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Geosites of Northern Mountainous Adygeya (Southwestern Russia): A Novel Vision

Anna V. Mikhailenko [1] and Dmitry A. Ruban [2,*]

[1] Department of Physical Geography, Ecology, and Nature Protection, Institute of Earth Sciences, Southern Federal University, Zorge Street 40, Rostov-on-Don 344090, Russia
[2] Department of Organization and Technologies of Service Activities, Institute of Tourism, Service and Creative Industries, Southern Federal University, 23-ja Linija Street 43, Rostov-on-Don 344019, Russia
* Correspondence: ruban-d@mail.ru

Abstract: Territorial inventories of geosites remain on the international agenda, and they can help in acquiring information for solving pure geological research tasks. New field investigations in the northern part of Mountainous Adygeya (geoheritage-rich territory in the western Greater Caucasus) permitted us to extend our knowledge of its geosites. Five geosites were described qualitatively and assessed semi-quantitatively, namely the Polkovnitskaya River Valley (ammonite-bearing concretions of Aptian glauconitic sandstones), the Little Khadzhokh River Valley (Aptian glauconitic sandstones with fossils and trace fossils), the Shakhan and Middle Khadzhokh River Valley (Upper Jurassic variegated siliciclastics, Hauterivian fluvial and deltaic sandstones, mixed ancient and modern clastic material), the Big Khadzhoh Waterfall (splendid waterfall and exposures of locally folded Oxfordian–Kimmeridgian limestones), and the Verblyud Mountain (small, camel-shaped cuesta's remnant). They were ranked nationally (one geosite), regionally (three geosites), and locally (one geosite). Close examination of the considered geosites permitted to register pure geological peculiarities (changes in the dip direction between sedimentary packages), which indicate the tectonic activity across the Jurassic–Cretaceous transition. Additionally, complex accessibility patterns were established in some geosites, and these patterns should be addressed in further refinements of the semi-quantitative approaches to geosite assessment.

Keywords: geoheritage; geological history; greater Caucasus; Mesozoic; tectonic activity

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1. Introduction

International research interest in geoheritage and geosites has grown spectacularly in the past decade [1–5]. Nonetheless, a lot of potentially unique objects remain characterized superficially or even not registered in many geological domains and many countries. Geosites are not only world-class localities, but also nationally, regionally, and locally valuable manifestations of geological phenomena, and, thus, the number of geosites yet to be examined is outstanding. Many geosites can be valorized, supported, and popularized through geological and natural history museums [6,7], in geoparks [8–10], and can be essential to geotourism development [11]. Extensive and regular inventories of geosites in particular territories remain on agenda. Importantly, these inventories do not only extend geoheritage knowledge itself but also contribute to a deeper understanding of geological environments and history (in other words, geoheritage studies as applied research are able to facilitate pure geological research). The available approaches to geosite assessment [12–19] facilitate geosite inventories and make the latter more systematic.

Although the mode of occurrence of geosites in the world's space differs, it has become common to pay attention to their groups located in particular territories often corresponding to administrative units, protected areas and geoparks, or geological domains [20–30]. In Russia, an important territory for geoheritage studies, which possesses many world-class and other geological localities and where conceptual ideas and new approaches have been tested, is Mountainous Adygeya in the western Caucasus (western part of the greater Caucasus orogen in the very southwest of the country) [17,31,32]. It is rather large, geologically complex, and not ideally accessible in some parts, as a result of which any full geosite inventory there would require many years (if not decades) of investigations. The previous studies concentrated in the central and southern parts of this territory, whereas the knowledge of geosites from its northern part has remained incomplete. The earlier inventory [17] considered only one geosite in this part of Mountainous Adygeya, offering its semi-quantitative assessment (this needs improvements in the light of the new studies) but not a description. The subsequent investigations led to the proposal of two other geosites [32,33], but these were neither assessed, nor fully described. Finally, new field works carried out in summers of 2023 and 2024 have permitted to register two new geosites, which were not considered by the earlier geoheritage studies in this territory, as well as to improve the knowledge of the earlier known geosites. A large amount of novel information has been accumulated, and it needs to be reported.

The objective of the present paper is to characterize geosites of Northern Mountainous Adygeya in the western Caucasus. This is urgent to make the information about geoheritage of the entire territory more comprehensive, especially because some geosites from its northern part represent features and geological time slices that do not exist in the other, better known parts of this territory. Although this paper reflects the outcomes from a regional geosite inventory, it also contributes to answering two more general research questions: (a) which geoheritage is associated with the Jurassic–Cretaceous transition in a late Cenozoic orogen? And (b) how can geoheritage studies contribute to pure geological investigations? The international importance of this study is determined by the outstanding geoheritage value of entire Mountainous Adygeya, as well as the provision of some new information from a vast and geologically complex, but still inadequately known domain. Deciphering geological history of the latter is important to understand better the development of the northern Neo-Tethyan margin during the Mesozoic.

2. Geological Setting

Northern Mountainous Adygeya is situated in the central part of the Maykop District of the Republic of Adygeya, which is an administrative unit of Russian Federation in the southwestern part of the country (Figure 1a). It occupies ~250 km^2 in the valleys of the Belaya River and its tributaries, as well as on adjacent mountain slopes (Figure 1b). The basic physical geographical information of this area was given by Bedanokov et al. [34]. This area is crossed from the west to the east by two, subparallel cuesta-type mountainous ranges, which are large elements of the northern slope of the greater Caucasus mountains (Figure 1b). The southern one (Skalisty Range, a part of which is called as the Una-Koz Range) with the locally highest mountain (Shidekht, 1116 m) is well-shaped with cliffs on its southern slopes and very gentle, plateau-like northern slopes. The northern cuesta (Pasture Range) has a more smoothed shape, and its heights are chiefly <800 m. The Belaya River valley stretches from the south to the north, and it narrows where crosses the above-mentioned cuestas. The climate is temperate, with mild winters and rather hot summers and the annual precipitation of ~700 mm [34]. The drainage network is rather dense, although not as dense as in the other parts of Mountainous Adygeya. Mountain slopes are covered by dense deciduous forests, whereas the Belaya River valley is dominated by anthropogenic landscapes. The largest settlement is Kamennomostskiy town, which is also an important center of tourist activities.

Presently, the study area belongs to the western segment of a large orogen of the greater Caucasus (western Caucasus). The latter has started to grow in the late Cenozoic, together with the Alpine orogeny [35–37]. Recently, this orogen is still evolving as a result of the northwards movement of the African and Arabian plates at a velocity of 20–30 mm/yr [38,39]. More generally, the study area belongs to one of the largest regions of convergent deformation on Earth [40]. Upper-Jurassic–Lower-Cretaceous sedimentary rocks dominate the study area (Figure 2a). Rich fossil assemblages (chiefly marine invertebrates, including ammonites) were used to establish ages of these deposits, and the related palaeontological and stratigraphical investigations have been carried out over more than a century [41–45]. Presently, some investigations of this kind have been related to geoheritage studies [32]. Nonetheless, the lithostratigraphy of these deposits remains underdeveloped in somewhat. This is why characteristic sedimentary packages with the known ages (e.g., Oxfordian–Kimmeridgian limestones and Aptian sandstones) remain in use, and they are also preferred in this work for better clarity. It should be stressed that the present version of the geological time scale [46] (see also updates in [47,48]) is followed in the present paper.

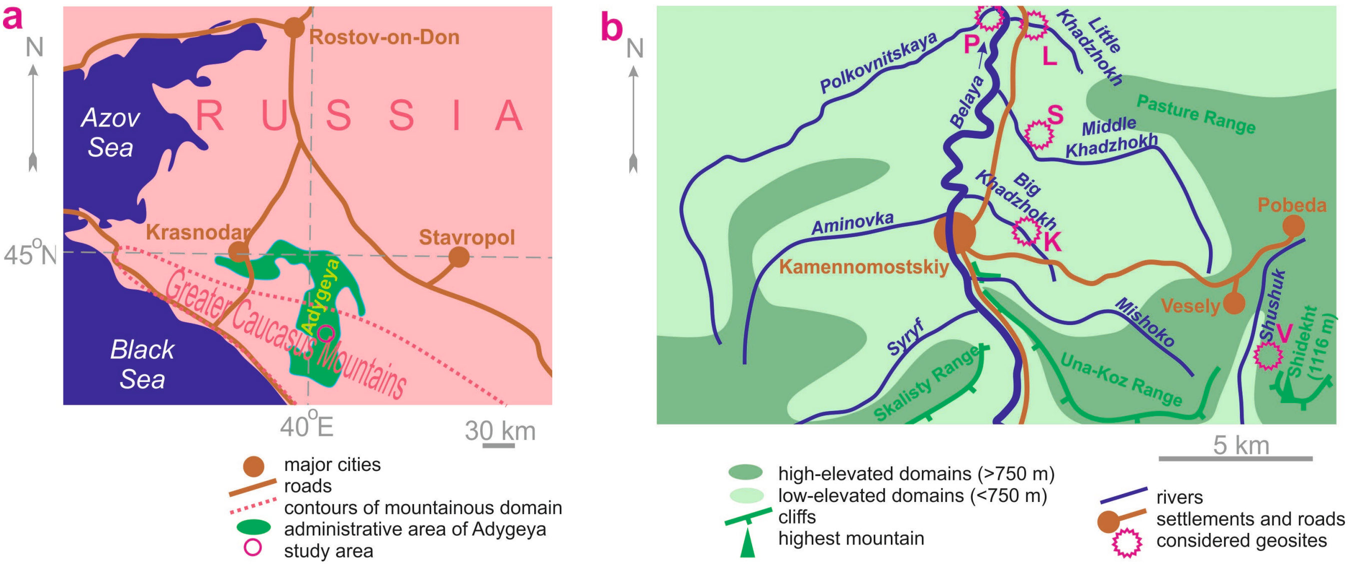

Figure 1. General geographical location of the study area in the Russian south (**a**) and location of the considered geosites in the study area (**b**). Geosites: P—Polkovnitskaya (Colonel) River Valley, L—Little Khadzhokh River Valley, S—Shakhan and Middle Khadzhokh River Valley, K—Big Khadzhoh Waterfall, V—Verblyud (Camel) Mountain. The basic geomorphological information is derived from [34] and the authors' personal observations.

The principal sedimentary packages known in the study area include Oxfordian–Kimmeridgian limestones, Kimmeridgian–Tithonian variegated siliciclastics (chiefly siltstones), Berriasian–Valanginian limestones, Hauterivian sandstones, and Aptian glauconitic (green) sandstones (Figure 2b). Barremian and Albian siliciclastic rocks deposits are also present, but their distribution is limited. These deposits were formed in a shallow-water, semi-enclosed tropical sea (and on nearby landmasses, including islands), which evolved during the Mesozoic–early-Cenozoic on the northern margin of the Neo-Tethys Ocean [33,49,50].

Tectonically, the study area is organized rather simply, although many details are yet to be known. Upper Jurassic–lower Cretaceous deposits dip generally to the north (Figure 2a) and form a kind of monocline (Figure 2c). The latter overlays folded deposits of older ages. It is accepted that the above-mentioned Mesozoic sea corresponded to a back-arc basin; the mid-Jurassic tectonic activity (most probably, in the Bajocian) resulted in folding [51], after which calmer tectonic conditions established together with a post-rift, thermal subsidence [52]. The noted monocline can be related to the Cenozoic orogenic motions.

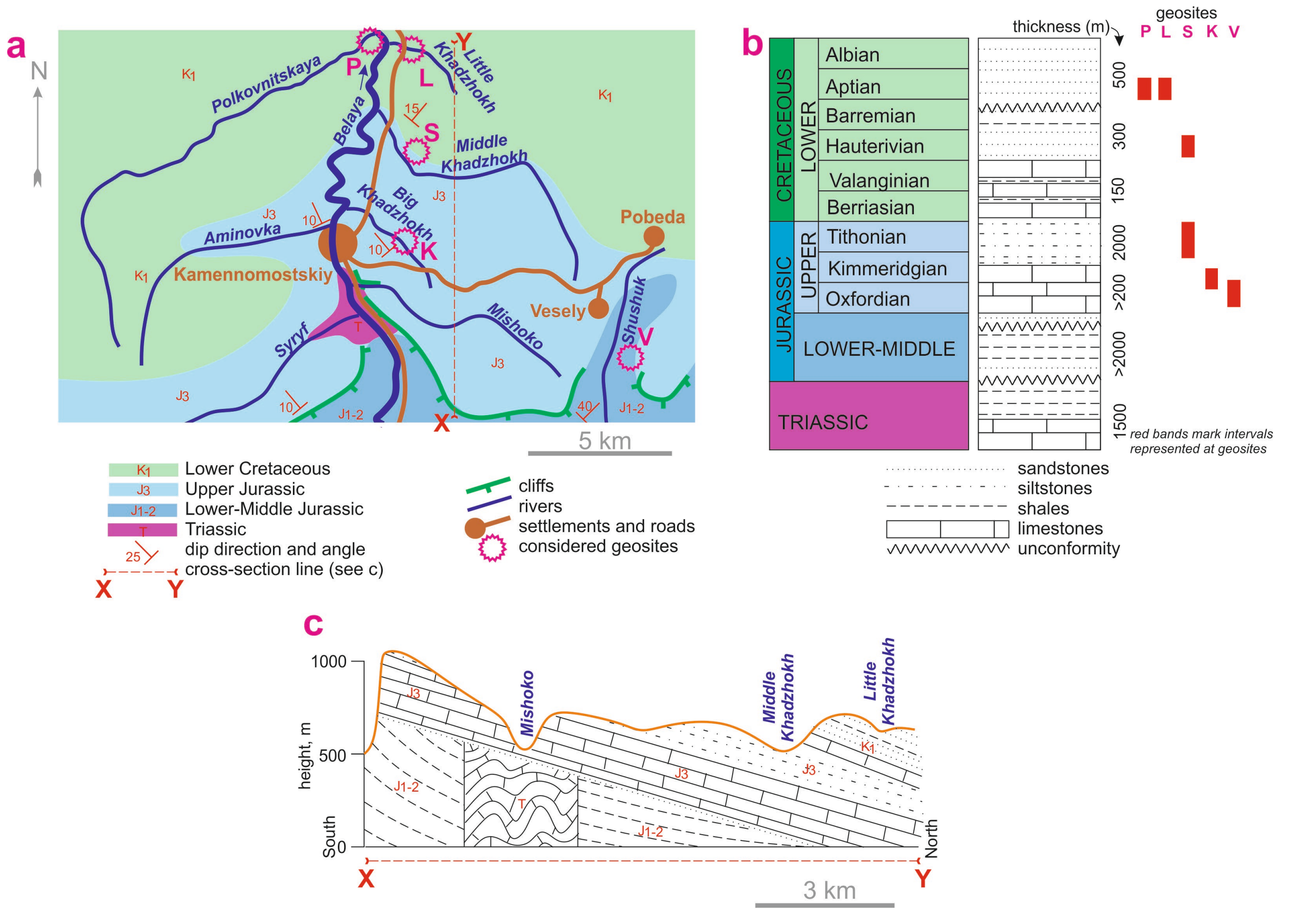

Figure 2. Geological scheme (**a**), generalized lithological column (**b**), and schematic cross-section (**c**) of the study area. See Figure 1b for geosite abbreviations. Due to the still limited knowledge and many open questions, the cross-section is given very tentatively and with various assumptions.

3. Materials and Methods

The present study follows the general principles of geosite inventories [12,53–56]. Various information about geological features in Northern Mountainous Adygeya, including personal observations made during the previous studies and popular stories circulating on tourism-related web-pages, was checked to outline target points for novel field works. One earlier-established [17] and two earlier-supposed [32,33] geosites, as well as two new promising localities, were distinguished. These five sites (Figure 1a) were specified for further examination.

Three basic procedures were as follows: First, each considered locality was visited (re-visited) in the field to establish their characteristic geological features, which was necessary for their proper description. This procedure required pure geological examination of the localities (identification of rocks, looking for fossils, measurements of dip directions and angles, landform descriptions, etc.), and it was essential to understand the nature of the represented phenomena. Second, the rarity of these features on local, regional, national, and international scales was checked to realize the presence of some (at least, local) heritage value and, thus, to argue the presence of geosites (it should be underlined that a geosite is not necessarily a world-class locality). Third, the observations made in the field permitted a semi-quantitative assessment of the geosites regarding their rarity and various technical properties, such as accessibility and vulnerability (see below).

From the available techniques of the semi-quantitative, score-based assessment of geosites [12–19], one technique already tested and used in the different parts of the greater

Caucasus [17,57] was employed. On the one hand, its choice permitted us to make the geoheritage knowledge from the greater Caucasus and, particularly, Mountainous Adygeya, consistent. On the other hand, this technique is appropriate for this particular territory regarding its natural, socio-economical, and cultural peculiarities (better to say, it was initially developed for such territories). Principally, this technique was used for the geosites of the same kind, and its suitability to all geosites of Mountainous Adygeya was proven [17]. The explanations of this technique, its basic principles, and the employed criteria and scores were published already [17,57], and this is why another, full-scale description of this technique is unreasonable (the detailed explanations can be found in the indicated works and some sources cited in them, and the related information is visualized in Figure 3). Nonetheless, it can briefly be restated that this technique scores geosites by the relative spatial rarity of represented features (e.g., whether the latter are rare on national or local scales); the related scores are subsequently corrected with additional scores related to several technical properties, such as accessibility or need for interpretation (Figure 3). The technique's aim is to rank geosites globally, nationally, regionally, or locally depending on the total scores; these ranks reflect the geosites' values. The differences in ranks and values do not mean that only global and national geosites should be conserved and exploited—geosites of all ranks are elements of territorial geoheritage and, thus, cannot be ignored.

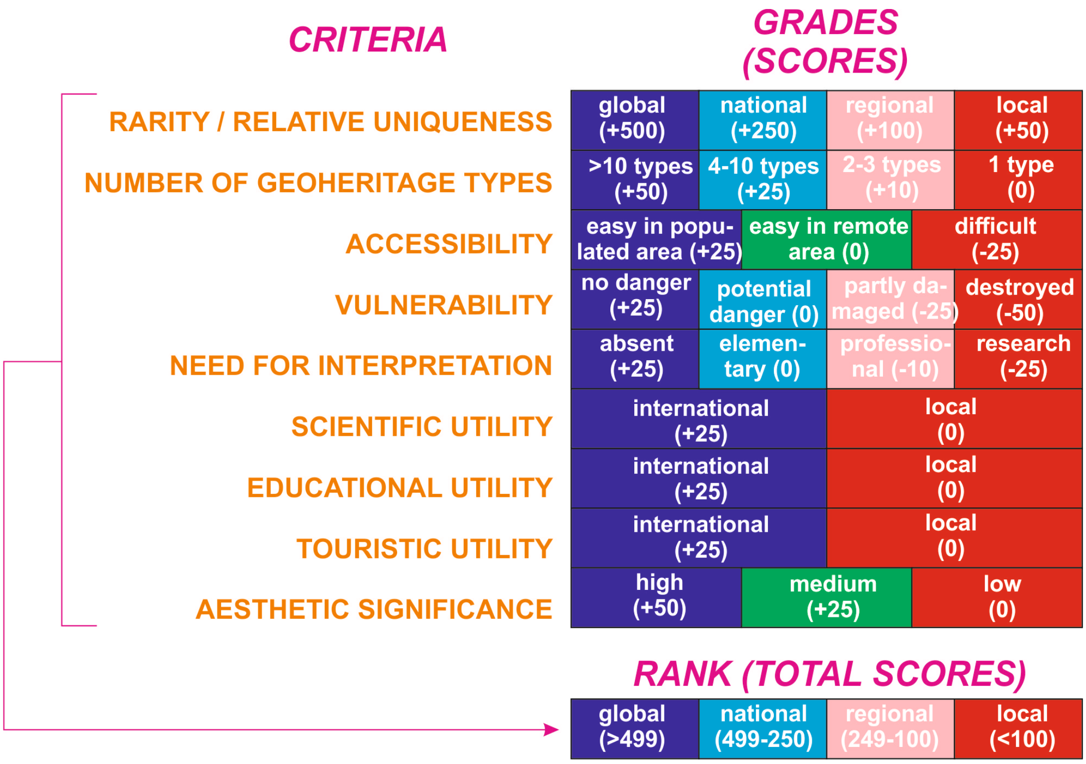

Figure 3. Criteria and scores used in the employed semi-quantitative assessment. Rarity is the main criterion, but considering the other criteria can change a geosite's rank. The colors are used for better visualization of grades. Republished from [57] with permission. The suitability of this technique to the entire Mountainous Adygeya was proven by Ruban et al. [17].

4. Results

4.1. Descriptions of Localities

The Polkovnitskaya (Colonel) River Valley locality is situated near the mouth of the Polkovnitskaya River, which is a left tributary of the Belaya River (Figure 1b). There, grayish-green, glauconitic marine sandstones of Aptian age (Figure 2b) are exposed directly in the stream and along its banks (Figure 4a,b). They bear numerous concretions made of the same sandstones, and they may reach a meter in size (Figure 4c). Some concretions bear shells of ammonites and other marine invertebrates (Figure 4d). This locality is known for gigantic ammonite shells found in concretions. Some of them are preserved exceptionally and filled (fully or partly) with calcite or (very rarely) pyrite. Due to its palaeontological richness, this locality has been visited by geologists and paleontologists since the 19th century; representatives of the ammonite families Ancyloceratidae, Desmoceratidae, Douvilleiceratidae, Lytoceratidae, Parahoplitidae, and Phylloceratidae were reported from there [45]. Seasonal increases in the erosive power of the stream wash out concretions, which then lay freely. Cutting/crushing them for checking the presence of ammonite shells is a typical fossil-hunting procedure (sometimes, it may look devastative). Importantly, outcrops of Aptian sandstones with concretions are found not only directly in the Polkovnitskaya River valley but also in the adjacent parts of the Belaya River valley (Figure 4c).

Figure 4. Polkovnitskaya (Colonel) River Valley (**a**–**d**) and Little Khadzhokh River Valley (**e**,**f**) geosites: general view of the Polkovnitskaya River flowing over layering surfaces of lower Cretaceous rocks (**a**), outcrop of glauconitic Aptian sandstones (indicated by arrow, A.V.M. stays for scale) (**b**), outcrop of Aptian sandstones with large concretions (indicated by arrow) in the bank of the Belaya River (**c**), marine macroinvertebrates from a sandstone concretion (number on scale in cm) (**d**), general view of the Little Khadzhokh River (water is absent due to abnormal lack of rainfall) (**e**), trace fossil in Aptian sandstones (indicated by arrow) (**f**).

The Little Khadzhokh River Valley locality is located on the right bank of the Belaya River (Figure 1b). Geographically, it "mirrors" the Polkovnitskaya River Valley locality, being almost identical to it geologically. A small river valley with dense vegetation (Figure 4e) hosts a series of outcrops of Aptian sandstones (Figure 2b) with fossil-bearing concretions. Although palaeontological findings are not so frequent there, trace fossils (Figure 4f) are more common, and this locality offers an interesting opportunity of ichnological investigations in glauconitic sedimentary rocks (this seems to be a promising, but not well-explored, research topic [58–60]). Moreover, this locality is less known to fossil hunters than the Polkovnitskaya River valley, and, thus, the former retains significant potential for ammonite studies.

The Shakhan and Middle Khadzhokh River Valley locality occurs to the northeast of Kamennomostskiy town (Figure 1b), and it has a complex geometry. It includes a rather large, elongated, abandoned sandstone quarry near the top of the Shakhan Mountain (Figure 5a), a series of outcrops along an unpaved road (Figure 5b) linking this quarry and the noted town, and a part of the valley of the Middle Khadzhokh River (Figure 5c), which is a right tributary of the Belaya River. The quarry offers a spectacular exposure of yellowish-white, non-marine sandstones (in some layers, they are cemented weakly and look like sands) of Hauterivian age (Figure 2b). The lower member was deposited in fluvial conditions and demonstrates cross-bedding, whereas the upper member was deposited in deltaic conditions and demonstrates subparallel bedding; a contact between these members is sharp and well-visible (Figure 5a). The previous study established that an ancient (Hauterivian) river, on a plain of which sandstones accumulated, flew to the northwest [33]. A panoramic view of the geological landscape of almost the entire Mountainous Adygeya is available from the quarry, although visibility of particular features and landforms depends on weather conditions. Outcrops along the road represent Kimmeridgian–Tithonian variegated siliciclastics (Figure 2b), which accumulated in lagoonal conditions and were colored with iron oxides due to arid palaeoclimate (Figure 5b). Finally, the valley itself gives an example of an active recycling of clastic material, which is washed out from upper Jurassic and lower Cretaceous rocks and deposited quickly as modern river sediment (Figure 5c).

The Big Khadzhoh Waterfall locality marks the northeastern edge of Kamennomostskiy town and corresponds to a small part of the valley of the Big Khadzhokh River where a splendid waterfall is present (Figure 1b). The waterfall is especially attractive in spring and after heavy rains, although it almost desiccates in summer (Figure 5d). Scientifically more important are rock exposures near this waterfall (Figure 5e) and directly in the stream (Figure 5f). They represent Oxfordian–Kimmeridgian limestones (Figure 2b), exposures of which are somewhat unexpected so far from the cuesta cliffs (Figure 2a) where they are commonly found. These limestones crop out locally thanks to the deep incision of the Big Khadzhokh River into relatively soft Kimmeridgian–Tithonian siliciclastics. Of special interest is a well-visible anticlinal and slightly asymmetrical fold in limestones (Figure 5e). Its presence indicates tectonic deformations, the age of which is discussed below. Importantly, the general dip direction and angle of these limestones is the same as in the other, quite remote localities of the study area (Figure 2a).

The Verblyud (Camel) Mountain is a pure geomorphological feature, which is situated south of Vesely village, on the left side of the Shushuk River valley (Figure 1b). It has an unusual form (Figure 6a,b), which resembles a lying Bactrian camel with two humps and head on a long neck (Figure 6c,d). Although the exact origin of the mountain's name is unknown, domesticated camels were present in this area at the transition between the 19th and 20th centuries when they were used for load transportation (particularly, in a large and prosperous local monastery). Essentially, this small mountain is a remnant of the retreating cuesta cliff of the Skalisty's Range and, more precisely, a large Shidekht Mountain (Figure 6a). Erosion, weathering, and karstification weaken Oxfordian–Kimmeridgian limestones (Figure 2b) that are exposed in the noted cliff and provoke its gravitational collapses (the latter may be triggered by heavy rainfall and microseismicity). Weak zones in a limestone massif are determined by a local network of joints, as a result of which cliff destruction and retreat occur with a different speed in space. In other words, the Verblyud Mountain is a small landform typical to dynamic cuesta-dominated landscapes [61]. Importantly, the camel-like shape of this landform can be comprehended from some distance, and the best observation points are found on the other side of the Shushuk River valley, in the vicinity of Vesely village. The previous research [62–64] emphasized the importance of such viewpoints in geoheritage management.

Figure 5. Shakhan and Middle Khadzhokh River Valley (**a**–**c**) and Big Khadzhoh Waterfall (**d**–**f**) geosites: general view of Hauterivian sandstones in an abandoned quarry (contact between cross-bedding in the lower member and subparallel-bedding in the upper member is shown by arrow, and bedding is shown by white dashed lines for better comprehension) (**a**), small outcross of Tithonian variegated siliciclastics (**b**), general view of the Middle Khadzhoh River with an exposure of recycled sand (indicated by arrow) (**c**), panoramic view of the Khadzhokh Waterfall of the Big Khadzhokh River (maximum size of the waterfall reached in spring and after heavy rainfalls is shown by blue dashed lines) (**d**), minor fold (indicated by arrow) in Oxfordian-Kimmeridgian limestones (**e**), the Big Khadzhokh River flowing over layering surfaces of late Jurassic rocks (height of this "waterfall" is <0.5 m) (**f**).

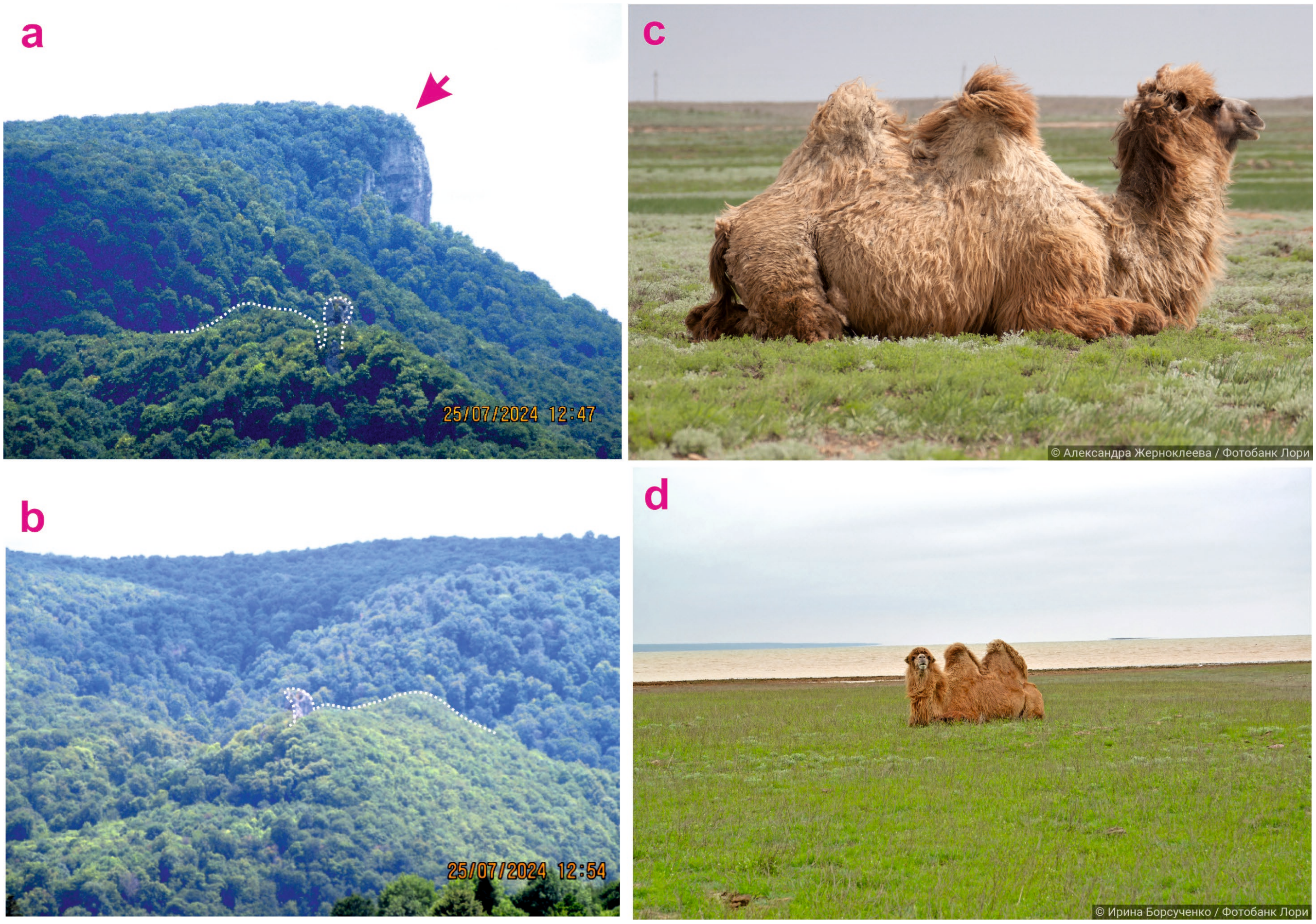

Figure 6. Verblyud (Camel) Mountain geosites photographed from two points in the vicinity of Vesely village (**a**,**b**), and Bactrian (two-humped) camels for better comprehension of the mountain's name (**c**,**d**); the landform shape is outlined by a white dotted line for better visibility, and the Shidekht Mountain (the highest mountain of the study area) is shown by the arrow. Photos by Aleksandra Zhernokleeva, Lori Photobank (**c**) and Irina Borsuchenko, Lori Photobank (**d**) are published with permission.

4.2. Assessment of Geosites

All five localities described above can be treated as geosites, although their rarity differs substantially. The exceptional palaeontological importance of the Polkovnitskaya River Valley and the rarity of similar objects in the country make it a geosite rare on the national scale (attention to its fossil record [45] allows for increasing the rank compared to the previous interpretations [17]). Moreover, one should note glauconite abundance in Aptian sandstones, which is a particular sedimentary phenomenon [65,66]. The Little Khadzhokh River Valley is a less fossil-rich locality, but it is unique on the scale of Mountainous Adygeya (especially taking into account its ichnological record). This permits us to judge it a local geosite. The Shakhan and Middle Khadzhokh River Valley locality is unique due to the outstanding exposure of fluvial and deltaic sandstones, which is uncommon in the western Caucasus, where Mesozoic deposits are commonly marine. This is why a regional rarity of this geosite is evident. The Big Khadzhoh Waterfall and the Verblyud Mountain are two notable localities, but their rarity is restricted to only Mountainous Adygeya, and, thus, these are local geosites.

The relative spatial rarity of the geosites permits us to establish their preliminary values, which can be corrected regarding their other properties (Figure 7). The employed scoring system is based on the objective criteria (Figure 3), and the related technical properties of the geosites are explained below for better clarity.

CRITERIA	GEOSITES P	L	S	K	V
RARITY / RELATIVE UNIQUENESS	+250	+50	+100	+50	+50
NUMBER OF GEOHERITAGE TYPES	+25	+25	+25	+25	0
ACCESSIBILITY	0	+25	+25	+25	-25
VULNERABILITY	-25	+25	0	+25	0
NEED FOR INTERPRETATION	-10	-10	-10	+25	+25
SCIENTIFIC UTILITY	+25	0	+25	0	0
EDUCATIONAL UTILITY	+25	0	0	0	0
TOURISTIC UTILITY	0	0	0	0	0
AESTHETIC SIGNIFICANCE	+25	0	+25	+50	+25
RANK	315	115	190	200	75

Figure 7. Results of the semi-quantitative assessment of the considered geosites. See Figure 3 for explanation of scores; zero values do not necessarily mean poor quality or absence of something. See Figure 1 for geosite abbreviations. Geosite P is scored with some differences from [17].

The analysis of geological features registered at the geosites implies that four of them are comparable by the number of geoheritage types (Figure 7). The Polkovnitskaya River Valley and the Little Khadzhokh River Valley can be attributed to the palaeontological, sedimentary, mineralogical, geomorphological, stratigraphical, palaeogeographical, and hydro(geo)logical geoheritage types, of which the first, the second, and the third are the most important. The Shakhan and Middle Khadzhokh River Valley geosite can be attributed to palaeogeographical, economical, geomorphological, stratigraphical, sedimentary, tectonic, and hydro(geo)logical geoheritage types, of which the first and the second are the most important. The Big Khadzhoh Waterfall geosite can be attributed to the hydro(geo)logical, sedimentary, tectonic, geomorphological, stratigraphical, and palaeogeographical geoheritage types, of which the first, the second, and the third are the most important. Finally, the Verblyud Mountain can be attributed to the only geomorphological type, i.e., it is a typical geomorphosite (sensu [67–71]); interestingly, camel-related geosites are also known beyond the study area [72].

The accessibility of the considered geosites differs (Figure 7). Three of them (Little Khadzhokh River Valley, Shakhan and Middle Khadzhokh River Valley, and Big Khadzhoh Waterfall) are accessible very easily because they are either crossed by roads or located in the urban area of Kamennomostskiy town. The Polkovnitskaya River Valley geosite is a bit remote: a well-established trail to it leads through a private area with access limitations, and an alternative route is longer and of worse quality. Finally, the Verblyud Mountain is difficult (even very difficult) to reach. Although some local trails to there may be available, they are ephemeral, irregularly used, and unknown to the broad public. Reaching the toe of this mountain requires long-distance hiking through dense forest and climbing steep slopes. The viewpoints, from which this landform can be observed distantly, are perfectly accessible from unpaved, but good local roads.

Although the geoheritage of the other parts of Mountainous Adygeya does not have serious problems with vulnerability [17], the situation is less optimistic in the study area (Figure 7). Only the Little Khadzhokh River Valley and Big Khadzhoh Waterfall geosites do not face negative influences. At the Shakhan and Middle Khadzhokh River Valley geosite, the abandoned quarry can experience either sudden collapse of walls or their extensive coverage by vegetation; moreover, its further exploitation cannot be excluded. These scenarios will affect the representativeness of Hauterivian non-marine sandstone exposures, and, thus, potential danger to geoheritage exists. A danger also exists for the Verblyud Mountain, where collapse of the limestone remnant (camel's "neck" and "head") due to natural forces (heavy rainfall, microseismicity, or weathering) cannot be excluded. As for the Polkovnitskaya River Valley, this geosite was already damaged by fossil hunters who over-collected ammonite shells and broke numerous sandstone concretions. Now, this geosite is a part of the protected area where fossil collecting is prohibited, although additional measures are necessary to implement this official status and the related regulations.

The Big Khadzhoh Waterfall and the Verblyud Mountain do not require any special knowledge for their comprehension, but three other geosites need professional interpretations (Figure 7). Waterfalls and animal-shaped landforms are clear to the broad public, whereas understanding such features as ammonite-bearing concretions and cross-bedding require explanations by experts.

Indeed, all considered geosites of the study area can be used for the purposes of science (further research projects), education (especially training university students in geology and geography), and tourism (Mountainous Adygeya is a growing tourist and, particularly, geotourist destination [17,73,74]). The related activities can be significant but restricted chiefly to the Russian south. For instance, the Big Khadzhokh Waterfall and associated geological features can be utilized for the purposes of summer field practices carried out annually by several large universities of the Russian South, but it would be unreasonable to include them into programs of the same practices of other universities of Russia or other countries. Moreover, such geosites as the Polkovnitskaya River Valley cannot be involved in major, international-level touristic activities due to the need to limit the number of visitors. Nonetheless, two geosites have international utility (Figure 7). The Polkovnitskaya River Valley is a remarkable palaeontological locality, and further, world-class investigations of Aptian ammonites and other marine invertebrates from there is possible; the expected results seem to be promising enough to be published in international journals. The same geosite can also be employed for well-organized visits of international groups of students because it serves as a kind of unique "window" into the mid-Cretaceous world. The Shakhan and Middle Khadzhokh River Valley geosite has also importance to the international research as a rare outcrop of early-Cretaceous non-marine strata in the greater Caucasus. For instance, there is a potential for world-class provenance analysis of sandstones and palynological studies.

Taking into account the broad meaning of esthetics [75,76], the considered geosites can be differentiated as follows (Figure 7). The Little Khadzhokh River Valley does not possess any esthetically attractive elements. The Polkovnitskaya River Valley boasts general landscape scenery, green color of sandstones, and geometrically regular shapes of concretions, which indicate its medium esthetic significance. Of course, ammonite shells (especially filled with calcite or pyrite) are very beautiful, but these constitute ex situ geoheritage moved to collections, and they are not exposed at this geosite. The moderate attractiveness of the Shakhan and Middle Khadzhokh River Valley can be related to cross-section bedding, variegated siliciclastics, and panoramic views. The same attractiveness of the Verblyud Mountain is determined by its animal-looking shape, but this landform is not large and, thus, not impressive enough to tell about high esthetic properties. The Big Khadzhokh Waterfall geosite seems to be esthetically significant due to the presence of the waterfall (such hydrological objects are commonly prioritized by visitors due to their natural beauty [77–79]), geometrical pattern of exposed folded limestones, and general landscape scenery.

The correction of the rarity-based scores with the scores related to the other properties characterized briefly above implies that one geosite of the study area is ranked nationally, two geosites are ranked regionally, and one geosite is ranked locally (Figure 7). This semi-quantitative assessment reveals also three tasks for further geoconservation planning and management. These tasks include improvement of accessibility (urgent for two geosites), mitigation of past negative impacts and existing risks (urgent for three geosites), and development of interpretative infrastructure (installation of panels, creation of supportive web-pages) (urgent for three geosites and can be very helpful to two others).

5. Discussion

The descriptions of the considered geosites and their semi-quantitative assessment imply that their entity is a substantial addition to the entire geoheritage of Mountainous Adygeya reported earlier [17,31]. The other geosites of this territory do not duplicate a significant portion of the content of the geosites of the study area. Moreover, attention to the localities considered in the present work permits discussion of two topics, one of which is purely geological, and the other is related to geoheritage properties.

5.1. Geological Inference: Tectonic Activity in the Western Caucasus

The northern margin of the Neo-Tethys was a vast and highly complex region in the Mesozoic [37,49,80–82]. A comprehension of its evolution requires attention to regularities of sedimentation and tectonic activities in its particular domains, one of which is the western Caucasus. The considered geosites of the study area represent Oxfordian–Tithonian and Hauterivian–Aptian sedimentary successions (Figure 2b), and the geological evidence available from them sheds light on some peculiarities of the regional late-Jurassic–early-Cretaceous evolution.

It is thought that north-dipping upper-Jurassic–lower-Cretaceous deposits form a monocline (Figure 2c) formed in the relatively calm conditions [51,52]. However, detailed studies of the geosites and some other localities indicate the differences in dip directions in the different sedimentary packages. Oxfordian–Kimmeridgian limestones dip to the northwest everywhere (Figure 2b). Kimmeridgian–Tithonian variegated siliciclastics dip to the northwest, north, and locally northeast (on average, they dip to the north). Hauterivian sandstones dip to the northeast and with a bit different angle (Figure 2b). If so, minor unconformities existing between these packages [41,44] seem to be angular and resulted from an accelerated tectonic activity at the Jurassic–Cretaceous transition. This activity could start yet in the Kimmeridgian and last until the Hauterivian, i.e., up to ~20 Ma. The noted minor unconformities are not well-documented, their spatial extent is questionable, and their tectonic importance is emphasized by the present study (this is why they are not shown on Figure 2b). It should be added that Berriasian–Valanginian limestones are locally absent in Northern Mountainous Adygeya [41], which is also a sign of tectonic motions in the beginning of the early Cretaceous. This activity can explain the presence of minor folds in Oxfordian–Kimmeridgian limestones (Figure 5e) and their apparent absence in Hauterivian and younger deposits. However, the folds (Figure 5e) and the noted monocline (Figure 2c) are structures of very different scales and orders. Moreover, the dip directions differ only a bit between the Kimmeridgian–Tithonian and Hauterivian packages. This is why a dominance of the monocline is unquestionable, although the internal structure of this monocline is complex and not homogeneous.

These interpretations mean that the upper-Jurassic–lower-Cretaceous sedimentary complex is structurally heterogeneous, and it did not form in a calm tectonic setting. It can also be hypothesized that the wide development of lagoons in the Kimmeridgian–Tithonian and the existence of an alluvial plain in the Hauterivian were determined by a regional uplift, and not necessary changes in accommodation space or eustatic influences (the global sea level experienced significant fall in the only Valanginian, but the level was not too low even in this stage [83,84]). Presently, it is too early to judge the suggested phase of tectonic activity at the Jurassic–Cretaceous transition either local or wider. However, (almost) synchronous deformations took place in some other northern Neo-Tethyan domains [37]. Anyway, it appears that this activity in the western Caucasus was not weaker than that responsible for the Barremian unconformity (Figure 2b). It is proposed to call the locally accelerated tectonic activity at the Jurassic–Cretaceous transition the Khadzhokh tectonic phase.

5.2. Geoheritage-Related Inference: Complex Accessibility and Seasonality

Accessibility is a very important property of geosites that is actively discussed in the literature [12,13,85–89]. However, this property is more complex than often imagined, and it has many aspects and often depends on particular, local situations. The approach implemented in this study (Figure 3) treats accessibility rather easily, which is unavoidable in general geosite inventories. However, examination of the particular geosites permitted to register some specific patterns of accessibility that seem to be worth noting for further methodological developments.

Two considered geosites, namely the Little Khadzhokh River Valley and the Verblyud Mountain, demonstrate complex accessibility patterns. The former is crossed by a principal, high-class, paved road connecting Mountain Adygeya with Maykop city in the north. This road with a regular public transportation allows for reaching the geosite very easily. The question is how to enter the valley itself for examination of outcrops along the stream. The valley is narrow (10–20 m), and from both sides, it is almost blocked by dense vegetation (deciduous trees and bushes). Although a trail leads along the valley, one needs either to cross the vegetation "barrier", which requires training and special cloth, or to undertake ~1 km of hiking to where this trail crosses the valley (Figure 5e) and then to move high and down along the latter (however, vegetation is also dense at the cross point). If so, the actual accessibility is very challenging, and reaching this geosite does not guarantee entering it. As for the Verblyud Mountain, this geosite has a remote position, and it is very difficult to reach (Figure 6a,b). However, the availability of the excellent and well-accessible viewpoints in the vicinity of Vesely village recompenses the noted limitation. Moreover, these viewpoints can be more important than the geosite itself because the camel-like shape can be comprehended via only distant observation. In such situations, a question about the real accessibility and the true limits of geosites can be posed.

The present study in Northern Mountainous Adygeya makes urgent paying attention to the factor of seasonality, which was already discussed by other researchers [90,91]. On the one hand, such geosites as the Little Khadzhokh River Valley are much better accessible in late autumn, winter, and early spring due to the absence of leaves on trees and less dense bushes. On the other hand, significant amount of water in the stream in spring and early summer may prohibit visits to the Polkovnitskaya River Valley.

Moreover, it becomes evident that accessibility may be a very dynamic property. When the Khadzhokh River Valley was visited in 2015, vegetation was significantly less dense, and it was possible to find easier access to outcrops. Ten years later, the vegetation "barrier" became very difficult to overcome. In the other case, the quarry with Hauterivian non-marine sandstones (the main element of the Shakhan and Middle Khadzhokh River Valley geosite) is abandoned now, but its possible future exploitation will limit or even prohibit access to this very important locality. Regarding the above, it appears very necessary to re-examine the accessibility of geosites regularly, i.e., every five or ten years. Indeed, this can lead to changes in the earlier-established values and even ranks of geosites (Figure 7), and, thus, the results of the semi-quantitative assessment are meaningful for only limited time intervals.

The inferences presented above indicate the urgency of refinement of the existing approaches to geosite assessment [12,17]. These approaches should become more complex but also more flexible to be applied in various situations. Their outcomes should be treated as important but not really final judgments, and they should not be prioritized to qualitative geosite descriptions and interpretations.

6. Conclusions

The present study of geosites in northern mountainous Adygeya permits making three general conclusions, as follows:

(1) A total of five geosites are registered in the study area, namely the Polkovnitskaya (Colonel) River Valley, the Little Khadzhokh River Valley, the Shakhan and Middle Khadzhokh River Valley, the Big Khadzhoh Waterfall, and the Verblyud (Camel) Mountain;

(2) These geosites represent various (palaeontological, tectonic, geomorphological, and other) features, many of which reflect the late-Jurassic–early-Cretaceous evolution of the study area, and the most valuable of these geosites are the Polkovnitskaya River Valley famous for ammonite-bearing concretions in Aptian glauconitic sandstones and the Shakhan and Middle Khadzhokh River Valley representing Hauterivian non-marine sandstones with cross- and subparallel bedding;

(3) The geological information obtained from the considered geosites indicates the structural heterogeneity of the Upper-Jurassic–Lower-Cretaceous sedimentary complex and implies tectonic activity (Khadzhokh phase) across the Jurassic–Cretaceous transition in the western Caucasus, i.e., in the particular domain of the northern Neo-Tethyan margin.

The present study extends the vision of internationally significant geoheritage of entire Mountainous Adygeya. It also permits us to raise the questions that are important for further developments of geosite assessment approaches. Indeed, the study area is vast enough, and some additional geosites can be found there in the future, which makes continuation of geoheritage inventory there urgent. Particularly, specialists have to spend efforts to find geosite(s) representing Berriasian–Valanginian deposits, which occur only locally. Their examination will permit us to justify the proposal of the Khadzhokh phase of tectonic activity, which also needs accurate correlation with tectonic events in other domains of the northern Neo-Tethyan margin.

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