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Research article

Devonian geoheritage of Siberia: A case of the northwestern Kemerovo region of Russia

Jaroslav M. Gutak [a], Dmitry A. Ruban [b,*], Vladimir A. Ermolaev [c]

[a] Department of Geology, Geodesy, and Life Security, Institute of Mining and Geosystems, Siberian State Industrial University, Kirov Street 42, Novokuznetsk, Kemerovo Region, 654007, Russia
[b] Department of Organization and Technologies of Service Activities, Higher School of Business, Southern Federal University, 23-ja Linija Street 43, Rostov-on-Don, 344019, Russia
[c] Department of Commodity Science and Expertise, Plekhanov Russian University of Economics, Stremyanny Lane 36, Moscow, 117997, Russia

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ABSTRACT

Southern Siberia demonstrates significant richness of the geological environment, but its uniqueness remains known poorly. Four geosites represent sections of Givetian–Famennian (Middle–Late Devonian) deposits formed in the tectonically active zone where small terranes accreted with the Siberian continent. There, carbonate deposition in tropical conditions prevailed and rich ecosystems evolved. Three geosites are dominated by the unique palaeogeographical features (notable palaeobiogeographical changes, facies of catastrophic outflow from palaeolake, Frasnian/Famennian mass extinction, and palaeoreefs), and one geosite is dominated by the stratigraphical feature (regionally representative section of the Frasnian/Famennian boundary). Additionally, all localities are rich in Devonian marine invertebrates, and one of them is also a topographical expression of palaeoreef. The semi-quantitative assessment of these geosites implies that one of them can be ranked nationally and three others can be ranked regionally. All localities are well accessible and important for international research. It is proposed to use these geosites for a new geopark development that would facilitate geotourism growth in the study area and, thus, provide socio-economic benefits to the region.

1. Introduction

Geoheritage and geotourism studies have grown exponentially in the past decades, with significant conceptual and methodological advances. Some works fixed their basic principles and terminology [1–10], and the others offered methodological and practical developments, including advanced assessment tools [11–19]. The amount of the related literature is huge, and it was reviewed, particularly, by Ólafsdóttir and Tverijonaite [20] and Herrera-Franco et al. [21]. Although there are many directions for research and actions in this field (for instance, they are related to geoconservation, geodiversity, geosystem services, geobranding, and geoeducation), geoheritage inventory, which is its basic approach, remains on research agenda because geosites from many vast and geologically-rich territories are almost (or even fully) unknown to the international geoscience community. A typical example is Siberia with the area of ~10 mln km^2 and extraordinarily rich and unique geology and geomorphology [22–26]. Geoheritage of this territory was almost not reported internationally. Few exceptions are the works by Gogin and Vdovets [27] and Gutak et al. [28] who

* Corresponding author.
E-mail address: ruban-d@mail.ru (D.A. Ruban).

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characterized some notable geosites from the eastern and western peripheries of Siberia, respectively. Indeed, this knowledge gap has to be filled gradually, which requires careful inventory and systematic description of the Siberian geoheritage, as well as evaluation of its geotourism potential.

The Kemerovo Region, an official administrative unit of the Russian Federation with the area of $95.7*10^3$ km^2 and population of ~2.6 million, is located in Southern Siberia where diverse geological objects of chiefly Paleozoic age crop out. Previous geoheritage inventories in this region have allowed to establish various unique features [29,30]. But this knowledge needs extension and detalization, as well as re-assessment with new techniques. Field investigations in the northwestern part of the Kemerovo Region permit to report four geologically unique localities representing Devonian palaeoenvironments and palaeoecosystems (chiefly marine, but partly terrestrial) of the southwestern periphery of the former Siberian continent. The objective of the present paper is to provide the first in-depth, semi-quantitative assessment of these geosites representing a portion of geodiversity of what is now Southern Siberia. Special attention is paid to the geotouristic potential of the examined geoheritage. The issue of sustainable tourism development is urgent to the Kemerovo Region and entire Siberia [31,32], and geotourism can contribute sufficiently to the solution of this important task.

2. Geological setting

The study area is located in the northwestern part of the Kemerovo Region, i.e., in the south of Siberia (Fig. 1). Geologically, this area represents a transition between the Early Paleozoic Salair Terrane in the southwest, the Mid-Paleozoic Tom'-Kolyvan Folded Zone in the northwest, and the Late Paleozoic Kuznetsk Basin in the east. The geological characteristics are summarized in several fundamental works, including the books by Fomichev et al. [33] and Gutak et al. [30]. Devonian–Permian deposits form the most widely distributed sedimentary complexes, with the total thickness measured by several kilometers [30,33]. They are highly heterogeneous lithologically and facially and include both terrestrial and marine siliciclastics, limestones (also reefal), coals, and volcanics and volcaniclastics (partly marine). The study area experienced significant changes during its Paleozoic history, and it remained tectonically active in the Mesozoic, when the present-day structural framework formed [30].

The Devonian Period marked several important events and changes in the regional geological evolution [30,34]. According to Cocks and Torsvik [22], this was the time when accretion of small terranes occurred on the active periphery of the isolated Siberian continent. The study area was located in the central part of this vast accretion belt at the palaeolatitude of 30° N. Small seas and landmasses, as well as island arc appeared and disappeared there, at the transition between the continent and the ocean, which was closed together with the accretion of Siberia, Baltica, Kazakh Terranes, Tarim, and smaller tectonic blocks in between. Wilhem et al.

Fig. 1. Location of the study area and the considered geosites (GR – Glubokinsky reef, KU – Kosoy utes, LE – Lebedyansky, YP – Yaya-Petropavlovsky).

[35] offered a different reconstruction for the Devonian, where the accreted terranes formed a kind of bundle that connected Siberia with Kazakhstan and some large "eastern" terranes; this bundle was washed by the waters of small oceans. The other reconstructions were developed by Domeier and Torsvik [36], Cao et al. [37], Golonka [38], Kocsis and Scotese [39], and Metcalfe [40]. These reconstructions have something in common with the above-mentioned views [22,35], and the differences between all of them indicate on serious uncertainties in the understanding of the regional Devonian evolution. Anyway, it is clear that the tropical conditions facilitated development of rich palaeoecosystems on the land and in the sea: the Devonian deposits of the study area bear rich assemblages of marine invertebrates and terrestrial plants; particularly, reefal palaeoecosystems flourished regionally [30].

3. Method

The materials for the present study have been collected in the course of the field investigations in the northwestern Kemerovo Region. Four potential geosites, namely Glubokinsky reef, Kosoy utes, Lebedyansky, and Yaya-Petropavlovsky (see Fig. 1 for locations and abbreviations) are identified thanks to the career-long geological exploration experience of the first author (see also [30]). These are characterized in a systematic way by the criteria explained below. In the other words, if even these localities have been known previously as geosites, they are fully re-considered for the purposes of this study. These geosites are essentially representative sections of Middle–Late Devonian deposits correlated on the basis of their fossil content [34]. These sections are chiefly natural outcrops, except for the LE geosite, which includes a quarry.

A wide spectrum of techniques for geosite assessment exists [15,41–54]. Some of them serve well for solution of only particular research tasks and seem to be somewhat intuitive, whereas some others are too attached to the European socio-economical and cultural frames, as well as the "Western" sense of space and time (see the related discussions in Ref. [55]). A new technique has been proposed recently to overcome these failures, and it has been tested positively with two representative and essentially different published reports, one of which is Russian [55,56]. Although none of the geosite assessment approaches can escape certain deficiencies and subjectivity, the above-mentioned technique seems to be rather comprehensive, and, thus, it is preferred for the purposes of the present study.

The approach consists of three procedures. First, when the presence of the unique features in a particular locality is known already from the literature or the previous geologists' experience [30,34], this locality can be selected as a geosite, which deserves further, close examination. Second, each geosite is checked in regard to the essence of the represented unique features. These are assigned to the standardized geoheritage types, which are geomorphological, tectonic, stratigraphical, palaeontological, sedimentary, palaeogeographical (sensu [57]), igneous (magmatic and volcanic), metamorphic, geochemical, mineralogical, cosmogenic, hydro (geo) logical (geological activity of surface and underground waters), geothermal, engineering, geocryological (permafrost), pedological (soil), economical, and geohistorical (history of geology, not geological history) types (e.g., see Ref. [55]). One or several types can be found in one geosite, and, thus, dominant type(s) (sensu [45]) can be established. Third, each geosite is assessed semi-quantitatively by several criteria, which reflect its uniqueness and technical properties (number of geoheritage types, accessibility, vulnerability, need for interpretation, scientific, educational, (geo)touristic, and aesthetical importance). Geosites are scored relatively to how they match these criteria. Importantly, the technical properties may either increase or decrease the uniqueness (rank) established initially. This scoring system has been introduced by Ruban et al. [56] and Ruban [55], and it is explained below, together with the results of the present study to avoid repetitions. Such a semi-quantitative assessment allows judgments about the value of the geosites.

4. Results

4.1. General remarks

The initial field examination of the four potentially unique geological localities of the northwestern Kemerovo Region characterized stratigraphically by Krasnov et al. [34] and Gutak et al. [30] confirmed that these are true geosites. Two of them are found in the vicinity of the city of Kemerovo (population >0.5 mln), which is the administrative center of the Kemerovo Region, and two others are situated close to the town of Anzhero-Sudzhensk (population ~0.07 mln), which is a local transport and coal-mining center (Fig. 1).

These geosites represent the Givetian–Famennian phase of the geological evolution of this part of Southern Siberia. The unique features are deposits with their facial peculiarities, fossil content, and topographical expression (Fig. 3). A total of four geoheritage types are registered (Table 1). Palaeogeographical features are dominant commonly, and the related type dominates three geosites; one geosite is more important stratigraphically (Table 1).

Table 1
Diversity of geoheritage represented at the considered geosites of the northwestern Kemerovo Region.

Geoheritage types	Geosites (see Fig. 1 for explanation of abbreviations)			
	LE	YP	KU	GR
Palaeogeographical	+ (dominant)	+ (dominant)	+	+ (dominant)
Stratigraphical	+	+	+ (dominant)	
Palaeontological	+	+	+	+
Geomorphological				+

4.2. Palaeogeographical features

The palaeogeographical type is found in all considered geosites (Table 1; the content of this type is understood according to Bruno et al. [57]). In the LE geosite, the unique feature is linked to the change of the palaeobiogeographical affinity of marine macroinvertbrates in the mid-Givetian. The section consists of shallow-water limestones (Fig. 2) bearing abundant fossils. However, these differ strikingly between the lower and upper parts of the section, which belong to the different stratigraphical units (Fig. 3). In the lower part, the assemblages have elements known from Baltica and the Urals, whereas the assemblages from the upper part include elements typical to Central Asia (particularly, Altai and Mongolia). The characteristic taxon of the former is *Stringocephalus burtini* (Defrance, 1825), and the characteristic taxon of the latter is *Euryspirifer cheehiel* (Koninck, 1846) (Fig. 3). Importantly, these two brachiopod taxa do not co-occur on any level in the section. Taking into account the Devonian global palaeobiogeographical reconstructions by Dowding and Ebach [58], it is possible to state that this shift on the palaeobiogeographical affinity of the study area happened on the level of provinces. Apparently, it was related to mobility and external connections of multiple terranes on the periphery of Siberia.

In the YP geosite, four unique palaeogeographical features can be outlined, namely rich Late Devonian shallow-marine palaeoecosystems, mid-Frasnian catastrophic lake outflow facies, the Upper Kellwasser event at the Frasnian–Famennian transition, and the late Famennian regional regression. The section comprises several types of sedimentary packages and facies (Fig. 2). The palaeolake outflow was a really peculiar event in the regional history: the Minusa palaeolake experienced catastrophic discharge to the nearby sea, as a result of which massive cross-bedded proluvial siliciclastic rocks (with remains of plants, fishes, and other terrestrial fossil organisms) formed (Fig. 3) and interrupted marine sedimentation [57,59]. The Upper Kellwasser event was one of the most important biogeochemical events in the mid-Paleozoic evolution of the Earth [60–62]. It was related to strong palaeoenvironmental perturbations and the associated Frasnian/Famennian mass extinction [63–67]. In the YP geosite, this event corresponds to the layer of grey, sulfur-rich algal limestone.

The KU geosite represents palaeoecosystems of the outer shelf, as well as the catastrophic event (mass extinction coupled with major palaeoenvironmental perturbation) at the Frasnian/Famennian boundary (Fig. 3). The noted palaeoecosystems were dominated by brachiopods and, particularly, *Anathyrella*, *Cyrtospirifer*, and *Mesoplica*. The catastrophic event is expressed locally by the absence of macroinvertebrate remains in the limestone layer and the striking taxonomic differences between the fossil assemblages found in the under- and overlying deposits.

The GR geosite is a notable palaeogeographical locality. This is an exposed Frasnian reef (Fig. 3). The reef builders were algae, with subordinate contribution of stromatoporoids and tabulate and rugose corals. A chain of reefs stretched along shelf edge on the study area in the late Frasnian, and this geosite provides with the most representative example. The Late Devonian and, particularly, the Frasnian were intervals of outstanding global distribution of reefs when there were reef belts measured by thousands of kilometers [38,68,69]. If so, the GR geosites represents the global-scale phenomenon of reefal growth. Moreover, as the sedimentary succession at this locality extends in the Famennian (Fig. 2), the geosite also marks the regional reef development at the time of the global palaeoenvironmental perturbations, which affected metazoan reefal communities [69].

4.3. Other features

All considered geosites are rich in fossils, which fact determines their palaeontological uniqueness (Table 1). The fossils include (and not limited to) marine macroinvertebrates (bivalves, brachiopods, bryozoans, corals, crinoids, gastropods, stromatoporoids, tentaculites, and trilobites) and vertebrates (fish), conodonts, ostracods, algae, as well as terrestrial macrofloral remains [34]. Many layers are extremely rich in fossils. The fossils represent the Giventian, Frasnian, and Famennian intervals of the biotic evolution, as well as the outstanding richness (diversity and abundance) of mid-Paleozoic tropical marine palaeoecosystems. Indeed, the available palaeontological material would contribute to the solution of some internationally urgent palaeontological questions like taxonomy

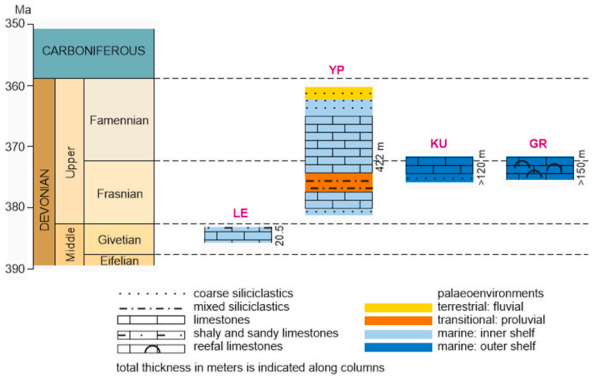

Fig. 2. Correlation of the considered sections. See Fig. 1 for abbreviations. The geological time scale follows developments by the International Commission on Stratigraphy (see stratigraphy.org).

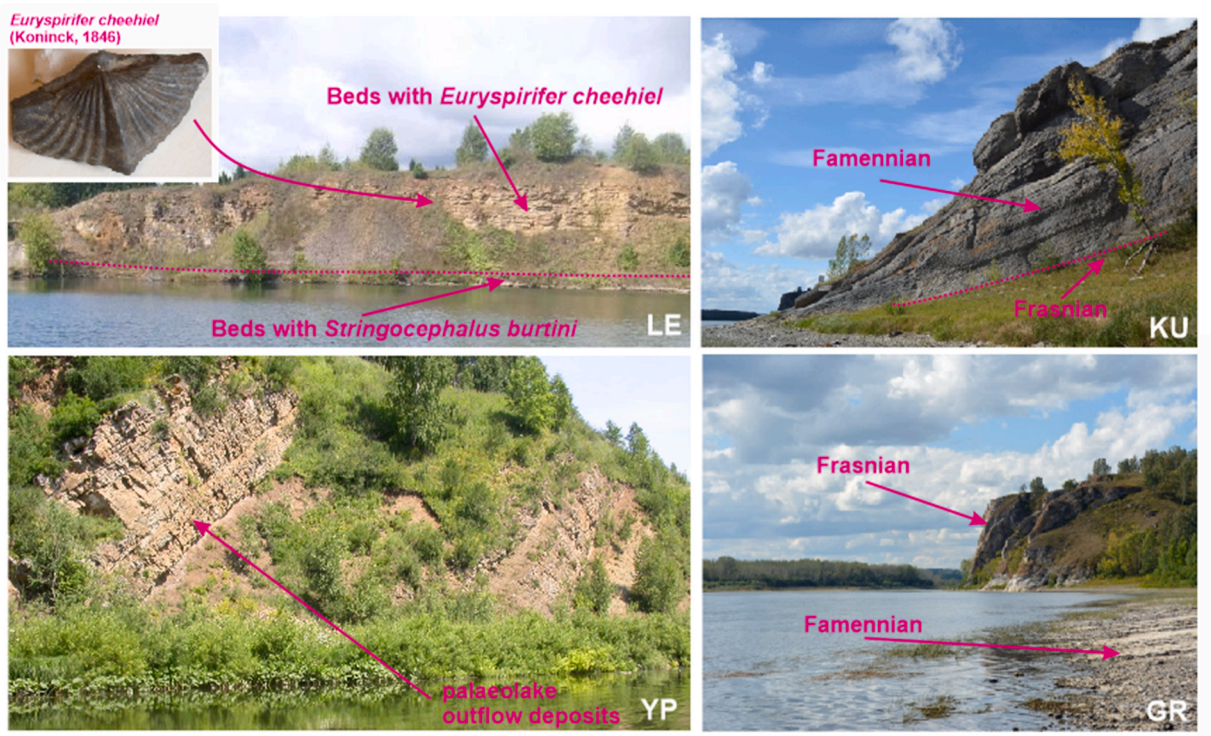

Fig. 3. General views of the considered geosites. See Fig. 1 for abbreviations. A modified version of the YP's image was published by Bruno et al. [57].

and palaeoecology of stromatoporoids [70]. The geosites are generally comparable by the richness of their fossil content, except of the YP geosite where remains of both terrestrial and marine organisms are found.

The palaeontological richness of the considered geological localities makes them very important stratigraphically [34] (Table 1). Particularly, the LE geosite is a reference section of the Givetian deposits, and the YP, KU, and GR geosites represent the Frasnian–Famennian transition (Fig. 2). Importantly, two geosites (at least), namely YP and KU, provide with clear evidence of the Frasnian/Famennian boundary. Particularly, the latter is established by the typical representatives of the *Palmatolepis triangulari* Conodont Zone [34,71], which is the base zone of the Famennian Stage [72,73]. This boundary is the best documented at the KU geosite where the presence of stratigraphically important taxa can be justified against the interval with impoverished (almost absent) fossils.

From the considered geosites, the only GR has clear and somewhat distinctive topographical expression (Table 1). The Late Devonian reef is represented as a positive landform with natural outcrops in a steep slope (Fig. 3). Apparently, the relatively hard reefal limestones are more resistant to erosion than the "softer" host rocks, and, thus, the present-day landform inherits its shape from the ancient reef. Such morphostructures are not too uncommon, and they are known, particularly, from southern Greece [74] and the

Table 2
General assessment the considered geosites of the northwestern Kemerovo Region.

Criteria and scores (adapted from Refs. [55,56])	Geosites (see Fig. 1 for explanation of abbreviations)			
	LE	YP	KU	GR
Rank/uniqueness: global (+500), national (+250), regional (+100), local (+50)	+100	+250	+100	+50
Number of geoheritage types: >10 (+50), 4–10 (+25), 2–3 (+10), 1 (0)	+10	+10	+10	+10
Accessibility: easy in populated area (+25), easy in remote area (0), difficult (−25).	+25	+25	+25	+25
Vulnerability: no danger (+25), potential danger (0), partly damaged (−25), fully destroyed (−50)	0	+25	+25	+25
Need for interpretation: absent (+25), basic geological knowledge required (0), professional geological knowledge required (−10), scientific analysis required (−25)	−10	−10	−25	−10
Scientific importance: international (+25), local (0)	+25	+25	+25	+25
Educational importance: international (+25), local (0)	0	0	0	0
Touristic importance: international (+25), local (0)	0	+25	0	0
Aesthetic importance: high (+50), medium (+25), low (0)	0	+25	0	+25
TOTAL SCORES	150	375	160	150
Finally justified rank/uniqueness: global (>499), national (250–499), regional (100–249), local (<100)	Regional	National	Regional	Regional

Western Caucasus [75]. Nonetheless, the reported inheritance is a notable geomorphological phenomenon, which makes an interdisciplinary "bridge" between geomorphology and palaeogeography.

4.4. Geoheritage value

The considered geosites differ (Table 2). The YP has few or no analogues in Russia (especially in regard to the palaeolake outflow deposits), and, thus, it can be ranked nationally. The LE and KU geosites reflect regionally unique peculiarities, while the GR geosite is one of several Late Devonian reef localities known from the study area. The regional and local ranks can be assigned, respectively (Table 2). The number of geoheritage types in all these geosites is the same (three types – Table 1).

The accessibility of these geosites is excellent (Table 2) because these are located in or near the urban areas with well-developed road infrastructure and multiple trails (Fig. 1). The space within the geosites allows direct access to outcrops and accommodation of groups of visitors, as well as their comfortable geological work (Fig. 3). There are not dangers for geoheritage from any natural or anthropogenic forces, although natural degradation of the quarry in the LE geosite can become factor of risk in the future (Table 2). The biggest challenge for usage of all geosites is the strong need in professional interpretation (Table 2). Only well-trained guides can explain the essence of the represented phenomena, although installing interpretive panels and using some other communication facilities would solve this problem partly [14,76–81]. Nonetheless, designing such tools requires significant advice from high-class geologists. Internet resources accessible via QR codes may also help, but these need permanent support and systematical updates. Additionally, the KU geosite is important stratigraphically, and, thus, full-scale, research-based interpretation is necessary to communicate about this unique locality correctly.

All considered geosites are of outstanding scientific importance (Table 2). They have already been used for stratigraphical, palaeontological, and palaeogeographical research [30,34], but even more investigations can be undertaken in the future. Many results from the previous, Soviet and Post-Soviet studies need re-interpretation and putting into the modern research context (nonetheless, the existence of this scientific information is enough for judgments of the geosites' values). The promising topics for future investigations include (and not limited to) justification of the Frasnian/Famennian boundary and its correlation to the sections in the other parts of Siberia and the word, geochemical sampling of the Upper Kellwasser interval, systematic studies of various fossil groups, including brachiopods, corals, and stromatoporoids, lithological sampling and carbonate facies analysis, and provenance analysis of the palaeolake outflow deposits. All these investigations can be carried out by the international research groups (if even they are inactive presently).

Indeed, the geosites of the northwestern Kemerovo Region has certain educational importance (Table 2). Particularly, these can be employed for training skills in fossil collecting, facies interpretation, and tracing stratigraphical units. There are several universities offering education in geology and geography in the Kemerovo Region (for instance, the Siberian State Industrial University in Novokuznetsk), as well as in the cities of the adjacent regions. However, similar objects are available in the other countries and even in the other parts of Russia, and, thus, the educational importance of the considered geosites is restricted to only Southern Siberia (Table 2). By the same reason, three of these geosites have only local touristic importance. Nonetheless, the YP locality can attract international geotourists by the possibility to see the palaeolake outflow deposits and the Upper Kellwasser horizon in one object (Fig. 3). From the international experience, it is known that specific facies are notable geotourist attractions (e.g., Ref. [82]). Finally, the aesthetic attractiveness of the geosites differs (Table 2). Two of them (LE and KU) do not boast exceptional beauty of the geological features, and two others (YP and GR) demonstrate certain attractiveness, although it is more related to the local landscape scenery (Fig. 3). The most important aesthetic characteristic of the considered geosites is their striped and lined pattern (sensu [83]) related to the well-visible layering (Fig. 3).

The semi-quantitative assessment of the four geosites implies that three of them (LE, KU, and GR) are valued more or less similarly (Table 2). Their total scores are 150–160, which corresponds to the regional rank of geoheritage. Interestingly, the GR geosite has only local uniqueness, but the other properties enlarge it significantly. The YP geosite differs strikingly. It gains 375 scores, which prove its national rank (Table 2). However, it would be wrong to pay attention to only this locality because all considered geosites differ essentially (see above) and reflect various aspects of the Middle–Late Devonian geological development of Southern Siberian. Local geoconservation and geotourism activities should not give any serious preference to one higher-valued geosite relatively to the three lower-valued geosites.

5. Discussion

The presence of four geosites in the study area (Table 2), as well as their accessibility and proximity to urban areas of Kemerovo and Anzhero-Sudzhensk (Fig. 1) makes them suitable for geotourism development. Potential geotourists may include "devoted" visitors (professional geologists with advanced knowledge needing in self-education or enjoying geological "wonders"), university students (either individual or groups guided by university lecturers), and lay public. Nature-based tourism in rather popular in the Kemerovo Region as noted by the regular observations of the authors, and this region also possesses the nationally-ranked resort area of Sheregesh. In such conditions, geosites can contribute to the diversity of natural attractions, and they can be included into the routes offered by the local tourism firms.

The most efficient solution to facilitate geotourism development would be establishment of a geopark. Such a project can be realized as initiative of the regional government (state–private partnership can also matter), and, if successful, this may later become a candidate to inclusion into the UNESCO Global Geoparks network. The related initiatives are actively debated in Russia [84–86], and the country already possesses its first global geopark (https://en.unesco.org/global-geoparks/list). Establishing geopark would also

help to develop plan for conservation activities related to geosites and, first of all, to consider their status as officially protected objects (for instance, the national legislations offers the statuses of geosite or natural monument with geological value), and to establish their exact limits.

Geoparks are essential for efficient geoheritage and geotourism management, and they can be drivers of local sustainable development [4,87–95]. The four geosites of the northwestern Kemerovo Region are well connected thematically (Table 1), and they represent peculiarities the Middle–Late Devonian environments and ecosystems of Southern Siberia. This integrated piece of geoheritage would permit to establish a geopark to be called provisionally as "Devonian Tropics of Siberia". Taking into account the presently severe climate of the study area, such a name sounds provocative and, thus, attractive to possible visitors, both locals and tourists from the other regions/countries. The main reason for geopark creation is the need in professional geosite interpretation (also with installing interpretive panels and recruiting guides), infrastructure development, geotourism promotion, well-balanced and responsible management of geoheritage and the related geotourist activities, and attracting administrative support and investments. A single geopark project would perform much better than local initiatives for separate geosites. Besides geosites, the possible geopark can be connected to the local museums and research institutions hosting collections of Devonian fossils from the Middle–Late Devonian deposits. The relevance of such collections to geoheritage was argued by Schemm-Gregory and Henriques [96], and the richness of Devonian fossils from the study area and, particularly, the four geosites adds value to this ex-situ geoheritage. One of such museums or institutions can also take administrative responsibilities of this geopark.

The proposed geopark has potential also because of some other circumstances. First, tourism grows and needs diversification in the Kemerovo Region; importantly, thematic directions like industrial tourism are in the focus of experts, as well as touristic exploitation of natural resources [31,97–100]. The regional government supports the related initiatives. Second, there are various, regular touristic events in the Kemerovo Region, which reveal its cultural identity and attract visitors (Table 3), and these events can be related to geopark functioning. Moreover, the proposed geopark can host some of these events and extend their programs. Third, the region boasts some notable traditions rooted into nature–people interactions. For instance, the local cuisine utilizes berries [101], and the related gastronomic experience would enjoy geopark visitors.

A strategy toward the usages of the considered geosites for the purposes of geotourism growth can be summarized as follows. First, enthusiastic local geologists can offer geosites to local tourism firms and regional authorities. Second, a new geopark can be planned and established with support of the regional government and local museums/institutions. Third, geotouristic activities should be combined with other forms of tourism and promoted accordingly. Apparently, the geosites will not be affected by geotourism growth, although, for any instance, the strategy should include activities linked to their close palaeontological examination for preserving all fossil species in collections before the beginning of intense touristic exploitation. Importantly, the latter will contribute to the people's awareness of unique geological phenomena, which is important for cultivating pro-environmental behavior. Indeed, geopark will bring socio-economic benefits to the region via new job creation, additional income, and stronger education in natural sciences.

Geoethics (also in relation to geoheritage and geodiversity) is a growing field of knowledge [102–108]. In the study area, its main dimensions include geological "literacy", responsible fossil collecting (especially in regard to the palaeobiogeographical importance of the LE geosite – see above and Fig. 3), and the above-mentioned contribution of geotourism to pro-environmental behavior development. Apparently, the very awareness of the heritage value of the considered localities can contribute to the more ethical treatment of the geological environment of the study area. The geopark should be planned to address these and the other possible geoethical issuesa. Future investigations should also aim at studying existing geoethical practices and people's attitudes, as well as mechanisms of their improvement (if required).

6. Conclusions

The investigation of the geoheritage from the northwestern Kemerovo Region allows making three general conclusions.

1) the four geosites represent unique palaeogeographical, stratigraphical, palaeontological, and geomorphological features, from which the former are the most valuable;

Table 3
Selected touristic activities in the Kemerovo Region, which can be related to the proposed geopark functioning.

Event	Basis	Essence	URL (state for November 25, 2021)
Festival of national cultures	Regular, regional, with zonal sections in particular towns like Anzhero-Sudzhensk	Demonstrating cultural diversity, traditions, and identities of the Kemerovo Region and its particular areas	https://kemobl.ru/news/detail/festival-natsionalnykh-kultur-my-zhivem-semey-edinoy-prokhodit-v-kuzbasse
Sibirsky valenok (Siberian felt boot)	Regular (November) in Anzhero-Sudzhensk	Putting the traditional winter boots of Siberia into the modern cultural context	https://visit-kuzbass.ru/events/sibirskij-valenok
City's Day – Kemerovo	Regular (June 12) in Kemerovo	Celebrating the city's history and modern identity	https://funnyfest.ru/events/den-goroda-v-kemerovo/
Town's Day – Anzhero-Sudzhensk	Regular (July 4) in Anzhero-Sudzhensk	Celebrating the town's history and modern identity	http://citiesdays.ru/kemerovo/anzherosudzhensk/den-goroda
Regional Festival of Sport Tourism among Youth and Students	Regular in various places of the region	Popularizing sport and conducting some sport competition	https://kemobl.ru/news/detail/festival-sportivnogo-turizma-sredi-molodezhi-startoval-v-kuzbasse

2) the studied geoheritage makes an insight into the Middle–Late Devonian environments and ecosystems of Southern Siberia, and it has the relatively high value, with one geosite ranked nationally;
3) the possible geopark creation seems to be suitable option for effective use of the four geosites of the study area, and this geopark functioning can be related to some other touristic activities in the region.

The present study proves the idea that Southern Siberia and, particularly, the Kemerovo Region have wide perspectives for geoheritage studies. New, field-based investigations are necessary to explore this important resource, to identify new geosites, and to establish the regional network of geoheritage and geotourism management.

Author contribution statement

Jaroslav M. Gutak, D.Sci. Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Dmitry A Ruban, Ph.D. Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Vladimir A. Ermolaev, D.Sci. Analyzed and interpreted the data; Wrote the paper.

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No data was used for the research described in the article.

Declaration of interest's statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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