Review
Geodiversity and Tourism Sustainability in the Anthropocene

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Abstract: Geodiversity has recently emerged as a key idea for recognizing the value of abiotic nature. The concept has vital implications for informing tourism sustainability research; however, to date, tourism scholarship has not shown adequate engagement with this concept. The issue also assumes further significance in the Anthropocene, where our species has become a geological force. Here, through a review of key works related to geodiversity and Anthropocene, their interface is analyzed, and implications for tourism sustainability are presented. It is argued that, in the Anthropocene, it is no longer enough for tourism sustainability research to remain preoccupied with the human predicament in the Anthropocene or the decline of biotic nature at some prominent tourism destinations, and it is imperative that tourism scholars embrace the concern for abiotic diversity and dynamic earth processes that provide vital resources and services for tourism planetwide.

Keywords: geodiversity; abiotic nature; Anthropocene; planetary change; geosystem services; tourism sustainability

1. Introduction
This position paper analyzes the importance of geodiversity for tourism sustainability in a time of pervasive anthropogenic change on a planetary scale. It reviews key works regarding geodiversity and explores the interface of geodiversity and the Anthropocene and posits the argument that the integrity of the diversity of abiotic nature should be at the forefront of tourism sustainability research in the Anthropocene. It also voices the need for safeguarding geodiversity across tourism destinations due to both the many important ‘services’ that tourism destinations derive from geodiversity and the increased anthropogenic impact on abiotic nature.

Geodiversity is defined as “the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), soil and hydrological features. It includes their assemblages, structures, systems and contributions to the landscape” [1]. From this definition, it becomes clear that geodiversity is the collective diversity of abiotic nature (including both specific features as well as processes that lead to them) on the planetary scale. Early mentions of the term can be found from the 1990s to early 2000s [2–4]. Current social engagement with geodiversity is centered on the twin aspects of education through formal academic programs and education at specific ‘sites’ [5]—this clearly shows that a powerful relationship exists between tourism and geodiversity.

The Anthropocene [6,7] is another often-mentioned concept in the contemporary natural and social sciences. Originally coined by the atmospheric chemist Paul Crutzen [8], the Anthropocene is generally seen as a shorthand for pervasive human influence in the earth system to the extent that major atmospheric, geomorphological, geochemical, and biological processes are seen as fundamentally altered due to human interference [6,7]. Although the Anthropocene concept has been frequently used to understand the intensifying extinction threat for species and the implication for biodiversity and ecosystems [9–12], anthropogenic alteration of geomorphological features is also recognized as significant at the global level [13,14]. Tourism studies show some awareness of the concept from a...
primarily social sciences angle, and some exploratory studies have sought to describe the broad contours of tourism in this time of rapid change in the geo-biosphere [15–17].

On the other hand, there is evidence of sufficient awareness of the ongoing global environmental change in tourism literature. Two notable aspects that have drawn attention of tourism scholars are climate change [18–20] and biodiversity loss [21–23]. Specifically, researchers have noted the threat climate change poses to international tourism [24]; the vulnerability of local destinations from climate change [25,26]; environmental degradation at tourism destinations [27,28]; various types of ‘ecotourism’ and their potential to deliver ecological awareness [29]; and emerging themes such as rewilding [30]. However, to date, there has not been sufficient engagement with these aspects and the core issue of the ongoing change, i.e., the human modification of the earth system and how that ought to be addressed through tourism research and practices. Here, the angle of ‘geodiversity’ is taken up on order to highlight both the ongoing pervasive anthropogenic impact on abiotic nature, as well as the key role of geodiversity in providing numerous tourism services. So far, tourism studies have not adequately featured discussions of ‘geodiversity’, which underpin all types of biotic and cultural landscapes of tourism and deserve central importance in tourism sustainability debates against the backdrop of planetary environmental change. Accordingly, it is posited here that geodiversity has a prominent role for speaking for the totality of the planet’s environment and for informing tourism sustainability in the Anthropocene.

2. Geodiversity and Geotourism: Key Facets and Interrelationships

2.1. Geodiversity: The Concept and Its Applications for Science and Sustainability

Geodiversity, as noted before, is a collective term for the planet’s abiotic diversity [1]. Early attention to the term as a benchmark for the protection of abiotic natural elements (i.e., mainly landforms and areas that feature them) can be traced back to the late 1980s and early 1990s, with notable examples from Australia and the UK [1,31]. Since its early days, the term has been seen as a partial response to the overemphasis on biodiversity in nature conservation research and practice and as an important concept that alludes to the totality of nature including its biotic and abiotic components [1]. Geodiversity sometimes has also been aligned with the concepts of ‘natural capital’ and ‘ecosystem services’ [32,33]. Global natural capital databases enlist abiotic elements such as geology, air, and water as fundamental assets for humanity [34], and there is widespread recognition of the fact that our planet’s abiotic diversity supports a number of materials and flows, i.e., ‘services’ that are vital for the human society—akin to the benefits or ‘services’ derived from healthy ecosystems. In a recent paper, Gray (2018) pointed out that most notable ecosystem services literature to date either excludes geodiversity and the benefits we derive from it or only refers to the term in a limited and partial manner [32]. It was proposed therein that the positioning of geodiversity and biodiversity should be equal when their contribution to the total stock of natural capital is taken into account, and that geosystem services should be seen as equally important as ecosystem services (with some instances of overlap between the two). A graphical representation of the proposed framing of geosystem services as an equal counterpart to ecosystem services is shown in Figure 1 below.

Three other facets regarding geodiversity are worth looking at for understanding its important role for informing conservation science, sustainability studies, and sustainable tourism research. These are: (i) geodiversity is not merely about impressive landforms that count as ‘heritage’, but also involves a multitude of earth processes, and is therefore dynamic in nature [1]; (ii) geodiversity underpins biodiversity—though not a rule of thumb, it is more often the case that diversity in landforms and processes results in diverse ecosystems and species richness [35,36]; (iii) geodiversity has an element of ‘geological time’ which is much older in scale than that which humans experience [37]. Thus, geodiversity can be seen as an emerging concept in nature conservation research that speaks for the equal importance of nonliving nature. A particularly important facet of geodiversity regarding
nature conservation is the fact that the term is planetary in scope and speaks for the intrinsic value of planetary processes and heterogeneity [1,31].

Figure 1. The current position of geosystem services in the prevalent ecosystem services literature is as a smaller counterpart to ecosystem services (left), which is inadequate given the many benefits ecosystems and societies derive from geosystem services, and should be reconceptualized as two equally important and interconnected components of geosystem and ecosystem services (right). Reproduced from [32] with permission from Elsevier, 2018.

In practice, geodiversity has mainly gained traction in protected area (henceforth PA) management, particularly at UNESCO World Natural Heritage (henceforth UNESCO WNHS) and UNESCO Global Geoparks programs. There are many locations where geodiversity is referred to or incorporated within the management of sites as part of these programs, and an academic journal (Geoheritage) regularly features such examples. Some instructive examples include the Gea Norvegica Geopark (Norway), which is based on a geological continuity of 1.5 billion years and the meeting point between older Scandinavian and newer European geological landmasses [38]; Beigua Geopark (Italy), where impressive examples of oceanic crust affected by alpine orogeny can be seen and there are various research, conservation, and communication programs to communicate the value of geological heritage [39]; Azores Geopark (Portugal), where geodiversity formed by several types and stages of volcanism can be observed [40]. However, while geoparks as an international initiative makes the most obvious reference to geodiversity, particularly in regard to tourism [41,42], it was pointed out that geopark designations are not adequate for conserving geodiversity on larger scales [43]. World Natural Heritage Sites (WNHS) also refer to geodiversity—a total of 93 WNHS are inscribed due to their representativeness of major stages of the planet’s history, land formation, and natural and physiographic processes [44]. Some notable examples include the Joggins Fossil Cliffs [45] and Mistaken Point [46] in Canada and the Giant’s Causeway and Causeway Coast in the UK [47]. Due to their enhanced level of protection, it can be argued that the UNESCO WNHS provide the most robust legal and societal engagement to protect geodiversity features. However, so far, their most prominent role has been to celebrate the diversity features they contain, and many WNHS are popular tourism destinations. It is argued here, with reference to the aforementioned works and what follows in subsequent sections, that internationally protected geodiversity-rich locations such as the WNHS have the additional and vital role of speaking for the integrity and diversity of nonliving nature. Needless to say, all internationally recognized protected areas can serve towards the safeguarding of geodiversity and should be augmented by national or sub-national level-protected landscapes wherever appropriate.
2.2. Geotourism as an Emerging Paradigm

Of late, “geotourism” has emerged as an important concept in contemporary tourism discourse and praxis [48–51]. Geotourism was initially defined by Dowling and Newsome (2006) as a niche type of tourism that is practiced in natural areas and is oriented towards geology, geomorphology, and landscapes [48]. This strand of definition subsequently became more inclusive in terms of target areas (i.e., not only limited to natural areas) and activities (i.e., either guided tours with explanations of geological features or personal visits out of interest) [49]. A notable early attempt by Hose (1995) posited geotourism as a form of tourism that enabled tourists to understand the geology and geomorphology of the destination and thus enabled an earth-science-based understanding of the place beyond immediate aesthetic appreciation [52]. Later, Hose (2012) expanded on the mandate of geotourism by proposing a ‘3G’ model where the three Gs stand for “Geoconservation”, “Geohistory”, and “Geo-interpretation” [53], showing that geotourism has a fundamental task of at least conserving those expressions of geodiversity that qualify as heritage attractions. However, while the definition of geotourism has continued to expand, perhaps unintentionally, its core focus has become somewhat diluted. Early indications of this dilution came from the attempts by the National Geographic Society that sought to include ecological and cultural elements and broadened the scope of geotourism even further to encompass various geographical characteristics of place [51,54]. Currently, the National Geographic Society espouses 13 principles for geotourism, which, geared towards sustainable destination stewardship as they are, primarily speak for the instrumental values of recreation and local socioeconomic benefit [55]. With regard to the overall evolution of the concept, the recent compilation by Dowling and Newsome (2018) succinctly describes that, over the years, geotourism has expanded from being a ‘type’ of tourism (i.e., referring to its core of geological/geomorphological features as attractions) to an ‘approach’ of tourism (i.e., one that incorporates different geographical areas of interest as well as a spectrum of activities) [51].

Thus, as the preceding discussion shows, geotourism started off as a geologically focused form of tourism but moved towards a more generic spectrum of activities. While initial key works mentioned the centrality of geology, geomorphology, and the natural aspects of the landscape and the processes that were creating those features (or, in other words, geodiversity) [48], over the years, geotourism has somewhat outgrown its core focus and mandate, and it now incorporates many facets other than geodiversity [51]. While a full analysis of geotourism, its characteristics, competing definitions, and practice examples is beyond the scope of this position paper and can be found elsewhere [48–51,56], it remains to be noted that, while geotourism has emerged as a new and promising paradigm in tourism related to the earth, its core focus today has been somewhat diluted, and a range of activities occurring in both natural and human-modified areas currently qualify as geotourism [51]. While this development may have expanded the scope of geotourism and the diversity of its contents, it also implies that the mandate of conserving geological/geomorphological features and processes with the full range of their diversity and natural extent [1,57] has been diffused to an extent.

2.3. Geoparks and International Protected Area Management Angles Regarding Geodiversity

As briefly touched on in the preceding section, the UNESCO Global Geoparks program is one of the more prominent international schemes that celebrate earth heritage. The Global Geoparks concept formally took shape in 2004 with 17 geoparks from Europe and 8 from China and eventually became a formal UNESCO initiative in 2015. Currently, there are 177 Global Geoparks in 46 countries and regions [58]. Nearly all geoparks connect to geodiversity through the visitation of attractions that may include important outcrops, landforms, fossil beds, and entire landscapes that showcase earth processes, and that, in many cases, also include examples of in situ conservation in the form of geosite designation and ex situ conservation in the form of museums and visitor centers [59]. UNESCO defines its Global Geoparks as “... single, unified geographical areas where sites and landscapes
of international geological significance are managed with a holistic concept of protection, education and sustainable development” [58]. On the UNESCO website, the main foci of geopark activities are listed as ‘Natural Resources’, ‘Geological Hazards’, ‘Climate Change’, ‘Education’, ‘Science’, ‘Culture’, ‘Women’, ‘Sustainable Development’, ‘Local and Indigenous Knowledge’, and ‘Geoconservation’ [60]. While this inclusive list upholds many good practices, it conspicuously does not feature geodiversity itself as a standalone focus. A further look into the ‘Geoconservation’ aspect reveals that the main concern here is protection of specific geological/geomorphological sites within geoparks and not the protection/conservation of geodiversity as a whole and at the planetary level. Nonetheless, there are examples of ongoing activities within UNESCO’s Global Geoparks that prioritize geodiversity, as some examples cited in the previous section show [38–40].

Apart from the UNESCO, the International Union for Conservation of Nature (IUCN) is a key international body that has started to focus on geodiversity and the benefits it extends to biodiversity in protected areas [57]. Several IUCN resolutions currently recognize the value of geodiversity in underpinning biological, cultural, and landscape diversity and, since 2014, the IUCN has organized a Geopark Specialist Group (GSG) as a part of its World Commission on Protected Areas (WCPA), which is expected to promote geodiversity management and advice on geodiversity/geoheritage-related aspects in WNHS nominations [57]. In addition, there are several emerging examples of how geodiversity is being seen as key for geotourism and local resource management in protected areas in different parts of the world [59, 61].

While these developments are commendable, as pointed out by Gordon et al. (2018), geodiversity and geoheritage are still poorly recognized and insufficiently integrated in protected area management in general [57]. The foregoing discussion in this paper also reflects this reality. Despite the emergence of geotourism as a powerful new paradigm that helps to connect with the earth and register many areas under the UNESCO Global Geoparks scheme, there is much room for improvement and exploration regarding the integration of geodiversity as a focal point in protected area management, and on how tourism could be fruitfully engaged with geodiversity. These are issues that assume further significance in the light of the Anthropocene, as elaborated below.


The Anthropocene is a concept that has influenced a broad range of natural and social sciences in recent years. The key idea is that, due to the influence of our species (Homo sapiens or the ‘anthropos’), the earth system has entered a new geological ‘epoch’ around the mid-twentieth century, which is fundamentally different from the Holocene epoch that began with the end of the last glacial maximum (or ‘ice age’ in more popular terms) about 11,700 years ago [6, 7]. Initially, the late atmospheric chemist Paul Crutzen, who is credited with coining the term, identified the onset of the Anthropocene with the industrial revolution in the British Isles [8]. Later, the so-called ‘Columbian exchange’ of plant and animal species across oceans in 1610 was proposed as a beginning date for the Anthropocene [62], and a yet more ancient date, that of the beginning of the agrarian lifestyle, has also been proposed [63]. However, the latest ‘consensus’ date is the middle of the last century, when the impact of the human species on the geo-biosphere became planetary and near-synchronous [6, 64]. It should be stated that the Anthropocene concept is still very young, and the debate on its onset is by no means settled for good, as are the debates surrounding whether it qualifies as a formal geological time unit or whether the impact of the human species as a collective is identifiable [65, 66]. However, due to the frequent usage of the term in natural and social sciences, it is perhaps safe to assume that the concept has been accepted as a valuable benchmark on the anthropogenic alteration of the geo-biosphere.

Along with the issue of its stratigraphic credentials (i.e., where in the geological timescale the Anthropocene should be located and what evidence should be deemed satisfactory for that positioning), there are a couple of related aspects that also have far-
reaching resonance for informing sustainability, conservation science, and, in extension, global, or rather, planetary tourism. These are: (i) the Great Acceleration of the 20th century as a once-in-a-geological-time, never-before phenomenon; (ii) the mark of the Anthropos, not only on local environments, but on the planet itself.

The Great Acceleration concept points out the unprecedented and planetary-scale expansion of the human enterprise that maps itself very closely with the changes in the earth-system [67]. The original Great Acceleration graphs traced key socioeconomic trends such as population, GDP, primary energy use, urban population growth, water use, transport, and international tourism, as well as earth system trends such as the levels of key greenhouse gases, tropical forest loss, land domestication, and terrestrial biosphere degradation. It was shown that, since around 1950s, all indicators show a sharp and unprecedented upward trend, which imply strong correlation between socioeconomic and earth system parameters. It should also be noted that some of the socioeconomic parameters such as international tourism and transportation growth enjoy a close synergy—that these, in turn, have a synergistic relationship with greenhouse gas emissions and the degradation of the biosphere. In addition, there is emerging literature on tourism’s dependence on petroleum and its impact on land and marine resources [68].

The disproportionate effect of the twentieth-century humanity’s modification of the biosphere has also been analyzed from historical and environmental pollution points of view even before the popularization of the term Anthropocene; such scholarship can be seen as a precursor to the current Anthropocene narrative [69–71]. It was observed how the human society (and prominently the advanced industrialized and capitalist countries) appropriated massive amounts of energy, and how the anthropogenic biomass (or Anthropomass) surpassed the natural biomass during the course of the 20th century—both key indicators for the great transformation of the geo-biosphere.

Current Anthropocene-related research has manifold foci, with insights on the state of the biosphere and the massive appropriation of natural resources, and the anthropogenic domination of geochemical cycles is particularly relevant for sustainability challenges. Scientists have cautioned that we are entering a phase of rapid planetary scale extinction of animal and plant species due to deforestation, habitat conversion, and overharvesting [72–75]. A global survey by the WWF has already made it clear in no uncertain terms that a million species are facing a threat of extinction due to human activities [76]. Moreover, aside from the number of species under threat, there is the ongoing simplification of ecosystems and intra-species mortality, termed as defaunation [9,77,78]. These studies leave little doubt that the biosphere and its constituent species are in serious trouble. At the same time, humans have also altered major geochemical cycles [79], adding another dimension to the anthropogenic impact on the planet that can rightly be termed geological. Human activities have already significantly altered nitrogen, carbon, and phosphorus cycles [80–83]. Since the 1950s, humans have become the dominant player in sediment mobilization and transport; human actions on waterways have resulted in a 215% increase in total fluvial sediment delivery (mainly due to increased erosion), yet a near-halving of fluvial sediment delivery to oceans (mainly due to damming and fragmentation of river–ocean connectivity) [84]. In addition, pervasive human influence has resulted in changes in the key geomorphic processes [13].


There are several emerging narratives regarding tourism and the Anthropocene [15,85–89]. Most of these works mainly focus on the predicament of human societies or wild species (i.e., biotic nature) in the Anthropocene, with analyses focusing on political ecological perspectives [86,88] and the meaning of tourism in an era of accelerating climate change [15] and the vulnerability of wild species in the light of the pervasive anthropogenic modification of the biosphere [89]. As a parallel-but-related focus, climate change has also taken a prominent position in the thinking of tourism researchers [24,90,91]. Regarding tourism sustainability, similarly,
foci have generally been on the impact (or redressal) of climate change [92–95], vulnerability of natural destinations with the biotic environment in the foreground [18,22,23], and vulnerability of local communities in the face of rapid and accelerating environmental change [95–97].

However, so far, there has been only limited engagement of tourism scholarship with the fundamental problem of the earth system in the Anthropocene [98]. Precisely because the human impact on the planet is now geological in scope, such engagement should not only be limited to climate change and biodiversity or species decline—which are nevertheless important—and should also embrace the nonliving, geological nature as well. Here again, it will perhaps be not too disputable to claim that there has been little engagement with geodiversity in tourism sustainability research to date. There is relatively little scholarship on how abiotic nature fares in this ‘age of humans’, which, as has been shown in the preceding sections, is precisely where the anthropogenic impact has become planetary and geological. Thus, it is argued here that geodiversity and the services derived from it—geodiversity services or geosystem services—should constitute a fundamental pillar of tourism sustainability research in the Anthropocene. The term geosystem services is defined as the various services provided by geodiversity (i.e., nonliving elements of natural diversity), and geosystem services include supporting services (e.g., habitat provision through geomorphic processes, soil processes such as erosion or buildup, land and water as vital elements for human societies); provisioning services (e.g., food and water, nutrients, energy and construction materials); cultural services (e.g., environmental quality such as local landscape character, geotourism and types of tourism, artistic inspiration); and knowledge services (e.g., understanding about past conditions that enabled biodiversity and society to flourish, scientific knowledge of the earth and environmental monitoring/forecasting) [32]. Based on this line of thought, some indicative pointers (broad contours) on how geodiversity can inform tourism sustainability in the Anthropocene are suggested below. It remains to be noted that these are only some indicators on how geodiversity can inform tourism sustainability in the Anthropocene, and there is no need to limit scholarship on these aspects; indeed, new angles/directions will doubtlessly emerge and perhaps even transcend these suggestions.

Firstly, it remains to be noted that there are already some inquiries regarding ‘vulnerable places’ in the Anthropocene, some examples of which are the thinning glaciers in Iceland [99] and the European Alps [100] and the Great Barrier Reef (affected by climate change and pollution) [101]. There is also indication that some form of place-attachment is also possible through visitor empathy and commitment for destinations that offer ‘last-chance tourism’ opportunities [102], although the paradox of increased empathy and attraction for such destinations leading to yet more carbon emissions persists and cannot be overstated [103,104].

Yet, as these examples help to highlight, such engagement is primarily ‘place-based’ and is not oriented towards the value of abiotic nature as a whole. In the Anthropocene, this is no longer adequate, as tourism sustainability is fundamentally related to the sustainability of the finite geo-biosphere or, in other terms, the integrity of the earth system. Against this backdrop, tourism needs to engage with the manifold facets of the abiotic earth (i.e., geodiversity) more holistically, taking into account the fact that the diversity of abiotic nature is fundamentally important for biodiversity, a multitude of tourism resources, and the well-being of both the host and guest communities across destinations. In the Anthropocene earth, both human inhabitants/visitors and their nonhuman counterparts in tourism destinations face an uncertain future due to a fast-changing planetary system that throws up new complexities and surprises. While it would be impossible to completely counter such change because, if the Anthropocene is a new geological epoch, we are left with no alternative but to accept the fundamentally altered parameters of planetary mechanisms, it is still possible to appreciate the key role of abiotic heterogeneity and processes and to safeguard their integrity to an extent. The difference of temporal scales in the evolution of geodiversity and biodiversity was invoked in a recent paper by Chakraborty and Gray (2020) [37], and the diagram of its evolution, presented in Figure 2, shows that
geodiversity has flourished since around 3 billion years ago with the evolution of the continental crust and is therefore more ancient compared to biodiversity, which has enjoyed its remarkable growth since around 500 million years ago. The key here is understanding the fact that, because geodiversity is engendered and maintained over geological time, anthropogenic alteration of such diversity will be near-permanent, as redressal will also necessarily warrant a geological timescale. It is therefore imperative that tourism scholars, protected area specialists, and landscape planners join forces to position geodiversity as a fundamental pillar of tourist attractions, particularly for areas that are known for exceptional geodiversity features (e.g., WNHS and other types of PAs). While pinpointing the onset of the Anthropocene and understanding its stratigraphic markers remain important issues, a more meaningful engagement that can connect destinations, area managers, visitors, and scientists may perhaps occur through understanding how the Anthropocene is currently unfolding across tourism destinations and what changes its trajectories will usher in for the abiotic resources of tourism. Thus, understanding the intensifying changes in the geo-biosphere in the wake of the Anthropocene—notably through the perspectives of earth system transitions (which may manifest themselves through changes in major biogeochemical cycles, landscape/landform processes, and climatic anomalies), the ongoing mass extinction, and defaunation events—emerges as a major duty for both visitors and tourism service providers in general and for protected area tourism stakeholders in particular. An important lead in this regard is the ‘Conserving nature’s stage’ approach, where, rather than preserving specific aspects or species, attention is given to the totality of the natural environment and the interaction between its constituent parts [105,106]. A recent paper by Gordon (2019) provides important benchmarks towards this by specifically addressing geodiversity for protected area management [107]. The two most important lessons from this work that also relate to tourism are (a) allowing space to enable natural processes to operate over the full range of their natural variability and (b) maintaining the connectivity of natural processes and landform elements. It is in this regard that internationally recognized protected areas can deliver to an extent, but only if management attention and tourist education on geodiversity is featured on a regular basis in such areas. Shifting the current focus of celebrating rare landforms or natural features found in those areas into a focus of a collective responsibility of protecting such diversity through visitor and local dialog will go a long way towards not only conserving the rare geodiversity features of those locations, but also raising awareness of visitors at the international level. Currently, there is an ongoing effort in the US National Park Services to create and maintain ‘geodiversity atlases’ for US National Parks, with the aim of educating visitors about geodiversity, geoconservation, and the integrated management of biotic and abiotic elements [108]. At a more personal and individual visitor level, hints towards connection with geodiversity may be drawn from emerging scholarship on issues such as ‘geophilia’ (i.e., the affective connection with the lithic, ancient, abiotic earth) and appreciation of different types of stones and minerals as representations of geological time (i.e., not seeing them as merely extractable resources but as vital connections between humans and an ancient earth) [109,110]. In addition, there are studies that call for understanding and protecting ‘geosystem services’, i.e., the geological base of ecosystem services [111,112]. This is equally important and could be implemented in tourist destinations regardless of their status as protected areas or otherwise, as perhaps all tourist destinations depend on geodiversity/geosystem services such as water, clean air, and surrounding landscapes to an extent. It has already been mentioned in a preceding section how human impacts have altered key geomorphic and geochemical processes—this awareness, in a nutshell, implies a willingness to understand and redress the pervasive alteration of abiotic processes to the broadest scale possible. The realization that tourism sustainability in the Anthropocene needs to move beyond the human predicament and the plight of some iconic species and should embrace an awareness of how the earth system itself is changing and how that change translates into the condition of geodiversity and geosystem services in tourism destinations has the potential to profoundly expand the responsibility of the Anthropocene tourist as a student of the earth, which, in turn,
implies a commitment to maintain the integrity of the full suite of natural processes in the geo-biosphere. While both destination managers and tourists share that responsibility, tourism scholars should take the lead in exploring the scope and practicality of such ideas at specific or multiple destinations through research and communication.

Figure 2. Curves showing the enrichment of biodiversity and geodiversity through time. Note the discrepancy in the temporal scale: while biodiversity has seen a steep rise since about 500 million years ago, geodiversity is more ancient, and its major enrichment phase dates to nearly 3 billion years ago with the evolution of the continental crust. Reproduced from [37], with permission from Elsevier, 2020.

5. Concluding Remarks

This position paper identified the lack of engagement in tourism studies regarding geodiversity, i.e., the diversity of abiotic nature and dynamic earth processes. Geodiversity has emerged as a powerful concept for understanding the value of abiotic nature and currently informs nature conservation in protected areas that are known for landform/landscape heterogeneity. However, the idea has further potential, including that of informing the core of tourism sustainability in the Anthropocene, because geodiversity and the resultant geosystem services support tourism activities in myriad forms. In the Anthropocene, where human impact on the geo-biosphere has resulted in the modification of key earth processes, the concept of geodiversity assumes further importance. It was shown through a review of key works that tourism scholarship to date has remained primarily preoccupied with the human predicament and changes such as climate change and the decline of biodiversity that impact tourism destinations. While some attention has been paid to a dynamic earth, and some place-based concern for abiotic elements can be identified, tourism sustainability research has so far not adequately engaged with the condition of abiotic nature itself. Against this backdrop, tourism scholars need to bring the diversity of abiotic nature at the forefront of tourism sustainability discourse, owing to the twin facts that such diversity supports a host of tourism resources and services across destinations and that, once depleted, it cannot be recovered in human timescales.

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