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JURASSIC TRACE FOSSIL LOCALITIES OF ADYGEYA (RUSSIA): NEW GEOHERITAGE UNDER ANTHROPOGENIC PRESSURE

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Abstract: Geological heritage, and generally geoheritage, needs identification in the regions known for the modern progress in geological research, and the risks of its damage have to be documented. Recent discoveries of trace fossil assemblages in the Early Jurassic rocks of Adygeya (Greater Caucasus, Russia) require the consideration of their key localities as geoheritage sites. The Guzeripl Main and Khamyshki–Lipovaya localities are the outcrops of the Toarcian rocks with abundant, rather diverse, and sometimes unusual ichnofossils belonging to the Cruziana ichnofacies and shedding light on the bottom life of an oxygen-depleted palaeosea. Both localities are unique on the regional and even national scales. Tourism growth in Adygeya provokes physical destruction of the geoheritage (as in the case of the Guzeripl Main site despite its location on the territory of the natural reserve), but it also increases in accessibility of unique features (as in the case of the Khamyshki–Lipovaya site). Geopark creation is recommended as the best solution for efficient ichnological geoheritage management in Adygeya.

Keywords: conservation; geosites; ichnofossil; tourism; Caucasus

Introduction

Geological heritage, and generally geoheritage, has become an important research topic since the end of the 20th century. The relevant ideas are diverse and well-conceptualized (Gordon, 2018; Mikhailenko, Nazarenko, Ruban, & Zayats, 2017; Prosser, 2013). However, geoheritage inventory has remained an urgent task for many regions, especially those where important geological, palaeontological, and geomorphological discoveries have been made only recently. Geoheritage risks and real/potential damage have been reported rarely (e.g., Carvalhido, Brilha, & Pereira, 2016; Szepesi et al., 2018), and their recognition remains on the agenda. Attention should be paid to specific kinds of unique geological objects. For instance, the geoheritage potential of trace fossil (ichnofossil) localities has been realized (Habibi, Nielsen, Ponedelnik, & Ruban, 2017; Neto de Carvalho, Rodrigues, & Baucon, 2014; Rabal-Garcés, Castanera, Luzón, Barco, & Canudo, 2018).

The Caucasus remains a poorly-known domain in regard to geoheritage and trace fossils, although it is rich in both. The decade-long field investigations of the author have enabled to find

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two especially unique localities of Jurassic trace fossils in Adygeya, a region in the northwestern part of the Caucasus. The objective of this study is the valuation of these localities as geosites. The urgency of this study is dictated, particularly, by strong anthropogenic pressure on the entire landscapes of this region linked to the rapid tourism-related infrastructure development. This pressure is a serious challenge to geoheritage conservation, the ignoring of which may result in damage or loss of important and just-discovered geological objects.

Geographical and geological setting

The Caucasus is a big, mountainous domain located between the Black Sea in the west, the Caspian Sea in the east, the Russian Plain in the north, and the Middle Eastern mountain ranges in the south. The highest peak is Elbrus (5,642 m). Its northern segment is known as the Greater Caucasus. The study area corresponds to the southern part of the Republic of Adygeya, which is one of the regions of the Russian South (Figure 1). This area is located in the northwestern part of the Greater Caucasus. It is crossed by several sub-parallel, west-east stretching mountain ranges with the elevations from 500 m to 2,500 m. The Belaya River, which is a big left tributary of the Kuban River crosses these ranges from the south to the north and divides the study area into two halves. The study area has become an important tourist destination of the Russian South, where nature serves as the main tourism resource.

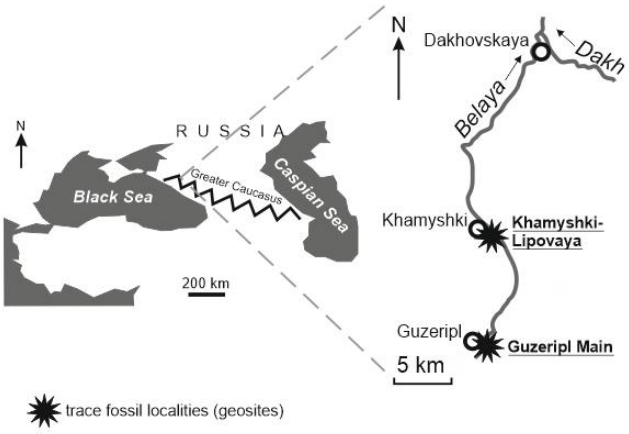

Figure 1. Location of the Jurassic ichnofossil-related geosites in Adygeya

Geologically, the study area belongs to the Cenozoic orogenic belt. The dominant sedimentary rocks are of Jurassic age, and these consist of two complexes (Ruban, Nielsen, Mikhailenko, Nazarenko, & Zayats, 2017). The Early–Middle Jurassic deposits are chiefly siliciclastics with a total thickness of up to 10 km, and the Late Jurassic rocks are carbonates overlain by evaporites with a total thickness of up to 3 km. The lower mega package represents the ancient deep, semi-enclosed, back-arc sea basin with oxygen-depleted conditions. The upper complex represents the carbonate platform.

Since 2007, many discoveries of Jurassic trace fossils have been made in Adygeya. For instance, the Guzeripl Main locality yields a very rich assemblage of the Toarcian (Early Jurassic) trace fossils.

Although this assemblage has been characterized by Ruban et al. (2017), new findings were made in 2018. The same field campaign resulted in interesting Toarcian trace fossil findings in the other locality, namely the Khamyshki–Lipovaya locality, which was earlier described by Ruban et al. (2018). These two objects seem to be the most important trace fossil localities of Adygeya.

Methodology

Two principal approaches were employed for the purposes of this study. First, the chosen geosites are formally described on the basis of the field inventory in July 2018. Special attention is paid to their ichnofossil content (principal trace fossils are identified) and argumentation of their uniqueness. The latter is the main criterion for geosite valuation (Ruban, 2010). The spatial dimension of the uniqueness is also considered. Second, the anthropogenic pressure on these geosites is documented. Visible signs of damage are inspected. Of interest are the anticipated effects of modern tourism growth in Adygeya. The factors of geoheritage risk (Carvalhido et al., 2016; Szepesi et al., 2018) are also taken into account.

This study involves the ichnological analysis. Its general principles were described by Seilacher (2007) and Buatois & Mángano (2011). Some information relevant to the ichnotaxa identification can also be found in Uchman (1998), Bednarz & McIlroy (2009), and Nara & Ikari (2011).

Results

The Guzeripl Main locality is situated on the right bank of the Belaya River near the town of Guzeripl (Figure 1). This is a single outcrop of alternating thin layers of fine and medium-sized siliciclastics of Toarcian age (Ruban et al., 2017) (Figure 2A). This locality boasts the significant abundance of trace fossils typical for oxygen-depleted conditions of a submarine fan. In addition to the representatives of ichnogenera *Chondrites*, *Gyrochorte*, *Nereites*, and *Planolites* identified earlier (Ruban et al., 2017), the trace identified as *Phycosiphon* isp. has been found recently. The uniqueness of this trace fossil locality as a geosite is determined by several circumstances. First, this is the first Jurassic ichnofossil locality established in Adygeya in 2007. Second, this locality is characterized by significant abundance and moderately high diversity of trace fossils. Third, the ichnofossils are well-visible on the exposed surfaces of rock layers, and these are easy to collect. Fourth, this locality provides a very typical example of the *Cruziana* ichnofacies and the deep submarine fan depositional environment. Fifth, this locality is crucial for the understanding of the bottom ecosystems of the Early Jurassic Caucasian Sea. Although other, less important localities of the same kind are known regionally (Ruban et al., 2017), this one is the most informative for Adygeya and, most probably, for the entire Greater Caucasus. Therefore, the uniqueness of the Guzeripl Main geosite is regional.

The Khamyshki–Lipovaya locality is situated on the left bank of the Belaya River in the southern part of the large village of Khamyshki (Figure 1). This is a lengthy, fragmented outcrop representing Toarcian shales with siliciclastic and carbonate interbeds (Ruban et al., 2018) (Figure 2B). Probably, the age of these strata is a bit younger than the age of the strata in the Guzeripl Main locality. The section of the Toarcian sedimentary rocks has been recognized recently as a geosite of a regional rank (Ruban et al., 2018), but before the discovery of ichnofossils there. The identified trace fossils include *Protovirgularia* cf. *rugosa*, *Arthrophycus tenuis*, *Nereites* isp., *Ophiomorpha* isp., *Palaeophycus tubularis*, and *Planolites* isp (these are also characteristic to the *Cruziana* ichnofacies). The first of the above-listed ichnotaxa (Figure 2C) is essentially a bivalve locomotion trace (Buatois & Mángano, 2011; Nara & Ikari, 2011; Uchman, 1998), and this is its first report from the Jurassic

deposits of Russia (to the author's knowledge). This evidence strengthens the arguments for the significant uniqueness of this geosite.

The study area experiences significant, permanently-rising anthropogenic pressure, which is linked to the growth of the regional tourism industry. This pressure includes three components. First, road construction and maintenance leads to the creation of new, artificial outcrops in roadcuts, but also to the destruction of the earlier-existed outcrops (both artificial and natural). Second, the creation of trails and spaces for open recreation increases access to some geological features, but the latter can also be damaged at the stage of infrastructural objects installation. Third, uncontrolled visits to geological localities provoke their occasional damage or fossil over-sampling.

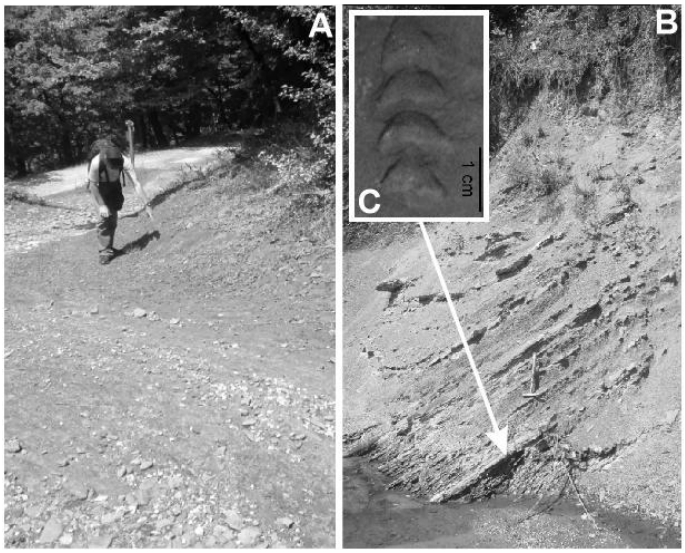

Figure 2. Views of the Guzeripl Main (A) and Khamyshki-Lipovaya (B) geosites and the trace fossil *Protovirgularia* cf. *rugosa* (C)

Both of the analyzed geosites are located in the areas directly and heavily affected by tourism activities. Although the Guzeripl Main locality belongs to the territory of the Caucasian State Natural Biosphere Reserve with strict regulation of visits, it is situated near the official entrance to this reserve, the popular exhibits, and the open recreation spaces. The daily number of visitors crossing the locality by trail is measured by dozens and even hundreds, according to the author's observations. Their walking destroys some exposed rock surfaces and "polishes" the outcrop, which results in the loss of the ichnological information. Moreover, trail maintenance for better comfort and safety of visitors has resulted in the locality modification, which is also a kind of a negative influence. There is significant anthropogenic pressure on this geosite and high risks for its further serious damage. In contrast, the Khamyshki–Lipovaya locality has gained a significant advantage because of tourism growth. This geosite has become well-accessible because of the metallic stairs constructed by the nearby hotel and the maintenance of the river bank recreation area. Despite the high number of visitors (up to a hundred per day, according to the author's observations), no negative influences have been documented. In this case, the anthropogenic pressure and the landscape modification are favorable to the ichnological geoheritage.

Discussion

It is not excluded that the uniqueness of the described geosites is national because they both represent bottom ecosystems of an oxygen-depleted palaeosea; and it is sensible to add that this oxygen depletion was linked to the global environmental perturbations (oceanic anoxia, mass extinction, etc.) in the Toarcian (Ait-Itto, Martinez, Price, & Ait Addi, 2018; Caruthers, Smith, & Gröcke, 2013; Danise, Twitchett, Little, & Clémence, 2013; Dunhill, Foster, Azaele, Sciberras, & Twitchett, 2018; Huang & Hesselbo, 2014; Krencker et al., 2014; Ruvalcaba Baroni et al., 2018). Geological objects of this kind seem to be rare for the territory of the entire Russia.

Both of the geosites experience significant anthropogenic pressure. The latter has a negative effect in one case, and a positive effect in the other case. Surprisingly, the former is established in the officially protected area, and the latter is found on the area of uncontrolled recreation. These observations imply that the standard nature protection does not guarantee efficient geoheritage conservation, and the very anthropogenic pressure may bring unexpected effects.

The analyzed geosites can be conserved more efficiently in the case of geopark creation in Adygeya. Geoparks provide significant advantages for geoheritage management (Henriques & Brilha, 2017). Notably, they have two functions. First, geoparks increase the awareness of local nature protection authorities and activists, public community, and visitors about the unique geological phenomena. This is very important in the case of the Guzeripl Main locality because of the high risks for this geosite resulting, most probably, from the unawareness of its true value. The Caucasian Reserve offers efficient protection of the unique wildlife of the northwestern part of the Greater Caucasus, but it is not clear whether it recognizes the value of the geoheritage (especially in the case of the newly-discovered trace fossil localities). Second, geoparks are focused by definition on finding a balance between geoheritage conservation and tourism activities (Henriques & Brilha, 2017). This function would be essential for the study area where the tourism-related anthropogenic pressure affects geoheritage so differently. The established uniqueness of the Guzeripl Main and Khamyshki–Lipovaya geosites implies these are very suitable candidates for inclusion into a possible geopark to be created in the mountainous part of Adygeya.

Conclusion

The two Jurassic trace fossil localities of Adygeya are considered as important geosites. The tourism development has both negative and positive effects on their state. The geopark creation seems to be an efficient approach for the geoheritage management on the study area. Further research should examine these effects in other geosites known locally, which will enable to develop an adequate strategy of geoheritage management in Adygeya.

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References

Ait-Itto, F.-Z., Martinez, M., Price, G. D., & Ait Addi, A. (2018). Synchronization of the astronomical time scales in the Early Toarcian: A link between anoxia, carbon-cycle perturbation, mass extinction and volcanism. *Earth and Planetary Science Letters, 493*, 1–11. https://doi.org/10.1016/j.epsl.2018.04.007

Bednarz, M., & McIlroy, D. (2009). Three-dimensional reconstruction of "phycosiphoniform" burrows: implications for identification of trace fossils in core. *Palaeontologica Electronica, 12*(3), 13A. Retrieved from https://palaeo-electronica.org/2009_3/195/195.pdf

Buatois, L. A., & Mángano, M. (2011). *Ichnology: Organism-Substrate Interactions in Space and Time*. Cambridge, UK: Cambridge University Press.

Carvalhido, R. J., Brilha, J. B., & Pereira, D. I. (2016). Designation of Natural Monuments by the Local Administration: the Example of Viana Do Castelo Municipality and its Engagement with Geoconservation (NW Portugal). *Geoheritage, 8*(3), 279–290. https://doi.org/10.1007/s12371-016-0183-2

Caruthers, A. H., Smith, P. L., & Gröcke, D. R. (2013). The Pliensbachian-Toarcian (Early Jurassic) extinction, a global multi-phased event. *Palaeogeography, Palaeoclimatology, Palaeoecology, 386*, 104–118. https://doi.org /10.1016/j.palaeo.2013.05.010

Danise, S., Twitchett, R. J., Little, C. T. S., & Clémence, M.-E. (2013). The Impact of Global Warming and Anoxia on Marine Benthic Community Dynamics: An Example from the Toarcian (Early Jurassic). *PLoS ONE, 8*(2), e56255. https://doi.org/10.1371/journal.pone.0056255

Dunhill, A. M., Foster, W. J., Azaele, S., Sciberras, J., & Twitchett, R. J. (2018). Modelling determinants of extinction across two Mesozoic hyperthermal events. *Proceedings of the Royal Society B: Biological Sciences, 285*, 20180404. https://doi.org/10.1098/rspb.2018.0404

Gordon, J. E. (2018). Geoheritage, geotourism and the cultural landscape: Enhancing the visitor experience and promoting geoconservation. *Geosciences, 8*(4), 136. https://doi.org/10.3390/geosciences8040136

Habibi, T., Nielsen, J. K., Ponedelnik, A. A., & Ruban, D. A. (2017). Palaeogeographical peculiarities of the Pabdeh Formation (Paleogene) in Iran: New evidence of global diversity-determined geological heritage. *Journal of African Earth Sciences, 135*, 24–33. https://doi.org/10.1016/j.jafrearsci.2017.08.006

Henriques, M. H., & Brilha, J. (2017). UNESCO Global Geoparks: a strategy towards global understanding and sustainability. *Episodes, 40*(4), 349–355. https://doi.org/10.18814/epiiugs/2017/v40i4/017036

Huang, C., & Hesselbo, S. P. (2014). Pacing of the Toarcian Oceanic Anoxic Event (Early Jurassic) from astronomical correlation of marine sections. *Gondwana Research, 25*(4), 1348–1356. https://doi.org/ 10.1016/j.gr.2013.06.023

Krencker, F. N., Bodin, S., Hoffmann, R., Suan, G., Mattioli, E., Kabiri, L., . . . Immenhauser, A. (2014). The middle Toarcian cold snap: Trigger of mass extinction and carbonate factory demise. *Global and Planetary Change, 117*, 64–78. https://doi.org/10.1016/j.gloplacha.2014.03.008

Mikhailenko, A. V., Nazarenko, O. V., Ruban, D. A., & Zayats, P. P. (2017). Aesthetics-based classification of geological structures in outcrops for geotourism purposes: a tentative proposal. *Geologos, 23*(1), 45–52. https://doi.org/10.1515/logos-2017-0004

Nara, M., & Ikari, Y. (2011). "Deep-sea bivalvian highways": An ethological interpretation of branched Protovirgularia of the Paleogene Muroto-Hanto Group, southwestern Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology, 305*(1–4), 250–255. https://doi.org/10.1016/j.palaeo.2011.03.005

Neto de Carvalho, C., Rodrigues, J. C., & Baucon, A. (2014). "Fossil Art": The importance and value of the palaeobiodiversity in the Naturtejo Global Geopark, under UNESCO (Portugal). *Comunicacoes Geologicas, 101*(1), 91–99. Retrieved from http://www.lneg.pt/download/9196/10_ART_CG13_012-3005.pdf

Prosser, C. D. (2013). Our rich and varied geoconservation portfolio: the foundation for the future. *Proceedings of the Geologists' Association, 124*(4), 568–580. https://doi.org/10.1016/j.pgeola.2012.06.001

Rabal-Garcés, R., Castanera, D., Luzón, A., Barco, J. L., & Canudo, J. I. (2018). A Palaeoichnological Itinerary Through the Cenozoic of the Southern Margin of the Pyrenees and the Northern Ebro Basin (Aragón, Northeast Spain). *Geoheritage, 10*(3), 499–509. https://doi.org/10.1007/s12371-017-0246-z

Ruban, D. A. (2010). Quantification of geodiversity and its loss. *Proceedings of the Geologists' Association, 121*(3),326–333. https://doi.org/10.1016/j.pgeola.2010.07.002

Ruban, D. A., Nielsen, J. K., Mikhailenko, A. V., Nazarenko, O. V., & Zayats, P. P. (2017). Ichnogeneric diversity in the Jurassic deposits of the Western Caucasus: A brief summary. *Stratigraphy and Sedimentology of Oil-Gas Basins, 19*(1), 3–10. Retrieved from http://www.isjss.com/view.php?lang=en&menu=archives&type=2&num=19

Ruban, D. A., Zorina, S. O., Morozov, V. P., Galiullin, B. M., Eskin, A. A., & Nikashin, K. I. (2018). The Khamyshki-Lipovaja section – a new geosite displaying unstable palaeoenvironments of the Early–Middle Jurassic semi-enclosed sea on the northern Neo-Tethyan margin. *Natura Nascota, 52*, 37–54. Retrieved from http://www.museomonfalcone.it/nnonline/natnas52.pdf

Ruvalcaba Baroni, I., Pohl, A., van Helmond, N. A. G. M., Papadomanolaki, N. M., Coe, A. L., Cohen, A. S., . . . Slomp, C. P. (2018). Ocean Circulation in the Toarcian (Early Jurassic): A Key Control on Deoxygenation and Carbon Burial on the European Shelf. *Paleoceanography and Paleoclimatology, 33*(9), 994–1012. https://doi.org/10.1029/2018PA003394

Seilacher, A. (2007). *Trace Fossil Analysis*. Berlin, Germany; New York, NY: Springer.

Szepesi, J., Ésik, Z., Soós, I., Novák, T., Süto, L., Rózsa, P., . . . Harangi, S. (2018). Földtani objektumok értékminosítése: Módszertani értékelés a védelem, bemutatás, fenntarthatóság és a geoturisztikai fejlesztések tükrében [Methodological review of geosite inventory and assessment work in the light of protection, sustainability and the development of geotourism]. *Foldtani Kozlony, 148*(2), 143–160. https://doi.org/10.23928/foldt.kozl.2018.148.2.143

Uchman, A. (1998). Taxonomy and ethology of flysch trace fossils: Revision of the Marian Ksiazkiewicz collection and studies of complementary material. *Annales Societatis Geologorum Poloniae, 68*, 105–218. Retrieved from https://geojournals.pgi.gov.pl/asgp/article/viewFile/12322/10796