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THEMATIC DIMENSION OF GEOLOGICAL HERITAGE: AN EVIDENCE FROM THE WESTERN CAUCASUS

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Abstract: The geodiversity hotspot comprising 14 geological heritage sites is located on the territory of Mountainous Adygeja in the Western Caucasus (southwestern Russia). The geosites represent some lengthy intervals of the geological history from the Precambrian to the Quaternary, as well as changes in the palaeotectonical affinity of the Greater Caucasus. Visitors of this territory can observe rocks, fossils, and facies, which are typical for the geological periods, especially the Permian, the Triassic, and Jurassic, and the Cretaceous. The same geosites permit to trace shift of the Greater Caucasus Terrane from the Gondwanan margin, where it was before the Devonian, to Laurussia and then Laurasia. Therefore, the geosites can be grouped thematically to facilitate arrangement of geoconservation and geotourism activities. This approach permits to increase the scientific and educational values of the geological heritage in Mountainous Adygeja and to make it more attractive for geotourists. However, such a thematic treatment of the regional geological heritage should not lead to underestimation of the other geological features.

Key words: geological heritage; tourism; geological history; Phanerozoic; Western Caucasus.

Introduction

Geological heritage is a complex category (Prosser, Bridgland, Brown, & Larwood, 2011; Ruban, 2010a; Ruban, 2010b; Wimbledon, 1999; Wimbledon & Smith-Meyer, 2012), which can be characterized as the entity of peculiar sites (geological heritage sites, geosites) on a given territory (cf. Ruban, 2010a). Its adequate management, which is the main goal of the growing geoconservation activity (Gordon, 2012; Gray, 2004; Gray, 2008; Henriques, Pena dos Reis, Brilha & Mota, 2011; Prosser, 2013; Prosser, Murphy, & Larwood, 2006; Prosser et al., 2011; Wimbledon, 1999; Wimbledon & Smith-Meyer, 2012;), should take into account non-random distribution of these geosites in space, as

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well as their different types, ranks, etc. (Ruban, 2010a). Geodiversity hotspots (Gray, 2008; Ruban, 2010a) are of utmost importance, because they represent exceptional pieces of geological heritage and provide the necessary resource for establishment of geoparks (Ruban, 2010b). One of such hotspots is located in the mountains of the Western Caucasus in the southwest of Russia (Figure 1) - a place known as Mountainous Adygeja (just to the north from the place of the Winter Olympics of 2014) (Ruban, 2010a; Ruban, 2010b). More than a dozen of geosites represent there wide spectrum of peculiar geological phenomena (Table 1).

Table 1. Geosites constituting the geodiversity hotspot of Mountainous Adygeja

Geosite	Dominant type(s)	Rank
Granite Gorge	engineering, geomorphological, hydrological and hydrogeological, magmatic	National
Gruzinka Valley	sedimentary	Local
Khadzhokh Canyon	geomorphological, palaeontological, stratigraphical, structural	International
Lago-Naki Highlands	geomorphological, palaeogeographical, sedimentological	National
Lower Moltchepa Valley	sedimentological	Regional
Lower Polkovnitskaja (Colonel's) Valley	palaeontological, sedimentological	Regional
Permian (Guzeripl'-Khamyshki) Gorge	engineering, palaeogeographical, sedimentological	National
Partisan Glade Road	engineering, sedimentological	Local
Prince's (Wildpig) Hill	geomorphological, sedimentological	Local
Raskol Cliff	palaeontological, palaeogeographical	International
Rufabgo Canyon	geomorphological, hydrological and hydrogeological, structural	National
Sakhraj Canyon	geomorphological, palaeogeographical	Regional
Sjuk Fossillagerstätte	palaeontological	Local
Sjuk Valley	metamorphic, sedimentological	Local

Source of data: After Ruban (2010a,b) with additions and revisions.

An examination of the geosites constituting the geodiversity hotspot of Mountainous Adygeja has led the authors to an idea of its thematic aspects. All geosites are more or less valuable from the stratigraphical, palaeontological, and palaeogeographical points of view, and all exhibit rocks that illustrate the complex tectonic history of the study territory. If so, why not to promote the importance of this geodiversity hotspot for learning the geological history? The

goal of this paper is to illustrate such a thematic dimension and to emphasize on its importance for geoconservation and geotourism in the Western Caucasus.

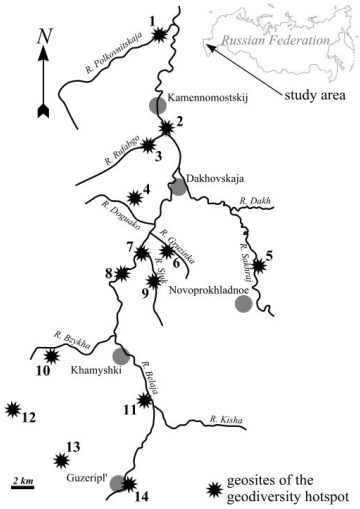

Figure 1. Map of the geodiversity hotspot of Mountainous Adygeja and its geosites. Geosite numbers: 1 - Lower Polkovnitskaja Valley, 2 - Khadzhokh Canyon, 3 - Rufabgo Canyon, 4 - Prince's Hill, 5 - Sakhraj Canyon, 6 - Gruzinka Valley, 7 - Sjuk Fossillagerstatte, 8 - Granite Gorge, 9 - Sjuk Valley, 10 - Raskol Cliff, 11 - Permian Gorge, 12 - Lago-Naki Highlands, 13 - Partisan Glade Road, 14 - Lower Moltchepa Valley.

Geological and geoconservation setting

Mountainous Adygeja belongs geographically to the northwestern slope of the Greater Caucasus mountain range stretching between the Black Sea and the Caspian Sea (Figure 1). Its rich natural resources have been characterized recently by Trepet (2011, 2012, 2013). Geologically, this is the western part of the fold-and-thrust belt of the Greater Caucasus that has been developed as a part of the Alpine orogenic belt since the late Cenozoic (Adamia et al., 2011a; Efendiyeva & Ruban, 2009; Ershov et al., 2003; Gamkrelidze, 1986; Laz'ko, 1975; Marinin & Saintot, 2012; Nikishin, Ziegler, Bolotov & Fokin, 2012; Saintot et al., 2006; Tawadros, Ruban, & Efendiyeva, 2006;). The Greater Caucasus is essentially an allochthonous Gondwana-derived terrane that was docked on the southern margin of Baltica in the only early Mesozoic (Ruban, 2007a; Ruban, 2007b; Ruban, 2013; Ruban, Zerfass, & Yang, 2007a; Ruban, Al-Husseini & Iwasaki, 2007b; Tawadros et al., 2006). Then, island arcs and back-arc basins evolved there (Adamia et al., 2011a; Adamia, Alania, Chabukiani, Kutelia, & Sadradze, 2011b; Efendiyeva & Ruban, 2009; Ershov et al., 2003;

Kazmin & Tikhonova, 2006; Lordkipanidze, Adamia & Asanidze, 1984; Saintot et al., 2006; Tawadros et al., 2006). Since the mid-Cenozoic, the major collision has resulted in orogenic uplift (Adamia et al., 2011a; Efendiyeva & Ruban, 2009; Ershov et al., 2003; Laz'ko, 1975; Saintot et al., 2006; Tawadros et al., 2006).

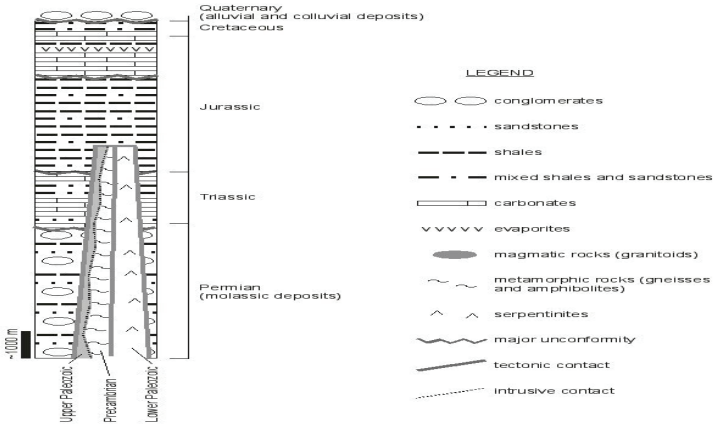

Figure 2. Generalized composite section of the rocks outcropped in the geodiversity hotspot of Mountainous Adygeja

Rocks of different composition and age are outcropped on the study territory (Figure 2). The oldest sedimentary rocks are red-coloured siliciclastics of the thick Lower-?Middle Permian molassic complex; these deposits are overlain disconformably by the uppermost Permian siliciclastics and reefal limestones (Kotlyar, Zakharov, & Polubotko, 2004; A. D. Miklukho-Maklaj & K. V. Miklukho-Maklaj, 1966; Valentseva, Skljarov, Ruban, & Pugatchev, 2006). The Triassic succession represents strata of all stages of this system, and it is dominated by carbonates and siliciclastics; flysch-type packages are known from the Ladinian-Carnian interval, and massive pink and white reefal limestones are common at the Norian-Rhaetian interval (Dagis & Robinson, 1973; Gaetani et al., 2005; Ruban, Zerfass, & Pugatchev, 2009). The Lower-Middle Jurassic deposits are chiefly silicilastic (often, these are dark-coloured laminated shales), whereas the Upper Jurassic deposits are carbonates (reefal somewhere), evaporites, and shales of variegated colour (Kuznetsov, 1993; Rostovtsev et al., 1992; Ruban, 2007c). The Lower Cretaceous package includes both carbonates and siliciclastics; a characteristic feature is the presence of the Aptian greenish-grey glauconitic sandstones (Moskvin, 1986). Finally, alluvial, deluvial, and colluvial deposits are distributed along river valleys and at the toe of slopes (Laz'ko, 1975; Lubova, Zayats, & Ruban, 2013).

Igneous and metamorphic rocks occur in the tectonic "window" (Figure 2). This geological structure is known as the Dakh Crystalline Massif. The Precambrian lithodeme is represented by gneisses and amphibolites (Popov, 2005). Serpentitines were emplaced into these metamorphic rocks, and this took place, probably, in the Early-Middle Paleozoic (Popov, 2005; Ruban, 2007d, Ruban, 2009; Sobolev, 1952). In the late Paleozoic, granitoid magmas were emplaced, and granites, granodiorites, and other igneous rocks were formed (Popov, 2005; Ruban, 2008a; Ruban 2008b; Ruban 2009). In the mid-Mesozoic, the entire crystalline block was uplifted to form the above-mentioned tectonic "window".

Numerous geosites have been described in Mountainous Adygeja, and more than a dozen of them constitute the geodiversity hotspot (Ruban, 2010a; Ruban 2010b) (Table 1). Some geosites (e.g., the Lago-Naki Highlands) are located in the Caucasus State Natural Biosphere Reserve, and some others (e.g., the Rufabgo Canyon) have been proclaimed as the regional monuments of nature. In other words, the official protected status of many geosites permit their effective conservation. Mountainous Adygeja has become an important tourist destination since the mid-20th century, and its importance has increased significantly in the past decade (Lozovoj, 1984; Trepet, 2011). Nature-based tourism and recreation, adventure tourism, winter tourism, ecotourism, health tourism, etc. are developed actively on this territory. Geosites play an important role in this tourism development, although geotourism sensu stricto (Dowling & Newsome, 2010; Gordon, 2012; Hose, 1996; Hose, 2000; Hose & Wickens, 2004; Hose & Vasiljević, 2012) has not yet become very important. Some elements of the latter exist only in combination with the other forms of tourism. The most attractive geosites for tourists are the Lago-Naki Highlands, the Rufabgo Canyon, and the Granite Gorge. The importance of the Partisan Glade road has increased in the last few years. Finally, most tourist routes stretch along the Khadzhokh Canyon, and this geosite is visited, therefore, by almost all visitors. The Khadzhokh Klamm and the Maiden's Stone, which are located in this canyon, serve as little-sized, but important tourist destinations. With regard to its outstanding geological heritage, Mountainous Adygeja is very promising for the full-scale development of geotourism, and this geodiversity hotspot is suitable for establishment of internationally-ranked geopark (Ruban, 2010b).

Theme 1: Geological history

All geosites from the geodiversity hotspot of Mountainous Adygeja provide valuable information about the geological history. An evidence from the Precambrian is available in the outcrops of metamorphic rocks of the Dakh Crystalline Massif (Figure 3). All three Phanerozoic erathems are represented in

many geosites, although the Permian-Cretaceous rocks are the most common in Mountainous Adygeja (Table 2). Serpentinite bodies reflect the Early-Middle Paleozoic geological history, but large uncertainties in their age (Ruban, 2009) preclude from definite judgement on this issue. Widely-distributed Quaternary formations provide essential knowledge about depositional environments of the late stage of the evolution of the Greater Caucasus.

Table 2. Intervals of the geological history represented in the geosites constituting the geodiversity hotspot of Mountainous Adygeja

Geosite	Geological age												
	PCm	Cm	O	S	D	C	P	T	J	K	Pg	N	Q
Granite Gorge	+		?	?	?	?	+		+				+
Gruzinka Valley									+			?	+
Khadzhokh Canyon								+	+				+
Lago-Naki Highlands									+	+			+
Lower Moltchepa Valley									+				+
Lower Polkovnitskaja Valley										+			+
Permian Gorge						?	+		+				+
Partisan Glade Road									+				
Prince's Hill									+				+
Raskol Cliff							+						
Rufabgo Canyon							?	+	+				+
Sakhraj Canyon								+	?				+
Sjuk Fossillagerstätte									+				
Sjuk Valley	+		?	?	?	?			+				+
TOTAL	+		?	?	?	?	+	+	+	+		?	+

Abbreviations of geological periods: PCm - Precambrian, Cm - Cambrian, O - Ordovician, S - Silurian, D - Devonian, C - Carboniferous, P - Permian, T - Triassic, J - Jurassic, K - Cretaceous, Pg - Paleogene, N - Neogene, Q- Quaternary.

Figure 3. Photo of Precambrian rocks outcropped in the Sjuk Valley (on the northern flank of the Dakh Crystalline Massif) and, particularly, in the waterfall cliff face (in the centre of this image).

The geodiversity hotspot of Mountainous Adygeja can be employed successfully for demonstration of the geological history or, at least, some of its most important intervals. On the one hand, this thematic dimension increases the scientific and educational value of the regional geological heritage and the particular geosites. In only a few other places, one can explore so complete Triassic succession as represented in the Khadzhokh, Rufabgo, and Sakhraj canyons (Dagis & Robinson, 1973; Gaetani et al., 2005; Ruban et al., 2009) or trace changes in reefal ecosystems from the Late Permian (the Raskol Cliff) to the Late Triassic (the Sakhraj Canyon) and the Late Jurassic (the Lago-Naki Highlands). If so, it seems to be sensible to arrange the regional geoconservation activities so to emphasize on the geological history and to promote the knowledge about this geological heritage accordingly. E.g., panels can be installed to inform about the geosite importance for understanding of the geological history.

On the other hand, such a representation of the geological time scale makes Mountainous Adygeja ideal for geotourists who have a unique chance to observe the natural way of the Earth's evolution from the Precambrian "hidden" world to the life-rich Mesozoic "greenhouse" conditions. Particularly, professional geologists, amateurs, and occasional "nature-oriented" visitors interested in peculiar, but famous organisms of the Mesozoic (e.g., ammonites) will be satisfied. Ammonite remains are common in Jurassic shales and limestones (e.g., Toarcian-Aalenian ammonites are abundant in the Sjuk Fossillagerstätte, and Callovian ammonites are numerous in one well-accessible exposure in the Khadzhokh Canyon). A travel starting from the northern entrance to the Granite

Gorge, where the oldest rocks (Precambrian gneisses and amphibolites and Early-Middle Paleozoic serpentinites) are exhibited, then along the Granite Gorge with its magnificent outcrops of late Paleozoic granitoids, the Permian Gorge with the Permian molassic red-beds, the Partisan Glade road with lengthy outcrops of the Lower Jurassic laminated shales with siderite concretions, and ending at the southern toe of the Lago-Naki Highlands with spectacular view towards the Oshten Mountain (an ancient carbonate buildup) and modern slope deposits enables a rather complete visualization of the geological history. The other possible route can start from the same point (the northern entrance to the Granite Gorge) and then stretch to the north, i.e., to the Lower Polkovnitskaja Valley. This will permit to visit also some important (and aesthetically-attractive) Triassic and Cretaceous outcrops.

Of course, the geosites constituting the geodiversity hotspot of Mountainous Adygeja do not reflect the geological history without interruptions. E.g., major unconformities are established at the Middle-Upper Permian interval and in the upper part of the Middle Jurassic succession (Ruban, 2007a). However, such an incompleteness does not appear to be so important for effective management of the entire geodiversity hotspot. More important is the representation of many periods of the geological history (Table 2), which gives a unique chance for scientific research, development of rich educational programs, and satisfaction of geotourists' curiosity on the relatively small territory. Speaking about geotourists, it should be noted that many of them are usually not well-experienced with geological matters (Hose, 1996, Hose, 2000; Hose & Vickens, 2004), and some are only amateurs. For them, the presence of Permian or Jurassic rocks is more important than the absence of some stages. This partly solves the problem with the incompleteness of the regional stratigraphic succession.

The thematic treatment of the geological heritage of Mountainous Adygeja can be facilitated by that fact it permits to judge about the geological history without regional restrictions. Firstly, many geosites are of international or national importance (Table 1). Secondly, rocks, fossils, and palaeoenvironments in the geosites of the study territory are very typical for some geological periods, and they should match expectations of unprepared visitors. For instance, the Permian Period is famous for the vast space with arid climatic conditions (Chen, Boucot, Scotese & Fan, 2012), and the red-coloured molassic deposits outcropped along the Permian Gorge provide an evidence of such conditions from Mountainous Adygeja. Numerous textbooks, popular books, and collector guides, as well as TV documentary series and web resources (e.g., see Carlson, Plummer & Hammersley, 2011; Levin, 2006; Parker, 2009; Volpe, 2007) leave an

impression that the Mesozoic was an era of ammonites and dinosaurs. And this stereotype finds a proof in the geodiversity hotspot of Mountainous Adygeja, where Triassic, Jurassic, and Cretaceous ammonite localities are not only frequent, but also rich in fossils (Ruban, 2011). Moreover, remains of unidentified latest Jurassic reptiles have been discovered recently on the same territory (A. I. Volkodav & Volkodav J. I., 2009).

Theme 2: Changes in palaeotectonical affinity

The geological history of the entire Greater Caucasus and, particularly, Mountainous Adygeja as its western part, was marked by strong changes in its palaeotectonical affinity (Figure 4; see also above). The geosites constituting the geodiversity hotspot of Mountainous Adygeja permit to trace all above-mentioned changes with its Galatian/Hanseatic state as a possible exception (Table 3). Such a palaeotectonical theme permits scientists to attempt various research aimed at deciphering the tectonic history of the Greater Caucasus: as shown by the present discussion (Ruban, 2013; Stampfli, 2013), many relevant questions remain open. By the same reason, the geosites of Mountainous Adygeja allow education programs, demonstrating plate tectonic mechanisms and providing the very idea of exotic terranes. The latter is important in the modern geoscience education (e.g., Frisch, Meschede & Blakey, 2011; Lutgens, Tarbuck & Tasa, 2011; Smith & Pun, 2010).

Table 3. Major palaeotectonical domains represented in the geosites constituting the geodiversity hotspot of Mountainous Adygeja

Geosite	Palaeotectonical affinity of the Greater Caucasus					
	northern Gondwanan margin	Galatian Superterrane	Variscan Europe (Proto-Alpine segment)	terrane moving eastwards	island-arc Laurasian margin	modern Alpine Belt (Caucasian segment)
Granite Gorge	+	?	+		+	+
Gruzinka Valley					+	+
Khadzhokh Canyon			+	+	+	+
Lago-Naki Highlands					+	+
Lower Moltchepa Valley					+	+
Lower Polkovnitskaja Valley					+	+
Permian Gorge			+		+	+
Partisan Glade Road					+	+
Prince's Hill					+	+
Raskol Cliff			+			
Rufabgo Canyon			+	+	+	+
Sakhraj Canyon			+	+	?	+
Sjuk Fossillagerstätte					+	
Sjuk Valley	+	?			+	+
TOTAL	+	?	+	+	+	+

This follows the interpretations of the geological history of the Greater Caucasus attempted by Laz'ko et al. (1975), Lordkipanidze et al. (1984), Ershov et al. (2003), Kazmin & Tikhonova (2006), Saintot et al. (2006), Tawadros et al. (2006), Ruban (2007a,b, 2013), and Ruban et al. (2007a,b), Efendiyeva & Ruban (2009), and Adamia et al. (2011a,b); see also Figure 4.

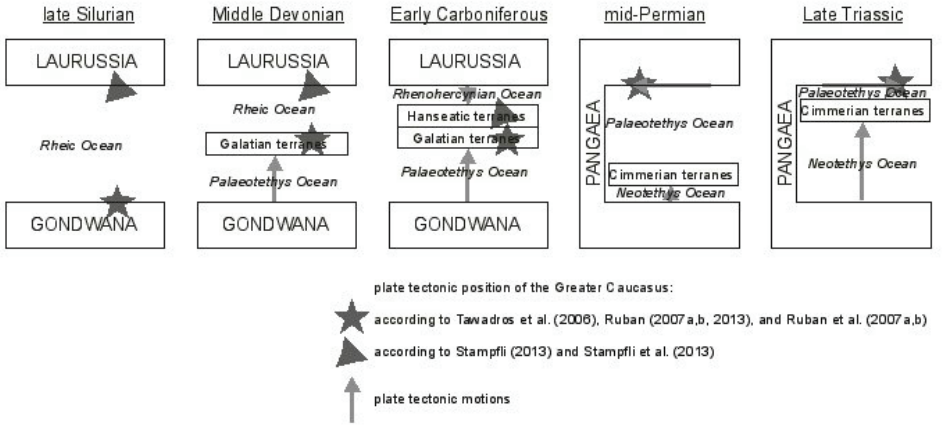

Figure 4. Schematic representation of the Middle Paleozoic-Triassic changes in the palaeotectonical affinity of the Greater Caucasus. Nomenclature and interpretation of the dynamics of major tectonic blocks and oceans follow Stampfli & Borel (2002) and Stampfli, Hochard, Vérard, Wilhem, & von Raumer (2013).

For unexperienced geotourists, it would be difficult to perceive the changes in the palaeotectonical affinity of the Greater Caucasus observing the only rocks outcropped at the geosites. However, professional explanations with certain simplifications (these could be offered by trained guides or on information panels) allow to attract their attention to this theme. For instance, visitors may be interested in to touch "a piece of Africa" or "a piece of Europe" visiting the Granite Gorge (Figure 5). This would be an unusual and intriguing experience for unexperienced geotourists. In the other words, the palaeotectonical theme increases the value of the geological heritage of Mountainous Adygeja and widens perspectives of the regional geoconservation and geotourism. Installing information panels in order to explain the palaeotectonical affinity at a given geosite, as well as the arrangement of geotourist routes and excursions will facilitate such a thematic treatment of this geodiversity hotspot and promotion of the knowledge on the latter.

Figure 5. Photo of the "Africa meets Europe" geotourist attraction (the length of the black line bar on the granitic rock is 15 cm).

Discussion

Undoubtedly, the thematic dimension of the geological heritage in Mountainous Adygeja allows some innovative solutions in the regional geoconservation and geotourism activities, which will make them more effective. However, emphases on the importance of geosites for the only representation of the geological history and/or the highly-complex palaeotectonics may be dangerous for adequate promotion of this geodiversity hotspot. The latter exhibits a lot of other valuable information (Table 1). That is why geosites, where stratigraphical, palaeontological, and/or palaeogeographical features do not dominate, should not be excluded from geoconservation and geotourism programs. Moreover, so large and complex geosites as the Lago-Naki Highlands should not be promoted as the only "remnant" of the Late Jurassic sea, because they host other peculiar phenomena. But this work shows that to ignore the thematic dimension and all relevant opportunities would be a kind of myopia in the management of the regional geological heritage.

Two strategies can be implemented in order to solve the noted dilemma. Firstly, the regional geoconservation and geotourism authorities may employ thematic treatment of the geological heritage as only one of many possible approaches. Secondly, they may try to multiply the themes, which the available geosites may contribute to. For instance, the geosites of the geodiversity hotspot in Mountainous Adygeja may be grouped so to serve for demonstration of 1) the abundance and the diversity of megaclasts, which are often intriguing objects for research and tourism (Lubova et al., 2013), 2) the intensity of true karst and pseudo-karst (the latter develops in granitoids of the Dakh Crystalline Massif, and it is well visible along the Granite Gorge), and 3) the spectrum of geological processes. An optimal choice of themes and their combination, as well as balancing between the thematic and non-thematic treatment of the geological heritage are premises for the rational development of geoconservation and geotourism on the study territory.

Conclusions

The geodiversity hotspot of Mountainous Adygeja allows to treat its geosites in two ways: 1) visualization of the geological history, especially the late Paleozoic-Mesozoic interval, and 2) tracing the changes in the palaeotectonical affinity of the Greater Caucasus terrane (this also helps to perceive some general ideas of the plate tectonics). Viewing the geological heritage in such a thematic dimension will facilitate and enrich the regional geoconservation and geotourism activities. However, the other peculiar geological phenomena occurring in Mountainous Adygeja should not be omitted, and the possibilities to arrange the geosites by the other themes should be taken into consideration.

Generally, the present study indicates some premises for successful applicaiton of the thematic approach in geoconservation and geotourism in Mountainous Adygeja and the other similar geodiversity hotspots. But, undoubtedly, effectiveness of this approach should be tested practically, and an analysis of outcomes from such testing is important task for further studies.

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