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GEOLOGOS

Geologos 27, 1 (2021): 57–65
DOI: 10.2478/logos-2021-0005

The power of colour in geoheritage studies and marketing: some tentative reflections

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Abstract

Colour is a common physical property in exposures of unique geological objects, but is only marginally addressed in geoheritage literature. We here present our point of view on how this feature can be treated in geoheritage studies, with the general aim at setting up a broad discussion. Three functions of colour in geoheritage are outlined, namely geological interpretation (e.g., compositional and genetic peculiarities of sedimentary rocks), higher visibility due to colour contrast and aesthetic attractiveness to geotourists. Assessment of colour at geosites is challenging, especially because of uncertain colour nomenclatures. We propose to focus on colour identification, calculation of the number of colours, qualitative evaluation of colour contrast and comparison of colours of a given geological object to its landscape context. Geoheritage colours may have different meanings to geosite visitors, and colour-emotion associations revealed by national and international studies are important to trace these meanings.

Key words: aesthetic properties, geoconservation, geotourism, emotions, Western Caucasus

1. Introduction

Geological heritage (geoheritage) constitutes an important natural resource, the social and economical values of which can be understood, particularly, through its relevance to ecosystem, geosystem and other services (Crofts & Gordon, 2014; Brilha et al., 2018; Ruban et al., 2018; Garcia, 2019; Henriques et al., 2020; Kubalíková, 2020). These values depend on various characteristics of unique geological objects, such as rarity, classical view, peculiarity, accessibility and educational importance; their aesthetic properties are very important among other characteristics as well (Ali et al., 2008; Unjah et al., 2013; Reynard & Coratza, 2016; Bollati et al., 2017; Gordon, 2018; Nazaruddin, 2019; Migoń & Maia, 2020). Apparently, these properties have formed historical premises for our interest in geoconservation and geotourism (Carcavilla et al., 2013; Hose, 2016). It should be also stressed that the aesthetic properties

of geoheritage are related directly to scenic beauty which is an essential value of natural landscapes, although highly complex to assess (Carlson, 1977; Schroeder & Daniel, 1981; Patsfall et al., 1984; Hull & Stewart, 1992; Clay & Daniel, 2000; Daniel, 2001; Ribe, 2002; Frank et al., 2013; Schirpke et al., 2013; Williams, 2019; Wang et al., 2020).

Evidently, aesthetic properties result from our interpretation of the physical properties of any given object. One of these physical properties that determine aesthetic judgements is colour (Kirillova et al., 2014). Mikhailenko et al. (2017) stressed the importance of a geoheritage pattern that is strongly tied to the colour of geological objects, and some other specialists also considered more or less similar matters in their studies (see below). However, a general framework for understanding geoheritage colour is still missing, although its necessity is dictated by the needs of geoconservation and geotourism. Geoconservation has to characterise all geoheritage properties comprehensively. Geotourism demands identifying properties which attract visitors because the relevant activities depend on proper geoheritage marketing. More generally, it should be stated that the colour of geoheritage is something more than the colour of geological objects. The latter is the physical property of rocks and minerals, and it is useful for their identification and interpretation, i.e., for scientific purposes. In contrast, the former is the property of geoheritage landscape elements and is important to both scientists and non-scientists who may perceive and interpret colours very differently. Apparently, geoheritage colour refers to landscape aesthetics, whereas the colour of geological objects refers to their composition.

The main objective of the present paper is to extend our understanding of colour in geoheritage studies via highlighting functions, assessment and interpretation of this important physical property of unique geological objects. Our note comprises several tentative proposals and reflects our point of view and personal experience. However, these proposals themselves stress objectively the general importance of colour for geoheritage assessment in both geoconservation and geotourism. This topic is significant, but also highly complex and has been rarely explored. Hence, our main goal is to attempt to start a broad discussion. This explains the brevity and structural peculiarities of the present note that cannot (and should not) be seen as full-blown research or review paper with regard to the present state of the knowledge.

The present paper lists several examples from the Mountainous Adygeya geodiversity hotspot, which is located in the Western Caucasus (Fig. 1). This mountainous area in southwestern Russia is dominated by marine Mesozoic sedimentary formations and represents the Late Cenozoic orogen of the Greater Caucasus (Adamia et al., 2011; Sharkov et al., 2015; Ismail-Zadeh et al., 2020; van Hinsbergen et al., 2020; Vasey et al., 2020). The area boasts a rich geoheritage (Ruban, 2010; Mikhailenko et al., 2017) and many geosites demonstrate striking colour peculiarities. On the one hand, this example is selected on the basis of our personal experience, while, on the other, we avoid reference to other, well-known and 'ideal' examples of coloured rocks for the same reasons why illustrations of 'ideally-looking' minerals detract from the usefulness of mineralogical guides and textbooks for practical mineral identification.

2. A brief literature overview

Fundamental works devoted to geoheritage assessment (Prosser et al., 2006; Brilha, 2016) review relevant properties of unique objects fairly comprehensively, but do not focus on colour. Gray's (2013) book puts geoheritage and geodiversity into a broader landscape frame, which is a premise for the recognition of the importance of colour, the front cover of this issue being all about colour variation. Reynard & Giusti (*in* Reynard & Brilha, 2018) recognised colour as an important property that is relevant to aesthetics and cultural value of geoheritage.

Cooper (2010) and Cooper et al. (2013) identified colour as an important property of heritage stones, while Cairncross (2011) indicated colour among mineral characteristics that he held to be relevant to heritage values. A highly important suggestion was made by Warowna et al. (2016), who used the number of colours to evaluate the aesthetic value of geosites, with one colour linked to low value, two to three colours to medium value and more than three colours to high value. A particular score was assigned to each value, and this simple, semi-quantitative technique was applied successfully for the purposes of territorial geoheritage assessment. One should take into account, however, that aesthetic properties cannot be equated just to colours (Kirillova et al., 2014; Ruban, 2016). At the same time, Mikhailenko et al. (2017) paid attention to the aesthetic value of various geological structures in the Mountainous Adygeya geodiversity hotspot, including layering and folding, which is often recognised by a combination or alternation of several colours. This latter

work bears an aesthetic classification of structures, but it does not home in on colour itself. More recently, in a review of the methodology used since 2007 for Spanish geoheritage inventories, García-Cortés et al. (2019) mentioned the use of overall assessment of colour variety in semi-quantitative analyses of aesthetic beauty for calculating educational and touristic value.

Colour as an important geoheritage characteristic has been mentioned 'here and there' in the literature. For instance, Kramar et al. (2015) noted the contrast between black rocks and white fossils as a characteristic feature of the Podpec Limestone in Slovenia. Németh & Moufti (2017) stressed that the bright white colour of the volcanoes of Harrat Khaybar in Saudi Arabia determined the high aesthetic value of the entire area, while Habibi & Ruban (2018) suggested that the red colour of the Cretaceous Neyriz radiolarites in Iran made their outcrops aesthetically attractive. Careddu & Grillo (2019) noted that the variegated colours of the Cenozoic volcanic rocks in Sardinia determined their aesthetics, while Kaur et al. (2020) paid attention to the yellow/golden Jaisalmer Limestone from India as a heritage stone. All these works prove that colour is an important physical property of geoheritage, but they tend to treat it intuitively and restrict it to determining aesthetic values.

The literature overviewed above is important and constitutes a premise for a 'deeper' consideration of colour in geoheritage studies. In our opinion, the three essential questions for understanding of this issue are as follows:

1. Is colour, as an aesthetics-related property, relevant just to geotourism?
2. How many colours can be found in a geosite?
3. Does colour have any special meaning to geosite visitors?

These questions, which remain open, refer to functions, assessment and interpretation of colour in geoheritage studies, respectively. The next sections in the present paper offer explanations and tentative proposals relevant to these three issues.

3. Functions of geoheritage colour

Here we identify three general functions of colour in relation to geoheritage objects; these are briefly outlined below. The first function is geological interpretation, linked to the scientific treatment of unique features. For instance, it is known that colour provides important clues for understanding composition, diagenetic features and depositional environments in sedimentary rocks (e.g., Tucker, 2011). In the southern part of the Mountainous Adygeya geodiversity hotspot, the Lower Jurassic (Pliensbachian–Toarcian; locally also Middle Jurassic) shales are often dark grey or black (Fig. 1), being enriched in carbon as a result of accumulation in a semi-restricted marine basin with strong oxygen depletion. In its northern part, there are outcrops of Lower Cretaceous (Aptian) sandstones, which are distinguished by their greyish green colour (Fig. 1). The latter is explained by the presence of glauconi, which reflects their very specific depositional setting. This first function addresses the colour of geological objects, but not that of geoheritage in its entirety (see above).

The second function is visibility: how are geosites as particular elements of geoheritage landscapes identified on the basis of colour of the rock contrasting to the colour of the surrounding landscape. In the central part of the Mountainous Adygeya geodiversity hotspot, the Upper Jurassic (Oxfordian–Kimmeridgian) carbonates (limestones and dolostones) crop out along tall and lengthy scarps of several cuesta-type ranges. The yellow-white colour of these rocks contrasts with the dominating green (summer) or grey (winter) colour of the entire landscape (Fig. 1), making the rocks and scarps well visible. The same holds true for the Granite Gorge, where the pink colour of the Upper Palaeozoic granitoids (granites and granodiorites) allows their tracing along the walls of the V-shaped valley of the River Belaya (Fig. 1). This function of colour is also of crucial importance in the case of the so-called viewpoint geosites, i.e., standpoints allowing distant, panoramic views of large-scale, unique features and geological landscapes (Migoń & Pijet-Migoń, 2017; Mikhailenko & Ruban, 2019). In this case, the geoheritage colour is considered.

The third function refers to aesthetics, as demonstrated in several studies referred to above. In view of the fact that colour is an important criterion in people's judgements of beauty (Kirillova et al., 2014), this makes unique geological objects either more or less attractive to observers depending on their individual and/or collective preferences. In the Mountainous Adygeya geodiversity hotspot, an impressive example can be found directly in the town of Kamennomostskiy, where the Upper Jurassic (Tithonian) red-coloured, iron-rich clays with sandy layers crop out extensively in the steep embankments of the River Belaya (Fig. 1), making the local landscape unusual and outstandingly picturesque.

The recognition of these three functions demonstrates the importance of colour in the practice of

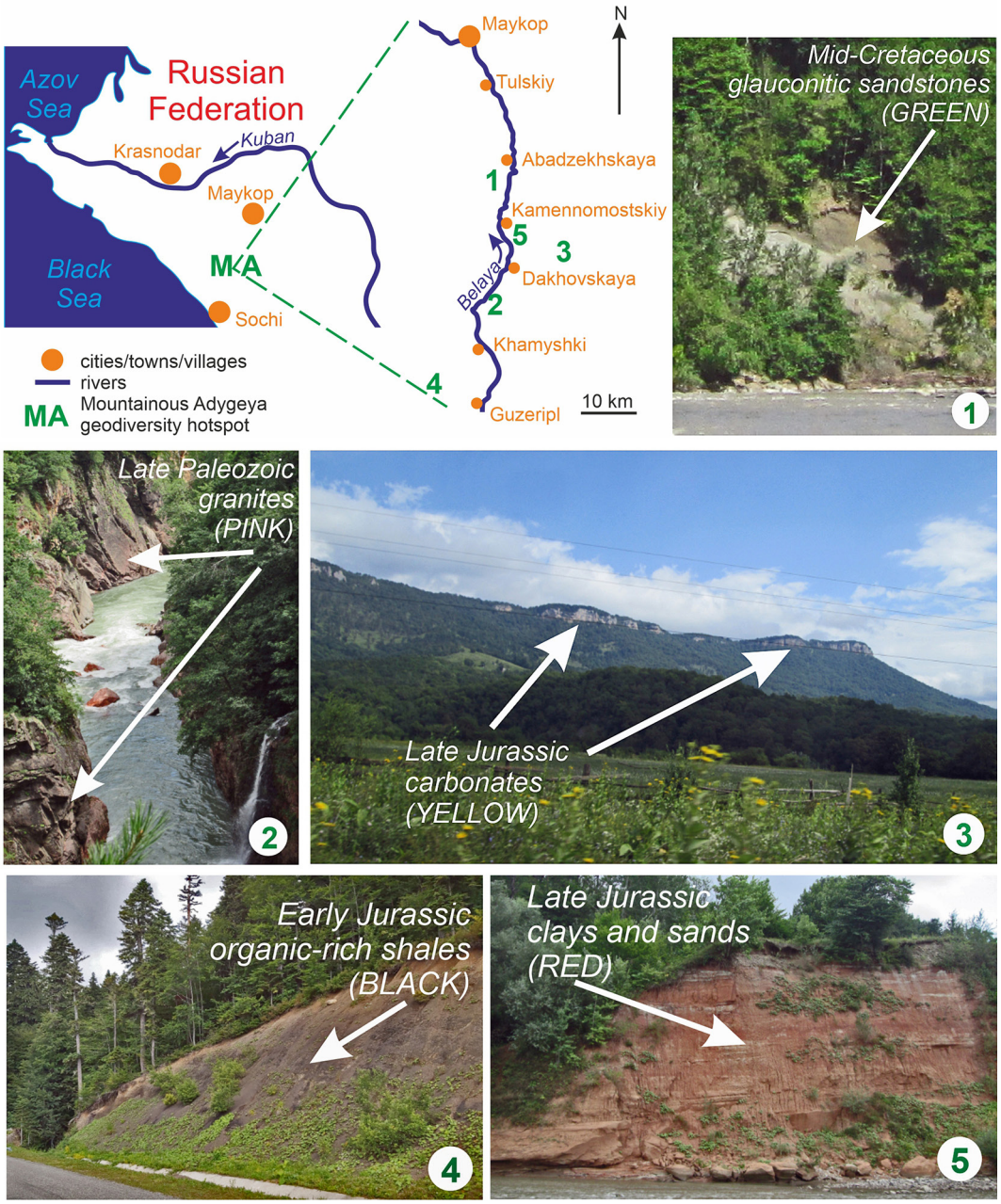

Fig. 1. Different colours of geoheritage: several examples from the Mountainous Adygeya geodiversity hotspot.

both geoconservation and geotourism (as well as in geological research), allowing to study and understand its relevance. Moreover, attention to colour may help in the promotion and branding of geosites and geoparks (geoheritage marketing), which is an important, yet highly challenging task (Migoń & Pijet-Migoń, 2016; Wang & Yuan, 2020). The impressive, unusual colour of unique features contributes to brand creation and memorisation. Generally, geoheritage colour functions with regard to both geological objects and the surrounding landscape and thus serves multiple purposes.

4. Assessment of geoheritage colour

Four procedures for colour assessment in geoheritage studies are herein proposed, namely:

1. Identification of colours (basic spectrum and other colours – Fig. 2) of unique geological features;
2. Calculation of the number of colours of unique features: a feature with one colour is monochromic, a feature with two or three colours is oligochromic and one with four or more colours is polychromic;

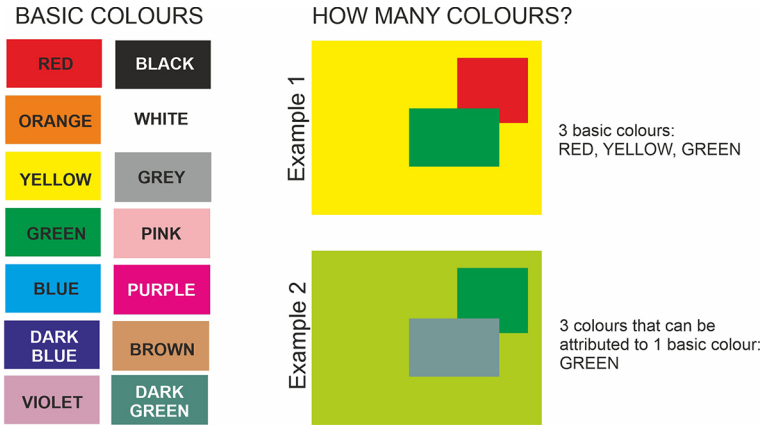

Fig. 2. A dilemma of geoheritage colour calculation.

3. Evaluation of the contrast of colours within any given object: generally, this can be judged either as small or large (naturally, contrast can be evaluated only for oligo- or polychromic features);
4. Comparison of the colour(s) of geological feature with respect to the colour(s) of landscape context.

Although these procedures seem to be elementary and easy to follow, they face several serious challenges, as follows:

1. It is questionable whether any given geoheritage colour should be attributed to basic colours (yellow, blue, green, etc.) or if these can be described in more detail (e.g., beige or yellowish green) – serious conflicts may arise regarding this issue (Fig. 2);
2. The point of view of various geoheritage describers may diverge (e.g., not all people can clearly distinguish green from blue);
3. Seasons, shadows, sunlight and other parameters have an impact on shades and hues;
4. Representatives of different cultures may have different perceptions and operate with different classifications of colour (e.g., for Russians, blue and deep blue are different basic colours, whereas differences between purple and red are more or less unclear).

It is mostly possible to facilitate the above-mentioned procedures and to overcome the difficulties noted with some advanced, computer-based techniques of colour identification and interpretation on the basis of RGB (Red–Green–Blue) or CMYK (Cyan–Magenta–Yellow–Key) colour models, but this will be time consuming and not reasonable. A more rational approach advocated herein is a field-based, intuitive colour description, as in traditional geological field studies (e.g., when any given rock appears to be red to any given geologist, it is referred to as red). Undoubtedly, the results of such colour assessments will be rather subjective, but they will make sense for any given geosite, which suffices for the majority of geoheritage studies. Moreover, it should be stressed that subjective definitions of mineral and rock colours in the century-long geological practice have not led to any serious confusions, except for a few, relatively specific cases.

Assessment procedures can be illustrated with examples from the Mountainous Adygeya geodiversity hotspot, and, particularly, from the Upper Palaeozoic granitoids of the Granite Gorge (Fig. 1). The colour of the main unique feature, namely the igneous rocks, can be called red, but usually is defined as pink. Although the intensity and shade of this colour vary within the geosite, the unique feature remains generally monochromic. The Granite Gorge geosite is a large object (Mikhailenko et al., 2019) and its landscape context is diverse. The dominant features are steep slopes covered by forest (green in summer and grey in winter) and the River Belaya (chiefly blue, but greyish brown after heavy rains). Hence, the entire geosite is oligochromic and has a significant colour contrast with unique features. This example shows that the colour of geoheritage is really something more than the colour of geological objects.

5. Interpretation of geoheritage colour

The assessment of geoheritage colour provides simple, yet important material for the solution of different tasks linked to the three functions of geoheritage colour outlined above. Particularly, established colours may be indicative of the composition and/or origin of any given unique feature (a 'purely' geological analysis) and high contrast contributes to a better visibility of geoheritage objects.

Interesting interpretations are linked to aesthetic properties. As explained by Kirillova et al. (2014), the intensity of colour has a significant impact on whether visitors pay attention to the object or not, and whether their overall opinion is positive or neg-

ative. This means that the colour-related aesthetic properties of geoheritage depend strongly on visitor preferences that may differ substantially. The preferences of typical visitors to each given geosite can be hypothesised subjectively, although the validity of such assumptions is always questionable. Those who prefer to spend holiday time on white sandy beaches may judge white sand(stone)s positively, but others have positive associations with yellow sand and even black sand beaches, and their preference of yellow or black sand(stone)s will not be surprising. Such preferences can be much better documented with special surveys or psychological experiments, which means conducting state-of-the-art research (Arriaza et al., 2004; Pranzini et al., 2010, 2016; Wang & Zhao, 2017; Huang & Lin, 2020). Unfortunately, such studies are impossible and unnecessary for the majority of geosites, especially small ones. With regard to these difficulties, attention should be paid to some international studies that have recorded nation-specific and nation-independent colour preferences. One of such studies is that by Jonauskaite et al. (2020), who related basic colours to common emotions in a few dozens of countries. On a global scale, they found both similarities and differences (see examples below). That study provides a valuable basis for anticipating emotions triggered by the colours of any given geosite.

Interpretations of geoheritage colours following the 'fresh' findings of Jonauskaite et al. (2020) may look as follows. The Upper Jurassic clays in the Mountainous Adygeya geodiversity hotspot are red (Fig. 1). To Russians, who could be the main visitors to this geosite, this colour is associated with such emotions as love and anger; its association with positive emotions, such as pride and joy, is stronger than with negative emotions (Jonauskaite et al., 2020). This observation allows us to expect that the red clays will generally be perceived positively, but some caution is called for. However, when visitors from Colombia would come to this geosite, their emotions would be more positive because of a stronger association of red with love and pleasure by Colombians (Jonauskaite et al., 2020). The other example is the exposure of the Upper Palaeozoic granitoids that are judged to be pink (Fig. 1). To Russians, pink is linked to positive emotions such as love, joy, pleasure and amusement (Jonauskaite et al., 2020), which allows to expect significant aesthetic attractiveness. The colour-emotion associations would be almost the same for visitors from other countries, although these associations are much weaker in the case of Egyptians (Jonauskaite et al., 2020) and the expected aesthetic attractiveness of these granitoids to visitors from Egypt seems to be lower. Although these examples are rather simplistic, they do indicate how geoheritage colour (physical prioperty) can be interpreted with regard to aesthetic properties. Undoubtedly, not only individual colours, but combinations of colours, as well as the number of colours and the intensity of contrast, can be related to emotions, with the potential to be properly studied, interpreted and harnessed in the future.

6. Conclusions

The present paper stresses the importance of colour in geoheritage studies and the need to pay more attention to this physical property of unique geological objects, as well as to their perception. Our understanding of this issue can be summarised as follows:

1. Colour facilitates scientific treatment, visibility and aesthetic attractiveness of geoheritage;
2. It is necessary to identify geoheritage colours, to measure their number, to evaluate their contrast and to compare them to colours of the surrouding landscape;
3. Country-scale meanings of colours facilitate expectations of aesthetic attractiveness of geosites and geoheritage marketing.

Indeed, specialists would prefer to deal with geoheritage colour depending on their own vision. For instance, one geologist may consider rock colours within the context of 'standard' colours used on geological maps (traditions of such colouring may differ substantially between countries), while another may consider white sand to be more attractive than black sand (this is nothing more than a particular preference or stereotypic view). In fact, such subjective and overly simplistic judgements need to be avoided. More objective or, rather, professional judgements of geoheritage colour would require geologists to consider some elementary learning in the fields of psychology, landscape architecture and marketing. Importantly, it should be stressed once again that the colour of geoheritage is something more than the colour of geological objects. A clear definition and conceptualisation of relevant ideas is a task for further investigations and discussions.

Undoubtedly, the ideas and proposals of the present paper are elementary, tentative and rather subjective. Nevertheless, the power of colour in geoheritage studies has been documented and deserves special investigations and broad, international discussions. The proposals in the present note mark several research lines that are sensible to

follow. Examples from the Mountainous Adygeya geodiversity hotspot are considered herein. However, a much larger number of suitable examples need attention. These examples can be found in such (geo)tourist destinations as the Grand Canyon and the Painted Desert in the USA, the Dorset Coast and the White Cliffs of Dover in the UK, the Danxia and, more specifically, the Rainbow Mountains in China, the Kislovodsk National Park in Russia, Vinicunca in Peru and Uluru in Australia. Moreover, accurate, colourful images often accompany geoheritage-related publications, field guides and online resources (including geopark webpages). This massive information is ready to be processed for testing the proposals and for developing the ideas outlined herein.

Dedication

This paper is dedicated to the memory of the brilliant German palaeontologist and science editor W. Riegraf, the enthusiastic French stratigrapher M. Bécaud, and the intelligent Russian geoscientists from the former Geology and Geography Faculty of the Rostov State University, Yu.N. Merinov, A.S. Orlinskiy, A.G. Granovskiy, M.M. Ryshkov and N.E. Fomenko, who contributed greatly to the corresponding author's professional growth with various support, fruitful discussions and helpful advice.

Acknowledgements

We wish to thank the journal editor and reviewers for valuable suggestions, C. Prosser (UK) and D. Jonauskaite (Switzerland) for useful comments and/or help with literature and Gennadiy Ivanovich (Russia) for logistic support. This work was carried out with financial support of the RF President grant MK-1862.2020.5, to A.V.M. The contributions of D.A.R. and N.N.Y. were not funded.

References

Adamia, S., Alania, V., Chabukiani, A., Kutelia, Z. & Sadradze, N., 2011. Great Caucasus (Cavcasioni): A Long-lived North-Tethyan Back-Arc Basin. *Turkish Journal of Earth Sciences* 20, 611–628.

Ali, C.A., Mohamed, K.R. & Komoo, I., 2008. Geoheritage of Pulau Balambangan, Kudat, Sabah. *Bulletin of the Geological Society of Malaysia* 54, 91–95.

Arriaza, M., Cañas-Ortega, J.F., Cañas-Madueño, J.A. & Ruiz-Aviles, P., 2004. Assessing the visual quality of rural landscapes. *Landscape and Urban Planning* 69, 115–125.

Bollati, I., Pellegrini, M., Reynard, E. & Pelfini, M., 2017. Water driven processes and landforms evolution rates in mountain geomorphosites: examples from Swiss Alps. *Catena* 158, 321–339.

Brilha, J., 2016. Inventory and quantitative assessment of geosites and geodiversity sites: a review. *Geoheritage* 8, 119–134.

Brilha, J., Gray, M., Pereira, D.I. & Pereira, P., 2018. Geodiversity: An integrative review as a contribution to the sustainable management of the whole of nature. *Environmental Science and Policy* 86, 19–28.

Cairncross, B., 2011. The national heritage resource act (1999): Can legislation protect South Africa's rare geoheritage resources? *Resources Policy* 36, 204–213.

Carcavilla, L., Díaz-Martínez, E., Erikstad, L. & García-Cortés, Á., 2013. Valuation of geoheritage in Europe. *Boletim Paranaense de Geosciencias* 70, 28–40.

Careddu, N. & Grillo, S.M., 2019. "Trachytes" from Sardinia: Geoheritage and current use. *Sustainability* 11, 3706.

Carlson, A.A. ¸1977. On the possibility of quantifying scenic beauty. *Landscape Planning* 4, 131–172.

Clay, G.R. & Daniel, T.C., 2000. Scenic landscape assessment: The effects of land management jurisdiction on public perception of scenic beauty. *Landscape and Urban Planning* 49, 1–13.

Cooper, B.J., 2010. Toward establishing a global heritage stone resource designation. *Episodes* 33, 38–41.

Cooper, B.J., Marker, B.R. & Thomas, I.A., 2013. Towards international designation of a heritage dimension stone. *Key Engineering Materials* 548, 329–335.

Crofts, R. & Gordon, J.E., 2014. Geoconservation in protected areas. *Parks* 20, 61–76

Daniel, T.C., 2001. Whither scenic beauty? Visual landscape quality assessment in the 21st century. *Landscape and Urban Planning* 54, 267–281.

Frank, S., Fürst, C., Koschke, L., Witt, A. & Makeschin, F., 2013. Assessment of landscape aesthetics – Validation of a landscape metrics-based assessment by visual estimation of the scenic beauty. *Ecological Indicators* 32, 222–231.

Garcia, M.G.M., 2019. Ecosystem Services Provided by Geodiversity: Preliminary Assessment and Perspectives for the Sustainable Use of Natur.al Resources in the Coastal Region of the S.te of São Paulo, Southeastern Brazil. *Geoheritage* 11, 1257–1266.

García-Cortés, Á., Vegas, J., Carcavilla, L. & Díaz-Martínez, E., 2019. Conceptual base and methodology of the Spanish Inventory of Sites of Geological Interest (IELIG). Instituto Geológico y Minero de España, Madrid, 102 pp.

Gordon, J.E., 2018. Geoheritage, geotourism and the cultural landscape: Enhancing the visitor experience and promoting geoconservation. *Geosciences* 8, 136.

Gray, M., 2013. *Geodiversity. Valuing and Conserving Abiotic Nature*. Wiley-Blackwell, Chichester, 495 pp.

Habibi, T. & Ruban, D.A., 2018. Geoheritage of the Neyriz ophiolite-related radiolarite sequence (Cretaceous; southwest Iran): First report and evaluation in region-

al and global contexts. *Journal of African Earth Sciences* 145, 227–233.

Henriques, M.H., Castro, A.R.S.F., Félix, Y.R. & Carvalho, I.S., 2020. Promoting sustainability in a low density territory through geoheritage: Casa da Pedra case-study (Araripe Geopark, NE Brazil). *Resources Policy* 67, 101684.

Hose, T.A., 2016. Three centuries (1670–1970) of appreciating physical landscapes. *Geological Society Special Publication* 417, 1–22.

Huang, A.S.-H. & Lin, Y.-J., 2020. The effect of landscape colour, complexity and preference on viewing behaviour. *Landscape Research* 45, 214–227.

Hull, R.B., IV & Stewart, W.P., 1992. Validity of photo-based scenic beauty judgments. *Journal of Environmental Psychology* 12, 101–114.

Ismail-Zadeh, A., Adamia, S., Chabukiani, A., Chelidze, T., Cloetingh, S., Floyd, M., Gorshkov, A., Gvishiani, A., Ismail-Zadeh, T., Kaban, M.K., Kadirov, F., Karapetyan, J., Kangarli, T., Kiria, J., Koulakov, I., Mosar, J., Mumladze, T., M?ller, B., Sadradze, N., Safarov, R., Schilling, F. & Soloviev, A., 2020. Geodynamics, seismicity, and seismic hazards of the Caucasus. *Earth-Science Reviews* 207, 103222.

Jonauskaite, D., Abu-Akel, A., Dael, N., Oberfeld, D., Abdel-Khalek, A.M., Al-Rasheed, A.S., Antonietti, J.-P., Bogushevskaya, V., Chamseddine, A., Chkonia, E., Corona, V., Fonseca-Pedrero, E., Griber, Y., Grimshaw, G., Hassan, A.A., Havelka, J., Hirnstein, M., Karlsson, B.S.A., Laurent, E., Lindeman M., Marquardt, L., Mefoh, P., Papadatou-Pastou, M., Pérez-Albéniz, A., Pouyan, N., Roinishvili, M., Romanyuk, L., Salgado Montejo, A., Schrag, Y., Sultanova, A., Uusküla, M., Vainio, S., Wąsowicz, G., Zdravković, S., Zhang, M. & Mohr, C., 2020. Universal patterns in color-emotion associations are further shaped by linguistic and geographic proximity. *Psychological Science* 31, 1245–1260.

Kaur, G., Kaur, P., Ahuja, A., Singh, A., Saini, J., Agarwal, P., Bhargava, O.N., Pandit, M., Goswami, R.G., Acharya, K. & Garg, S., 2020. Jaisalmer Golden Limestone: A Heritage Stone Resource from the Desert of Western India. *Geoheritage* 12, 53.

Kirillova, K., Fu, X., Lehto, X. & Cai, L., 2014. What makes a destination beautiful? Dimensions of tourist aesthetic judgment. *Tourism Management* 42, 282–293.

Kramar, S., Bedjanic, M., Mirtic, B., Mladenovic, A., Rožic, B., Skaberne, D., Gutman, M., Zupancic, N. & Cooper, B., 2015. Podpec limestone: A heritage stone from Slovenia. *Geological Society Special Publication* 407, 219–231.

Kubalíková, L., 2020. Cultural ecosystem services of geodiversity: A case study from Stranska skala (Brno, Czech Republic). *Land* 9, 105.

Migoń, P. & Maia, R.P., 2020. Pedra da Boca, Pai Mateus, and Quixadá—Three Possible Key Geoheritage Sites in Northeast Brazil. *Geoheritage* 12, 51.

Migoń, P. & Pijet-Migoń, E., 2016. Overlooked Geomorphological Component of Volcanic Geoheritage—Diversity and Perspectives for Tourism Industry, Pogórze Kaczawskie Region, SW Poland. *Geoheritage* 8, 333–350.

Migoń, P. & Pijet-Migoń, E., 2017. Viewpoint geosites – values, conservation and management issues. *Proceedings of the Geologists' Association* 128, 511–522.

Mikhailenko, A.V. & Ruban, D.A., 2019. Environment of Viewpoint Geosites: Evidence from the Western Caucasus. *Land* 8, 93.

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, 45–52.

Mikhailenko, A.V., Ruban, D.A., Yashalova, N.N. & Rebezov, M.B., 2019. The Unique Granite Gorge in Mountainous Adygeya, Russia: Evidence of Big and Complex Geosite Disproportions. *Geosciences* 9, 372.

Nazaruddin, D.A., 2019. Selected geosites for geoheritage, geotourism, and geoconservation in Songkhla Province, Southern Thailand. *Quaestiones Geographicae* 38, 161–177.

Németh, K. & Moufti, M.R., 2017. Geoheritage Values of a Mature Monogenetic Volcanic Field in Intra-continental Settings: Harrat Khaybar, Kingdom of Saudi Arabia. *Geoheritage* 9, 311–328.

Patsfall, M.R., Feimer, N.R., Buhyoff, G.J. & Wellman, J.D., 1984. The prediction of scenic beauty from landscape content and composition. *Journal of Environmental Psychology* 4, 7–26.

Pranzini, E., Simonetti, D. & Vitale, G., 2010. Sand colour rating and chromatic compatibility of borrow sediments. *Journal of Coastal Research* 26, 798–808.

Pranzini, E., Anfuso, G., Botero, C.-M., Cabrera, A., Apin Campos, Y., Casas Martinez, G. & Williams, A.T., 2016. Sand colour at Cuba and its influence on beach nourishment and management. *Ocean and Coastal Management* 126, 51–60.

Prosser, C., Murphy, M. & Larwood, J., 2006. *Geological conservation: a guide to good practice*. English Nature, Peterborough, 145 pp.

Reynard, E. & Brilha, J. (Eds.), 2018. *Geoheritage: Assessment, Protection, and Management*. Elsevier, Amsterdam, 482 pp.

Reynard, E. & Coratza, P, 2016. The importance of mountain geomorphosites for environmental education: Examples from the Italian Dolomites and the Swiss Alps. *Acta Geographica Slovenica* 56, 291–303.

Ribe, R.G.¸2002. Is scenic beauty a proxy for acceptable management? The influence of environmental attitudes on landscape perceptions. *Environment and Behavior* 34, 757–780.

Ruban, D.A., 2010. Quantification of geodiversity and its loss. *Proceedings of the Geologists' Association* 121, 326–333.

Ruban, D.A., 2016. Comment on "Geotourist values of loess geoheritage within the planned Geopark Malopolska Vistula River Gap, Poland" by J. Warowna et al. [Quaternary International, 399, 46–57]. *Quaternary International* 425, 196–197.

Ruban, D.A., Tiess, G., Sallam, E.S., Ponedelnik, A.A. & Yashalova, N.N., 2018. Combined mineral and geoheritage resources related to kaolin, phosphate, and cement production in Egypt: Conceptualization, as-

sessment, and policy implications. *Sustainable Environment Research* 28, 454–461.

Schirpke, U., Tasser, E. & Tappeiner, U. ¸2013. Predicting scenic beauty of mountain regions. *Landscape and Urban Planning* 111, 1–12.

Schroeder, H. & Daniel, T.C., 1981. Progress in predicting the perceived scenic beauty of forest landscapes. *Forest Science* 27, 71–80.

Sharkov, E., Lebedev, V., Chugaev, A., Zabarinskaya, L., Rodnikov, A., Sergeeva, N. & Safonova, I., 2015. The Caucasian-Arabian segment of the Alpine-Himalayan collisional belt: Geology, volcanism and neotectonics. *Geoscience Frontiers* 6, 513–522.

Tucker, M.E., 2011. *Sedimentary Rocks in the Field: A Practical Guide*. Wiley-Blackwell, Chichester, 276 pp.

Unjah, T., Leman, M.S. & Komoo, I., 2013. Geological landscape and public perception: A case for Dataran Lang viewpoint, Langkawi. *Bulletin of the Geological Society of Malaysia* 59, 101–107.

van Hinsbergen, D.J.J., Torsvik, T.H., Schmid, S.M., Matenco, L.C., Maffione, M., Vissers, R.L.M., Gurer, D. & Spakman, W., 2020. Orogenic architecture of the Mediterranean region and kinematic reconstruction of its tectonic evolution since the Triassic. *Gondwana Research* 81, 79–229.

Vasey, D., Cowgill, E., Roeske, S.M., Niemi, N.A., Godoladze, T., Skhirtladze, I. & Gogoladze, S., 2020. Evolution of the Greater Caucasus Basement and Formation of the Main Caucasus Thrust, Georgia. *Tectonics* 39, e2019TC005828.

Wang, R. & Zhao, J., 2017. Demographic groups' differences in visual preference for vegetated landscapes in urban green space. *Sustainable Cities and Society* 28, 350–357.

Wang, Z. & Yuan, B., 2020. Harmonizing the Branding Strategy of World Natural Heritage in China: Visitors' Awareness of the Multiple Brands of Wulingyuan, Zhangjiajie. *Geoheritage* 12, 41.

Wang, Z., Li, M., Zhang, X. & Song, L., 2020. Modeling the scenic beauty of autumnal tree color at the landscape scale: A case study of Purple Mountain, Nanjing, China. *Urban Forestry and Urban Greening* 47, 126526.

Warowna, J., Zglobicki, W., Kolodynska-Gawrysiak, R., Gajek, G., Gawrysiak, L. & Telecka, M., 2016. Geotourist values of loess geoheritage within the planned Geopark Malopolska Vistula River Gap, E Poland. *Quaternary International* 399, 46–57.

Williams, A.T. ¸2019. The concept of scenic beauty in a landscape. *Coastal Research Library* 26, 17–41.

Manuscript submitted: 12 November 2020
Revision accepted: 10 February 2021