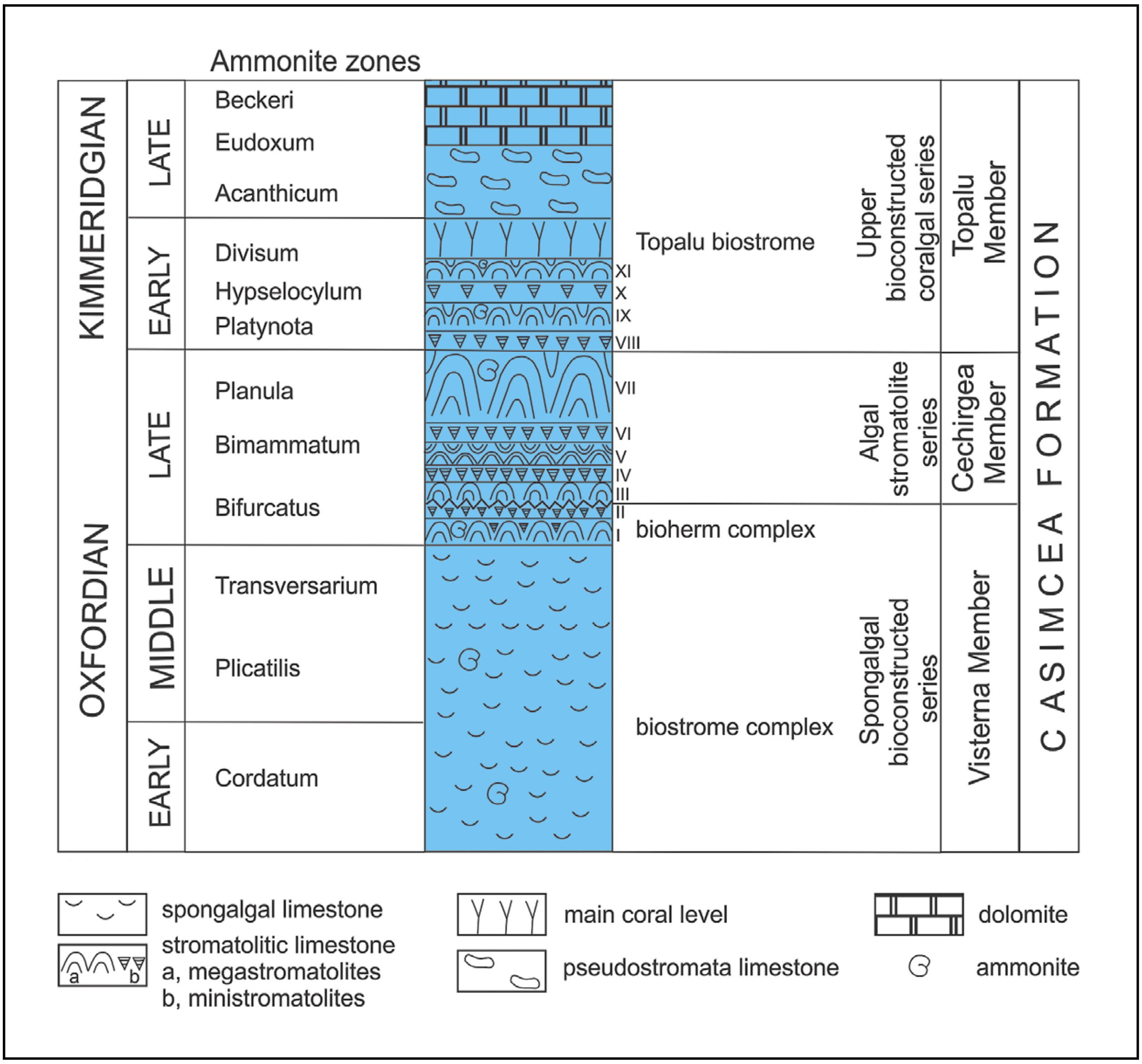

Figure 12. Lithological column showing the main facies and subdivisions of the Late Jurassic deposits from Central Dobrogea (Casimcea Formation) (after Drăgănescu, 1976 a); the Topalu reef is lying on top of the Late Oxfordian-Early Kimmeridgian stromatolitic levels (I-XI). The biostratigraphy of the Late Jurassic is based on ammonite zones (after Bărbulescu, 1974 and 1998, in Dragastan *et al.*, 1998).

the southern part of the North Topalu section, is recognized as zonal index for the Lower Kimmeridgian.

Associated to the Neo-Jurassic coral fauna, other bioconstructing colonial organisms were identified at Topalu, such as sponges (Bărbulescu, 1961 a, b, 1964, 1971,1974; Andrăşanu *et al.*, 1982; Dragastan *et al.*, 1998), some sponge species beingconsidered endemic, as *Laocoetis parallela* (Goldfuss), *Laocoetis procumbens* Goldfuss, *Cribrospongia reticulata* var. *piriformis* (Goldfuss), *Trochobolus* cf. *dentatus* Kolb, *Melonella radiata* Quenstedt (Ungureanu and Barbu, 2004); other bioconstructing organisms described are chaetetides (*Blaustochaetetes capilliformis, Ptychochaetetes* sp.) and hydrozoans *(Actinostromaria tokadiensis, Milleporidium remesi, Hudsonella dobrogensis*) (Fig. 13).

Beside corals, the brachiopods, studied by Macovei (1907), Simionescu (1909), as well as Grădinaru and Bărbulescu (1994) are extremely important for the paleoenvironmental reconstructions. From a quantitative perspective, it was observed that with diversification and increase in abundance of coral associations, a regress in brachiopods abundance and change of their morphology occurs, indicating special adaptations to the coral facies (Dragastan *et al.*, 1998).

Scientific value. The Topalu Fossil Site shows a large diversity and abundance of coral species. The rich fauna of this outcrop not only makes it representative for the Upper Oxfordian-Lower Kimmeridgian interval in Dobrogea, but ranks it as one of the top positions in the entire Europe (Roniewicz, 1976). Beyond its paleontological significance, the site is ex-

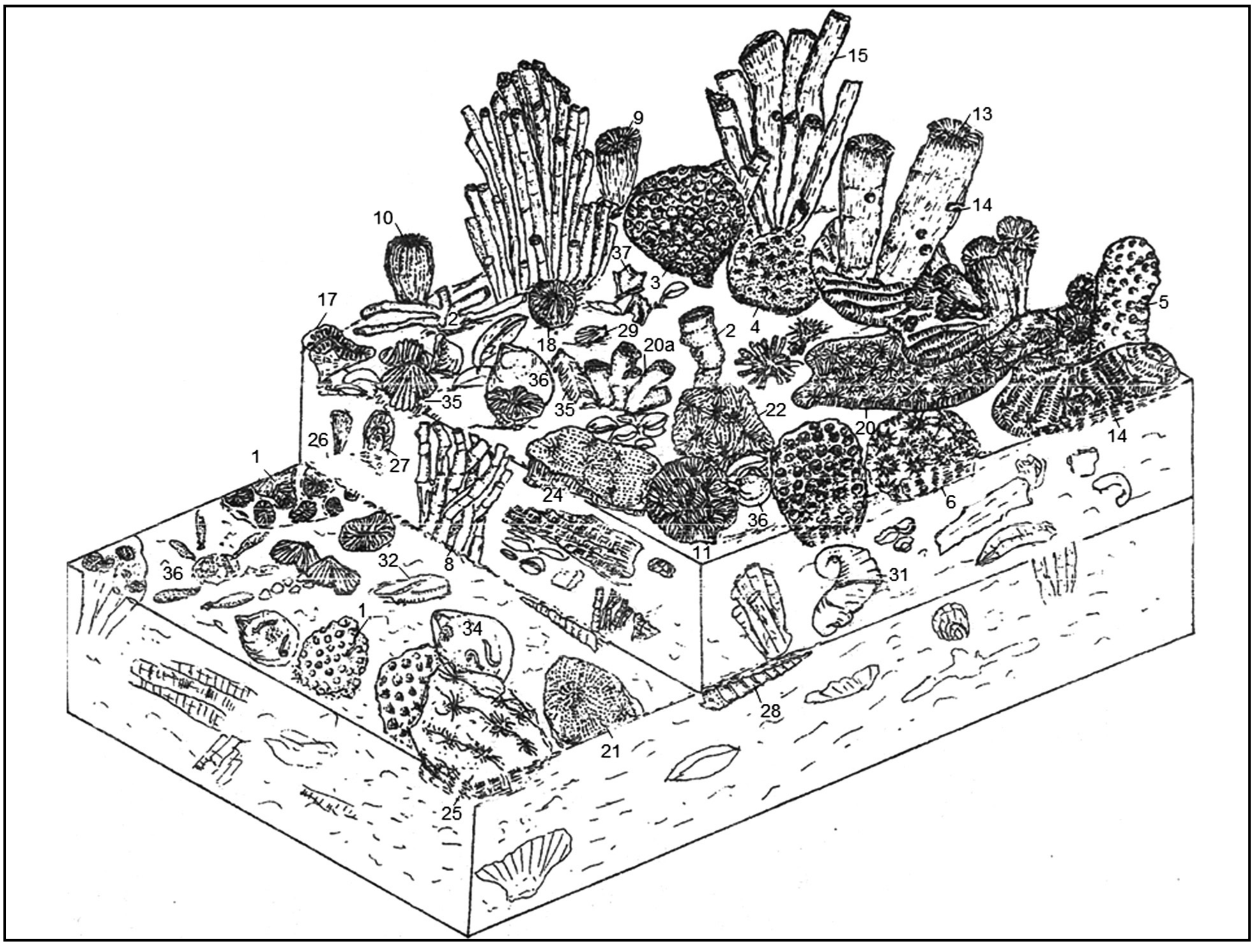

Figure 13. Reconstruction of the Topalu reef (after Bărbulescu, in Dragastan *et al.*, 1998), showing the Lower Kimmeridgian reefal communities from Topalu. **1**, *Stephanastraea jurassica* Roniewicz; **2**, *Cheilosmilia rugosa* (Koby); **3**, *Pleurophyllia minuscula* Roniewicz; **4**, *Pseudocoenia breviseptata* Roniewicz; **5**, *Pseudocoenia limbata* (Goldfuss); **6**, *Pseudocoeniopsis major* Roniewicz; **7**, *Stylosmilia coralina* Koby; **8**, *Proaplophyllia sexradiata* Roniewicz; **9**, *Montlivaltia tenuilamellata* Roniewicz; **10**, *Montlivaltia* sp.; **11**, *Clausastraea topalensis* Roniewicz; **12**, *Rhabdophyllia flexuosa* Roniewicz; **13**, *Epistreptophyllum giganteum* Roniewicz; **14**, Litophaga borings; **15**, *Calamophylliopsis stockesi* (Edwards et Haime); **16**, *Calamophylliopsis compacta* (Koby); **17**, *Rhypidogyra langi* Koby; **18**, *Haplaraea elegans* Milaschewitchi; **19**, *Meandraraea gresslyi* Ettalon; **20**, *Mesomorpha simionescui* Roniewicz; **21**, *Actinaraea minuta* Roniewicz; **22**, *Kobyastraea tenuis* Roniewicz; **23**, *Trochoplegmopsis gregory* (Koby); **24**, *Microsolena foliosa* Roniewicz; **25**, *Comophyllia polymorpha* Koby; **26**, *Blastochaetetes capilliformis* Dietrich; **27**, *Actinostromaria tocadiensis* Yabe et Sugiyama; **28**, *Nerinea* sp.; **29**, *Spondylopecten globosus* (Quenstedt); **30**, *Alectryonia rastellaria* Munster; **31**, *Diceras speciosus* Munster; **32**, *Torquirhynchia speciosa* (Munster); **33**, *Septaliphoria moravica* (Uhlig); **34**, *Juralina kokkoziensis* (Moiseev); **35**, *Juralina topalensis* Simionescu; **36**, *Juralina castellensis* (Douvillé); **37**, *Cheirothyris fleurieusa* (d'Orbigny); **38**, various Cidarids.

tremely important for understanding the phases which led to the formation of this reef, as the platform regime of Central Dobrogea allowed the preservation of deposits in their initial, quasi-horizontal position (Bleahu *et al*., 1976) (Fig. 14).

Cultural value. The name "Topalu Neo-Jurassic Reef" refers, indirectly, to geodiversity elements. The generality of the term „reef" is given with a term specifying the position of this reef in the chronostratigraphic scale, in the Neo-Jurassic. (It should be mentioned that the name was given when the site was designated for protection, so there is no local tradition, as in the case of Dealul Pietros from Agighiol in North Dobrogea).

Aesthetic value. Included in most tourist routes in Dobrogea, the Topalu area is attractive due to its natural landscape, specific to Dobrogea, with gently sloping, flat hills, covered with meadows or woods and surrounded by vast flat areas. The Geological Reserve is located on such a slope, north of Topalu locality.

Economic and functional value. The access to the Topalu Neo-Jurassic Reef, located between Constanța and Cernavodă, is favored by the national road network. The site shows the geological diversity elements whose economic value can support the development of geotourism activities in surrounding villages (Tichileşti, Topalu). Associated with these activities, beyond the guided trips, another source of

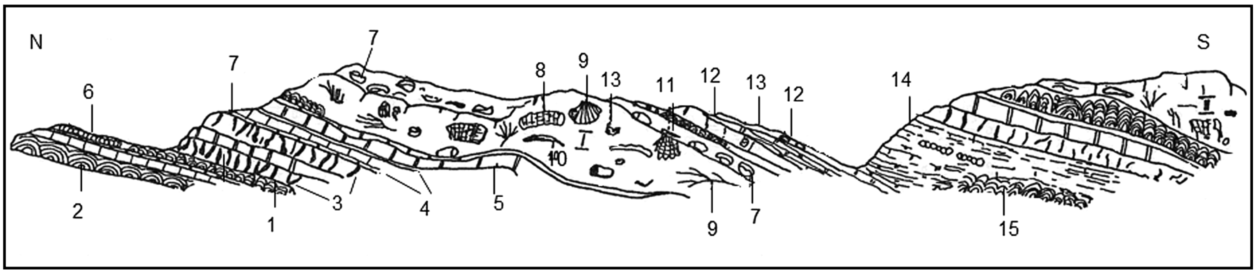

Figure 14. Panoramic sketch of the Upper Jurassic coral reef complex, showing the graded transition from the stromatolitic facies with sponges to that with corals (after Bărbulescu, 1974 and Bărbulescu, in Dragastan *et al.*, 1998). **1**, limestones with ministromatolites; **2**, limestones with megastromatolites; **3**, limestones with tubular voids; **4**, thin bedded dolomitic limestones; **5**, thick bedded dolomites; **6**, *Decipia topalensis*; **7**, brachiopods; **8**, massive colonial corals; **9**, branching colonial corals; **10**, lamellar colonial corals; **11**, cup shaped siliceous sponges; **12**, cylindrical sponnges; **13**, calcareous sponges (*Neuropora*, *Eudea*, *Corinella*); **14**, *Idoceras planula*, *I. laxevoluta*; **15**, *Terebratulina*, *Megerlea*, *Moeschia*.

income in the Site area could be selling of small souvenirs, replicas of the Late Jurassic fossils from the Topalu reef. The fossils from the site, as well as the limestone, represent local economic resources.

3.3.4. Vulnerabilities and threats to the Topalu Neo-Jurassic Reef Site

Easy public access in the site means vulnerability. An online article about ways to relax during the weekend says: "If you don't feel an artistic call for the weekend, you may have as an option the paleontological reserve East of Topalu, where you can admire the Neo-Jurassic corals." (Mălin Muşatescu, http://www.9am.ro/stiri-revista-presei/2007-02-22/topalu-pictura-cu-pesti.html). Like other geological sites from Dobrogea, the Topalu Neo-Jurassic Reef lacks a special infrastructure dedicated to the (geo)tourism activities (indicator signs, trails, guide, guard, etc.). This is the reason why unmonitored visits can have irreversible effects over time. This is, indeed, a threat to all paleontological sites. Harvesting of fossil material, climbing slopes and using tools to extract fossils, improvising fireplaces and throwing the waste all over, also represent threats to the site integrity, as well as pollution sources. Changing the landscape, by installing wind turbines near the site (emplacement of a wind power plant of 200 KW in locality Topalu, http://apmct.anpm.ro/proiecte_care_nu_se_supun_evaluarii_impactului_asupra_mediului_2011-20832), represent a major threat to the aesthetic value of the place, the visual impact of the turbines being felt at great distances.

3.4. Cernavodă Fossil Site, Geological Reserve

Cernavodă Fossil site, a Natural Monument, is located on the right bank of the Danube, at the southern edge of Carasu Valley, near the road bridge at Cernavodă. At the end of the nineteenth century, Toula (1893) published a note, which was resumed several years later, indicating, for the first time, a rich fossil fauna, collected from the Rasova-Cernavodă-Mircea Vodă section. He also included several new species, but as these have not been described, they remained *nomina nuda*. Paquier (1901), based on samples provided by Victor Anastasiu and coming from the Danube Bank at Cernavodă, describes a pachiodont fauna in which he had noticed a mixture of Upper Jurassic and Cretaceous species that he assigned to the Beriassian-Middle Valanginian.

3.4.1. General information

As already mentioned, the Cernavodă Fossil Site is included within the Canaralele Dunării Site of Community Interest (RO SCI 0022). The Fossil Site is located on the right bank of the Danube N 44°20'17", E 28°02'01"), in the county of Constanța, in the steppe biogeographic region of South Dobrogea. Within the SCI, the Cernavodă Fossil Site occupies an area of 3 ha only, being designated as a mixt nature monument, both geologic and paleontologic (Fig. 11). The site is in custody of Constanța Forestry Department.

According to the Natura 2000 Standard Form, the SCI area is 26,064 ha, with maximum altitude of 133 m (http//natura2000.mmediu.ro). Geologically, the fossil site belongs to the South Dobrogea tectonic block of the Moesian Platform, as part of its sedimentary cover.

3.4.2. Geodiversity values of the Cernavodă Fossil Site, Geological Reserve

The limestones from Cernavodă were studied by a number of prestigious geologists. Early research in the nineteenth century of the outcrops from the right bank of the Danube, between Rasova and Hârşova, can be found in the work of Boué (1837). Michael (1856) details remarkably the section between Rasova and Cernavodă, stating the presence of a series of "white limestone with numerous fossils", which he assignes to the Lower Neocomian. In 1865, the first micropaleontological study on the Senonian chalk from South Dobrogea is published by Reuss (Neagu, 1987). A complex geographical and geological study - a monograph - is published on Dobrogea (including its southern area) by Peters (1867).

Following the establishment of the Geological Bureau in 1882, the geologist responsible with the study of South Dobrogea included in his first work the Cernavodă section (Anastasiu,1896), where he stated the presence of the Neocomian based on paleontological evidence. Later, Anastasiu (1898) divided the Cretaceous deposits into two separate sequences: a lower sequence, exposed on the Danube bank and consisting of organogenic limestones intercalated with marls and sands with sandstone interbeds, assigned to the Neocomian – Aptian on the basis of fauna; an upper sequence of foliated marls, sandstones, clays, conglomerates and white chalks, assigned to Turonian – Senonian based on the fossil fauna. The late XIXth century is marked by the emergence of the "Elementary Course of Geology" by Gregoriu Ştefănescu, comprising the first geological map of Romania in colors, scale 1:2.000.000; on this map, the outcrops from South Dobrogea (Cernavodă, Alimanu, Lipnița, Ostrov-Bugeac), were assigned to the Upper Jurassic. In the 1898 edition of the course, a correction was made and the limestone series from Cernavodă-Rasova-Alimanu-Lipnița-Băneasa were assigned to the Lower Cretaceous.

In the XXth century, Simionescu (1906) studies the ammonites from Cernavodă. Macovei and Atanasiu (1934) perform a synthesis in which all litho - chronostratigraphical units of the Cretaceous deposits from South Dobrogea are detailed. Băncilă (1973) considers that the age of the zoogene limestone series from Cernavodă area is Berriasian - Valanginian – Hauterivian, abandoning the idea of the presence of the Lower Barremian in the Cernavodă – Medgidia area.

Neagu (1985) starts the detailed study of the entire Cretaceous foraminifera fauna of South Dobrogea, publishing a number of papers and collaborating with other authors (Neagu and Dragastan 1984; Neagu and Pană, 1995, Neagu *et al*., 1977, 1997) who have brought their own contributions to the geological research of South Dobrogea (Pană et al., 1975; Dragastan, 1978, 1995, 1999, 2001).

Considering the evolution and stratigraphic ranges of taxa of dasycladaceae algae and of the foraminifers from Alimanu quarry, Dragastan (1978, 1980, 1999), introduced a series of biozones with value of Assemblage zones, also describing several new species of algae in the Hauterivian - Lower Barremian range.

In their litho- and biostratigraphical synthesis of Jurassic and Cretaceous of the Moesian Platform and Southern Dobrogea, Avram *et al*. (1996) introduced and described new lithostratigraphical units, correlated with those described in the Bulgarian part of the platform.

Intrinsic value. Lithostratigraphically, the geological reserve Cernavodă Fossil Site belongs to the Lower Cretaceous Cernavodă Carbonate Formation (Neagu and Dragastan, 1984), as part of the Moesian platform sedimentary cover. The geological succession of the Cernavodă section, transgressive and unconformable upon the Lower Berriasian Zăvoaia Member of Amara Formation (Dragastan, 1995), starts with the upper Berriasian Hinog member (Dragastan, 1995) made of conglomerates, grey marly limestones, oosparites, sandy clays and limestones containing a gastropod fauna (*Harpagodes pelagi, Saulea neocomiensis* Pană) (Fig. 15). The Valanginian Alimanu Member of the Cernavodă Formation (Avram *et al*., 1988), transgressively and unconformably overlying the Hinog Member, is dominated by limestones. The lower Valanginian succession starts with brecciated marly limestones, followed by grey micritic limestones, whitish-yellowish oolitic limestones, limestones with *Nerinea* sp., marly clays, lenses of pachyodont limestones (*Matheronia baksanensis* and *M. valanginiensis* identified by Masse) and 3 levels of reefal buildups of patch-reef type (P-R 1, P-2, P-R 3), bioconstructed by demosponges. The P-R 1 reefal buildup is constructed by actinostromariids (*Disparistromaria tenuissima*) and varioparietid species (*Granatiparietes simionescui* Dragastan), as well as by arborescent species of milleporidiids (*Steinerella gigantea* and *S. loxola*). The reefal buildup is cemented by various types of lithoclasts and bioclasts and covered by an algal crust of *Lithocodium* and *Bacinella* (Dragastan, 1999). The P-R 2 reefal buildup is bioconstructed largely by arborescent colonies of *Steineralla neagui* Dragastan. Another important colonizer is *Barroisia anastomosans*. Atop the P-R 2 reefal buildup, the Lower Valanginian succession continues with micritic-pelmicritic limestones, accumulated as 1 m thick beds. The beds are bioturbated, suggesting that various organisms were crossing and filtering the carbonate muds. The surface of this accumulation shows ferruginous crusts with subvertical, branching bottle-neck perforations, corresponding to *Gastrochaenolites* ichnogenus (Dragastan *et al*., 1998) (Fig. 16). *Gastrochaenolites* gives important paleobatimetric and sedimentological information, indicating distal intertidal and proximal subtidal depositional environments (Koch and Stearley, 1987). The Lower Valanginian succession ends with a tabular reefal buildup (lower P-R 3), 10-15 m long and 2-3 m thick, with a core built by various species of *Actinostromaria, Steinerella, Steineria* or *Axiparietes*, seldom of scleractinian corals, surrounded by species of pachyodont bivalves (*Monopleura valanginiensis* and *M. baksanensis*), while on the margins *Ampullina* and *Nerinea* gastropods develop, covered by *Lithocodium* and *Bacinella* algal crusts (Dragastan *et al*., 1998).

The Upper Valanginian succession is again unconformable and transgressive, starting with a detrital sequence, with angular litho- and bioclasts of limestones, microconglomeratic gravels, overlain by thin oolitic sands, followed by pelsparitic limestones interlayered with clays and overlain by a massive reefal buildup (upper P-R3), 6-10 m thick. The core of reefal buildup consists of blade-slaped crusts of demosponges, surrounded by pachiodont shells (*Matheronia baksanensis*) and gastropods (*Nerinea, Purpuroidea, Leviathania, Harpagodes, Ampullina*, etc.), while coquina layers with *Ostrea germiani*, 20-25 cm thick, form the upper part of the buildup.

In the Valanginian deposits at Cernavodă, Simionescu (1906) and Andrăşanu (1993) described nectonic species of Nautiloidea of *Cymatoceras* genus (*Cymatoceras neocomiensis* and *C. Pseudoelegans*) (Dragastan *et al*., 2013, in press).

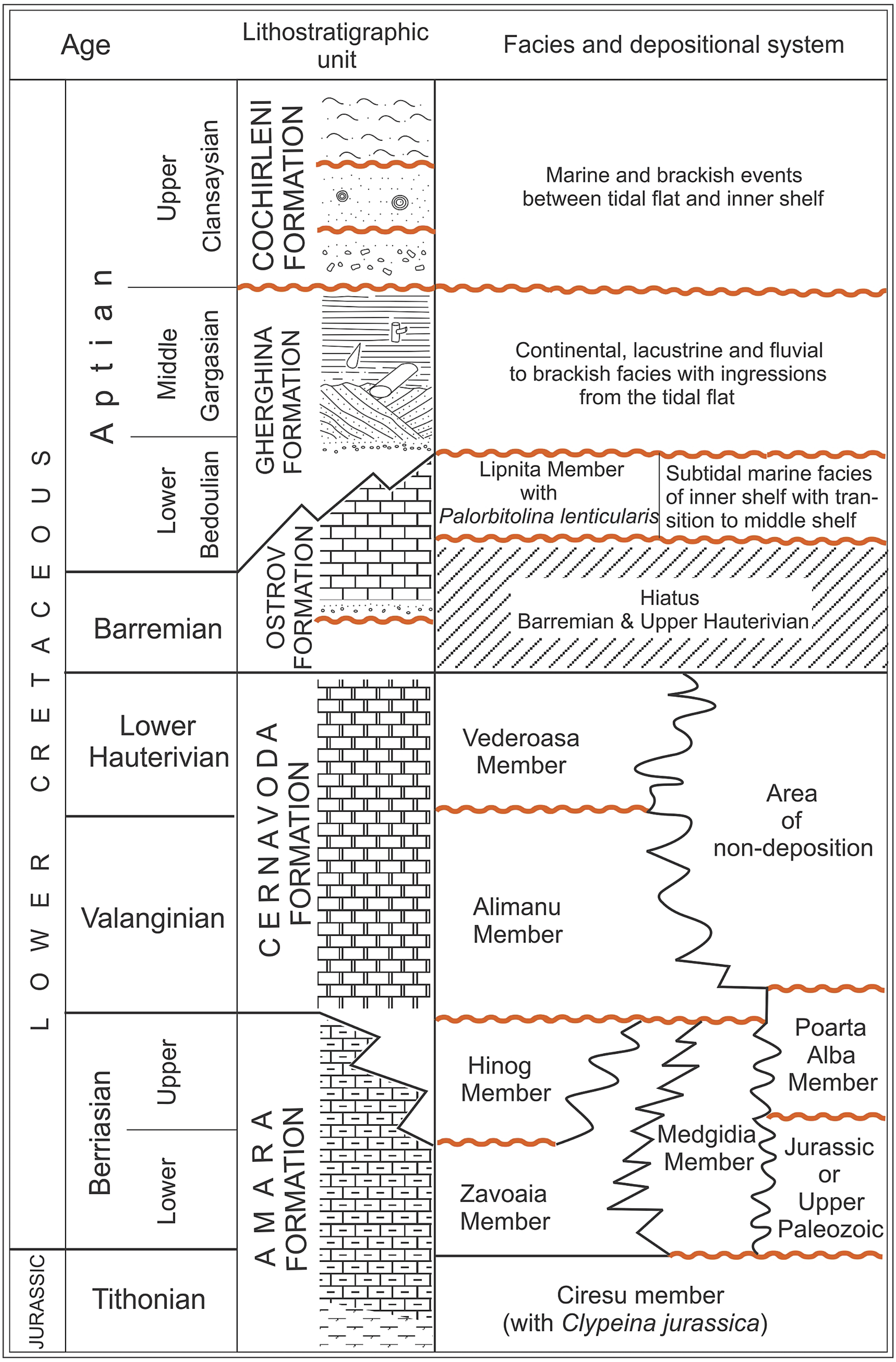

Figure 15. Lithostratigraphic log of the Cernavodă Formation (after Dragastan *et al.*, 2013).

Figure 16. Photograph of the Cernavodă outcrop, showing that *Gastrochaenolites* burrowing channels are disposed in horizontal plane; inset image (from Seghedi and Barbu, 2010) shows detailes of *Gastrochaenolites* burrows.

The Lower Hauterivian Vederoasa member of Cernavodă Formation (Dragastan, 1995), first identified within the lower Cretaceous succession SE of Aliman village, was later found within the succession at Cernavodă (Dragastan *et al*., 2013, in press). At Cernavodă, the Hauterivian is transgressive upon the Upper Valanginian, starting with oolitic limestones and sandy oolitic limestones with ostreid shells, followed by white-yellowish pelsparitic limestones and white-grey, seldom reddish, micritic limestones. The succession supports a reefal buildup of patch-reef type (P-R4), up to 2 m thick. The reefal buildup has a core of demosponges (*Granatiparietes simionescui* Dragastan, *Axipariets tremulus, Actinostromaria coacta, Steinerella neagui* Dragastan), while its flanks show *Lithocodium - Bacinella* algal crusts cementing the structure, together with bioclasts of sponges, algae and foraminifera. The Lower Hauterivian succession continues with oolitic limestones and variegated clays, interbedded with oolitic layers and is topped by white-yellowish clays interbedded with oolitic sands with *Ostrea* accumulations, followed by a small reefal buildup of patch-reef type (P-R 5), formed by the *Actinostromaria coacta* sponge.

The Lower Hauterivian deposits from Cernavodă are unconformably and transgressively overlain by the marine deposits of the Lower Aptian Lipnița Member (Dragastan *et al*., 1998) of the Ostrov Formation (Dragastan, 1985, emend Dragastan *et al*., 1998). Characterized by *Palorbitolina lenticularis,* they are covered unconformably by the Middle Aptian continental deposits of the Gherghina Formation (Avram *et al*., 1988), consisting of interlayered conglomerates, gravels, sands, kaolinitic clays rich in coal or in silicified wood (the latter discovered at Hinog by Neagu and Dragastan, during the field campaigns of 1974 – 1980). The Middle Aptian is transgressively followed by the Upper Aptian deposits of the Cochirleni Formation (Avram *et al*., 1988); this starts with conglomerates and gravels with shell debris, overlain by glauconitic sands and marly clays with phosphatized shells of ammonites, gastropods and bivalves (Chiriac, 1968, 1981, 1988).

Scientific value. Although the Type Section of the Alimanu Member is described in the deposits present on the territory of Alimanu locality (situated at about 20 km from Cernavodă), the Cernavodă Fossil Site is one of the few places in the country where a continuous succession of Lower Cretaceous deposits can be followed, especially the Lower and Upper Valanginian successions. Rich fossil fauna, consisting mainly of gastropods, bivalves, brachiopods, pycnodont fishes, sponges, hexacorals, foraminifers, algae and ostracods, as well as the identification of several species of nautiloids, like *Cymatoceras pseudo-elegans* (d'Orbigny), *Cymatoceras neocomiensis* (d'Orbigny) (Andrăşanu, 1993), place the Cernavodă Geological Reserve at the top of the richest fossiliferous sites in the country (Fig. 17) . Moreover, at the level of South Dobrogea, the Lower Cretaceous fossil fauna specific to the carbonate facies and estimated to contain more than 400 taxa (Dragastan 2009, unpublished data) is situated on a place close to that occupied by the Jurassic fossil site from Solnhofen, Germany, where more than 600 taxa were identified (Billy and Cailleux, 1969).

Economic and functional value. The natural capital of a region should represent a defining element in its development strategy. In the public document from 2008, "Local Development Strategy of the Cernavodă Town", revised version (http://www.primaria-Cernavodă.ro/Fisiere/Proiecte/Strategia/De/Dezvoltare Locala/Cernavodă/Revizuita.pdf), there is a specification on natural resources with potential for the town development (II.11.2): "The Fossil Site located 4 km south of the town is an area of 3 hectares on the Danube steep cliff. The place is considered a natural monument with both geological and paleontological significance and development projects located in its proximity should include protection measures and possibly valorization methods." Obviously, the public administration of the Cernavodă township understands that, besides the scientific value of the site, this also representsa an important economic resource. The same document stipulates that „improving the quality of the environment - protection and enhancement of the natural areas landscape" is one of the objectives for local development. Promoting the local geological features may stimulate geotourism, especially when it is done through the administrative structures of an area.

3.4.3. Vulnerabilities and threats of the Cernavodă Fossil Site, Geological Reserve

In addition to the beneficial effects on the local economy, promoting geodiversity of a protected site can attract threats alike. The vulnerability of the Cernavodă Fossil Site is high, taking into consideration the easy access to the area (A2 motorway, the Feteşti railway complex). Development of geotourism activities beyond those caused by fishing in the

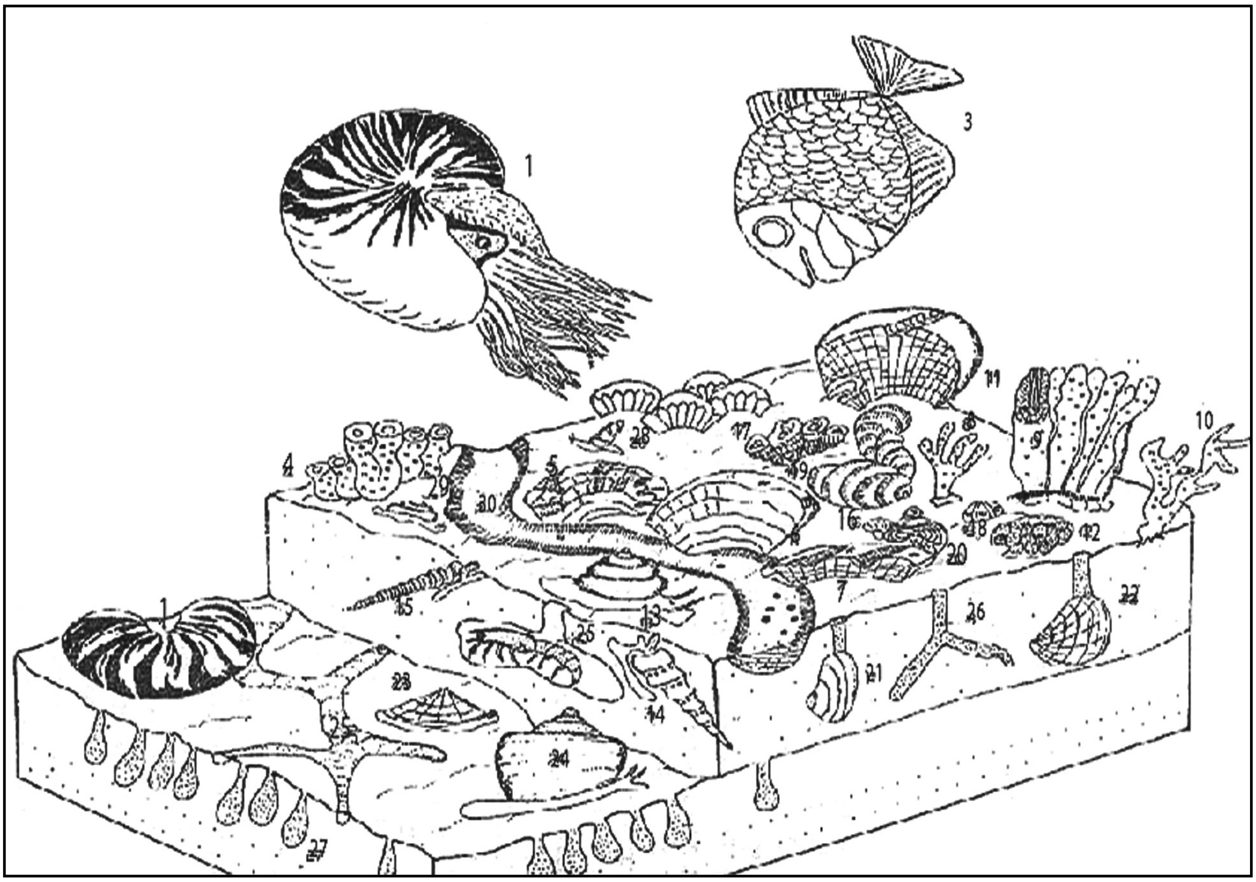

Figure 17. Reefal communities in the Valanginian Cernavodă Formation (after Dragastan *et al*., 1998). **1**, *Cymathoceras pseudoelegans* (Nautiloidea); **3**, *Coelodus* sp. (Pycnodonts); **4-11**, Spongia: **4**, *Barroisia*; **5**, *Actinostromaria regularis*; **6**, *A. cernavodensis*; **7**, *Siphostroma arzieri*; **8**, *Steinerella loxola*; **9**, *S. gigantea*; **10**, *S. neagui*; **11**, *Granatiparietes rumanus*; **12**, Hexacorals, *Styllina*; **13-15**, **23-24**, **28-29**, Gastropoda: **13**, *Pleurotomaria defrancei*; **14**, *Nerinea*; **15**, *Haustator gertrudae*; **23**, *Patella alta*; **24**, *Leviathania leviathan*; **28**, *Saulea neocomiensis*; **29**, *Nummocalcar ornatus*; **16**, **19-22**, Bivalvia: **16**, *Ostrea* sp.; **19**, *Monopleura valanginiensis*; **20**, *Matheronia bakssanensis*; **21**, *Panope* sp.; **22**, *Pholadomya neocomiensis*; **17**, Brachiopoda: **18**, Echinoidea – *Codiopsis lorini*; **25**, *Thalassinoides*; **26**, *Ophiomorpha*; **27**, *Gastrochaenolites* sp.; **30**, intrareefal channel.

Danube, given the lack of necessary infrastructure (walking paths, signposts, waste disposal sites, security, etc.) can irreversibly affect the site. The existence of fossils and the attraction they exert on those who visit the area is another threat to geodiversity of the Cernavodă Fossil Site.

3.5. Alimanu Fossil Site Geological Reserve

Presented in the book of Bleahu *et al*. (1976) as a paleontological reserve and proposed for protection in order to prevent the disappearance of the fossils by quarrying, the Alimanu Fossil site was declared protected initially by DCCC 425/1970 and subsequently by Law 5/2000.

3.5.1. General information

The Alimanu Fossil Site is a geological reserve included in the Vederoasa Lake SPA (RO SPA 0007). It is located southwest of Rasova, on the territory of the Alimanu Commune (N 44° 12 ,30", E 27° 54′ 25′) in the steppe biogeographic region of Southern Dobrogea, Constanța county (Fig. 18). The site is in the custody of Dobrogea - Litoral Water Directorate, Cernavodă Forestry District.

According to the Natura 2000 Standard Form, the site area is 2,104 ha, the maximum altitude is 156 m (http//natura2000.mmediu.ro/29/rospa0007.html). Within the SPA, the area of the Alimanu Fossil Site is 11,13 ha. From geological point of view, the site belongs to the eastern part of the Moesian platform cover exposed in South Dobrogea.

3.5.2. Quality and importance

According to the Natura 2000 Standard Form, the Vederoasa Lake SPA was declared a nature reserve by the Governmental Decision 2151/2004, being an extremely important site for migratory bird species (mainly pelicans and geese). During this period, over 20,000 such birds can be found here, the site being considered a possible RAMSAR candidate (http//natura2000.mmediu.ro). The datasheet also specifies the existence, within RO SCI 0007, of the Alimanu Fossil Site, geological natural monument, first declared protected by DCCC 425/1970 and subsequently by Law 5/2000.

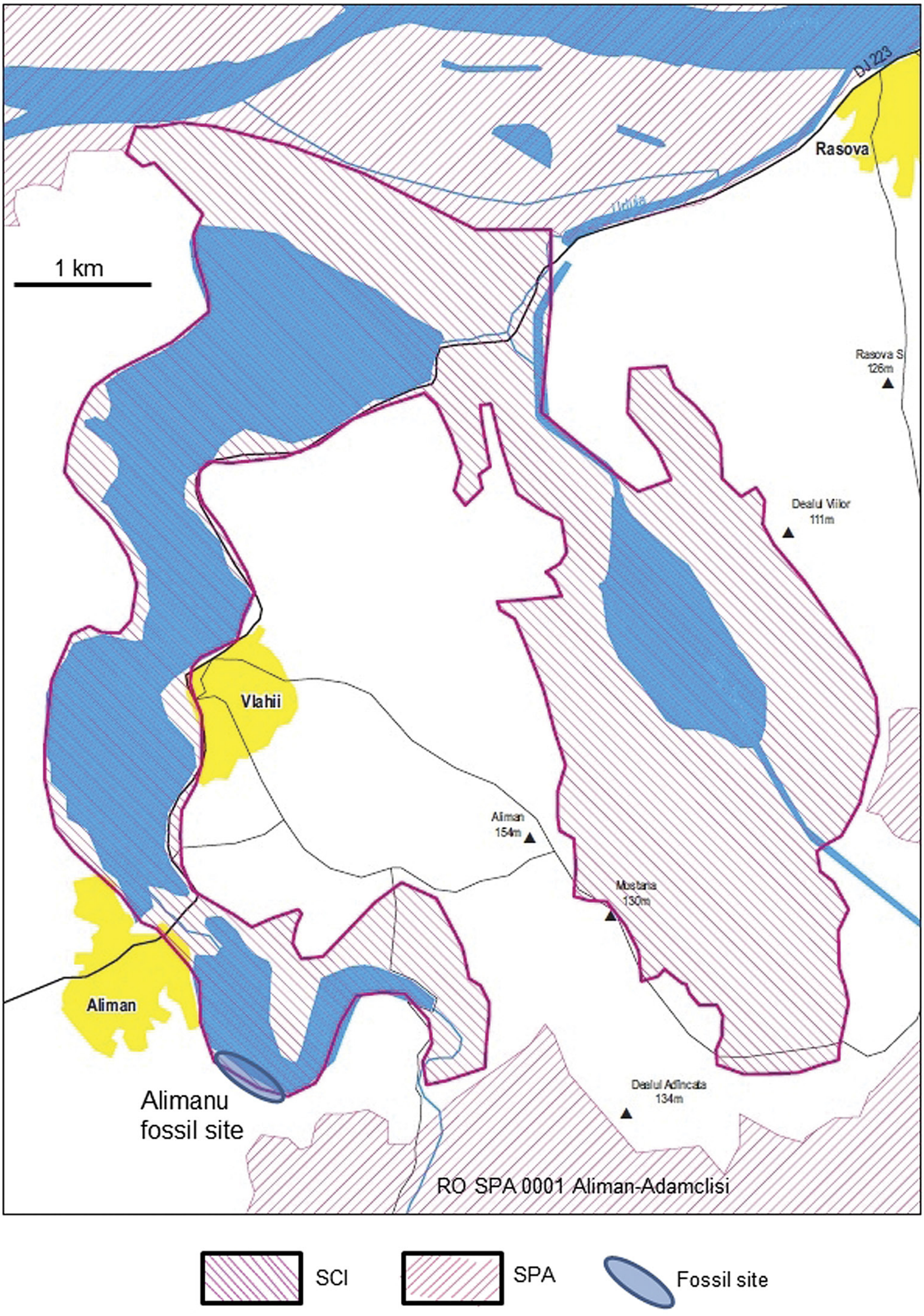

Figure 18. Location of the Alimanu Fossil site on the Vederoasa Lake RO SPA 0007 map (after the website of the Ministry of the Environment, http://natura2000.mmediu.ro/site/35/ rospa0007.html).

3.5.3. Geodiversity values of Alimanu Fossil Site, Geological Reserve

The carbonate deposits that outcrop in the Geological Reserve of Alimanu Fossil Site are part of the Cernavodă Formation. The type sections of the Alimanu Member (Valanginian) and of the Vederoasa Member (Hauterivian) were described here (Dragastan, 1978, 1980; Neagu and Dragastan, 1984; Neagu and Pană, 1995; Neagu *et al.*, 1997), the latter being transgressive and unconformable onto the Alimanu Member (Fig. 18). The succession of the Vederoasa Member is unconformably overstepped by the deposits of the Adâncata Member belonging to the carbonate Ostrov Formation (Lower Barremian) (Dragastan, 1985).

Intrinsic value. The Alimanu Fossil Site, listed as IUCN Category III, Natural Monuments, is a geological reserve essential for deciphering the paleobiogeography of the Lower Cretaceous carbonate platform areas from the entire Europe.

The lower part of Alimanu member starts with sands, gravels and clays containing limestone nodules, covered by oosparitic limestones (Fig. 19). The transgressive sequence of Hauterivian from the lower part of the Alimanu Member is followed by a sequence of argillaceous limestones with Pholadomidae, in life position (*Isognomon*, *Panope*, *Pholadomya*), rarely with Trigonid shells, interlayered with micritic and pelmicritic limestones, 10-20 cm thick. The sequence continues with a the patch reef – R5, built by Demosponges with massive, mamelon-like colonies (*Tosastroma magna*) or flebeliform collonies (*Axiparietes tremulus*) (Dragastan, 1978; Dragastan *et al*., 1998). The upper part of the Vederoasa Member consists of pelsparitic/oosparitic limestones few meters thick, characterized by the frequent presence of gastropods *Potamnicola cretacea, Cosmocerithium aureliae, Sycostoma vilersensis*, the terminal part of the sequence being characterized by interlayered clays with limestone nodules and yellow or reddish-brown clays.

Transgressively overlying various terms of the Cernavodă Formation, the carbonate-dominated Ostrov Formation consists of layered accumulations of pachiodont shells, sponges and coral reefs and orbitolinid coquinas. The Adâncata Member is the first subunit of the Ostrov Formation, unconformably and transgressively overlying the Vederoasa Member. In the Alimanu left side profile, the Adâncata Member (Lower Barremian in age) begins with reddened, detrital clays, reddish-yellowish pelsparitic limestones, oosparitic limestones and centimetric interlayers of yellow-reddish clays, alternating with tabular reefal buildups PT-R6. The latter are composed of semispheroid colonies of *Chaetetopsis zonata* and *Varioparietes lamellosus*, as well as from 10-20 cm thick coquina-type limestones, made of *Requienia renevieri, Requienia ammonia* and Harpagoside shells (*Bancilites*, *Derventites*). This sequence continues with yellow – reddish micritic and pelmicritic limestones, which close the lower series of the Member. The thickness of deposits ranges between 2-10 m, gradually decreasing southward. At Alimanu, the upper limit of the Adâncata Member is transgressive and corresponds to a discordant contact with the Miocene deposits.

Scientific importance. From scientific point of view, the geological diversity elements present in the area of Alimanu Fossil Site Geological Reserve (geomorphology, lithology or paleobiodiversity) are extremely important for the characterization of shallow water benthic ecosystems of the Lower Cretaceous carbonate platforms across Europe. The abundance of fossils in the limestone bodies from Alimanu, the size of some of them (especially gastropods) and their state of conservation have a great scientific importance, both nationally and internationally, this site representing one of the few places in the country where we can follow continuously the Lower Cretaceous stratigraphic succession, from Valanginian to Hauterivian and Lower Barremian stages. The Valanginian sequence contains two patch-reefs (P-R3 and P-R4), built by sponges like *Actinostromaria cernavodensis*, *Siphostroma*, *Granatiparietites rumanus* (Simionescu) Dragastan, along with scleractinian corals, assemblages more or less similar with the builder organisms from Cernavodă section (Fig. 19).

Aesthetic value. The natural landscape specific to Alimanu area fits into the overall landscape of South Dobrogea, characterized by the alternation of flat hills with wooded slopes, or planted with vines, and wide valleys with vertical slopes, mirrors of water and large marshy areas, belonging to the Danube lakes. All these create a unique landscape and a great potential for tourism. The aesthetic value of the Fossil site itself refers mainly to the beauty of its fossils (Fig. 20).

Economic and functional value. In the chapter dedicated to tourism development prospects of the area, the Local Economic and Social Development Strategy of Alimanu for 2007-2013 (http://www.primaria-aliman.ro/documente/Strategia.pdf) specifies that among other categories of tourist attractions, the Alimanu Fossil Point is „... another point of interest within the village ...". Beyond this statement, we should mention that, along with agrotourism and ecotourism, geotourism is indeed a very important economic resource, not only for Alimanu, but for the entire territory of South Dobrogea (Aniţăi, 2012). Relatively small distances between points of geological interest favor the organization of regional geological trails. Such trails can include visits to archeological sites and discuss the rocks from local sources used in the building of sites or as ornamental stones. Correlated, accommodation services can be developed in small agro-tourism guest houses and souvenir shops. The existence of the limestone was an exploitable economic resource in former quarries at Alimanu. Today the stone is mined only by locals, for domestic purposes.

3.5.4. Vulnerabilities and threats to Alimanu Fossil Point Geological Reserve

Beyond the natural erosional process, the prospects of tourism development in the area, given the lack of clear measures of Site protection, represent a threat to geodiversity of the Alimanu Fossil Point. The abundance and size of some of the fossils, urges the visitor to so-called "fossils hunter".

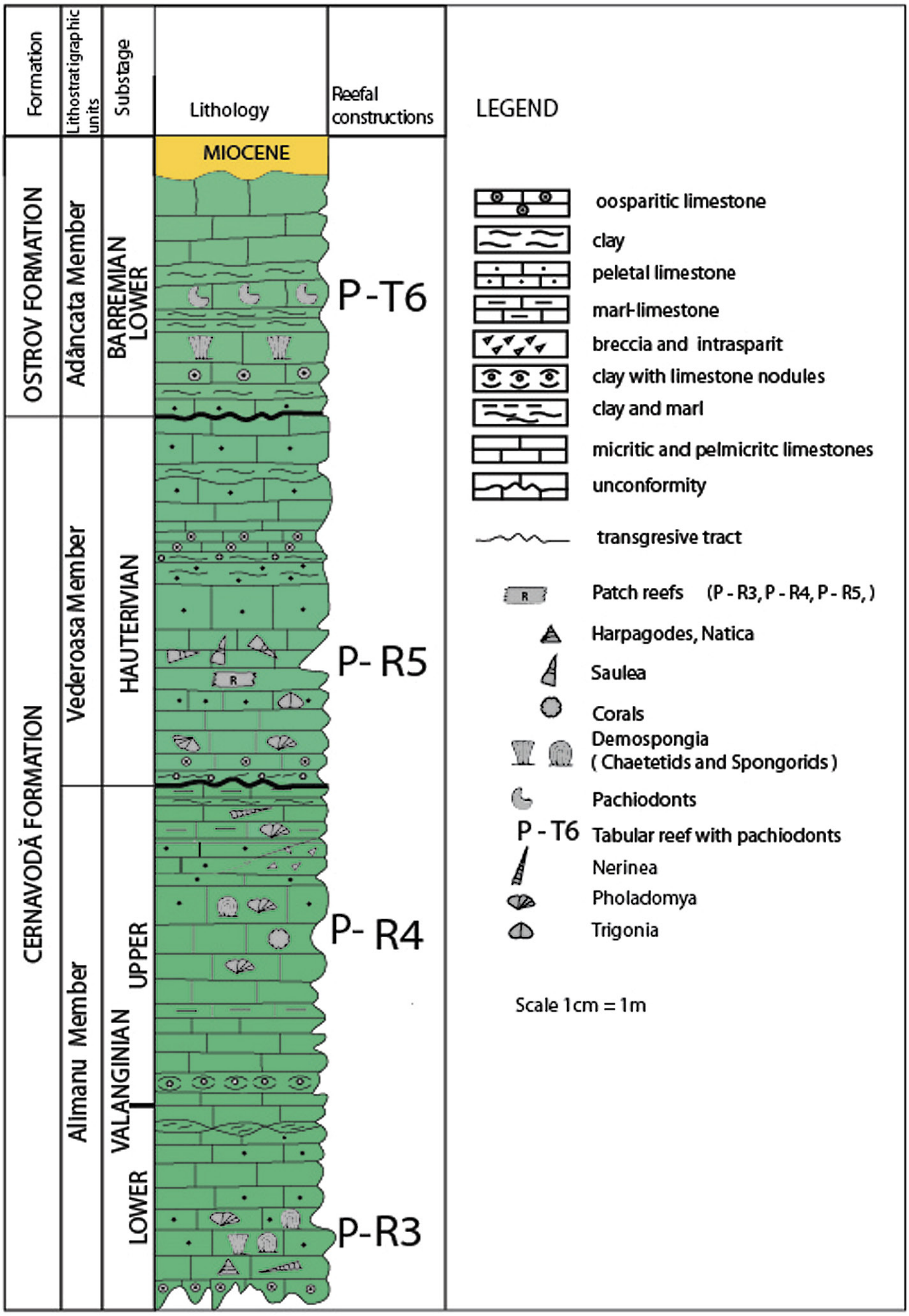

Figure 19. Lithostratigraphic log of the Alimanu fossil site in the left side outcrop (redrawn after Dragastan, 1978, 1980, 1985 and Dragastan *et al*., 1998).

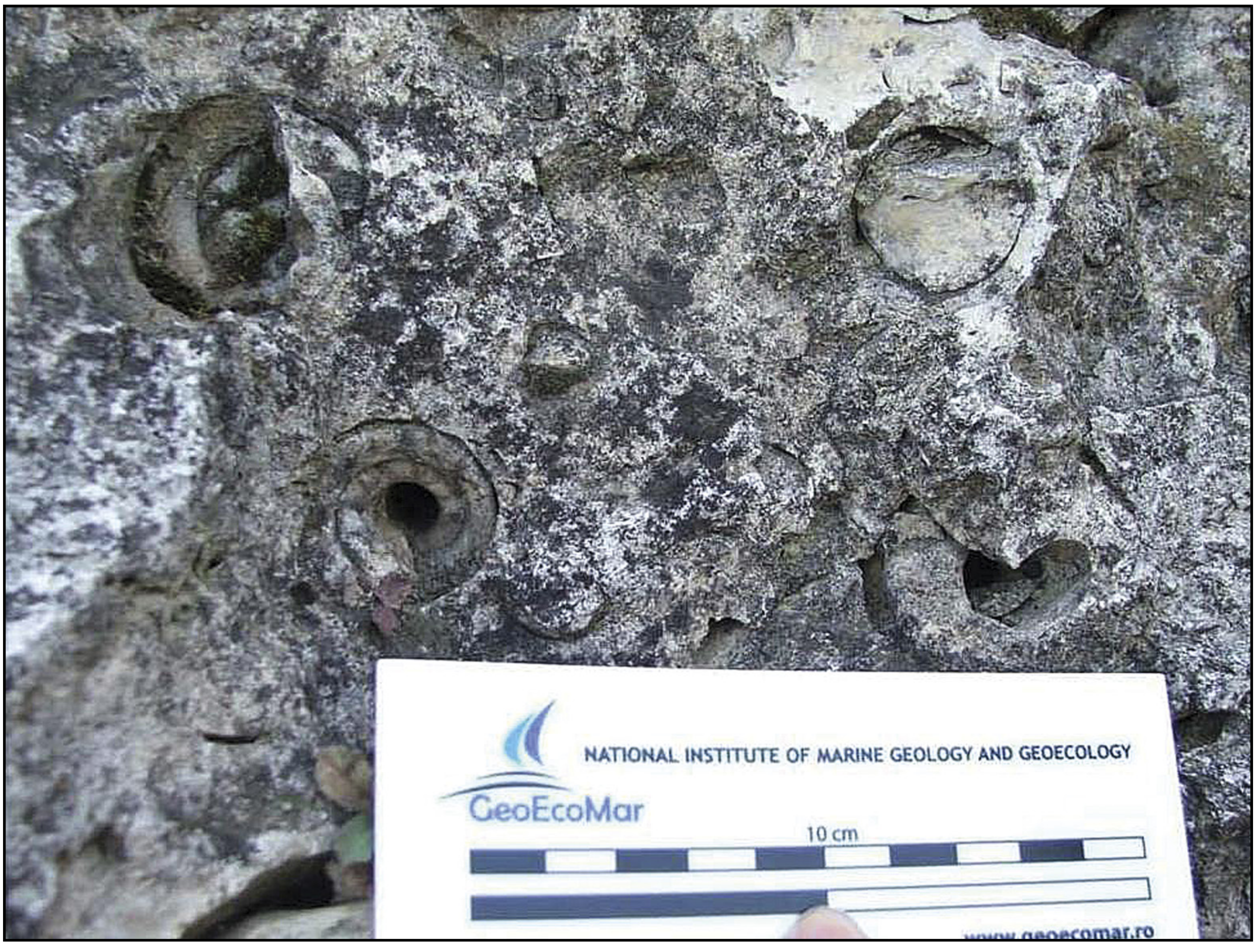

Figure 20. Fossil fauna (mainly gastropods) in limestones from the Alimanu site.

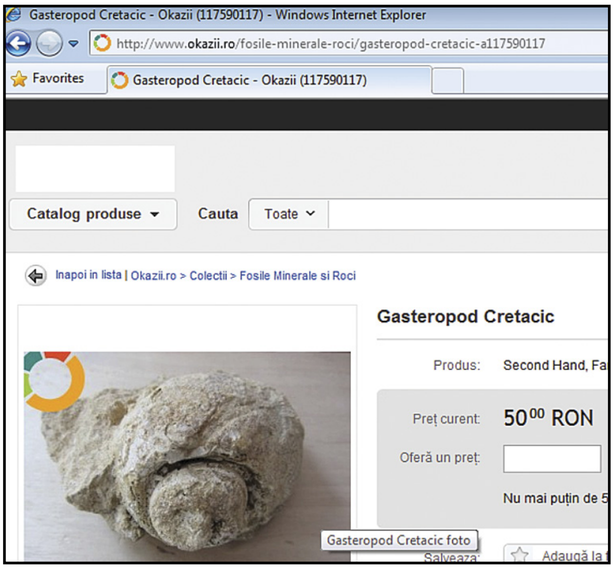

Figure 21. „Cretaceous Gastropod, Dobrogea, 12/9 cm", description of a gastropod fossil sampled from the Cretaceous deposits of Dobrogea and sold on the internet (www.okazii.ro).

This phenomenon cause irreparable damage to the affected sites. Desire to discover and to acquire the biggest fossil involves, among others, very destructive techniques (using of blunt objects, electric hammer type, etc.). Other effect is the loss of other several hundreds of fossils, insignificant for the"collector", but extremely valuable for geodiversity. Another major threat is the sale of fossils from the site (Fig. 21).

4. GEOCONSERVATION AND GEODIVERSITY MANAGEMENT OF THE GEOLOGICAL RESERVES FROM DOBROGEA

Geoconservation is a measure or a set of measures that a civilized society should apply to protect the natural abiotic elements, threatened by the huge variety of human activities (Gray, 2004). Considering the Romanian legislation referring to protected areas (Law 5/2000, Law 49/2011, GEO 57/2007, GEO 154/2008, Order 135/2012, HG445/2009, GEO 195/2005, Law 265/2006, Order 1964/2007, GD 1284/2007, Government Decision no. 230/2003, Government Decision no. 2151/2004, Order 1948/2010, GD 1581/2005, GD 1143/2007, Order 135/2010, Commission Decision of 12 December 2008, the Order 410/2008) and the list of threats to geodiversity presented for each geological site, we can see that, in most cases, the situation is similar: the lack of indicator panels or information points, information materials of any kind (flyers, brochures), trails, security, camping and waste storage places, guided tours, in other words, the lack of any planning, supervision, promotion or administration methods. To this we should add the anthropogenic intervention in the landscape by quarrying of stone and placing of wind turbines. According to the Natura 2000 Standard Forms for the steppe bioregion, published on the website of the Ministry of Environment and Forests, Management Plans were not developed so far for any of the examples discussed in this paper. The management of a protected area involves the elaboration of such a plan that should provide, for sites including geological reserves and monuments, but not only, the application for geodiversity of similar methods of assessment and conservation as for the biodiversity.

However, in the absence of management plans, custodians are required to provide the Ministry with action plans for the site. In fact, one of the requirements of the Order 1948/2010 (related to the Methodology of assignment of the management of the protected natural areas that require the establishment of administrative structures and of those that do not require such structures) stipulates that, in the action plan of the custodians of protected areas, "...ways of inventorying and monitoring of biodiversity and *geodiversity* ..." must be included.

As an example, the custodian of the Agighiol Hills SCI applied in 2011 for European structural funding in order to elaborate the management plan. The project implementation started in August 2012 and various promotional materials will be elaborated by the end of November 2012, materials that need to be distributed to stakeholders in the Tulcea County, including local authorities, local communities, schools, local businesses. By the end of the project, in 2014, panels will be emplaced in the site area and trails will be marked.

Known, especially in the British literature, under the name of Geological Audit (Geoaudit) (Gray, 2004), this aims at detailed analysis of the state of specific geological resources of an area, in the idea of establishing an action plan to support and promote their conservation. Geoaudits address and try to involve local authorities, educational institutions, financial institutions, organizations involved in nature protection, etc., in the activity of inventorying of the existing geological heritage and in establishing the relationship between it and local biodiversity, culture and tradition. The utility of a geological audit for geodiversity conservation of some areas (in this case the geological reserves from Dobrogea) resides in the fact that knowing the state of geological elements at a specific moment in time, it can help to set up sustainable management measures for them. Knowledge of local geodiversity condition (even when it is that of a protected site) can help to lay the foundations of an Action Plan on Geodiversity. Such a plan shall provide all necessary resources starting with human capital, financial, scientific resources, IT resources, promotion methods, methods of dissemination of information and all the necessary cooperation for long-term monitoring of geodiversity of the site. Development of such local plans, and their integration into a national network, could help to set the foundation of a National Action Plan on Geodiversity.

Signer of the Declaration of the Digne, France, 1991 and member of the European Association for the Conservation of Geological Heritage (ProGEO), listed in the UNESCO's Geoparks Network (with the Hațeg County Dinosaur Geopark), Romania has good premises regarding the integration into European trends of geological heritage protection, among other countries such as Poland, Italy, Switzerland, Spain, UK, Northern countries, etc.

Anyway, for the moment, Romania is dealing with two major issues: lack of legal framework and lack of funds. Even if the premises are good, the persons who are involved in geological heritage protection (custodians, ProGEO members, or any other individuals interested in nature protection) can resume only to simple inventories of the geological sites, because a national network of institutions preocupied by geoconservation and monitoring of the geological heritage is still missing. And, of course, in Romania, besides the university level, there is no real geological education in order to protect and conserve such an important heritage.

5. EDUCATION AND PROMOTION OF GEODIVERSITY OF PROTECTED SITES

An essential element for geoconservation and geodiversity management is public awareness. Promotion of geodiversity of the geological sites is more than necessary, in order to increase the public interest in geodiversity, in appreciation of its values and in understanding the need to protect it.

Thus, the geodiversity of the geological sites can be promoted through a series of activities organized directly in nature, such as tours or thematic camps. The purpose of such actions, which can be addressed including to adults, is to introduce basic notions of geoconservation. For the geodiversity of Dobrogea, a good example is the "Junior Ranger" camp, organized in 2010 by Association GeoD for promoting geodiversity (www.ageod.org), in partnership with the "George Banea" Elementary School in Măcin and the Măcin Mountains National Park. During this four days camp, one day was dedicated to the geology of the Măcin Mountains National Park and of the private protected site of Suluk Regia. This day, the students collected samples, learned to distinguish several types of rocks in the park, learned about the advantages brought by quarries for the local community, as well as the disadvantages they represent for the protected areas and for the landscape. In the evening, the students worked in teams and presented posters on concepts they learned about geology during the day. The next step would be, following the example of the European Geoparks Network (Andrăşanu, 2010), the development for each protected area of textbooks dedicated to the local natural heritage, textbooks that could be accepted in the school curricula, even as optional courses.

Museums play an important role in promoting geodiversity. Through temporary and permanent exhibitions (in case of nature history or geology museums), information on the components of geodiversity, its value, threats and protection methods can be transmitted in a way easily understandable to the general public (Seghedi and Nailia, 2010; Saint Martin *et al*., 2010). The artistic expression of the fossil world is easier perceived by the general public and the art of fossils is superbly illustrated in the sketches with elaborated symmetry of Haeckel (1904).

An exceptional exhibition, entitled „Fossil Art", belongs to Professor Dolf Seilacher of the University of Tübingen, Germany. In 2008, this temporary exhibition was displayed at the National Museum of Geology (Seghedi and Nailia, 2010). The exhibits represent casts of fossils and traces of their biological activities (traces of movement, feeding, burrowing, etc., *i.e.* trace fossils), exceptional both in size and preservation quality, that have, at the same time, an exceptional aesthetic value. Traces were collected from outcrops worldwide, some from the national parks or geoparks. The exhibition is based on the idea that fossils can represent both objects of knowledge, as well as aesthetic objects, pleasing the eye and as an example that fossil traces can be seen as works of art (Seilacher, 2008).

The multidisciplinary exhibition „Dobrogea Between Land and Sea - the Imprint of Time and Man" (2012-2013), accomplished in 2012 by several institutions in Bucharest (the Institute of Archaeology of the Romanian Academy, National Museum of History, Institute of Marine Geology and Geoecology – GeoEcoMar, Institute of Speleology "Emil Racoviță", the University of Bucharest) and Dobrogea (Eco-Museum Research Institute Tulcea, Museum of National History and Archaeology Constanța), in collaboration with paleontologists from the Museum of Natural History in Paris, under the patronage and the sponsorship of the French Embassy in Bucharest, is such an example. The geological part of the exhibition, dedicated to geoheritage, geodiversity, geoconservation, provided concrete examples of protected geological sites in Dobrogea (Agighiol Hills, Cheia Jurassic Reefs, Movile Cave). The exhibition illustrated, in a way easily understandable for the public, the geological evolution of Dobrogea, based on the paleobiodiversity evolution in four moments of geological time: the Late Precambrian (Ediacaran), the Early-Middle Triassic (Fig. 22), the Late Jurassic (Fig. 23) and the Sarmatian. In the same exhibition, a module consisting of pencil drawings, entitled „Lost Landscapes" reconstructed, in the author's imagination, the sequences of the environments in six moments in the history of life in Dobrogea: Silurian, Middle Devonian, Permian, Triassic, Lower Cretaceous and Sarmatian (Fig. 24). The Agighiol fossils served as inspiration to illustrate the Triassic seascape of this module.

Another way to promote geodiversity in museums is by organizing educational workshops dedicated to children, as well as conferences for the general public. Worth mentioning are the workshops initiated and organized by the National Museum of Geology since 2006: „The Dinosaurs Era", „Before and After the Dinosaurs"; summer schools like „T-Rex's Workshop", „Gold Diggers" as well as programs for schools at the museum (Seghedi and Nailia, 2010). The conferences for the general public were also initiated in the National Museum of Geology simultaneously with the "Earth Science Week" event, carried out in October, during 2006-2008.

In Bucharest, conferences on geological themes were introduced at the National Institute of Geology and Geoecology – GeoEcoMar since 2009, on the occasion of the "Earth Science Week" event and had continued with geological conferences on various topics: "GeoEco Israel, or life on a continental plate margin", "The Blue Schist of the Aegean Belt", "Iceland – between Pluto and Neptune", etc. (www.geoecomar.ro).

The „Geoparks Week", an event dedicated to geodiversity and biodiversity in protected areas, was organized in 2007 at the National Museum of Geology (Seghedi and Nailia, 2010). Unfortunately, the museum does not organize this event anymore, and although some national parks in Romania are organizing it every year, the part regarding the geodiversity has been lost.

Another method for promoting geodiversity of a site consists in establishment of information points or centers in the city halls, schools, or within protected sites. Research institutions and universities also have an important role in promoting geodiversity of geological sites from Romania, through dedicated research projects, or by organizing national and international conferences, trips and camps for domestic and foreign students and scientists. Instead, Geoparks play an important role in fostering geological heritage through geotourism and educational activities. Currently, in Romania there are four geoparks: the Haţeg Country Dinosaur Geopark (part of the European Geopark Network) and a national Geopark – Mehedinți Geopark; for Buzău and Perşani Geoparks, no governmental decisions were issued so far.

All the actions presented for public awareness regarding the existence of geodiversity in general, and of geodiversity of the geological sites, in particular, must be accompanied and supported by adequate informative campaigns on different media (requiring special funds): presentation posters, banners, brochures, flyers, folders and presentation CDs, guide books, monographs, radio and TV commercials or written articles (in magazines and newspapers), along with personalized items such as caps, pens, T-shirts, backpacks, mugs, etc.

6. CONCLUSIONS

Along with biodiversity, the geodiversity of the geological sites from Dobrogea is very rich. It has intrinsic and extrinsic values (scientific, economic, aesthetic, functional, etc.). It is threatened naturally by erosion and artificially by human intervention. But as the rate of erosion (measurable in hundreds and millions of years) is much slower than the fast anthropogenic changes, various types of activities undertaken

Figure 22. Mural pannel from the travelling exhibition „Dobrogea, between the land and sea, the fingerprint of time and man", illustrating an imaginary limestone bed rich in ammonoids from Dealul Pietros, Agighiol. The pannel was exposed at the National Museum of Geology, Bucharest, starting with 18-th of May 2012.

Figure 23. Pop-up illustrating the Cheia geological reserve from the travelling exhibition „Dobrogea between land and sea – the fingerprint of time and men", opened in September 2012 at the Archaeology and History Museum in Tulcea.

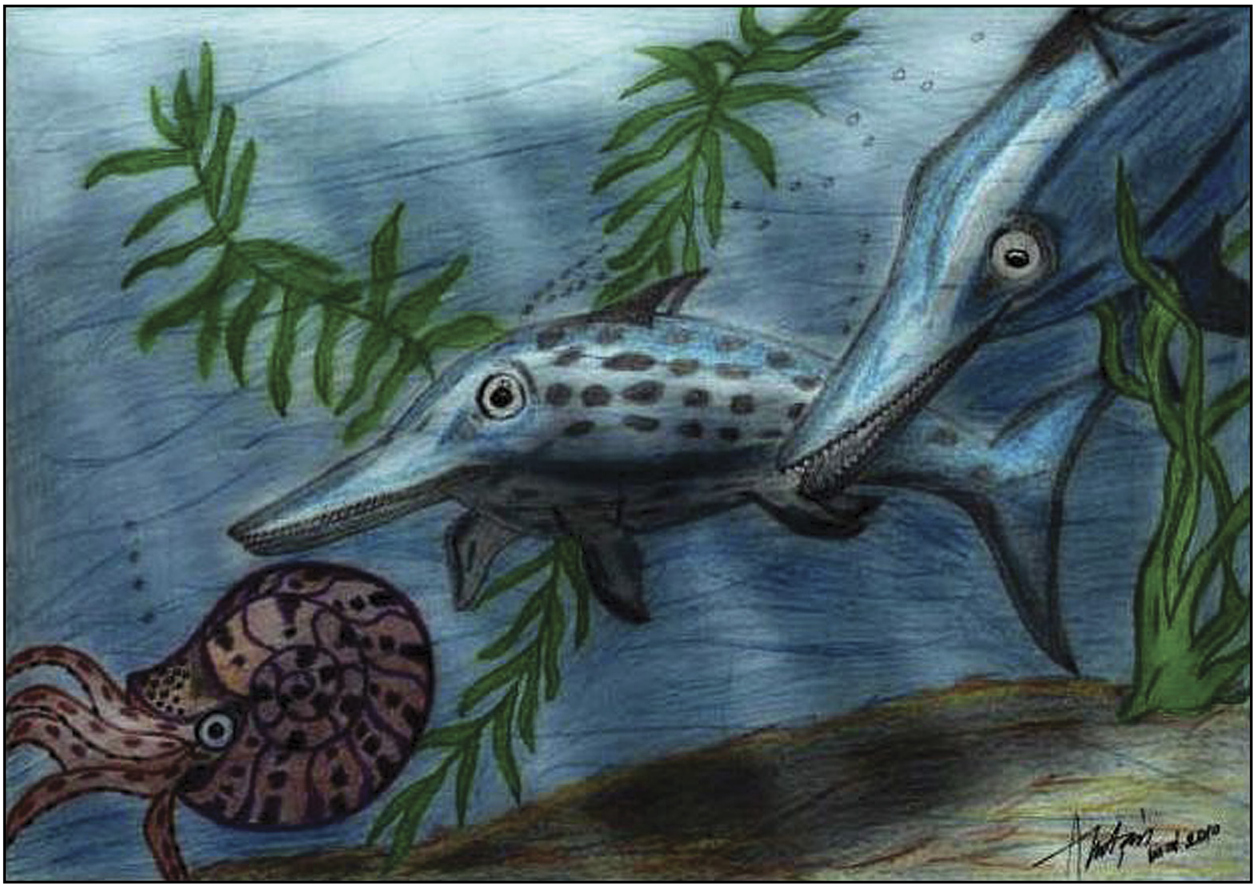

Figure 24. *Agighiol in Triassic* - drawing by Nicoleta Aniţăi included in the module „Dobrogea – Lost Landscapes" of the travelling exhibition „Dobrogea between land and sea – the fingerprint of time and men".

by humans on economic purpose or for leisure can produce, in a very short period of time, destructive effects on geodiversity. The correct geoconservation methods to be taken can be determined only after an updated inventory of the geological capital of the sites is done, as well as after determining the vulnerability degree of each site. Today, the term of geodiversity is found in the Romanian legislation and it is recognized at European level through organizations, such as ProGEO.

Along with the development and implementation of Management Plans by authorities and institutions managing protected sites, to the extent that these documents will take into consideration both biotic and abiotic natural components, there are prerequisites that signs and certain infrastructure are necessary in order to develop a sustainable geotourism. If this happens, besides a direct relation with nature, visitors could learn a lot about a protected site, its value and vulnerabilities.

Although it was not mentioned on any of the lists of threats, lack of knowledge is, probably, the greatest threat to geodiversity and biodiversity. Public ignorance, eloquently illustrated by images from the protected geological sites that become in summertime real tourist refugee camps, leaving behind mountains of garbage and doubtful artistic expressions of graffiti type on rock surfaces, all these destroy, slowly but surely, nature as a whole. Education to increase public awareness on geodiversity has started in places, but it is a long process to change mentalities and the results are not easily seen. Such educational activities started several years ago, but there is still a long way to go in order to create a geological culture among the people of Romania, as long as geology is not taught in schools anymore.

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