PROMOTING GEOETHICAL GEOCONSERVATION PRACTICES

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ABSTRACT

Geoethics and geoconservation are relatively new disciplines within the Earth Sciences, whose relationship and shared vision are yet to be clearly established. The aim of this paper is to organise and highlight aspects of geoethics that can be incorporated into geoconservation to enhance the effectiveness of geoheritage management strategies and actions. The paper begins with an overview of the origin, development, and scope of geoconservation and geoethics, followed by a comprehensive review of geoethics publications that specifically address aspects of geoconservation. Then, it presents a set of geoethical recommendations or practices for geoconservation, together with ethical dilemmas and questions to encourage reflection and discussion. Finally, it concludes that, owing to the absence of specific geoconservation laws in much of Latin America and the prevalence of a markedly extractivist view of geodiversity in Chile, the promotion of geoethics in academia may be an effective tool in the medium term for conserving geoheritage.

Keywords: *Geoheritage; Geoethical dilemmas; Latin America; Chile*.

RESUMEN. Promoviendo prácticas geoéticas para la geoconservación. La geoética y la geoconservación son disciplinas relativamente nuevas de las Ciencias de la Tierra, cuyas relaciones y visiones comunes aún no han sido claramente establecidas. El objetivo de este artículo es organizar y destacar los aspectos de la geoética que pueden ser incorporados en la geoconservación, con la finalidad de hacer más eficaces las estrategias y acciones de gestión del geopatrimonio. El artículo comienza con una visión general del origen, desarrollo y alcance de la geoconservación y la geoética, seguido de una revisión exhaustiva de las publicaciones sobre geoética que abordan, específicamente, aspectos sobre geoconservación. A continuación, se presenta un conjunto de recomendaciones o prácticas geoéticas para la geoconservación, junto con cuestiones y dilemas éticos para fomentar la reflexión y el debate. Por último, se concluye que, dada la ausencia de leyes específicas de geoconservación en gran parte de América Latina y el predominio de una visión marcadamente extractivista de la geodiversidad en Chile, la promoción de la geoética en el ámbito académico puede ser una herramienta eficaz, a mediano plazo, para la protección del geopatrimonio.

Palabras clave: Geopatrimonio; Dilemas geoéticos; Latinoamérica; Chile.

1. INTRODUCTION

Geoethics and geoconservation are relatively new disciplines within the Earth Sciences. The values of geoethics often encompass aspects of geoconservation (for example, the Cape Town Statement on Geoethics; Di Capua *et al*., 2017), and it has been shown that in synergistic contexts, such as UNESCO Global Geoparks, the actions of one discipline can enhance the

development of the other (Koupatsiaris and Drinia, 2025). Complementarily, it is reasonable to assert that a society with an ethical awareness for the Earth System should result in positive effects for the conservation of geoheritage.

Despite this, very few studies have addressed the relationship between both disciplines (e.g., DeMiguel *et al*., 2020, 2021; Koupatsiaris and Drinia, 2025) and, specifically, the scope of ethical issues for geoconservation has not been well defined. Consequently, this study highlights and systematises the aspects of geoethics that can be incorporated into geoconservation, with the purpose of making its strategies and management plans more effective.

2. A BRIEF DESCRIPTION OF GEOCONSERVATION

A considerable number of publications define the term "geoconservation" (e.g., Sharples, 2002; Brilha, 2005; Carcavilla *et al*., 2007; Burek and Prosser, 2008). There are no substantial differences among these definitions; on the contrary, they all share a core idea: that geoheritage possesses significant value, is subject to major threats, and therefore must be conserved. For the purposes of this paper, geoconservation is understood as the discipline that promotes the study and practice of methods and actions leading to the preservation and sustainable use of geoheritage.

The application of different methods and actions is often called a “geoconservation strategy”. The most widely implemented strategies include the inventory, monitoring, protection, outreach-enhancement, and restoration of geoheritage (Brilha, 2005; Carcavilla *et al.*, 2007;

Henriques *et al*., 2011; Benado, 2025).

The origin and historical development of geoconservation are well-documented, with the works of Burek and Prosser (2008) and Brilha (2022) being particularly recommended for a general overview of its history and major global milestones. For a general impression of geoconservation initiatives in Europe, Latin America, Asia, and Africa, the works of Wimbledon and Smith-Meyer (2012), Palacios *et al*. (2016), Shafeea *et al*. (2008), and Errami *et al*. (2015) are respectively suggested. For those specifically interested in geoconservation in Chile, Benado *et al*. (2019) is a reference.

These works describe how the history of geoconservation spans at least the last five decades (Fig. 1), a period during which it has been led at an institutional level by UNESCO, the International Union for Conservation of Nature (IUCN), the International Union of Geological Sciences (IUGS), and the International Association for the Conservation of Geological Heritage (ProGEO), among others.

In very general terms, these 50 years of development have been characterised by the following:

- 1970s - The first major institutional event for geoheritage conservation occurred with the adoption of the UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage, specifically through its criterion (viii) of Outstanding Universal Value (OUV).
- 1990s - This decade saw the consolidation of a set of working groups and international

initiatives on geoheritage, whose origins or initial approaches were developed in the 1980s. Examples include the creation of ProGEO, the Global Geosites project, and the signing of the “International Declaration on the Rights of Earth Memory” in the city of Digne, France.

- 2000s - The first decade of the 21st century witnessed the birth and growing popularity of geoparks, for instance, through the creation of the European, Asia-Pacific, and Global networks. Furthermore, the IUCN signed the resolution on "Conservation of geodiversity and geological heritage" in Barcelona, Spain, in 2008 (Appendix, Link 1), the first on geoconservation for this prestigious institution.
- 2010s - The second decade of the 21st century saw a strengthening of geoconservation initiatives at the international institutional level. Examples include the creation of the "International Geoscience and Geoparks Programme" by UNESCO and the "International Commission on Geoheritage" (ICG) by the IUGS; the recently created ICG aims to establish and maintain standards for the conservation of geoheritage, including the selection of globally significant geosites.

In this general history of geoconservation, Chile played an advanced role in the Latin American context, for example, through the pioneer creation in 2007 of the "Programme for the Detection and Establishment of Geosites in Chile" by the Geological Society of Chile (SGCh). However, this leading role lasted only a few years. To date, the most developed countries in geoconservation in South America include Brazil, Argentina, and Uruguay.

Fig. 1. Summary of major institutional initiatives related to geoconservation, both global and

Chilean. The image is based on the work of Brilha (2022). Chilean milestones are highlighted in grey.

3. A BRIEF DESCRIPTION OF GEOETHICS

As an emerging discipline, the understanding of what constitutes geoethics and its scope of action is still under development. An interesting review of how the definition of geoethics has evolved can be found in Di Capua and Peppoloni (2019). In the context of this study, geoethics will be understood as defined by the International Association for Promoting Geoethics (IAPG) (Appendix, Link 2): "*Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system*".

Numerous publications and works reflect on, propose, and/or describe ideas to support geoethics (e.g., Di Capua *et al*., 2017; Mogk, 2017; Peppoloni *et al*., 2019; Almeida, 2020). These ideas are mostly designated as "principles," "values," or "codes", among other terms. However, likely because it is still an emerging discipline, there is no consensus on which are the most appropriate, and there is even an inconsistent use of terminology. Two commonly cited lists of values are the 10 fundamental ethical values proposed in the Cape Town Statement on Geoethics (Di Capua *et al*., 2017) and the geoethical principles established by Almeida (2020); it is important to highlight that both explicitly include values that promote geoconservation.

Recently, prominent researchers Peppoloni and Di Capua (2021) proposed a new conceptual

structure (Fig. 2). Based on three fundamental principles (Responsibility, Freedom, and Dignity) applied across four major geothetical domains (Personal, Interpersonal, Societal, and Environmental), they define values such as honesty, transparency, fairness, and fostering inclusion, among others. These values, when virtuously put into practice, would allow for aspirations toward a more just world with greater awareness and respect for nature (including human beings). This structure could be useful for better organising the constantly developing concepts and ideas presented in the reflection on geoethics.

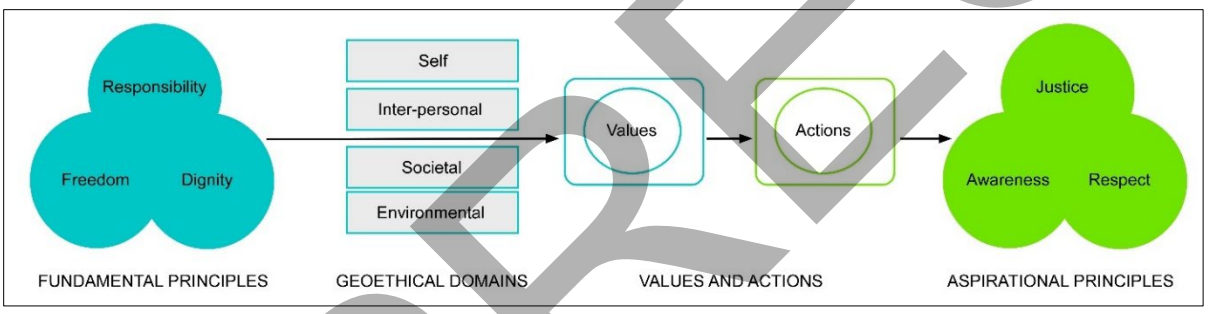

Fig. 2. Conceptual structure of geoethics, digitised from Peppoloni and Di Capua (2021).

Regarding its origin, DeMiguel *et al*. (2021) describe that geoethics arises from the idea that human actions have an impact (positive and/or negative) on the environment, and therefore, ethical criteria are needed to guide these interactions. Almeida (2020) describes geoethics as a discipline rooted in Environmental ethics and Bioethics, as it questions the role of humans in nature and proposes the need to create a deontological code for Earth Science professionals, respectively.

Since the 1990s, the international geoscientific community has increasingly incorporated ideas,

developed the concept of geoethics, and promoted its discipline (Němec, 2007; Martínez-Frías *et al*., 2011; Bobrowsky *et al*., 2017). Some relevant milestones include:

- 1993 - The scientist Václav Němec, in the context of the 1st International Conference on Geoscience Education and Training held in Southampton, UK, formally used the compound word "geoethics" for the first time.
- 2000 - A special symposium dedicated solely to geoethics was organised for the first time in Rio de Janeiro, Brazil.
- 2004 - A working group for geoethics was created with the support of the Association of Geoscientists for International Development (AGID).
- 2012 - The International Association for Promoting Geoethics (IAPG), the largest and most active international group on this discipline, was founded during the 34th International Geological Congress in Brisbane, Australia.
- 2016 - The "Cape Town Statement on Geoethics" was approved during the 35th International Geological Congress in Cape Town, South Africa. It establishes agreements on geoethical values and principles for geoscientists and proposes a Hippocratic-type oath to encourage the practice of the discipline.
- 2022 - The journal *Geoethics and Social Geosciences* (JGSG) (Appendix, Link 3), the first academic publication exclusively dedicated to geoethics, was launched.
- 2023 - The IUGS Executive Council formalised the creation of the Commission on Geoethics (IUGS-CG) (Appendix, Link 4).

For specific information on the development of geoethics in Latin America, the publications by

Acevedo and Frías (2018) and Villacorta *et al*. (2023) are recommended. In the specific case of Chile, the Geological Society of Chile (SGCh) has had a Group of Specialists in Geoethics since 2019, which serves as the national representative of the IAPG. After three years of participatory work, in April 2024, this group presented its first Code of Geoethics to the community (Appendix, Link 5). This code considers the various fields of practice for Earth Science professionals, including research, training, scientific outreach, and the relationship with society and nature.

4. GEOETHICS IN THE CONTEXT OF GEOCONSERVATION

Publications on geoethics are as diverse as its scope of action is vast. Next, to establish a solid framework for linking geoethics with geoconservation, a review of the literature was conducted following two main phases.

First, an exhaustive search was performed using the databases Web of Science, Scopus, and Google Scholar, among others, using keywords such as "geoethics", "geoconservation", "geoheritage" and "UNESCO Global Geoparks" in English, Portuguese, and Spanish. The search period covered publications from the emergence of geoethics discipline in the early 1990s to the present (2025), with a particular focus on the last decade (2015–2025) to capture the rapid evolution of the discipline following the establishment of the International Association for Promoting Geoethics (IAPG) and the publication of the Cape Town Statement. The inclusion criteria prioritized contributions that explicitly linked ethical principles (responsibility, integrity, sustainability) with practical management strategies of geoheritage. This resulted in the

identification of a list of key publications.

Second, the selected literature was then subjected to a thematic content analysis to identify geoethical practices and recurrent ethical dilemmas in geoconservation. The synthesis of this analysis process is presented in Section 5.

From the selected literature, the works of Nikitina (2012), Druguet *et al*. (2013), Mansur *et al*. (2017), Poch (2018), Antić *et al*. (2020), DeMiguel *et al*. (2020, 2021), Vasconcelos *et al*. (2020), Cisneros *et al*. (2021, 2022), Peppoloni and Di Capua (2022), Chan and Mogk (2023), Koupatsiaris and Drinia (2025), and Ruchkys *et al*. (2025) are particularly noteworthy for their emphasis on aspects that relate geoethics to geoconservation. The following are the key topics or ideas addressed in these publications:

- Nikitina (2012) reflects on the different values of geodiversity and proposes seven ethical principles for its conservation.
- Druguet *et al*. (2013) show the damage to geoheritage caused by injudicious sampling, particularly with drilling methods (for example, those used in palaeomagnetism), and advocate for geoethical education to combat this practice.
- Mansur *et al*. (2017) make a pioneering proposal for a Code of Conduct for Fieldwork for Brazilian geoscientists, consisting of 29 good practice suggestions.
- DeMiguel *et al*. (2020, 2021) offer a general overview of the meaning and scope of geoethics and its relationship with geoheritage conservation. Their work is of particular interest as it promotes discussion and reflection through case studies, highlighting

examples of good and bad practices. In order to illustrate this fact, Table 1 summarises the ethical issues raised by the authors regarding the popular practice, found throughout the world, of holding events to sell geological specimens (fossils, minerals, and rocks, among others).

- Vasconcelos *et al*. (2020) is a book with pedagogical resources for teaching geoethics. Among these resources, there are some specifics to geoethics in the context of geoconservation.
- Cisneros *et al*. (2021, 2022) provide examples, and discuss the ethical aspects, of what has been termed "palaeontological colonialism", meaning cases in which low- and middle-income countries are perceived just as suppliers of data and specimens for countries in the Global North, but the contributions of local collaborators are devalued or omitted, and the legal frameworks for the extraction and study of fossils are trivialized or even ignored.
- Peppoloni and Di Capua (2022) develop the relationship between geotourism and geoethics, highlighting how it has formative potential for human beings and for geoconservation.
- Chan and Mogk (2023) describe the results of surveys conducted among geoscientists about their behaviours when taking samples in the field. Based on an analysis of the responses, they suggest topics and practices that should be addressed under the criterion of geoethics to promote geoconservation.
- Koupatsiaris and Drinia (2025) present the development and validation of a Geoethical Awareness Scale (GAS) to measure the attitudes and perceptions of residents in UNESCO

Global Geoparks. The application of this scale in Greek geoparks shows that these geoparks not only protect geoheritage but also act as catalysts for greater ethical awareness.

- Ruchkys *et al*. (2025) address the conflict between mining activity and the conservation of speleological heritage in Brazil. They propose an integrated plan that uses geoethics as a framework to delineate the limits between exploitation and conservation in a high-impact context such as mining.

Table 1. Geoethical issues regarding events for the exhibition and sale of geodiversity specimens (e.g., fossils, rocks, minerals). Summarised from DeMiguel *et al*. (2021).

ARGUMENTS IN FAVOUR
These events can have an educational character, raise public awareness of a lesser-known natural world and potentially encourage young people to pursue a geoscientific career.
At these events, many critically important specimens are acquired by major museums, facilitating their access for research and outreach.
Directly or indirectly, these events are a source of income for many local populations, including miners, excavators, and artisans who prepare and restore fossils.
The development of a fossil industry contributes to the exploration and exploitation of outcrops, which allows for new discoveries that, for example, considering the few palaeontologists that exist, would not otherwise occur.

While most museums have considerably reduced their laboratory staff, many collectors and dealers working at these events have great skill in preparing rock and fossil specimens, which is a benefit for research (for example, palaeontological), as they perform processes more quickly and efficiently.

ARGUMENTS AGAINST

They are places that encourage and facilitate the illegal trafficking of specimens (fossils, rocks, minerals, among others), many of singular value.

Although the transfer of specimens may be legal or unregulated in a given country, it can be unjust because:

- It leads to the enrichment of the geoheritage of organisations (for example, large museums or universities) in developed countries and the impoverishment of countries with fewer economic resources.
- Specimen sales are not usually conducted under fair trade, meaning the work of local collectors and preparers is generally not remunerated in line with the price paid by the final recipient.
- The countries of origin of the specimens generally do not collect taxes on the transactions.

Fossil specimens for sale were not necessarily excavated and extracted with the corresponding permits and protocols. This can lead to a loss at the sites, which in many cases contain information even more valuable than the fossil itself.

The excessive international demand for specimens, particularly at these events, could be causing the loss of fossil and mineral sites of special scientific relevance.

In addition to these publications, several ethical codes from various international and national associations and groups address specific topics relevant to geoconservation. Some examples are: Global Geoparks Network (GGN) Code of Ethics for UNESCO Global Geoparks and Global Geopark Professionals (Appendix, Link 6); Geological Field Work Code (Appendix, Link 7) and Code of Conduct for Rock Coring (Appendix, Link 8), both from the UK-based Geologists' Association; Scottish Fossil Code (Appendix, Link 9) and Code on Cosmogenic Sampling (Appendix, Link 10), both from the Scottish Nature Agency (NatureScot); and Ethical Considerations for Responsible Geological Fieldwork and Sampling (Appendix, Link 11), promoted by the IAPG. For illustrative purposes, Table 2 summarises the section of the GGN's ethical code related to geoheritage.

Table 2. Summary of the section on geoheritage conservation, from the GGN Code of Ethics for UNESCO Global Geoparks and Global Geopark Professionals.

N°	DESCRIPTION OF THE ARTICLE
	Geological heritage conservation policy
1	The management body of the geopark must adopt and publish a geoheritage conservation policy. This should address its protection, care, and rational use.
	Sale of geoheritage elements is prohibited
2	A GGN member must respect local and national laws regarding the protection of geoheritage. It must not participate in the sale of geological objects within the

	geopark (fossils, rocks and minerals, among other), regardless of their origin, and must actively discourage the unsustainable trade of geological materials. The sale of material extracted from quarries or mines for industrial or domestic use is permitted, subject to evaluation, under national legislation.
3	**Preventive conservation** GGN members have a responsibility to create and maintain a preventive protection environment for the geoheritage present in their territories.
4	**Collections policy** It is recommended that the geopark's administrative body adopt and publish a collections policy. The policy should clarify the position of any material that will not be catalogued, conserved, or displayed in local museums, and geological specimens that have been collected, sold, or transferred in contravention of (international and national) legislation should not be acquired.
5	**Objects and specimens from unauthorised or unscientific fieldwork** GGN members must not acquire geological objects for which there are reasonable grounds to believe that: their recovery has involved the unauthorised destruction or damage of the extraction site; has involved the illegal or unethical use of labour; or the findings have not been reported to the owner or occupier of the land, the legal authorities, and/or the traditional landowners, as appropriate.
6	**Repositories as a last resort**

	GGN members may act as repositories, of last resort, for specimens illegally collected or recovered in the territory they administer.
7	**Continuity of geoheritage sites and collections** GGN members must establish and implement policies to ensure that their geoheritage localities, collections (both permanent and temporary), and associated information, duly catalogued, are available for current use and are transmitted to future generations in optimal condition.
8	**Documentation of geological outcrops and collections** Geological sites and collections must be documented according to accepted professional standards. Such documentation must include detailed identification and characterisation (for example, provenance, state of conservation, and current location). These data must be kept in a secure environment and properly backed up.
9	**Accessibility of geoheritage localities and elements** GGN members have a responsibility to facilitate access to geoheritage localities and elements, along with all relevant information, as freely as possible.
10	**Sample collection** GGN members conducting sample collection activities in the field must develop policies consistent with academic standards and national, regional, local, and indigenous legislation, as appropriate. Fieldwork will ensure respect for the views of local communities.

11	**Research** Research conducted by the staff of GGN members must be related to the mission and objectives of said geoparks and conform to established legal, ethical, and academic practices.
12	**Sharing knowledge** Employees of GGN members have an obligation to share their knowledge and experience with colleagues, academics, and students in relevant fields. They must respect and acknowledge those from whom they have learned and must pass on advances in techniques and experience that may be of benefit to others.

5. PROPOSED GEOETHICAL PRACTICES AND TOPICS FOR GEOCONSERVATION

Based on the analysis and synthesis of the background described in Section 4, with an emphasis on the identified codes of conduct and the publications of Mansur *et al*. (2017) and Almeida (2020), a set of recommendations for geoethical practices aimed at geoconservation has been compiled. These recommendations are shown in Table 3 and consist of 17 suggestions, divided into three main groups: practices for promoting societal knowledge of geodiversity and geoheritage; practices for fostering the protection of geoheritage; and specific practices for fieldwork.

It is relevant to mention that a primary version of these suggestions was presented to the Group of Specialists in Geoethics of the SGCh during the creation of its respective code, published in

2024. After a process of socialisation and reflection by the group, a significant portion of these suggestions was incorporated under Title III – "Geosciences and their Relationship with the Environment". This fact demonstrates the growing appreciation for geoconservation within the Chilean geoscientist community.

Table 3. Suggestions for ethical practices for geoconservation.

N°	SUGGESTED GEOETHICAL PRACTICE
1	**Promote the importance and social knowledge of geodiversity and geoheritage, highlighting their values, uses, and ecosystem services, among the scientific community, educational institutions, the media, non-formal learning institutions, and local communities, among others. To this end, it is suggested to:**
1.1	Contribute to the inclusion of truthful information related to geodiversity and geoheritage in museum settings (visitor centres in protected areas and local museums, among others).
1.2	The results obtained from the analysis of collected material and studies conducted in a specific area, should be disseminated to the owners or managers of the area, the population, and local communities.
1.3	After analysis, samples of rocks, fossils, or their duplicates should be donated to local institutions, such as universities or museum halls.

1.4	Earth Science educators should incorporate the values and services of geodiversity and topics related to geoheritage conservation into their educational programmes.
2	**Promote the protection of geoheritage. To this end, it is suggested that:**
2.1	Geoscience professionals in decision-making positions (for example, in legal matters, protected areas, and environmental impact analysis) should promote: • The need for public institutions and officials dedicated to geoheritage conservation. • The incorporation of aspects related to geoheritage conservation in environmental assessment processes. • The creation of specific laws and protected areas for geoheritage (e.g., UNESCO Geoparks).
2.2	Prior to starting fieldwork, all members of the team or group must be aware of the legal implications of working in protected areas, regarding the removal of fossils and/or other legally protected materials.
2.3	Before beginning fieldwork, check whether there are any elements or places recognised in national geoheritage inventories in your study area. If so, inform the work team and try not to alter this geoheritage.
2.4	Professionals and enthusiasts of the Earth Sciences who discover new specimens or places of potential special scientific value, for example, from the early history

	of the Universe (e.g., meteorites or impact structures) or fossils, among others, will report their findings to qualified professionals in the field.
2.5	Professionals and enthusiasts of the Earth Sciences should not participate in the commercialisation of geological specimens of special value (fossils, minerals or meteorites, among others).
3	**When conducting fieldwork, strive as much as possible to respect the principle of minimal anthropic intervention on outcrops. To this end, it is suggested that researchers, students, professionals, and geoscience enthusiasts:**
3.1	Ask colleagues or peers, prior to their field activities, if they have samples, analyses, or descriptions of their study area. With the collaboration of others, it may not be necessary to collect samples and, therefore, to alter the outcrops again.
3.2	Collect the strictly necessary amount of materials (rocks, sediments or fossils, among others).
3.3	Collect samples from less visible parts of the outcrops to avoid altering their scenic value. In the specific case of sampling with equipment that causes "unnatural" alterations (for example, drills used in palaeomagnetism or palaeontological excavations), fill the holes with fragments of material of the same lithology.

3.4	Avoid making marks (symbols, indications and characteristics, among others) on outcrops with permanent markers or paints. After the fieldwork, any marks made should be removed.
3.5	Avoid climbing on outcrops unless it is essential for the research, especially if the area is already suffering from erosion.
3.6	For activities involving students or groups of enthusiasts, it is suggested that: • Those in charge explain that, for the conservation of the outcrop and its future use by the community, indiscriminate hammering should be avoided. • Activities and sample collection should be conducted only in the places and on the outcrops, respectively, indicated by the group leader (for example, the professor or assistant). • During a field activity, previously collected educational samples (for example, by a colleague, the university, or museums) can be used to represent the geodiversity of the study area.
3.7	Keep in mind that after visiting the outcrops, any changes should be reversible and/or minimised in order to maintain the conditions found before the fieldwork. Consequently, all equipment and materials used, particularly the waste produced during sample extraction, must be removed.

3.8	Maximise the scientific value of the collected samples, so that it is not necessary to alter the geodiversity of the study area again with more research. To this end, it is recommended, for example, to: • Record as much relevant information as possible about the samples, such as their spatial distribution, geological context, stratigraphic position, and photographs. • Make the extracted field material (samples, notes, and more) available for consultation by other researchers (for example, on a website or deposited in an appropriate institution).

Complementarily, the analysis of the identified publications revealed that the most contentious ethical issues in geoconservation relate to the collection and commercial exploitation of specimens (mainly fossils, but also minerals and meteorites), the use of these specimens by museums and scientists, the procedures and methods of fieldwork sampling, and the impact of industry (for example, mining and urban development) and tourism on geoheritage. To contribute to the reflection on these topics, Table 4 systematises questions for these conflict areas.

Table 4. Proposed ethical questions to promote geoconservation.

COLLECTION AND COMMERCIALISATION OF SPECIMENS (FOSSILS, MINERALS, AMONG OTHERS)

- Is it ethical for a scientist to publish research on a specimen purchased on the private market, knowing that this could increase its commercial value and encourage more non-scientific collection?
- How can the right of impoverished local communities to benefit economically from fossils found on their land be balanced with the need to preserve geoheritage for science and society in general?
- Should the scientific community boycott the study of illegally collected specimens to avoid legitimising a trade linked to conflict, even if it means losing irreplaceable scientific information?

SAMPLING

- Under what circumstances is it ethically justifiable to take a destructive sample from a geosite? Who should make that decision?
- Should there be zones where sampling is completely prohibited, similar to how some historical monuments or archaeological sites are treated?
- What responsibility do universities and research supervisors have in educating new generations of geoscientists about responsible and respectful sampling practices?

INDUSTRY

- What should prevail, the economic and social benefit of a new infrastructure or the conservation of a newly discovered geological element of special value, which also represents a long-term social benefit?

- Who should bear the costs of a rescue excavation of fossils found during the construction of an industrial initiative: the construction company, the government, or the geoscientific community?
- How can large development projects incorporate protocols to manage unforeseen discoveries of geoheritage effectively and ethically?
- When an area has high geoheritage value and high potential for industrial development, what ethical principles should guide land-use decision-making?
- Is the loss of irreplaceable geoheritage an acceptable cost for economic development? How can a unique landscape be "valued" against the economic benefits of industry?
- What role should geoscientists play in governmental planning processes to ensure that the value of geoheritage is adequately considered against economic interests?

TOURISM

- What is the acceptable balance between making a geosite accessible for public education and enjoyment and preserving its pristine state for future generations?
- Should the revenue generated by geotourism at a specific geosite be obligatorily reinvested in its conservation?
- When is it advisable to keep the location of a vulnerable geosite secret instead of promoting it, and who (scientists, administrations, local communities) should make that decision?

RESEARCH
• Is it ethical for geoscientists to study and publish on specimens whose legal provenance is dubious or that have been obtained without the collaboration of scientists from the country of origin? • What responsibility do scientific journals and museums have to verify the legality and ethical origin of specimens before publishing studies on them or incorporating them into their collections? • How can the historical damage of "scientific colonialism" be addressed and ensure that future international collaborations are truly equitable and beneficial for all parties?

6. FINAL CONSIDERATIONS

The review of publications conducted here shows that geoethics, since its beginnings and especially in the last decade, has had a field of action oriented towards geoconservation. Specifically, geoethics contributes to broadening the philosophical and social basis of the discipline of geoconservation, while geoconservation is one of the possibilities for putting the reflections of the discipline of geoethics into practice.

However, reflection on the ethical principles that should guide Earth Science professionals with respect to geoheritage remains scarce, considering the threats and pressures to which abiotic nature is subjected.

Unlike countries with a tradition in geoconservation, such as the United Kingdom, Spain or Portugal, Latin America lacks specific laws for geoconservation (Benado, 2025). Specifically in Chile, Law N°21.600/2023 was recently approved, creating the "Biodiversity and Protected Areas Service and the National System of Protected Areas," which very likely represents the greatest advance in nature conservation in the country in the 21st century. Although this law was under discussion in the National Congress for over 10 years, the institutions and individuals linked to geoconservation were unable to include specific provisions on these topics: it does not establish any new institutional framework for promoting the conservation of abiotic nature, nor does it include any definitions or specific management or protection measures for geodiversity, geoheritage, and/or geoparks.

This failure (hopefully temporary) is multicausal, but it is clear that the marked perception of Chilean society in general, and Earth Science professionals in particular, of geodiversity as a resource for economic exploitation—mining (extractivist paradigm) over other values or ecosystem services that it provides, is a very relevant factor.

Despite this setback, the inclusion of a section on geoconservation in the recently approved code of geoethics of the SGCh constitutes a small shift in perspective on the part of national geoscientists. Additionally, some national universities (for example, University of Chile, University of Antofagasta, and University Andrés Bello) have been incorporating courses or aspects of geoethics into their geology curricula. This could, in the medium term, have a positive

impact on modifying the extractivist paradigm.

In this context of gradual changes, promoting the conduct recommendations and the proposed ethical questions and dilemmas in tables 3 and 4, respectively, are preventive actions that could be relevant for the protection of geoheritage. For example, *ad hoc* versions of the proposed behaviours (Table 3) could be incorporated into UNESCO geopark policies and geopark projects, into management plans for protected areas of special geological interest, and as fieldwork protocols for geologists. Also, the authors strongly recommend the use of geoethical dilemmas related to geoconservation (Table 4) in the context of higher education, as these allow for the exploration of different perspectives, the connection of theory with practical work, and reflection on the often overlapping or contradictory values presented by the work of Earth Science professionals with regard to geoheritage.

It is hoped that the information provided in this work can be a tangible contribution to fostering reflection and debate among professionals, teachers, and students of the Earth Sciences in Latin America in general, and in Chile in particular, on the ethical aspects of their interaction with geoheritage.

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APPENDIX

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