Journal of *Marine Science and Engineering*

MDPI

Communication

On the Duality of Marine Geoheritage: Evidence from the Abrau Area of the Russian Black Sea Coast

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Abstract: Marine geoheritage is an important but still underdeveloped concept. Field investigations in the Abrau area (Krasnodar Region, southwestern Russia) and subsequent interpretations allow for the characterization of its geoheritage. Two geosites, namely Abrau and Limanchik, are delineated and assessed semi-qualitatively. Their high heritage value, complexity, and appropriate "technical" properties are appraised. The Abrau geosite features Abrau Lake with its enigmatic origin and the outcrops of deformed Upper Cretaceous carbonate flysch deposits. The Limanchik geosite represents an outstanding example of coastal abrasion, Paleocene siliciclastic flysch with trace fossils, and a coastal lagoon separated from the sea by a bar. The heritage aspects of the study areas are related to the development of the Late Cretaceous, Paleocene, and Pliocene seas, as well as to the active dynamics of the Black Sea coastal zone. The duality of marine geoheritage is linked to its relation to both ancient and modern marine environments.

Keywords: coastal zone; deep-marine setting; geosites; Paleocene; Northwestern Caucasus

Citation: Ruban, D.A. On the Duality of Marine Geoheritage: Evidence from the Abrau Area of the Russian Black Sea Coast. *J. Mar. Sci. Eng.* **2021**, *9*, 921. https://doi.org/10.3390/jmse9090921

Academic Editor: Gary Wilson

Received: 5 August 2021
Accepted: 24 August 2021
Published: 24 August 2021

1. Introduction

Investigations of geological and geomorphological heritage (geoheritage) have become an important direction of research among international geosciences, with an accumulation of significant amounts of diverse knowledge [1–7]. However, many particular aspects of geoheritage are yet to be fully understood. One of them is the concept of marine geoheritage—a category which sounds particularly evident, but too vague. Coratza et al. [8] and Rovere et al. [9] focused on underwater geoheritage. Li et al. [10] demonstrated the relevance of geoheritage to marine parks. According to Gutak et al. [11], marine geoheritage comprises unique features linked to dynamics, and thus geological forces of ancient and modern oceans and seas. Additionally, Chiba et al. [12], Peng et al. [13], and Vescovo et al. [14] paid attention to pollution, waste accumulation, and related conservation in the Mariana Trench, which seems to be a global geoheritage feature due to its outstanding depth. Generally, it appears that more evidence from various (terrestrial, coastal, and submarine) localities is necessary to further develop the concept of marine geoheritage.

The Abrau area in the southwestern part of Russia hosts several notable manifestations, which contribute to the understanding of marine geoheritage. This area represents the Black Sea coast along the Northwestern Caucasus. It belongs to a nationally important tourist destination and boasts both natural [15–17] and cultural [18,19] heritage. Aspects of the Abrau area's geoheritatge have already been reported by Baraboshkin et al. [20], Karpunin et al. [21], and Ruban [22], but without any in-depth assessment. Nonetheless, these preliminary studies have prepared the way to establish a better framework for subsequent investigations. The outcomes of the field studies aimed at a geoheritage inventory for the Abrau area help to characterize related features. Not only general descriptions, but semi-quantitative assessment is also possible. The outcomes of these new studies also provide valuable information for discussion of the concept of marine geoheritage. The objective of the present paper is to give the first systematic characteristics of the Abrau area's geoheritage, with a focus on its most important manifestations, namely geoheritage

sites (geosites) and their relevance to the concept of marine geoheritage. More generally, this paper makes a contribution to the literature by emphasizing marine geoheritage as a specific geoheritage category, which is highly important, but still poorly conceptualized. The Abrau area is used as a reference locality for testing the related ideas and methods.

2. Geological Setting

The study area is located on the northeastern coast of the Black Sea bordering the northwestern edge of the Greater Caucasus mountain chain (Figure 1a). The latter is a late Cenozoic orogen, the origin of which is related to a collision between the much larger Eurasian lithospheric plate to the north and the smaller Arabian plate in the south [23–27]. Mesozoic and Cenozoic sedimentary packages crop out widely there, and these are often deformed due to ongoing orogenesis and earlier phases of tectonic activity. These packages formed in a series of back-arc basins (Figure 1b), which evolved on the wide northern periphery of the Neo-Tethys Ocean until its final re-organization [23,26–28].

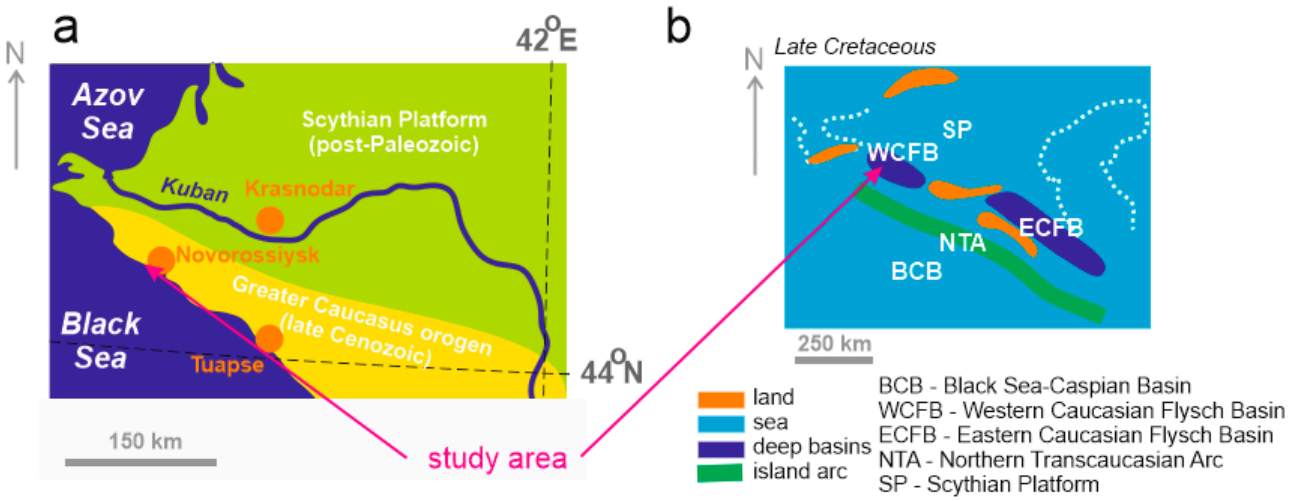

Figure 1. Location of the study area and the principal tectonic elements: (**a**)—present, (**b**)—Late Cretaceous (partly based on the information from [28]).

The Abrau area is a mountainous domain with elevations up to 500 m above sea level. It is situated west of the large city of Novorossiysk (Figure 1a). Administratively, it belongs to the Krasnodar Region of the Russian Federation. The characteristic geographical elements consist of Abrau Lake and the Black Sea coastal zone (Figure 2). Its northern part is occupied by the urban zone of Abrau-Dyurso, and its central and southern parts are actively exploited for the purposes of tourism and outdoor recreation, with many related facilities (camps, lodges, etc.). The slopes of short mountain ranges are covered by forests or used for the purposes of the wine and recreation industries.

The local geology is reviewed by Baraboshkin et al. [20], Kropotkin [29], Ruban [22], and Trikhunkov et al. [30,31]. The Abrau area occupies the southwestern periphery of the Northwestern Caucasus, which is the edge of the Greater Caucasus orogen. It is dominated by flysch deposits, namely Upper Cretaceous (Campanian–Maastrichtian) carbonate flysch with alternating limestones, marlstones, sandstones, and siltstones (the total thickness is >2000 m), and Paleocene (Selandian–Thanetian) siliciclastic flysch with alternating sandstones, siltstones, and rare marlstones (the total thickness is >1000 m) [20,22]. Upper Cretaceous carbonate flysch dominates the northeastern half of the study area, and Paleocene siliciclastic flysch forms its southwestern part (Figure 2). All deposits are strongly distorted by tectonic forces, often exhibiting high-angle dipping. These deposits are exposed in small tectonic blocks between numerous late Cenozoic faults trending from the northwest to the southeast. The regional plate tectonic reconstructions [28] imply that both flysch packages formed in the central part of the same Western Caucasian Flysch Basin,

which evolved through the Late Cretaceous–Paleocene (Figure 1b). This basin was relatively small, and it occupied the western part of the present orogen between the Northern Transcaucasian Arc in the south and the Scythian Platform (the southern element of the Russian Platform) in the north. This basin subsided actively, and it was rather deep (up to 3 km). It was occupied by a semi-enclosed, marginal Caucasian Sea, which was warm (tropical conditions), with normal salinity, and populated by abundant marine invertebrates [32]. Marine life is evident from trace fossils reported locally from the Upper Cretaceous [20] and the Paleocene [22]. The Cretaceous–Paleogene transition is marked by a hiatus [20], which can be explained by a short-term episode of tectonic uplift. In the second half of the Cenozoic, the uplift of the Greater Caucasus and some other mountain chains in the neighboring domains resulted in the development of the Paratethys Sea with a complex configuration; this sea existed until the very end of the Cenozoic, including the Pliocene, and the modern Azov, Black, and Caspian seas can be judged its remnants [33–36].

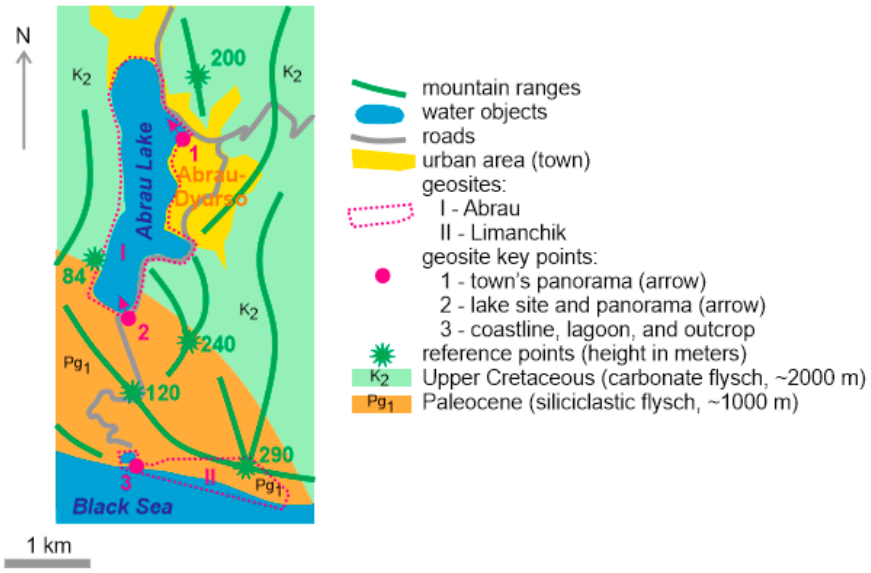

Figure 2. The Abrau area and its geosites.

3. Methodology

The present study is based on field investigations in the Abrau area with subsequent interpretations of observations, descriptions, and photographs. The original field research and the earlier preliminary studies [20–22] contributed to the establishment of the Abrau and Limanchik geosites (Figure 2).

Geoheritage studies balance methodologically between natural and social sciences. These studies need not only fact-based judgments and semi-quantitative analyses, but also qualitative (even philosophical) interpretations and individual researchers' vision. These approaches are mixed because geoheritage is a both objective (real geological objects) and subjective (people's interpretation of these objects). The present study follows the basic principles of the "standard" geoheritage-related studies, the outcomes of which are published in professional international journals (for instance, [37–39]).

From various methods of geosite-based geoheritage assessment [40–43], the new approach by Ruban et al. [44] was employed. To avoid repetitions from the previous work, this method is explained below only briefly. Nonetheless, the novelty and the innovativeness of this method should be stressed, as it differs from the approaches proposed earlier [7,40–43]. This method aims at being more comprehensive, less subjective, and independent from national (cultural, economical, etc.) contexts, particular situations, and regional traditions of geoconservation experience. It has previously been employed only once (and in an extremely different situation) [44], and thus, to deserve wide application, it

needs testing in several reference localities from the different part of the world. Moreover, its suitability to documenting marine geoheritage is documented.

Each geosite is examined to underscore its uniqueness. The uniqueness is defined as a spatial rarity of particular features (this may be physical rarity, but also rare possibilities for studying any particular phenomenon, its standardization, or teaching any aspect of the Earth's evolution). For instance, if a given mineral is found in the only locality of the country, but it is known from many localities of the other countries, its national uniqueness is amplified. Similarly, if the only section from the given region represents any particular episode of the geological history, but similar sections are available in the other regions, this is example of regional uniqueness. When a given geosite includes two and more notable features, the uniqueness is established for each of them and the uniqueness of the entire geosite is equal to the biggest uniqueness of its features. Evidently, such a basic valuation requires perfect geological and/or geomorphological inventories of geosites. Undoubtedly, uniqueness is an essential category for understanding and valuing geoheritage, although it is rather subjective (it depends on our current geological knowledge, society attitude to geoheritage, and the researcher's ability to argue higher or lower value of a particular feature). Nonetheless, its analysis can be undertaken objectively via documenting the relative distribution of the particular class of potentially unique features. In this study, the uniqueness is treated in three steps. First, descriptions of potentially unique features found in the Abrau area are provided. Second, the spatial rarity of these features is checked in qualitative manner. Third, this information is tabulated for better, scientifically sound representation in order to facilitate establishing scores specified in Table 1.

The other, "technical" ("supplementary") geosite properties of geosites are also documented. These may either increase or decrease the basic geoheritage value. A scoring system has been proposed to take these properties into account and to assess geosites semi-quantitatively (Table 1). In rare cases, the "technical" properties can increase or decrease the geosite's value so much as to shift it to a higher or lower rank, respectively. In any case, geosites with a higher total score are more valuable than the others. Judgments on aesthetic properties are always difficult and highly subjective. For the purposes of the present study, some basic ideas offering the broad understanding of these properties and their relevance to geoheritage [45–47] are applied. In particular, the aesthetics are not restricted to only color properties or availability of spectacular views, but these also refer to sounds, openness, identity, etc.

Each geosite within the Abrau area is delineated to embrace the plot occupied by the related features. Justification of this task is facilitated by employing satellite images from the "Google Earth". As these geosites are rather large, their key points, which are ideal for visiting, observing, and understanding their heritage, are specified on the basis of the observations in the course of field investigations. The idea of such points has been introduced, particularly, by Ruban et al. [48]. Landscape panoramas are essential for the comprehension of geoheritage, and thus, viewpoints (sensu [49–53]) are distinguished within the above-mentioned key points.

Table 1. Criteria of geosite assessment (based on [44]).

Criteria (Properties)	Subdivisions	Scores
Basic valuation		
Rank/Uniqueness	Global (planetary)	+500
	National (country-scale)	+250
	Regional (provincial)	+100
	Local (area-restricted)	+50
Amendments depending on "technical" properties		
Number of geoheritage types	>10	+50
	4–10	+25
	2–3	+10
	1	0
Accessibility	Easy in populated area	+25
	Easy in remote area	0
	Difficult	–25
Vulnerability	No danger	+25
	Potential danger	0
	Partly damaged	–25
	Fully destroyed	–50
Need for interpretation	Absent	+25
	Basic geological knowledge required	0
	Professional geological knowledge required	–10
	Scientific analysis required	–25
Scientific importance	International	+25
	Local	0
Educational importance	International	+25
	Local	0
Touristic importance	International	+25
	Local	0
Aesthetic properties	High	+50
	Medium	+25
	Low	0

4. Results

4.1. The Abrau Geosite

The Abrau geosite is congruent with Abrau Lake (Figure 3), which dominates the northern part of the study area (Figure 2). This elongated lake has a length of ~2.6 km, width of ~600 m, depth of ~10 m, and area of ~1.6 km^2 [20]. It is one of the biggest lakes of the Northwestern Caucasus, and its geological uniqueness is linked, first of all, to its enigmatic origin. Two hypotheses have been proposed [20] and are both highly popular among both tourist guides and experts. On the one hand, it is possible that the former valley of a small river was dammed by a giant landslide, which may have been triggered by seismic activity along a local fault system. This hypothesis is generally plausible, but one should note the presence of mountain ranges to the south of the lake, which surround the latter and are larger than any natural dam. On the other hand, this lake could be a remnant of the former Pliocene marine basin, which was separated by uplifted ranges. This hypothesis is supported by the presence of not only freshwater, but also a brackish water ichthyofauna in the modern lake [20]. Nonetheless, there may be alternative explanations of how fish could populate the lake (for instance, bird transport cannot be excluded). Additionally, one should note the presence of a spectacular outcrop of Upper Cretaceous flysch on the lake's northern shore (Figure 3a). These rocks exhibit rhythmic accumulation of carbonates in the deep Western Caucasian Flysch Basin during the Campanian–Maastrichtian (Figure 1b). This sedimentary package experienced significant tectonic stress (probably related to the

late Cenozoic orogeny), and the rocks demonstrate a pattern of almost vertical dipping (Figure 3b). These qualitative descriptions form basis for judgments of spatial rarity of the potentially unique features of the Abrau geosite (Table 2). Some related explanations are also provided below, together with the geoheritage type characteristics.

Figure 3. The Abrau geosite: (**a**,**b**)—views from the town's promenade lakefront, (**c**)—panoramic view from the southern coast. Arrows indicate views towards north.

Table 2. Features of the Abrau geosite.

Features	Spatial Occurrence of Similar Features	State of Uniqueness
Abrau Lake	The only lake in Russia with such hypothesized relations to the nearby sea => National uniqueness	Specific geographical setting, debated origin, possible geological catastrophe of the Past
Outcrops of Upper Cretaceous carbonate flysch	Widely distributed in the NW Caucasus outside the study area (although this may be the only lakeshore exposure) => Local uniqueness	Record of deep marine basin of Campanian–Maastrichtian age with rhythmic sedimentation
Tectonic deformations	Widely distributed in the NW Caucasus outside the study area => Local uniqueness	Cenozoic tectonic deformations linked, probably, to the orogen growth
A single, most important reason to judge the entire object unique	Enigmatic lake–sea relationships in the late Cenozoic history of a growing orogen (this object demonstrates complexities of near-marine lake formation due to various possible geological forces in the uplifted areas and pitfalls of scientists to solve the problem of lake origin; no analogues in Russia)	

The Abrau geosite can be assigned to three geoheritage types (Table 3) related to the potentially unique features (Table 2). Although the flysch outcrop indicative of the local Late Cretaceous palaeogeography and the Cenozoic tectonic deformations is of only local importance due to the availability of the similar objects on the adjacent areas (e.g., [20]), the lake itself represents a hydro(geo)global phenomenon, which is rare on a country-wide scale [21]. The debatable origin of the lake, involving catastrophic scenarios, contributes to its uniqueness. The highest rank is national, and thus the entire geosite can

be judged to be of national value. The latter is not challenged by "technical" properties (Table 4). Although this geosite boasts only three geoheritage types, it is highly accessible because a road stretches along its eastern coast (Figure 2). Vulnerability of this geosite is linked to the possible fall in lake level due to anthropogenically induced changes in the water balance in an actively exploited recreational zone. A negative factor is the need for professional interpretation—ordinary visitors without geological knowledge and additional explanations will see the only a beautiful lake, whereas their attention should be turned to its enigmatic origin and the above-mentioned scenarios. Although Abrau Lake serves chiefly for local research, education, and tourism, it boasts exceptional aesthetic properties due to spectacular panoramic views (Figure 3a,c), clean water, and the sound of solitude.

Table 3. Geoheritage types in the geosites of the Abrau area (see text for details).

Geoheritage Type	Geosites (Rank/Uniqueness Is Indicated)	
	Abrau	**Limanchik**
Stratigraphical	-	Local
Palaeogeographical	Local (MA)	National (MA)
Tectonic	Local	Local
Sedimentary	-	Regional (MA)
Geomorphological	-	Local (MP)
Engineering	-	Local
Hydro(geo)logical	National (MA)	Local (MP)
TOTAL	3 types, the highest rank—national	7 types, the highest rank—national

Note: the relations to the ancient marine (MA) and present marine (MP) environments are marked.

Table 4. Scoring the geosites of the Abrau area (see text for details).

Criteria	Geosites	
	Abrau	**Limanchik**
Rank/uniqueness	+250	+250
Number of geoheritage types	+10	+25
Accessibility	+25	+25
Vulnerability	0	+25
Need for interpretation	–10	–10
Scientific importance	0	0
Educational importance	0	0
Touristic importance	0	0
Aesthetic properties	+50	+25
TOTAL	325 (National rank not changed)	340 (National rank not changed)

The Abrau geosite is relatively large, and its limits coincide generally with the coastline of Abrau Lake (Figure 2). Two key points can be proposed. The first of them is located on the wide promenade lakefront of Abrau-Dyurso (Figure 2). It offers a panoramic view of the northern part of Abrau Lake (Figure 3a) and, particularly, the outcrop of Upper Cretaceous carbonate flysch (Figure 3b), i.e., it allows an enjoyment of all geoheritage types of this geosite. The second key location is at the very southern edge of the lake (Figure 2), from where a spectacular panorama of the lake and the surrounding mountain ranges can be viewed from the road (visitors can also stay on a narrow lake shore or even swim in the lake) (Figure 3c). Both of these proposed key spots are essentially viewpoints (sensu [50,52]).

4.2. The Limanchik Geosite

The Limanchik geosite corresponds to the Black Sea coast in the southern part of the study area (Figure 2). It embraces a narrow (usually <20–30 m) strip between the coastline and the extremely tall (up to 250 m) cliff, with a length of ~1.5 km. Various phenomena are exhibited at this spot (Figure 4). These include the modern rocky shore with a cover of cobbles and boulders and active abrasion, the extensive outcrops of tectonically deformed Paleocene flysch representing siliciclastic sedimentation in a deep basin (Figure 1b), and a small lagoon called Limanchik or Maly Liman, which is separated from the Black Sea by a bar. Waves from the open sea bring saline water to this lagoon during severe winter storms. Some other notable features also should be pointed out. The most important is the occurrence of trace fossils in a particular horizon of the flysch (Figure 4c). The *Ophiomorpha rudis* ichnosubfacies established there gives this locality outstanding national importance [22]. Together with other evidence, it puts a focus on turbidite sedimentation on the basin slope. Another feature is linked to slope processes on the cliff, where gravity causes frequent dislodgements and even full-scale rockfalls. The coincidence of abrasion-linked and gravity-linked destruction of the parent rocks with subsequent formation of the mixed sediment at the cliff toe seems to be characteristic of this rocky shoreline (Figure 4c). The triangle-shaped cliff is an interesting landform, which points to a complex relationship between coastal evolution and the geological structure. These qualitative descriptions form the basis for judgments of spatial rarity of the potentially unique features of the Limanchik geosite (Table 5). Some related explanations are also provided below, together with the geoheritage type characteristics.

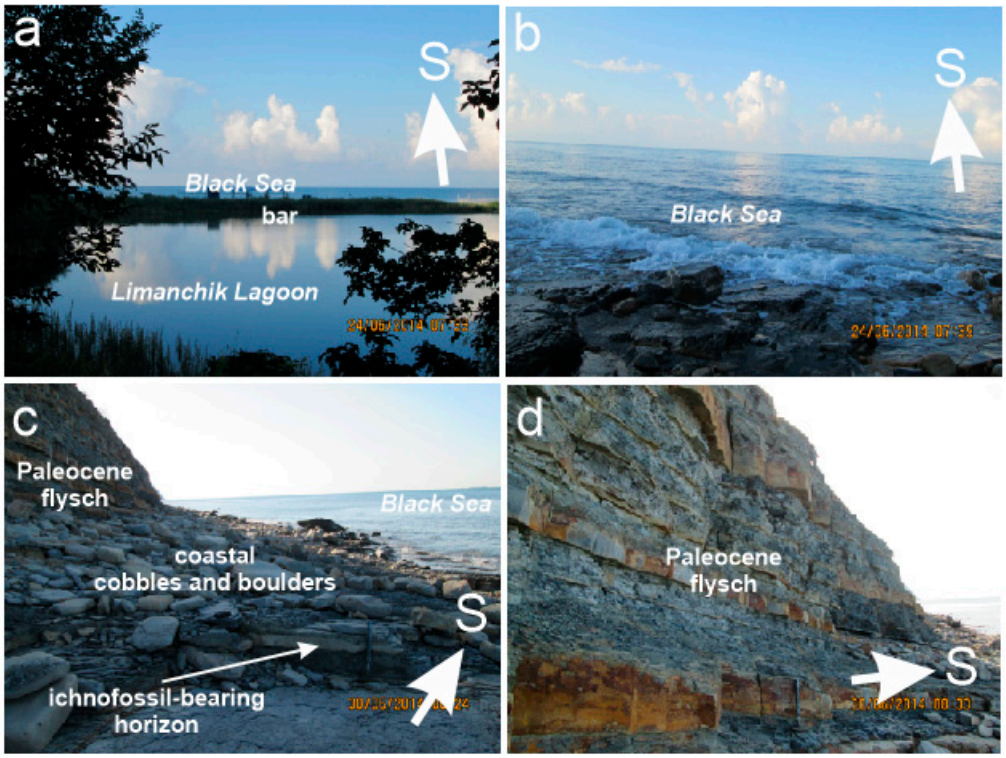

Figure 4. The Limanchik geosite: (**a**)—lagoon, (**b**)—coastline, (**c**)—shore and ichnofossil-bearing strata, (**d**)—cliff outcrops. Arrows indicate views towards south.

Table 5. Features of the Limanchik geosite.

Features	Spatial Occurrence of Similar Features	State of Uniqueness
Outcrops of Paleocene siliciclastic flysch	The study area provides the best record of the Paleocene deposits in the NW Caucasus, similar deposits may be found in the other, remote regions of Russia => Local to regional uniqueness	Local record of deep marine basin of Paleocene age with turbidite sedimentation
		Local Paleocene reference section
		Regional occurrence of siliciclastic flysch
Tectonic deformations in Paleocene siliciclastic flysch	Widely distributed in the NW Caucasus outside the study area => Local uniqueness	Cenozoic tectonic deformations linked, probably, to the orogen growth
Trace fossils	The first (and, probably, the only) locality of this kind => National uniqueness	*Ophiomorpha rudis* ichnosubfacies
Coastline	Similar shores are known from the other areas of the NW Caucasus => Local uniqueness	Modern rocky shore with a cover of cobbles and boulders and active abrasion
Triangle-shaped cliff	Similar cliffs can be found in the other areas of the NW Caucasus => Local uniqueness	Unusual shape related to geomorphological processes in a specific geological setting
Limanchik lagoon	A few water objects of this kind can be found on the Russian Black Sea (although this may be the only lagoon of this kind on the rocky shore) => Local uniqueness	Clues to the understanding of the present coastal dynamics and the past position of the shoreline
A single, most important reason to judge the entire object unique	Reference section of the Paleocene siliciclastic flysch with a highly specific trace fossil assemblage (this object provides essential information for the understanding of the Paleocene deep-marine environments and bottom life; no analogues in Russia)	

The Limanchik geosite can be assigned to seven geoheritage types (Table 3), which is indicative of its significant complexity. These types are related to the potentially unique features (Table 5). The palaeogeographical type is linked to an interpreted depositional environment of Paleocene flysch and, first of all, to the trace fossil evidence (see above). This is among the first localities of the noted ichnosubfacies reported from Russia [22]. One should take into account the novelty and international research importance of these ichnosubfacies [54]. The sedimentary type is ranked regionally: although the rocks of Paleocene flysch taken separately are extremely common rocks on all scales, the siliciclastic flysch is a rather rare feature at the scale of the Northwestern Caucasus [20]. The other types are ranked locally because although they represent notable features, are quite common in the other areas of the Northwestern Caucasus. The stratigraphical type is linked to the reference section of the Paleocene deposits, the tectonic type is linked to the rock deformation (most probably, late Cenozoic) and exposure of small fault planes, the geomorphological type is linked to the coastal cliff and the dynamics of the coastal zone (including bar development), the engineering type is linked to the slope processes, and the hydro(geo)logical type is linked to the presence of the above-mentioned small lagoon. The highest rank is national, and thus the entire Limanchik geosite has national value. The latter is not challenged by the "technical properties" (Table 4). This geosite comprises seven geoheritage types, which contributes to its overall value. Its accessibility is excellent. Visitors can reach it via a road leading from the Abrau Lake to the permanent recreational and educational camp of a big university near the Limanchik lagoon (Figure 2). Some of these visitors may be accommodated in this camp. Careful examination of the geosite has not revealed any factor of danger to its preservation in its natural state (the rocks are relatively hard for occasional ichnofossil damage). However, understanding the local geology needs professional support. The depositional environments of Paleocene flysch, the trace

fossils, and the origin of the lagoon should be explained properly, which requires specific knowledge. The scientific, educational, and touristic importance is undisputable, but it is local. Nonetheless, it should be noted that the above-mentioned camp is actively used for the summer field practice of university students in the Earth sciences. As for aesthetic properties, these are judged as moderate. On the one hand, the coastal panoramas are spectacular (Figure 4a,b), and the sharp-layering of siliciclastic flysch (Figure 4d) matches the attractive striped pattern [52]. On the other hand, the rocks and the shore deposits look grey, the panoramas are extremely common to the Black Sea coasts, and the geosite's openness is restricted due to a narrow shoreline. The Limanchik geosite is smaller in size than the Abrau geosite, but the former also occupies a rather large plot (Figure 2). The only proposed key point is located in a well accessible place between the lagoon and the western edge of the cliff (Figure 2). Staying there, a visitor can comprehend all geoheritage types of this complex geosite and, particularly, observe the lagoon and the bar (Figure 4a), the coastline (Figure 4b), the ichnofossil-bearing horizon (Figure 4c), and the cliff with Paleocene siliciclastic flysch (Figure 4d). This key point is well accessible, and it comprises the feature of the natural rock outcrop and the dynamic coastal environment. However, the entire geosite cannot be restricted to only this key point because it should embrace the entire lagoon and the entire Paleocene section stretching far eastwards (Figure 2).

4.3. The Abrau Area

The semi-quantitative assessment addressed to the two geosites of the Abrau area (Table 4) implies that their values are comparable, if even the value of the Limanchik geosite is greater than that of the Abrau geosite (due to its higher complexity and lower vulnerability). Both geosites are ranked nationally. Generally, this means that the geoheritage value of the entire Abrau area is relatively high.

It appears to be highly important that both geosites and the proposed key points are fully accessible. Moreover, they are located along the principal roads (Figure 2). This means that the geoheritage of the Abrau area demonstrates significant connectivity, which is also facilitated by the availability of viewpoints. Notably, the road between Abrau Lake and the Black Sea coast crosses the landforms, comprehension of which is important to realize either lake damming or lake separation from the former marine basin (both are mere popular hypotheses), i.e., this connection is essential for the geoheritage interpretation.

5. Discussion and Conclusions

Appraisal of the Abrau area's general geoheritage is worthy on its own account, but attention should also be paid to its relevance to the concept of marine geoheritage. In the case of the Abrau geosite, two of three geoheritage types are related to a marine theme (Table 3). The hydro(geo)logical feature (the lake itself) demonstrates such a relation because of the debated origin of the lake. As explained above, one plausible hypothesis relates this object to the former, Pliocene marine basin [20]. The palaeogeographical feature (Upper Cretaceous carbonate flysch) represents particularly deep-marine depositional environments of the ancient Caucasian Sea, which impacted the study area in the Mesozoic–early Cenozoic [32]. In the case of the Limanchik geosite, four of seven geoheritage types are related to a marine theme (Table 3). The sedimentary and palaeogeographical features (the Paleocene siliciclastic flysch and the trace fossils) indicate deep-marine depositional environments and the nature of bottom life in the Caucasian Sea. The geomorphological and the hydro(geo)logical features (the shore with abrasion processes and the lagoon) represent a modern, highly dynamic coastal environment of the Black Sea. The noted relations of these unique features to a marine theme resonate with its value to the general geoheritage of the Abrau area. A duality of this relationship can be noted as follows. On the one hand, there are features representing the ancient (Late Cretaceous, Paleocene, and Pliocene) marine environments. On the other hand, some features represent the modern coastal environment (although this environment is transitional, its direct connection to the

marine basin is evident). This duality can be documented not only in general (as earlier noted by Gutak et al. [11]), but also within the same area and even within the same geosite.

A relationship both to the ancient and modern marine environments is a characteristic aspect of marine geoheritage. This category refers to the essence of geoheritage, i.e., the entity of unique features. The previous indications by Coratza et al. [8], Li et al. [10], and Rovere et al. [9] stressed that geoheritage can be related to the marine theme through not only its essence, but also form. This means that marine environments host geoheritage value, irrespective of whether it represents unique ancient/modern marine features. This is a submarine (underwater) form of geoheritage, which can be judged on the basis of submarine geosites depending on their location. The other form is when geoheritage (not necessarily marine by its essence) is included in sea-based geoparks or other marine protected areas. It appears that the development of marine protection and increase in the efficacy of marine management [55,56] would facilitate geoconservation. Evidently, the noted forms should not be mixed with the idea of marine geoheritage to avoid uncertainty and misinterpretations (Figure 5).

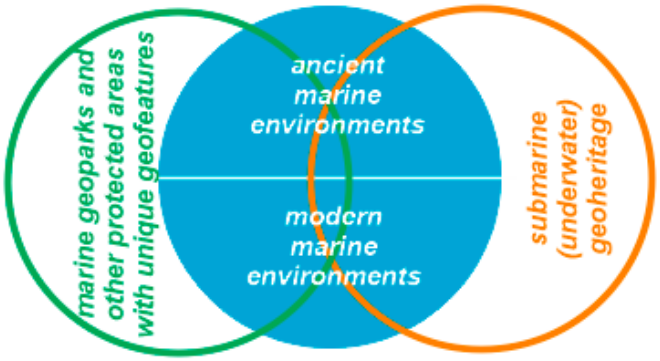

Figure 5. Duality of marine geoheritage (blue) and the other categories.

The outcomes of the present study imply conclusively that the Abrau area features high-value, large, and complex geoheritage objects, and its geosites are essential for realizing the duality of marine geoheritage. Practically, the co-existence of the ancient and modern sea-related features in the study area is useful to geoconservation. The persistence of the marine theme avoids differentiation between the coastal ("mainstream") and inland ("marginal") objects, also when geoheritage management needs will be presented to local policymakers. Additionally, the importance of the geoheritage reported from the Abrau area is linked to the possibility to extend the knowledge of specific, biogeochemical phenomena in the Black Sea reported form the other areas [57], as well as to develop the joint eno- and geotourism activities, which is urgent on the European scale [58] and may contribute to tourism growth in Russia [59]. Overall, the idea of marine geoheritage is a promising, but needs further investigation on the basis of multiple examples, as well as further conceptualization. There are many areas promising for studying marine geoheritage—for instance, these can be found on the coasts of the Baltic Sea (Denmark, Estonia, and Sweden), the Mediterranean Sea (Greek islands), the Pacific Ocean (Peru), etc. Particularly, Baltic amber found on the Baltic coast of Poland and Russia may be judged to be an outstanding example of the marine geoheritage duality. Cataloguing and interpreting such objects and localities seems to be an important task for international research.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The author gratefully thanks the journal editors and the reviewers for support and helpful recommendations.

Conflicts of Interest: The author declares no conflict of interest.

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