

# Geoethics in the Scenario of the Geological Society in Brazil

Rosely Aparecida Liguori Imbernon <sup>1,\*</sup> , Paulo de Tarso Amorim Castro <sup>2</sup>  and Kátia Leite Mansur <sup>3</sup> 

<sup>1</sup> School of Arts, Sciences and Humanities (EACH), University of São Paulo, São Paulo 05508-060, Brazil

<sup>2</sup> Departamento de Geologia, Federal University of Ouro Preto, Ouro Preto 35400-000, Brazil; ptacastro@gmail.com

<sup>3</sup> Geology Department, Federal University of Rio de Janeiro, Rio de Janeiro 22290-240, Brazil; katia@geologia.ufrj.br

\* Correspondence: imbernon@usp.br; Tel.: +55-11-996-706-568

**Abstract:** The development model assumed by human society over the last century is opposed to the Earth system's resilience, which has resulted in global environmental problems such as global warming, desertification, depredation of geoheritage, etc. The concept of geoethics, proposed in 1993, was initially associated with ethical principles to mining and environmental, social and economic issues inherent to the exploration of these resources. Over the last few years, geoethics has turned to education, proposing a reflection on the way human beings relate to the geosphere, and particularly on the way geologists work during their academic and professional activities. In Brazil, geoethics entered the Brazilian Society of Geology scenario only from the end of the second decade of the 20th century and promoted changes in the academic and professional spheres.

**Keywords:** geoethics; geoethical professional performance; geoethical academic performance



**Citation:** Imbernon, R.A.L.; Castro, P.d.T.A.; Mansur, K.L. Geoethics in the Scenario of the Geological Society in Brazil. *Geosciences* **2021**, *11*, 462. <https://doi.org/10.3390/geosciences11110462>

Academic Editors: Clara Vasconcelos and Jesus Martinez-Frias

Received: 6 June 2021

Accepted: 4 November 2021

Published: 9 November 2021

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## 1. Introduction

Society does not perceive that many natural phenomena, both in space and time, are periodic and hierarchical and that these phenomena are not predictable. Thus, from the geosphere use and occupation perspective, the environment should receive value according to the moral and ethical principles often accepted by humanity [1].

Therefore, geological factors should be objects of reflective thought and respected in any concept of environmental sustainability, since, in general, the biological environment arouses greater attention than the physical environment (river basins, coastal plains, rocky formations, etc.).

Frodeman [2] points out that the increased participation of society in managing the processes of natural resources is a way of reducing dependence on governmental actions during a time in which the creation of a culture of belonging and being responsible for the environment is increasing in society.

However, this participation requires society to have geoscientific knowledge and clearly constructed geoethical values, as without them the citizen does not perceive that the use of natural resources also involves alterations to the Earth system. Therefore, it also falls to geology professionals, such as those in the realm of teaching geology, to be conscious of such geoethical aspects.

An example of the small Brazilian scientific contribution to geoethics can be obtained by carrying out a search by “subject” on the Portal de Periódicos CAPES/MEC (CAPES, [3]. It is an important repository of scientific information in Brazil that allows free access to national and international scientific publications. Using the word “geoética” (geoethics) in Portuguese, few studies were found. They are recent and distributed between 2012 and 2016, including publications in Portuguese by researchers from Portugal, Argentina, and Greece.

When using the search word in English, “geoethics”, the results reached 163, mostly concentrated in the first two decades of the 21st century, especially in the years after 2012.

The concern with geoethics in Brazil, in general, began in the last decade with the work of [4]. Some reasons for its flourishing can be listed: the socioeconomic and environmental context of the country, whose economic orientation is that of a country that generates commodities (including agribusiness and mining) and has little institutional concern for environmental and labor issues, including the weakening of norms and procedures in these sectors.

Considering that there is still little discourse on the topic of geoethics, this article aims to present the actions developed by the Brazilian Society of Geology, through its Geoethics Commission, to incorporate the discussion on this topic within the scope of the Brazilian geoscientific community. When discussing geoethics in the scope of the Sociedade Brasileira de Geologia (Brazilian Geological Society)—SBG, we also discuss the factors that led to the constitution of the Comissão de Geoética (Geoethics Commission) in 2019. This has multiplied in actions of formation, promotion, and affirmation of geoethics among the country's geology professionals, with ramifications in society. In this sense, we will approach two cases that point to the immediate need to discuss the geoethics theme in mining and in the formation of geologists in Brazil.

The recent nature of the interest from geoscientists about geoethics shows that it relates to education and research, practice, and communication in geosciences [5]. It can be highlighted that despite the theme of geoethics having gained significant visibility within the scientific community through IAPG—International Association for Promoting Geoethics, founded in 2012, in Brazil the theme remains incipient in both scientific and professional debates.

In the context of global debates on environmental problems and considering the ethical and social aspects involved in geoscience issues, we discuss the impacts caused by centuries of use and occupation of human societies on and in the geosphere.

*Specifically, such reflection aims at clarifying the boundaries of an anthropic action capable of confronting responsibly with the quality of current and future human life and with the conservation of the other biotic and abiotic elements that make up the Earth system. [6] (p. 1)*

The solutions presented for facing global challenges in the future must involve integration between different fields of knowledge, referring to knowledge of the Earth system and its functioning; the understanding of systems of social and cultural values and their dynamic; the understanding of economic realities; and the raising of awareness of philosophical approaches that influence human actions and generate negative impacts, which are often catastrophic and irreversible in human existence and ecosystems [7].

Geosciences, as historical-interpretative sciences, provide the reasoning necessary to face global environmental issues, which have been urgent since the 1960s but have only increased in the 21st century [2]. Such perspectives are exclusive to geosciences and allow analysis from the point of view of geological time and complex systems, enabling interpretation of interactions between the human social system (noosphere) and the Earth system, which provide the foundation for the unique contributions that geoethics can make in respect to environmental ethics and related ongoing work in other domains [6].

In the presented scenario, the appearance of this new area of knowledge, geoethics, came to define a conceptual basis for thinking and interacting with the Earth system, which broadens the cultural horizon of the knowledge of geosciences and contributes to guiding scientists and society in choices for responsible conduct towards the planet [5].

*It addresses firstly the geoscience community but has important significance also to society, as it synthesizes some values that must guide human actions with respect to the Earth system. [8] (p. 3)*

In Brazil, the perception of geoethics in the professional context is still confused with issues of professional ethics, and the debates in the scope of regional and national scientific meetings invariably involve the diffusion of the concept and the proposals of geoethics, even if the term is not explicitly mentioned.

In this debate, in the ambit of professional sectors that involve geoscientists, we should consider distinct levels of responsibility in geoethics that are involved (1) in the individual conduct of the work of each geoscientist; (2) in the multidisciplinary cooperation with other colleagues; (3) with society, aiming to minimize environmental impacts and respect the natural dynamic; and (4) with the Earth system, which should be conserved for future generations [9].

Geoethics can be considered in the field of geosciences as a rediscovery by geoscientists, as, in addition to professional action, it involves a real process of awareness, raising the social role geologists should play in support of society in facing global anthropogenic changes [6,9].

Therefore, two cases point to the immediate need to discuss the geoethics approach in Brazil, mining, and the training of geologists.

## 2. Mining and Geoethics in Brazil

One of the sectors that should be considered in these debates in Brazil is that of mining. After all, it saw an increase in revenue of 36% between 2019 and 2020, with iron ore and gold exports standing out, with positive variations of 16% and 36%, respectively (in US dollars) (<https://www.gov.br/anm/pt-br/centrais-de-conteudo/publicacoes/serie-estatisticas-e-economia-mineral/outras-publicacoes-1/3-1-2013-minerio-de-ferro-e-aco>, accessed on 10 August 2021) in comparison with 2019. It is one of the most important sectors in the national economy but is also recognized as having a large environmental and social impact.

Brazil is an exporter of mineral commodities, and therefore, the discussion related to levels of responsibility, represented by items 3 and 4 in the paragraph above, is particularly sensitive. An aspect that should be analyzed in the large-scale production of iron and gold is related to the expressive participation of exportation in the production. According to IBGM (Instituto Brasileiro de Gemas e Metais Preciosos, 2021) (Brazilian Institute of Gems and Precious Metals), the entire gold production in 2018 by large mining companies, around 90 tons, was allocated to exportation. Regarding the sale of this production, only the Compensação Financeira pela Exploração de Recursos Minerais (1.5%) (Financial Compensation for the Exploration of Mineral Resources) remains in the country.

The consequences for the environment and their extension in the social dimension need to be disclosed. Considering a gold/mineral content of 3.0 g per ton, 4,286,000 tons of tailings are shifted, composed of material with a similar density to quartz ( $2.65 \text{ g/cm}^3$ ), the density of gold being seven times greater ( $19.3 \text{ g/cm}^3$ ). Most of the tailings are stored on the surface. For this calculation, the gold content is much higher than that observed in Minas Gerais (MG), the main gold producer in the country [9], which means that the estimated mass of the tailings produced is very conservative. Regarding iron ore, around 410 million tons were produced in Brazil compared to only 32.6 million tons of steel. Considering an iron ore content of around 50% iron (also optimistic for the aim of the text), there were around 189 million tons of waste deposited on the surface in 2019 alone, mostly behind tailings dams. In this estimate, it should be considered that the tailings are composed of material with a density similar to that of quartz ( $2.65 \text{ g/cm}^3$ ), which, in turn, is half the density of hematite ( $4.9$  to  $5.3 \text{ g/cm}^3$ ).

Mining is an unsustainable sector [10], but changes in thinking about mining and sustainable development have been observed in recent decades. This is shown by the introduction of numerous guidelines, plans, and protocols, in the form of certifications, which aim to provide accountability to society of sustainable or responsible mining based on more ethical foundations.

In fact, it cannot be assumed that sustainable mining exists—it is not possible—as there will be no replacement for the materials consumed by the present generations for the generation that succeeds ours. However, we can look to responsible mining that practices circular economy (with recycling) and initiatives in urban mining, which are stimulating public policies and research that enable the aggregation of value to waste [11,12].

When we assume the principles of geoethics in the mining sector [13], we indicate paths that can be followed and that contribute to the generation of jobs, enabling the mitigation of environmental impacts inherent to mineral exploration processes [11], promoting greater competitiveness, and, above all, promoting actions in the transition from a linear economy to a circular economy [12]. In this scenario, Brazil has examples that demonstrate that a market exists and that it still has not been totally absorbed by the productive sectors.

### 3. Education and Geoethics in Brazil

It addresses firstly the geoscience community but has important significance also to society, as it synthesizes some values that must guide human actions with respect to the Earth system [14].

*This, the motivations, and actions to combat global anthropic changes and their intense impacts on the planet need to be governed by an ethical framework capable of merging a solid conceptual structure with practical approaches based on geoscientific knowledge, since Geoethics has constantly featured in geoscientific debates. [14]*

In other countries where geology also has a fundamental role in the economy, like the USA, the scenario remains far from ideal:

*In the US, though the need of ethical conduct by geoscientists has always existed, the uneven professional licensing and standards for geoscientists as well as high profile misconduct by geoscientists is driving employer demand for geoethical competency. [15]*

The authors also indicate that undergraduate programs do not include the content and/or disciplines to teach geoethics, and the proposal to deal with this deficiency is to promote the proactive engagement by the community and students in co-curricular activities in the form of online on-demand professional development courses, despite the problems that remain, especially in acceptance by faculty and employers [15]. With the aim of enhancing the teaching of geoethics in various universities at a worldwide level, based on an international project, educative resources and a curricular program have been constructed to be applied to teaching in higher education [16].

The introduction of geoethical considerations to the curricula, teaching methods, research, etc., for student development in university departments demands continuous commitment [16]. Moreover, according to the author, geoethics should be the common thread that can bind a geoscience department together.

*There are also many pedagogic reasons for including geoethics in both undergraduate and graduate geoscience curricula. Formalized study of geoethics will likely accomplish several goals and will enhance student experiences in higher education. Geoethics promotes critical thinking and review. It provides students with opportunities to formulate responsible solutions to socioeconomic problems. [17] (p. 237)*

Mansur et al. [18] indicate the need for a Código Brasileiro de Conduta (Brazilian Code of Conduct) for geological field work, considering the numerous events that have prohibited the development of scientific projects or caused destruction of outcrops. The authors indicate that, in general, this destruction is attributed to the lack of knowledge about the relevance of geological sites.

### 4. The Creation of the Geoethics Commission of SBG: Before and after Mariana and Brumadinho (MG), Brazil

From the beginning of the 21st century, debates on geoethics in Brazil were, in general, associated with geoheritage and the teaching of geosciences, with a focus on environmental education.

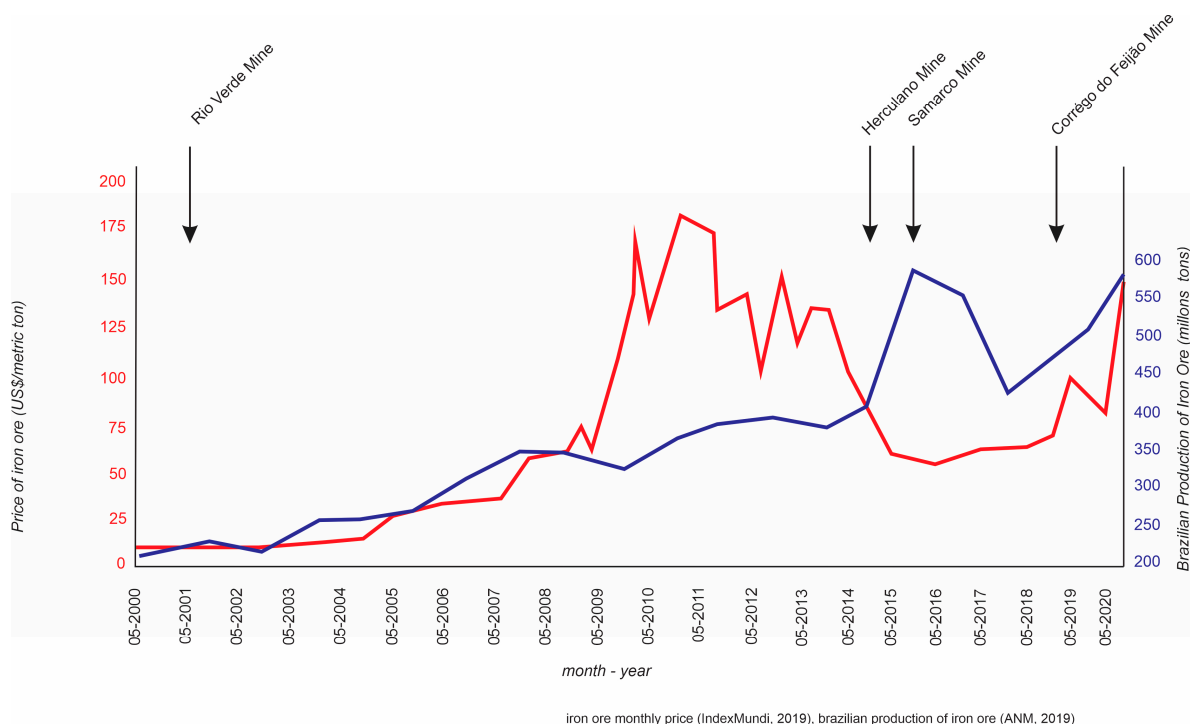
Mining-related issues, however, did not have the same approach, despite the inherent impacts that many regions in Brazil that still seek mitigation.

Mineral exploration in Brazil was an activity without legal control for a long time and has been part of the country's history since the 16th century. With Portuguese colonization, mining was governed by laws created in large part after the arrival of the Portuguese royal family in the country. At the end of the 19th century, changes began to have the representation of society, from the Proclamation of the Republic, with the promulgation of the First Republican Constitution, on 24 February 1891, which profoundly altered the property regime of the subsoil, and therefore, exploration of mineral resources in the country [19].

The state of Minas Gerais, in southeast Brazil, is one of the largest mining areas in the country, and historically, it was the main center of mineral exploration from the time of Portuguese colonization to the present day.

The development of geoethics in the country is marked by the occurrence of major disasters in the mining industry in Minas Gerais State in the southeast of Brazil, with strong social and environmental consequences [20–23]. The intensity and recurrence of disasters in the Quadrilátero Ferrífero mineral province in Minas Gerais, is remarkable. Ruptures in iron-mining tailings dams have taken place over the last 20 years and are directly related to the growth of regional production, which reaches more than half of what is produced in the country. Currently, Brazil exports around 90% of all iron production (580 million tons), which is concentrated in two mineral provinces: the Quadrilátero Ferrífero and Carajás, in Pará state.

The graph (Figure 1) shows the evolution of iron production in Brazil, the price of the commodity and the collapse of iron tailings dams that occurred throughout the 21st century. There has been an intensification in the number of disasters and their magnitude, with an increase in the price and production of iron. As the mineral industry is a medium- and long-term investment, the drop in iron prices in 2014 resulted in an increase in production to compensate in scale for the drop in prices. The failure of the Mineração Herculano and Samarco dams coincides with this increase in production.



**Figure 1.** Brazilian iron production throughout the 21st century, the price per ton of iron and the occurrence of tailings dam failures with environmental and social consequences [24].

There are many large mining ventures concentrated in the Quadrilátero Ferrífero (QF) region, all of which are privately owned.

In recent years, the region rendered geoscientists across the planet speechless, due to two massive disasters resulting from the rupture of tailings dams: Fundão (2015), owned by Samarco/BHP/Vale S.A., and Córrego do Feijão (2019), owned by Vale S.A. There are various iron mines with dams at a potentially high risk in the region [20], many of which are older and were erected in the 2000s and 2010s when commodity production was high [9]. Given the evolution of the price of iron on international markets, which was valued in August 2021 at USD 162 a ton, close to the peak iron price reached in 2011 [22], the growth in production is of great concern, especially in Minas Gerais. In this scenario, bearing in mind the environmental disasters with profound social consequences that have already occurred in this century in the Quadrilátero Ferrífero, the mineral industry needs to evolve, adopting the principles of geoethics.

On 5 November 2015, when the Fundão dam owned by Samarco Mineração S.A. ruptured in the municipality of Mariana, MG, Brazil, around 32 million m<sup>3</sup> of mine tailings were released. The slurry spread along the water courses downstream of the tailings dam until reaching the mouth of the Doce River, in Espírito Santo. Around 22 million m<sup>3</sup> accumulated in the channels and on the slopes and floodplains of the Santarém stream, the Gualaxo do Norte River, and the Carmo River, while around 10 million m<sup>3</sup> flowed through the channel of the Doce River [21,23].

After this disaster of unprecedented proportions, in 2019, at the Córrego do Feijão mining complex of Vale S.A., located in Brumadinho—MG, on the mountain slopes of the Quadrilátero Ferrífero, the rupture of tailings dam 1 (B1) caused the death of 270 people and released 12 million m<sup>3</sup> of mining waste. The tailings reached the Paraopebas River, which supplied 17 million liters of water to the region, and the slurry hit more than 19 municipalities.

In addition to these two massive disasters involving tailings dams of mining companies active in the Quadrilátero Ferrífero, most of the dams in the region present a medium to high potential for damage. However, few technical measures and/or public policies promoting more effective preventative measures have been employed in the region or nationally, bearing in mind that until the first semester of 2021, the social and environmental problems caused by the disastrous events remained unresolved.

As [25] points out, there is a common interest in the mineral value chain among mining companies and other stakeholders regarding mitigating the negative social, economic, and environmental impacts of mining. In contrast, the author indicates the recognition of good practices with the interest of benefits being maximized and shared equitably, both by those directly using mineral resources (industry and transformation sectors) and those benefitting indirectly, such as investors and consumers.

Nevertheless, to achieve such objectives, it is necessary to be in alignment with the sustainability perspectives of each segment. When geoethics is incorporated into the actions involved in the mining production chain, it will mean more than the involvement of new technologies; it will mean working with society regarding responsible consumption; raising awareness of the impacts caused in communities affected by mining; and the accountability of public policymakers in presenting administration proposals, achieving sustainability in the production and consumption of minerals [25].

*Geosciences have major impacts on the functioning and knowledgebase of modern societies. Humans are recognized as a “geological force”, capable of modifying natural environments, and in virtue of this prerogative they have an ethical responsibility towards the planet. By studying and managing the Earth system, exploiting its geo-resources, intervening in natural processes are actions that involve great responsibilities towards society and the environment, of which perhaps geoscientists, are not sufficiently aware. Only by increasing the awareness of this responsibility, can geoscientists work with wisdom and foresight, and respect the balances that exist in nature while guaranteeing a sustainable development for future generations. [26] (p. 2)*

However, as [25] points out, the geoethics proposal in the context of sectors involved in the mining production chain remains fragmented, which recalls results such as the events observed in Mariana (2015) and Brumadinho (2019), whose devastating consequences are still reflected in the surrounding communities.

### 5. Discussion: Impacts of the Geoethics Commission of the Sociedade Brasileira de Geologia—SBG (Brazilian Geological Society)

The SBG (Brazilian Geological Society), with more than 70 years of activity and over three thousand associates, is the largest Brazilian technical-scientific entity. According to its statute, its mission is to promote knowledge and development of the geosciences, of applied geology, and of research and correlated technology, and the rational and sustainable use of mineral and hydric resources (<http://www.sbgeo.org.br/home/pages/2>, accessed on 10 August 2021).

On 27 April 2019, within the scope of the SBG, the Comissão de Geoética (Geoethics Commission) was created. It has fully recognized the objectives indicated by the IAPG (<https://www.geoethics.org/definition>, accessed on 10 August 2021), in particular: (a) To evoke and conduct debates and reflections on the values that support appropriate behavior and practices, wherever human activities interact with the Earth system, bringing the theme of geoethics to the debates promoted by the Sociedade Brasileira de Geologia (Brazilian Geological Society); (b) To share the ethical, social, and cultural implications of knowledge, education, research, practice, and communication of the geosciences, providing a point of intersection for the geosciences, sociology, philosophy, environmental sciences, and economics, together with Brazilian society, governmental institutions, and other stakeholders in this theme, by publication through its various mediums (scientific events and scientific and professional disclosure, as well as books, articles, booklets, electronic sites, videos, or other forms of geoscientific communication); (c) To work so that geoscientists become more conscious of their social role and more aware of their responsibilities in the conducting of their activities, as a tool to influence the conscience of society in relation to problems related to the use of mineral, hydric, and energy resources; and (d) To propose the support of the Society for the dissemination of geoethics on curricula for the formation of geoscience professionals and in society.

The Internal Rules of the Geoethics Commission can be accessed at [http://sbgeo.org.br/assets/admin/imgCk/files/Comissoes/regimento\\_geo%C3%A9tica.pdf](http://sbgeo.org.br/assets/admin/imgCk/files/Comissoes/regimento_geo%C3%A9tica.pdf) (accessed on 7 October 2021). Since its creation, the Geoethics Commission has supported and assisted the board of directors of the entity in themes that require geoethical analysis related to companies, the government, teaching, and professional activities. This occurs through the preparation of documents, holding events, and participation in debates to promote geoethics.

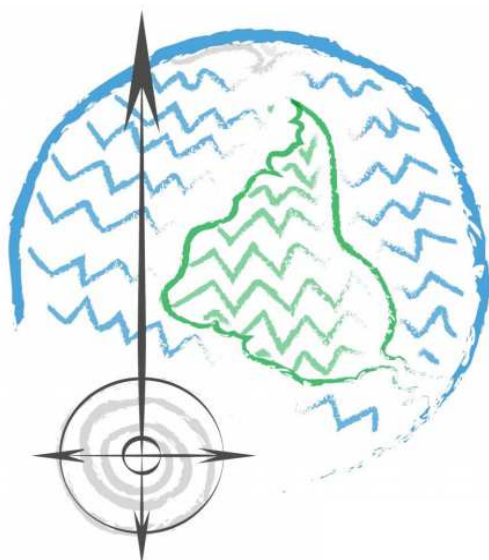
The commission logo was developed according to geoethical premises and within a decolonial vision, indicating the need for deep discussion within and beyond the entity, with the aim of translating geoethical principles. The logo of the Geoethics Commission is structured by three syntactical groups:

- The first is a large incomplete circle, with an irregular light blue line, containing a map of Brazil situated in South America and outlined in green.
- The ocean area is filled in with 'kenê', which is typical of indigenous populations from the Amazon, in light blue, and in the continental area the same graphics appear in green.
- The map of Brazil is positioned in the center of the globe with the south pointing to the upper edge, in an allusion to the need for new visions on the world.

By putting the representation of the place where we live in the center, it is a reminder of the first lesson of Anaximandro [27], who made a pioneering map of the Earth in the sixth century B.C. Furthermore, the position of the south at the upper edge also invites us to view the Earth systems from the point of view of the history of their representation. In this case,

the logo brings new perceptions, such as that of decolonization and of the horizontality of the relationships between the cultures that inhabit our common planetary home.

The 'kenê' graphics in blue and green recall the native cultures and their views on permanent care of the Earth, which are part of the human adventure of knowing and transforming this world (Figure 2).



**Figure 2.** Logo of the Comissão de Geoética of the Sociedade Brasileira de Geologia—SBG representative of Brazilian history and identity (proposition of Bárbara Zambelli Azevedo, Geologist and member of the Geoethics Commission, with descriptions finalized by Kátia L. Mansur, Rosely A. Liguori Imbernon, Paulo de Tarso A. Castro, Bárbara Zambelli Azevedo, and Rualdo Menegat).

One of the most important actions carried out by the commission in the first two years of activities was the discussion and approval in the scope of the Fórum de Coordenadores dos Cursos de Geologia do Brasil da Promessa Geoética (Forum of Brazilian Geology Course Coordinators of the Geoethical Promise), which was constructed in accordance with the Brazilian reality, and based on the proposition of IAPG, included in the Cape Town Statement on geoethics [8] (p. 6). The text proposed to be submitted to Brazilian universities is as follows:

*I promise that . . .*

*...I will practice my profession fully aware of the societal implications, and I will do my best for the protection of the Earth system for the benefit of humankind and the environment.*

*...I understand my responsibilities to society, future generations and the Earth in order to promote sustainability.*

*...I will put the interest of society first in my work, with attention to native peoples, traditional communities and minorities.*

*...I will never misuse my academic and professional knowledge, resisting constraints or coercion.*

*...I will always be ready to provide my professional assistance when necessary and will be impartial when disclosing my knowledge to decision makers.*

*...I will continue to develop my academic and professional knowledge throughout my life.*

*...I will always maintain intellectual honesty in my work, being aware of the limits of my competencies and skills.*

*... I will be active in the promotion of progress in the Geosciences, in the sharing of geoscientific knowledge and in the disclosure of the Geoethics approach.*

*...I will always be completely respectful of the Earth's processes in my professional practice.*

*I promise!* (Forum of Brazilian Geology Courses, 2021)

In the formation of professionals in geology, geological engineering, and other areas of earth sciences, there have been important achievements both through the insertion of geoethics in debates, and its insertion into disciplinary content. In addition to geoethics, geoconservation and geoheritage as geoethical premises have found strong adhesion among the scientific community of the Brazilian scenario, having been incorporated into regular undergraduate and graduate disciplines.

When establishing the Geoethics Commission in the scope of the Sociedade Brasileira de Geologia—SBG, we extrapolated the actions to other scenarios involving the professional practice of geology, such as the Conselho Regional de Engenharia e Agronomia (Regional Council of Engineering and Agronomy)—CREA, the professional regulatory body to which geologists are connected; FEBRAGEO—A Federação Brasileira de Geólogos (The Brazilian Federation of Geologists), which gathers the representative entities consisting exclusively of geologists or geological engineers; and entities that are active in the formation of geologists in Brazil, the Forum dos Cursos de Geologia do Brasil (Forum of Brazilian Geology Courses), public and private universities, and graduate programs in the area of exact sciences and Earth sciences.

## 6. Conclusions

There is no doubt that mining in Brazil brings benefits to the states and municipalities where it is developed, be it through the payment of royalties, the generation of jobs, or the transference of technology. However, all this may come at a high environmental and social cost, as in the disasters that occurred in Mariana and Brumadinho, Minas Gerais, the consequences of which transposed the limits that could have justified the generated impacts. The companies need to have a strong ethical compass and aim to distribute the benefits of exploration equitably, minimizing the risks and negative effects as much as possible [13].

Upon completing two decades of the 21st century, despite the intense environmental debates begun half a century ago, we are still faced with the growing use of natural resources and few mitigation proposals for the interventions caused by exploration. In Brazil, we can actually see a regression with the altering of legislation that permits mining in indigenous areas and relaxations on the regulations on mining in the buffer zones of nature conservation units.

According to [5,26], society has been awakened to issues involving planetary sustainability in relation to the exhaustion of the Earth's natural resources, the impacts produced from this exploration, and protection against dynamic Earth processes, or natural disasters.

The disasters in Minas Gerais provoked upset in the geoscientific community and demonstrated the need for a space in which actions can be adopted and themes can be discussed, incorporating the premises of Geoethics from the debates involving mining on indigenous lands to specific public policies for the preservation of national Geoheritage. The Geoethics Commission of the SBG has established new benchmarks and is increasing debates in Brazil.

**Author Contributions:** For the preparation of the manuscript all authors (R.A.L.I.; P.d.T.A.C.; K.L.M.) are participate in the: conceptualization, methodology, validation, formal analysis, investigation, writing—original draft preparation, writing—review and editing, visualization. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Data Availability Statement:** Brazilian Society of Geology <http://www.sbgeo.org.br/home/pages/12> (accessed on 10 August 2021).

**Acknowledgments:** Sociedade Brasileira de Geologia—SBGeo (Geological Society in Brazil—SBGeo). National Council for Research and Technological Development—CNPq—for the researcher grant (CNPq 2).

**Conflicts of Interest:** The authors declare no conflict of interest.

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