

# THE ROLE OF GEOLOGY IN A SUSTAINABLE SOCIETY: PERCEPTIONS OF UNIVERSITY STUDENTS

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## Abstract

Geology has been at the service of an instrumental view of nature contributing to its exploitation, and helping providing the raw materials needed for economic development, frequently with high ecological impacts. However, Environmental Geology and Geoconservation are fields more concerned with environmental protection and its preservation. At the same time, Geology is responsible for a certain ambiguity of values, choosing the hammer as a symbol but focusing its action on the field, which helps to generate a sense of reverence for Earth. Based on these ideas, a questionnaire was applied to 36 master students who will teach Geology (20) or will exercise other professions related with it (16), in order to ascertain how respondents characterize the work of geologists related to nature, and see their opinion about the contribution of this science to a fairer and more sustainable society. The general results show that the students identify more with a less exploiting view of this science and prefer to highlight its role for a fairer and more sustainable society especially concerning a more sustainable exploitation of Earth resources and rising of awareness of geohazards. This can support the idea of paradigm changing in Geosciences, adding an element of caution to our actions instead of helping the mutilation of the planet.

Keywords: Geology, Sustainable society, students' conceptions.

## 1 INTRODUCTION

Similar to what happened to the living world (and that is still happening), the inanimate world has been looked in a purely instrumental way. Geologists have greatly contributed to this, because they are often linked to professions related to resource exploitation, participating in the mutilation of the abiotic environment sometimes irreparably. Surface mining, even when operated with some environmental regulations, is perhaps the best example of this mutilation, damaging ecosystems, since the inanimate world is the support of the living world. Underground mining is apparently less aggressive in visual terms, but compete with surface mining in other types of impacts, like the accumulation of mining debris, the contamination of soils and surface and groundwater by chemicals used during mining processes with a negative impact in public health.

It is true that mining has been restrained by tighter environmental legislation. But these regulations are often confined to the developed countries, and can never totally prevent the negative impacts of its operations.

As we have argued, the role of geologists is inseparable from this destructive action, especially if we take into account the data provided by [1] Blatt (1997) that about 90% of these professionals, in the nineties of the twentieth century, were engaged in careers connected with the exploitation of oil and natural gas. Accentuating the same trend, [2] [3] Pemberton (2001, 2007) states that most geologists practise their profession in extractive industries, while, by comparison, a significant percentage of biologists is involved in professional activities related to biodiversity conservation. Therefore, if you add all those who are associated with the exploitation of fossil fuels and other resources, we have the terrifying picture of a range of professionals whose function is to engage directly or indirectly to harm the planet.

However, we could argue that this mutilation has been at the service of the welfare of mankind, and therefore is widely legitimized by this main reason. But not only the human being has also been affected by this whole range of actions, as it is questionable that this mutilation has always resulted as

an effective benefit to humanity; in a lot of situations those who benefited were only a set of economic agents greedy for increasing profits.

However, it would be unfair not to point out the growing number of geologists who have been devoting themselves to professions in the area of environmental management, particularly in the fields of Environmental Geology and Geoconservation. Environmental Geology, as stated by [4] Almeida & Amador (2006), has sought to reconcile the instrumental view of nature exploitation with environmental concerns, although [1] Blatt (1997) reminds us that only a small number of geologists has been dedicated to this field. Studies concerning the negative effects of natural disasters and exploitation of resources, like those involving landslides, floods, soil contamination, waste disposal, pollution and rehabilitation of quarries are examples of problems that Environmental Geology deals with. Regarding Geoconservation, the preservationist role of those who are working in this field is even clearer. However, it should be noted that a paradox arises when we notice that several places that we now intend to preserve were discovered through the mutilating human action. For example, some dinosaur footprints were discovered only because of the action of blasting quarries, and some of these findings were subsequently subject to preservation.

Even so, to [5] Franklin (2008), we are witnessing a paradigm shift concerning human-nature relationship. For this author, and perhaps as a result of the present environmental crisis, this new paradigm has been reflected particularly in the relationship between humans and animals, and has been leading to the conception that human welfare, translated by needs and desires of different degree, does not always override the respect that other animals deserve to us. Consequently, a less exploitative way of looking at nature has been widespread. Still, it seems clear that this paradigm shift has been gradual and we must not forget that the instrumental view towards other living beings persists in several societies. Good examples can be cited like animal production or the use of animals for human amusement involving their mutilation or death.

If this paradigm shift is also generalizing to the inanimate world, it is a reflection that somehow was initiated by [6] [7] [8] Frodeman (2000, 2003, 2004) when he discussed the ambiguity of the values that can be associated with Geology. The destructive vision and the maintenance of the ideal of nature's exploiter seems obvious if we look at the contribution of this science in the exploitation of resources such as water, soil, ores and diverse raw materials, including obviously fossil fuels, associating the view of Earth as a resource. Furthermore, as [7] Frodeman states (2003), by electing the hammer as a privileged instrument, even as an icon, geologists accentuate the idea of mutilation of nature, which after all can be exercised by anyone, professional or apprentice.

But Frodeman also explains that this is only a part, even the dominant one, which normally we can associate with Geology. This science is closer to ecology than to physics or chemistry, by choosing the field, and not the lab, as its privileged research place. And if the lab is a space without time or place, distant from the rest of the world, the field scientist fits to the patterns of nature (and not otherwise) and is subject to the elements, is dazzled with unforeseen setbacks, confronted with the beauty and wisdom of the natural world, and there is an intuitive dimension that is missing in the laboratory. The simplicity of life during research field work is indeed fundamental to geological experience. You get a sense of reverence for the Earth and the person feels part of the system rather than disconnected from it ([9] Turner, 2000). Simultaneously, the notion of geological time makes it possible to go beyond the anthropocentric view of time. "If the world is hundreds of millions or billions of years old, we are clearly a small part of a much greater story" ([8] Frodeman, 2004, p. 162). Therefore, he maintains that, as a result of these ideas, a new paradigm is emerging in the field of Earth sciences. Geology helps us to venerate the processes and natural limits and therefore to develop a critical eye towards technological advancement. In addition, a science based on the field conveys an image of science epistemologically more realistic and socially compromised.

## **2 METHODOLOGY**

Due to the possibility that we are in a process of paradigm changing, wherein the ideas of domination and mutilation of nature are beginning to be substituted by more preservationist ones, we designed a research project to try to answer the following problem:

*How do masters students connected to Geosciences perceive the role of the geologist nowadays, particularly in its contribution for building a more just and sustainable society?*

A questionnaire written in Portuguese was applied to 36 graduate students who will teach Geology in basic and secondary schools (20 from the Educational Branch - EB) or will exercise other professions

related with it (16 from the Scientific and Technological Branches - STB), in order to ascertain how respondents characterize the work of geologists, and their contribution to a fairer and more sustainable society. We also tried to verify possible differences in the thinking of the respondents from the two groups (EB and STB), given their specific training.

The students were from two Faculties of Sciences (Oporto and Lisbon, the two most important cities in Portugal). The size of the two groups is approximate and their distribution by gender is the following: the EB has 14 female and six male students and the STB has nine females and seven males. The average age of both groups is also very similar, 25.9 and 26 respectively, but with a different range of ages: the first group between 20 and 47 and the second between 21 and 35. Still, most students in both groups are between 20 and 29 years old, which happens to 16 from EB and 13 from STB. The sample can be considered as non-random, because similar courses are offered in other faculties in Portugal. But the choice was related to the cities where the members of the research team work.

The questionnaire that was applied covered several issues and questions but in this paper we present the results of the following three: (1) and (2) Considering the following designations, - controller, lover, manipulator, admirer, explorer or mutilator of nature - choose the two that best describe the work of geologists and the term that least characterizes their work in relation to nature. Justify; (3) what can be the contribution of the geologist in a fairer and more sustainable society? Its application took place in the institutions cited, respectively in November 2012 and January 2013. The fact that it was always the same researcher that applied the questionnaires in the two contexts guaranteed that a constant posture was kept, for example, in providing any response clues to the respondents.

Open responses were subjected to content analysis, which allowed us to determine the frequency of certain topics or ideas, combining quantitative and qualitative methods. We have respected the principles defined by [10] Cohen, Manion and Morrison (2007) when identifying units of analysis revealed by similar phrases and the same ideas, and categories, which organized them in wider fields. The categorization of the answers was made *a posteriori* for not knowing any theoretical framework that allowed us to insert them *a priori*, in categories already defined.

Descriptive statistics were also used to check the frequency of responses, which allowed us to compare their incidence in the two groups. The small size of the groups and the perception that the frequencies of the answers during data treatment were not very different, made the use of inferential statistical unnecessary. During the presentation of the data, we privileged the inclusion of whole or partial answers of some students, chosen by the research team according to their relevance.

[11] Seidman's recommendation (1998) to correct some answers of the respondents from a syntactic point of view was adopted, since the study did not intend to evaluate the linguistic performance of the students. We considered, as quoted by this author, that this is the best way to value the ideas of the participants, ensuring their dignity in the process of reporting the results.

### 3 RESULTS

As we mentioned before, the results between groups were not very different. Even so, we decided during data presentation to present the frequencies obtained in each group, and when the transcription of a particular response occurs, to refer to each group of students it belongs to.

In the case of the first question, the two designations selected by each student to better describe the work of geologists were presented in Fig. 1. Taking into account the small differences in the size of the groups, the frequencies were very similar.

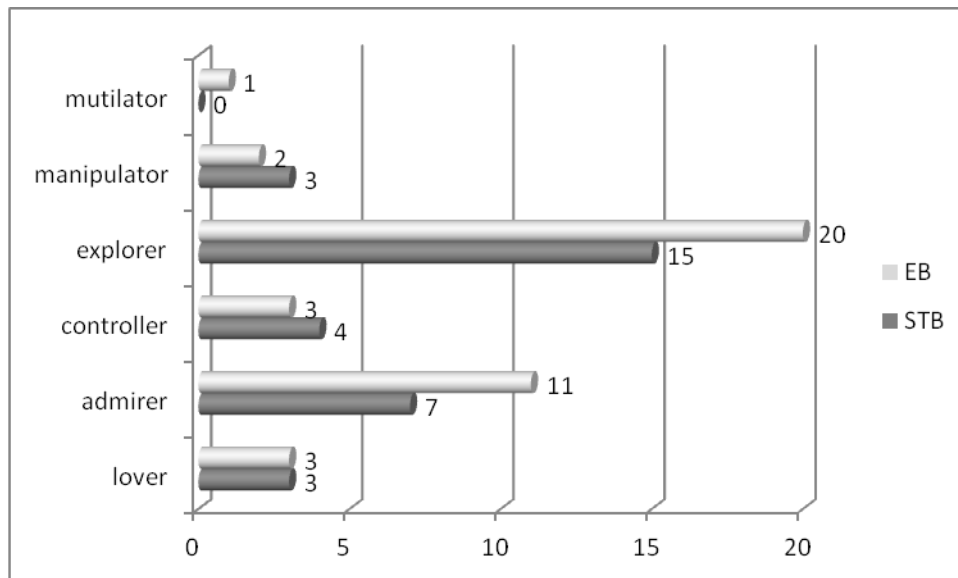


Fig. 1: The designations more often chosen by the respondents of both groups to better describe the work of geologists in their relationship to nature. We remind that the respondents were asked to select two of the six designations presented.

Thus, the designations considered more appropriate by the respondents of both groups were nature's explorer (selected by 20 respondents from EB and by 15 from STB) and nature's admirer (chosen by eleven and seven, respectively). It is important to mention that in the Portuguese language we only have the term "explorador" that can mean explorer or exploiter, and only the context allows us to find in which sense a respondent uses it. Therefore, if the demand of justification is normally important in closed questions, in this case it was even more fundamental to understand the true meaning associated with the term "explorador".

However, respondents interpreted it mostly in the first sense, the explorer that can be defined as associated with the research and discovery of new knowledge, rather than with the exploitation of raw materials and other profits from the natural world. This dominant interpretation can be found in the responses presented hereafter: "*The geologist investigates / explores nature, trying to understand how it works and the reasons associated with its function*" (EB); "*The geologist, like any scientist, explores nature in order to produce knowledge, to know it better*", (EB); "*the geologist has an intrinsic need to understand the processes involved in the Earth system*", (STB).

Even so, the other interpretation of the term "explorador", the exploiter, was also present but with much lower frequencies, as it is possible to identify in the following examples:

"*The geologist is an exploiter as it exploits and extracts resources that are available on Earth to allow the production of new materials*", (EB); "*The work of the geologist is undoubtedly to exploit nature in the different scientific branches that are included in this science like, for example, building construction, mining and oil exploitation*", (STB). It is also important to say that one of the respondents mentioned in his answer the two assumptions of the term "explorador". He said:

*The geologist explores nature in a positive sense, in association, for instance, to the discovery of caves and spaces that are important to preserve, concerning their importance in the geological heritage of Earth; But his work can also be negative, because he can exploit and destroy geological resources, and this action, when it is badly managed, can have a very large negative impact*, (EB).

In the discussion of the answers to this question, we also considered relevant to present the frequencies by pair of designations selected by the respondents from both groups (Fig. 2).

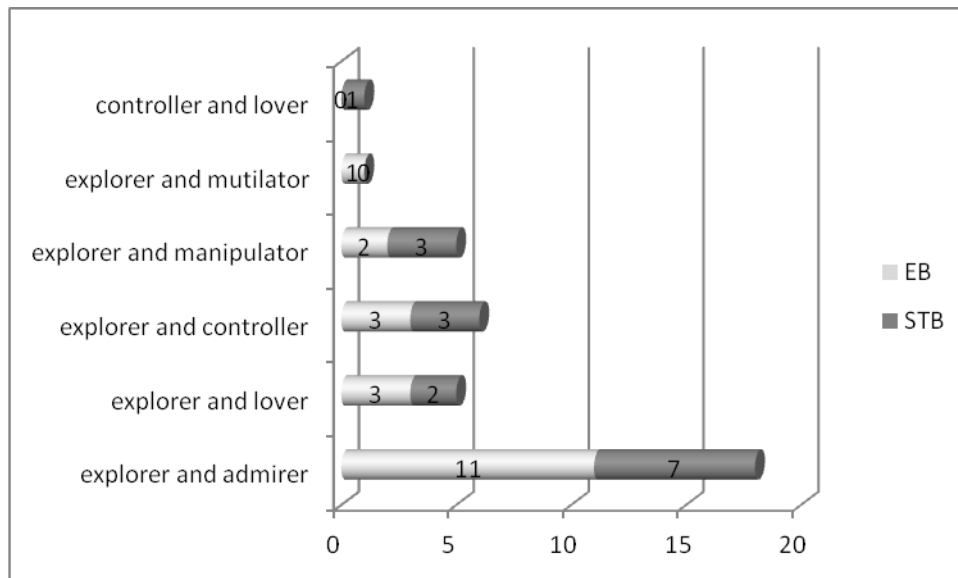


Fig. 2: Pairs of designations chosen by the respondents of both groups to better describe the work of geologists in their relation with nature.

Thus, the selection of the term “explorador”, in its majority meaning explorer, was almost always followed by the designation of nature’s admirer, as if both designations were complementary. This type of selection occurred with 18 respondents, eleven of them from the EB. One example of an integrative answer of this type is the following: “*First of all a geologist should admire and explore nature in order to know it and respect it better*”, (STB).

This positive sense of “explorador” has also emerged in association with the designation of nature’s lover in five answers, three of them from the EB. The central idea exposed was that loving his study object, nature, the geologist discovers it and tries to reduce the negative impacts on it. One of respondents mentioned that this love comes from the methodological basis of this science “*...because the geologist has to do fieldwork, working in nature during long periods. And someone that has to do it often, must love nature*”, (EB). This kind of justification reminds us of several ideas discussed in the introduction of this paper proposed by Frodeman.

The respondents that associate the term “explorador” with the meaning of nature’s exploiter prefer to choose the designation of nature’s manipulator together with it, since the contribution of geologists to the exploitation of resources is also changing nature as it is the case in building and other large construction projects. As one respondent said: “*the geologist can build everything in every type of soils and rocks*”, (STB). Three respondents of each group also associated this sense of the term “explorador” with nature’s controller, in the sense that geologists prevent disasters such as earthquakes, volcanic activity, landslides, etc. Here’s an illustrative example: “*The geologist is an exploiter as he exploits areas of human interest and also a controller to predict and prevent events with negative implications to the population, for example, solving problems related with the instability associated with building infrastructure*”, (STB).

Only one respondent associated the term “explorador”, in the sense of exploiter, with mutilator. However, his answer is quite interesting and that’s why we present it here. He wrote:

*This entire extraction process leads to harm the nature as in the case of surface mining. This process often causes great perturbation in nature at the ecosystem level, although what it many times counts is the economic value and the potential uses of the resources exploited*, (EB).

Given all these results, it was without surprise that we verified that the designations that respondents considered that least characterize the work of geologists in their relationship to nature were nature’s mutilator (16 answers, nine of them from EB), nature’s controller (eleven answers, six of them from EB) and nature’s manipulator (six answers, four of them from EB). It also important to state that the frequencies of all those designations were very similar in both groups (Fig. 3).

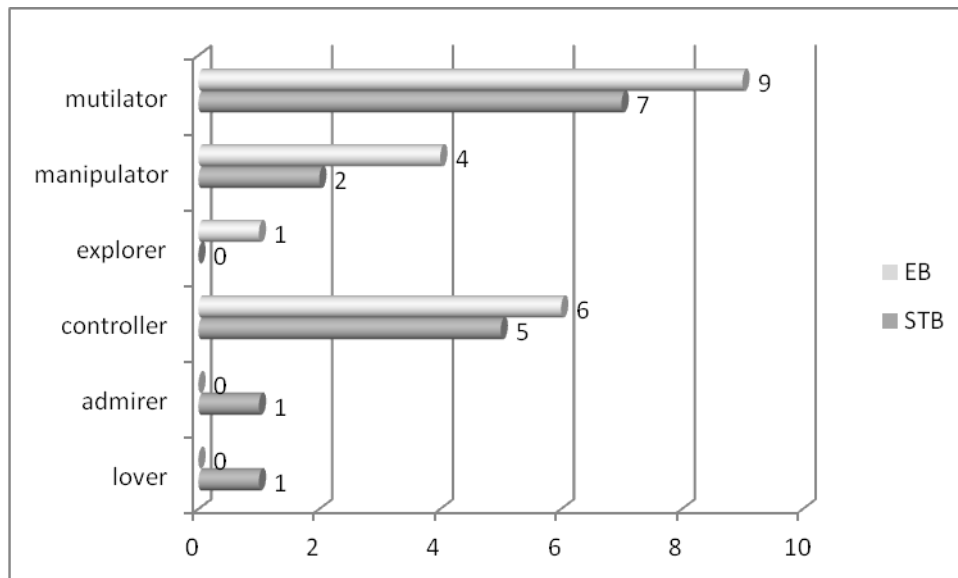


Fig. 3: Designations less often chosen by the respondents of both groups to better describe the work of geologists in their relationship to nature. We remind that the respondents were asked to select only one of the six designations.

It was especially interesting to verify how the students considered these designative expressions as unrepresentative of the work of geologists. In the case of nature's mutilator the respondents rejected this idea with conviction: "I think that most geologists respect nature and try to avoid mutilating it", (EB); "For me, a geologist never wants to mutilate or harm nature", (EB); "The work of a geologist can never be described as a mutilation of nature. Instead, the geologist can have the necessary tools to prevent such harm", (STB) or "The geologist is not at all a mutilator of nature. The geologist respects first and foremost all nature and its processes. He understands that these processes occur independently of his action", (STB).

However, the rejection of this designation was not always so affirmative; it seems that some respondents reject an idea that at the same time somehow bothers them, perhaps because they recognize some truth in it. Two examples:

*Although some of us often associate Geology with mining, a highly mutilating activity, I don't think that the work of a geologist is related with that mutilation, but rather with information about a certain resource that exists at a particular location, (EB);*

*What least features the work of a geologist is the mutilation of nature, because during his work he must obey to a project of environmental impact, which must be applied during and after the exploitation process, because the geologist should not be concerned only with the present, (EB).*

These responses are particularly curious, since the first externalizes the mutilation of the work of geologists, who merely have the role to inform other professionals, who will be responsible for the mutilation process; the second raises the question of the role of the geologist associated with a controlled mutilation, subject to rules and to the principle, always controversial, like the destruction / recovery cycle.

Perhaps, less prone to subjective analyses as those previously advanced; seem to be the reasons for rejection of the controller designation, in which respondents seem to share the idea that nature is somehow uncontrollable. Three examples:

*A geologist can predict certain types of events that occur in nature but not others, for instance, earthquakes. Geologists can predict earthquakes and alert society to minimize their impact, but they cannot avoid their occurrence; that is out of their control, to activate a mechanism for the earthquake not to occur, (EB);*

*I selected controller of nature because, as much as the human being wants, he can never control nature. Take the case of the Portuguese coast, where the sea is advancing. As much as man wants to control this phenomenon, building a stronger coastline, in the end he will be never able to control this advance, (EB);*

*The designation nature's controller may be the feature that can be related with the work of a geologist the least because, in many cases, we are not able to do that. Phenomena such as earthquakes, volcanoes, and even mass movements are currently difficult to predict and control. However, I think that this designation in the future will be increasingly true, (STB).*

This latter respondent thus raises the possibility that the control of nature, despite the difficulties in the present days, will likely be a growing reality in the future. As far as the rejection of nature's manipulator is concerned, justifications were related mainly to the characteristics of the geological science itself, that is very different from other sciences more focused in laboratories as it is the case of physics or chemistry: Two examples: "A geologist does not manipulate nature, because he does not interfere with geological processes; he only studies and investigates them", (ME); "a geologist must not alter natural phenomena so that they can better suit theories proposed to explain them" (STB).

Very similar ideas were obtained in the third question analyzed for this paper and which inquired about the role of Geology in a more just and sustainable society. The main ideas are summarized in Table 1. Several of them are related to one another, but we considered that their focus was sufficiently distinct to consider each one a different idea.

Table 1: Roles assigned by respondents from both groups to Geology in the building of a more just and sustainable society.

Main roles of the Geology	Frequency	
	EA	STB
-to exploit resources in a more sustainable way	14	9
-to inform and to sensitize society	9	3
-to mitigate natural disasters	4	2
-to implement planning and environmental impact studies	1	3
-to fight criminal occurrences	1	1
-no justification	1	1

Ten respondents from EB and three from STB indicated two roles each one.

As it is possible to verify in the table, the most frequent role given to Geology for a more just and sustainable society was its contribution in a more sustainable exploitation of resources. Some examples of answers that elaborate on this idea: "The geologist observes nature and tries to explain its phenomena and soon understands it better than anyone else. It helps that he can have a clearer notion of the sustainability of a resource and consequently of the whole nature", (EB); "The geologist studies and understands the limitations and the capabilities of planet Earth, and with this information he can help making more appropriate options concerning the resources that we have", (EB); "The access to drinking water is still conditioned in many places on the planet. Thus, the geologist can help good water management, allowing it to reach everyone, thus helping to build a more just society", (STB), or, in a somewhat more idyllic way: "The fact that geologists study the Earth resources helps to build a more just and sustainable society to the extent that these resources come to be used in a more noble and controlled way", (STB).

Another idea with some expression, especially in the EB group, was the informative role of geologists. This idea was in some answers directly related with a more sustainable use of the Earth resources. Some examples: "Geology can raise population awareness about Earth History, making clear that before Man other species already existed, and none of them harmed the planet like we do", (EB); "geologists, in relation to situations that are within their scope, can serve as mediators, informers for society that can help it to become more just and sustainable", (EB); Or the next example in which the previous and these ideas are articulated even more clearly: "The role can be an increase of awareness among people, enterprises and governments for a greater control in their activities, particularly in terms of exploitation of fossil fuels or ores, even because we are not alone on the planet", (EB).

The mitigation of natural disasters was also referred with some expression. This idea was referred alone or in articulation with other arguments, especially those related to land use or planning, as is perceptible in the following example: "In geotechnical terms we have a better perception of the most suitable places for construction, allowing us less costs and enabling us to avoid the areas of greatest risk", (STB). Thus, it appears that the respondents recognize that geological knowledge can give

authorizations but it also determines impossibilities for human action, though the latter are often ignored by national, regional or local powers.

Finally, for its originality, the idea expressed by two respondents, one from each group, about the role of Forensic Geology in the building of a better society deserves to be quoted. As one of them said: "One of the contributions is doing research in the area of forensic Geology to dissuade those who try to escape or commit to a fairer and more sustainable society", (EB).

## 4 CONCLUSIONS

This study allowed us to conclude some relevant aspects related with how students perceive the role of Geology in society. Thus, students from both groups moved away from the mutilating view of Geology concerning nature, and prefer to emphasize the exploratory side of geologists in search of new knowledge, which is inseparable from a deep appreciation of nature. With this view, they show a high concordance with the new paradigm concerning a more preservationist way of looking at nature, as we noted in the introduction. Even so, some of the respondents acknowledge the role of geologists in the mutilation of nature, although they tend to relativize this more negative side, emphasizing the importance of this science in the sustainable management of resources, information and awareness of society about several issues related with Geosciences, as it is the case of natural disasters mitigation.

[7] Frodeman (2003) believes that Geology is becoming the science that imposes limits, adding the dimension of caution to our plans and ambitions. As this author systematizes:

In the modern era, Geology was predominantly an economic discipline, supplying raw materials needed for economic development. In the future, the central role of the Earth sciences should be political, helping to define the limits that individuals and communities must live within in order to flourish. (p. 117)

With this new role, [8] Frodeman (2004) states that Geology becomes a leading science in the promotion of a new mentality concerning nature, since it allows a unified understanding of our relationship with the planet. For this reason, he says that we can imagine an era in which we will moderate our technological imperative, respecting natural limits. And for him, this new era has already started in the present century, and can be called the age of Geology, transforming this science that both says no and yes to society, imposing limits in our activities, and noting geological hazards, resource scarcity and ecosystems stress. And this awareness, to [6] Frodeman (2000), is awaking the community of Geosciences who claims to have discovered the importance of their role and responsibility in society, which forces scientists to a clear political and cultural commitment.

As we saw, the majority of the respondents share several of these ideas. The question is, whether over their professional future, they will be able to remain faithful to them and contribute effectively to the affirmation of a role of Geosciences increasingly aligned with the principles of ecological sustainability.

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