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# A decade since the International Year of Planet Earth – Earth Sciences for society

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## Abstract

Developed between 2007 and 2008, the International Year of Planet Earth (IYPE) was proclaimed by United Nations Organization with the objective to divulge the importance of the Earth Sciences for society and to alert for the main problems mankind will face in this Century related to ten big themes: Groundwater, Megacities, Climate, Earth crust and core, Natural disasters, Oceans, Natural resources (minerals) and Energy, Soils, Earth and health (or medical geology) and Earth and life. After ten years of the suggestions and recommendations to be developed by geoscientists there were important advances in some of those themes such as Climate, Earth crust, and core and Natural resources and Energy. In the other seven years, there was relatively few scientific or technological advances in the word. This shows that one decade was not enough for mankind to get knowing and solving the big problems itself caused and continues to cause to the planet. In spite of this, the Brazilian geoscientific community was sensitive to most of the IYPE themes and promoted the divulging of Earth sciences through workshops, symposia, congresses, classes, becoming one of the most active groups in the world.

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## 1. Introduction

In January 2007 began the celebrations of the International Year of Planet Earth, whose apex occurred in 2008 and whose activities ended in December 2009. (Unesco/IUGS, 2008; Berbert, 2008). Proclaimed by the United Nations in its General Assembly in December 2005, the IYPE had as main objective the dissemination of the importance of Earth sciences to society in general, not yet understood or ignored. (Nield et al, 2005). Every human being depends on the Earth for its life. Not only from what it offers as minerals, food, and energy, as usually thought but from the climate, the oceans, the water, and the prevention from natural disasters and even its health. The International Year of the Planet Earth proposes were to divulge and to stimulate reflections in all those matters to society. It also had the objective to put several questions to the scientific communities, encouraging them to seek answers and solutions based on studies and research.

These goals were centered on ten major themes selected by dozens of researchers and engineers from various parts of the world, who elected them as priorities in view of the problems for mankind in the future, and the level of knowledge that existed then: Groundwater, Megacities, Climate, Crust, and Terrestrial Core, Natural Disasters, Oceans, Natural Resources (in particular minerals) and Energy, Soils, Earth and Health (medical geology), Earth and Life (evolution of life). Disclosed the problems and recommendations for each topic around the world, what has evolved in these ten years from the scientific and/or technological point of view?

## 2. Groundwater

Groundwater is the main reserve of freshwater for humans, occurring in virtually all geological environments and in various types of rocks, filling spaces between grains or in their fractures. The entire hydrological cycle begins with groundwater, which can take thousands of years to reach its destination in the aquifers (Ministério do Meio Ambiente - MMA, 2001, Berbert, 2003, Struckmeir et al., 2006).

According to Tóth (2000), the two fundamental factors for the active role of groundwater in nature are its ability to interact with the environment and the spatial distribution of the underground flow. Both take place simultaneously and on any spatial or temporal scale. In other words, the underground flow begins on the surface and goes to great depths, on scales ranging from a few hours to several thousand years.



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The interaction occurs through chemical, physical and kinetic ways, making groundwater a definitely component of high importance in environmental issues and interconnection with surface waters.

In the decade of 1980, industrialized countries, concerned with contamination by industrial waste, urban garbage, and pesticides, began to worry also about the quality of groundwater, adding a more important parameter to the aquifers' evaluation. The extent and quality of them are that they will depend on the type of prospecting, the extraction, the production, the natural filtration, and the supply regularization.

It is estimated that more than 70% of all the freshwater used by man are in irrigation, remaining about 20-25% for the industry and less than 10% for domestic consumption. In various parts of the world, underground sheets are larger, or even unique, sources of supply and their disorderly exploitation constitutes a very serious problem, especially in developing countries such as Brazil. In many large cities, more than 70% of the water supply comes from underground aquifers, and in some places like North China, India, and our country, part of the aquifers is being blown up hundreds of times faster than they are being recharged. According to the Brazilian Institute of Geography and Statistics (IBGE), in 1988 about 51% of the supply of drinking water in Brazil originated from underground water resources. Since then this percentage has been increasing rapidly.

Groundwater can have a huge social outreach role when well researched and rationally exploited. Because they are relatively more protected from pollution, they do not require any major treatment for the use by population, which, alongside the lower uptake and distribution costs in relation to surface waters, makes them more economical. In addition, the spatial and temporal planning of its exploitation is more precise and easy to be promoted, if there are reliable basic studies.

Thus, considering the volume and importance of groundwater for mankind, its interest for study is relatively recent. Most countries still lack a more precise notion of this importance and the dimension of the problems that can hopelessly affect them. This is reflected in disorderly exploitation, in the lowering of aquifers, in the possibility of rapid chemical pollution, in the lack of reliable information, in the absence of adequate legislation and institutional instruments of control, problems that constitute the main challenges indicated in the International Year of Planet Earth for this theme.

It is estimated that the total volume of surface water on Earth is at the order of 523 million of km³, of which 97.2% are in the oceans and inland seas, 2.2% in the polar ice and mountainous glaciers, and 0.6% in rivers and lakes. Groundwater is estimated at 3.6 million km³ or 97.7% of all freshwater in the world. Of this total, about 112,000 km³ would be in Brazil according to the Ministry of Environment (MMA, 2001), distributed in virtually all regions and states of the country, mainly in the large sedimentary basins ranging from Proterozoic (2,5 Ga – 542 Ma), as the Bambuí Group in the central portion, up to recent deposits, passing through the large Paleozoic sedimentary basins (570 Ma-70 Ma) of the South (Paraná Basin), Northeast (Parnaíba Basin) and North (Amazonas Basin) areas of the country. Our major problems regarding groundwater are in three different situations and have differentiated reasons: in the semi-arid Northeast, characterized by scarcity and high salinity; in coastal regions, with great tourist flow and the consequent contamination of aquifers by seawater; and in most major cities by disorderly and exaggerated exploitation, which is leading to a rapid downgrading of groundwater and the risk of its pollution.

In the field of knowledge of the potential of these resources, Brazil has considerably advanced in the last 40 years, thanks to the works developed by the Superintendence of Development for Northeastern (SUDENE) and the Geological Survey of Brazil (CPRM). More recently excellent work has been done by the Commission of Guarani Aquifer (CGA) in Southern Brazil and the Brazilian Underground Water Association (ABAS). The legislation still inaccurate about the exploitation, the lack of oversight by government institutions and urban expansion constitutes an enormous problem for the management of the underground resources in our country.

An example of these problems was recently observed by CPRM in the North of Minas Gerais state, mainly in the region of Montes Claros, where the enormous number of wells is rapidly diminishing the reserves of the groundwater, forcing the increasingly deeper drillings (and logically more expensive) to obtain water. This causes the depletion in these areas, due to the difficulty of recharging because of the small amount of rainfall in the region. According to the Gazeta Norte Mineira newspaper, from July 2019, about 12,000 drilled wells were registered in the valleys of the Jequitinhonha and Mucuri rivers of the cited regions. These figures were discussed in the debate cycle of the agricultural exposition of Montes Claros in May last year. However, the amount of clandestine wells is much larger and can double that in those regions. The same has been recorded in the Federal District (Brasília), in São Paulo and in almost all other regions of the country.

The issue of water constitutes a permanent problem in Northeastern Brazil, as well as in several other similar areas on the planet. Occurring in underground accumulations of sedimentary basins in the states of Maranhão, Ceará, Piauí and in the Recôncavo Baiano (state of Bahia). The same occurs in the Bambuí Group, a sedimentary unit that crosses several states, and in fractures of very old geological terrain, where the greatest difficulties are found to be used. In addition to the low abundance, the groundwater in these fractures is extremely saline. If the extraction is already difficult and costly, it is the desalination the biggest problem. Not in the technique itself, but in the destination of the tailings. If it stays on free air it is carried by the wind and makes plantations unviable; or is taken by rains and contaminates the waters of rivers and streams.

In December 2018 French and Brazilian scientists published an interesting article on the underground aquifers of the Amazon Basin, based on observations in the period of 2003-2010 under the GRACE mission (Gravity Recovery and Climate Experience). These observations, carried out from multi satellites, provided not only a calculation of the volume of groundwater contained therein, but also its relationship with the volume of surface water, showing the annual variations caused by climate change. An example of this was the great drought of 2005 that reduced the surface flow and soil moisture, causing a decrease in groundwater reserves (Frappart et al.).

## 3. Megacities

According to the UN data, in 1950 30% of the world population lived in urban centers. In 2000, this percentage was 47% and in 2010 it reached more than 50%, accelerating

the various problems already faced in cities, such as transportation, housing, provisioning, energy, sanitation, etc. (Krass et al., 2000).

Megacities are urban areas with more than 5 million inhabitants. These centers reached the number of 60 in 2015, concentrating more than 600 million inhabitants according to estimates by scientists from the University of Koln, Germany.

The first result of this accelerated expansion is the negative environmental impact and the decline in the quality of people's life due to the destruction of vegetation, the unorganized exploitation of natural resources for civil construction, and surficial contamination by industrial and human waste. Trash disposals and cemeteries become crucial sources of this, particularly in developing countries with rapid population growth.

The planning of territorial occupation would be ideal and can be accomplished if politicians, rulers, and society are aware of their environmental and social risks. The role of the geoscientist here is fundamental in promoting or contributing to the planning through the economic-ecological survey of the surrounding regions. The indication of areas of environmental risk (flood zones, landslides, land depressions, etc.), in addition to preservation areas for mineral exploitation, agricultural, energetic and recreational use are some of the possibilities (Berbert, 2007). An excellent example of the basis for planning the expansion of a large city is the "Environmental Atlas of Porto Alegre", executed by a team from the Federal University of Rio Grande do Sul, under the coordination general of Prof. Rualdo Menegat in 2008. A splendid work that, in my opinion, was never implemented by local governments.

In this sense, developing countries are far from promoting adequate planning of territorial occupation and much less in urban areas, which generally expand in an absolutely disorderly manner. Even Brasília, a city created under the aegis of planning, and which is not yet a megacity in the UN sense, faces this problem. The same occurs with Belo Horizonte, Goiânia, Campo Grande, Palmas, Boa Vista, cities also planned without due care with their future expansion. Moreover, economic-social-environmental planning should be prioritized in all Brazilian cities, and in particular in large urban centers, where the large part of the population is concentrated in search of opportunities for employment and education.

Nevertheless, since 1990, some engineering and architectural professors began to join groups and discuss the dynamics of territorial occupation. Among these groups emerged the Integrated Territorial Planning Center – CIORD, born from an agreement signed by the Secretariat of Strategic Affairs of the Presidency of the Republic and the University of Brasília (UnB) in 1995. In 2001, this center promoted, in Brasília, the "International Workshop of Territorial Dynamics – Trends and Challenges of Integration of Contemporary Brazil", with the support of many government and private institutions. This meeting focused on the difficulty of *"urban management in Brazil, due to the lack of working methods, lack of integration between institutions, lack of qualified human resources, and the delays of legal procedures and processes for the implementation of policies of social interest"*. It was also observed that most Brazilian municipalities are unable to integrate among themselves, and that is possible through the creation of associations and consortia for example. Regarding the theme of basic sanitation (water and sewer), it was emphasized that public subsidies should be used for the care of the poorest populations and that is fundamental the participation of these communities in the process" (Santos, 2001). Until today there has been no advancement in these themes and in many areas, there have been serious setbacks, with loss of lives.

The workshop brought excellent ideas and demonstrated the extreme difficulty of addressing urban issues in the country, whose main problems reside in the social factor, which, in turn, is closely linked to the geosciences (mineral and water resources, energy, building materials, soils, etc.). As a developing country, Brazil is still far from adopting solutions for them.

Large landslides and urban floods are examples of the disordered expansion of cities, with the consequent economic and social problems, including the health issue of the affected population. This has been observed not only in Brazil, but also in countries such as China, India, Italy and tends to increase if there are no drastic political and social decisions that prevent the occupation of areas of risk or do not promote innovations for the safeguard of the population in these locations.

## 4. Climate

The history of mankind, its actions and cultures, and social differences are intimately linked to the climatic conditions prevailing in the various periods of terrestrial evolution and in the different regions of the planet. Thus, the understanding of the past climatic phenomena is of crucial importance to prospect the future, and this can be done through the study of the previous societies, their behavior, their food, besides the purely geological records. The important interaction between the oceans, the atmosphere, and the terrestrial environments has been evidenced through the times, making the analysis of paleoclimatic conditions more complex. (Dodson et al., 2004).

A few hundred years of direct climatic measures cover only a small period of climatic variations. But it has been enough to detect that a crucial element has been added to natural phenomena in the process of climate change: man. This happens since the nineteenth century, with the dissemination of the Industrial Revolution, and in particular, after the Second World War. Today, with the inevitable globalization of processes, actions, activities, and population growth in the word the problem tends to be bigger and bigger.

It is known that in the history of planet Earth there have been at least 5 periods of mass extinction of species, directly or indirectly related to climatic phenomena (CNRS Intl. Magazine, 2016). Of these, the best known is that of the dinosaurs about 65 million years ago, supposedly due to the shock of a gigantic meteor that caused a deep alteration in the climate of the planet.

The next major extinction of species could be caused by accelerated global warming, detected by about 2,500 scientists from 130 countries that drafted the Intergovernmental Panel on Climate Change (IPCC) reports in 1988. By the surveys then disclosed, the surface temperature of the Earth has increased 0.6 ºC in the last 100 years and the predictions for the end of this Century are much worse.

The Paris Climate Agreement has established $CO_2$ emissions of 580 billion tons to limit the terrestrial temperature at that lower level. However, the world investments planned for thermoelectric plants (mainly in China) allow to foresee that these emissions will reach 846 billion in the coming decades,

according to researchers at the University of California in Irvine, U.S.A. in an article published in the journal *Nature* (in JcNotícias, Jul. 2019).

The first consequence (already observed in practice) is the melting of the ice caps of the high mountain chains and the polar regions, with the resulting increase in the level of the oceans on scales that can go from several centimeters to meters, depending on the seawater evaporation conditions and the modifications expected in the underwater currents. (Mckay, 2019, Rignot et al., 2019, Clarck et al., Harbeck, 2020).

According to scientists from NASA and American universities, the ice cover of Antarctica has melted the equivalent of an area four times greater than France in just a few years (PNUMA, 2019). In the period 2014 to 2017, according to the studies, *"Antarctica lost almost as much as the Arctic in almost 40 years"*. From a peak area of 12.8 million km² in 2017, the sea ice cover has declined 2 million km ² (Rignot et al., 2019).

The ice defrosting in the poles and high mountains will cause the expansion of the seas and dramatic results for billions of people, as it is known that 75% of the world's population will be living in a range of 100 km wide from the coastal zone up to 2025, compared to 60% of the beginning of this 21st Century (CNRS Intl. Magazine, 2016).

Global warming is inevitable, even because it is part of the evolution of the Earth. Mankind has the capacity to slow it down warranting measures to contain the emission of gases and discovering new forms of energy and food production through "clean" processes. Climate forecasts should become more and more sophisticated in order to meet the growing demands of the economic, agricultural, and industrial sectors for fast and reliable information, and society itself as regards extreme weather events such as hurricanes, prolonged droughts, and extraordinary floods, to just name a few.

According to the Intergovernmental Panel on Climate Change reports, in 2,100:

• The overall temperature can increase up to 6.1º C (most scientists admit variation higher than 1.1 º C at least);

• In the regions of medium and high latitudes there may be an increase of up to 20% in rainfall and snowstorm;

• Each year, between 2 and 7 million people will be affected by floods, especially in coastal areas of high demographic density and in the deltas of West Africa, Asia, and the Mississippi River;

• The sea level should rise between 18 and 59 cm on average, depending on the burning of fossil fuels;

• About 3.2 billion people, at least, may suffer from the problem of the pollution of drinking water and 600 million should be affected by drought, degradation and water salinization;

• Between 20 to 30% of animal and plant species may disappear if world temperatures increase between 1.5 and 2.5 º.

In the preparation of the theme Climate scientists raised some key issues for reflection and eventual suggestions by academic and technological researches:

• What was the "great scenario" for climate change patterns in the last two or, if possible, the last four glacial periods of the Earth?

• What was the climatic variability in the last 1,000 years?

• What impact did climate change in the recent past have caused to societies?

• What is the role of human activities in climate change?

• What is the role of modeling in the future climate forecast and how can we confirm its merits?

• What to expect from the future trajectories of the climate?

The development of reliable climatic models will diminish the degree of uncertainty of society, which may best be opposed to the disasters that should occur by the end of this Century.

Earth sciences, as discussed in the International Year of Planet Earth, if properly directed to the field of research and dissemination to society, will certainly minimize the consequences of climate change.

The Corporation for the International Year of Planet Earth, headed by the International Union of Geological Sciences - IUGS and UNESCO recommended the following research agenda for the climate theme under the IYPE (Dodson et al., 2004):

• Increased knowledge of climate and environmental patterns in the last two glacial periods of the Earth;

• Identification of how glacial conditions were developed;

• Identification of the frequency and causes of extreme events in geological records;

• Construction of broader historical series with better resolution, especially in the regions of the tropics and the Southern hemisphere;

• Better understanding of the tropical heat system and how it binds to climate change in temperate zones;

• Paleoenvironmental studies focused on areas with better archaeological records, especially where cultural changes occurred;

• Studies of biological, geological, pedological and oceanographic processes aiming to identify the relations between climate and changes in systems, including studies of carbon flow variability;

• More precise identification of coastal areas where subsidence and withdrawals occur, as a form of subsidies to assess the elevation of the ocean level;

• Cooperation between scientists working with modeling and paleo data;

• Promotion of advances in chronological methodologies;

• Analysis of instrumental and biophysical data to discover connections, sensitivity, inertia, and lag in systems in the various regions observed.

In the background, what we need to know with more confidence is what is the contribution of nature to global warming and what is the true participation/intensity of man in this phenomenon, so that swift and correct measures can be taken to minimize their effects.

Our country has experienced a considerable advancement in this subject in these last two decades, thanks to the researches developed at the National Institute of Space Research (INPE) of the Ministry of Science, Technology, Innovations, and Communications (MCTIC).

Another excellent work has been developed in the Amazon region under the coordination of the National Institute of Research of the Amazon (INPA), of the MCTIC also. This is the LBA project – a large scale biosphere-atmosphere experiment in the Amazon, "an international initiative led by Brazil, aiming to understand the role of the Amazon in the climate system of the Earth, and the role of the impacts of the land uses of the region and global changes in the Amazonian systems themselves "(Ministry of Science and Technology, 2007). Currently, LBA has the participation of more than 2,000 researchers and more than 100 research institutions from Brazil, USA, Europe, and other South American countries.

Initiated in 1998, through international agreements, it relies on national and international funding, having already trained and formed more than 1,000 young researchers. In the list of its researches are studies on the chemistry of the atmosphere, storage and exchange of carbon, changes in the uses of land and vegetation, biogeochemistry, climate physics, hydrology and water chemistry, among others.

In September 2008 it happened in Rio de Janeiro, as part of the activities of the International Year of Planet Earth, the XV Brazilian Congress of Meteorology, where these and other issues were discussed.

In the international field, countless meetings, symposia, seminars, and other scientific meetings have caused intense debates on the subject, some countries placing themselves in positions contrary to the researches carried out and in realization and to the so-called " global warming ". Worse. Many countries are not worried about the accelerated variations of climate change in this Century. These variations are showed by more and more rigorous winters and summers already observed each year, mainly in the Northern hemisphere, where the largest number of industries and large populations of the planet are concentrated.

The climate issue is no longer a problem of the future but a huge problem already, considering the increasing number of deaths in the winter and summer periods, the growth of floods and arid areas, typhoons and major storms, the advancement of the sea on several continents and their planetary warming.

## 5. Terrestrial Crust and Core

In the last 40-60 years, the Earth sciences have evolved rapidly and allowed today the production of scientific models able to reconstruct the past and predict future processes related to our planet (Cloeting et al. 2005)

Advances in techniques of deep soundings, in geophysical methods, in computational systems and in remote sensors (satellites) have been fundamental to the geoscientific knowledge. The understanding of Plate Tectonic theory has led to a better view of many natural phenomena affecting the life of mankind, such as volcanic eruptions and seismic shocks, contributing to safely predict earthquakes in the future perhaps, from which large and destructive tsunamis can take place, such as those of 2004 and 2018 that destroyed towns and villages in several Eastern countries.

Knowledge of the terrestrial structure is fundamental to the basic needs of mankind, such as the location of mineral goods and water, as well as protection against natural disasters and control of environmental degradation, the role of responsibility of the geoscientist.

Despite these advances, there are great challenges still to be overpassed, such as the complete understanding of the growth processes of the continents; its thickness and its dynamics in relation to the upper mantle; the mechanisms that control the continental tectonic and its effects on the vertical movements of the Earth, among many others.

In this topic of the International Year of the Earth, two major questions were expected to be considered by the geoscientists:

• How can we better understand the mass transfer of the Earth's surface and its relationship to the deep recycling of material from the land?

• How can our best understanding of geological processes improve our forecasts of natural disasters?

One other issue at least should be added today in this topic in my view:

• How can the deep earth crust be economically explored for the generation of clean, thermal energy that does not affect nature and helps to face climate changes?

## 6. Natural Disasters

Many of the natural disasters that today affect planet Earth are the result of global climate change, such as hurricanes, floods, desertification as already mentioned. (Artaxo e Marengo, 2020). Others result from the force of the evolution of the Earth itself, such as earthquakes and volcanic eruptions. A third group, however, is often a result of the man's action, such as the landslides of deforested slopes for planting or housing, cave collapses under cities because of poorly planned foundations for big constructions, ambitious exploitation of groundwater, destruction of forests along drainages, to just mention a few examples.

Disasters such as those mentioned are responsible for the loss of thousands of lives each year besides incalculable economic losses, and several of them do not differentiate developed countries from the poorly developed, even though in the last ones' human losses tend to be larger.

In the study of these phenomena, the geoscientist has to work in multidisciplinary teams, which add researchers from the economic and social areas, in addition to engineers of various specialties, in a way to provide information that is applied to anticipate natural risks to society and decision-makers. The identification of consequences through systematic registration of disasters; the assessment of the certainties, uncertainties, and probabilities involved in the risks for people; the determination and action of options available for control, minimization and adaptation to risks; the establishment of monitoring systems are important also. An efficient monitoring system would have, of course, saved thousands of lives in Asia on the occasion of the tsunami that struck down in December 2004.

In the International Year of Planet Earth, four major issues deserved the special attention of the geoscientists (Beer et al., 2004):

• How does mankind change the geosphere, the biosphere, and geomorphology, contributing to the increasing of certain natural disasters and amplification of their vulnerability to them?

• What technologies and methodologies are needed to reduce the vulnerability of people and places to natural disasters and how can they be used in a variety of spatial scales?

• How can our current knowledge follow, predict, and minimize variations of a major natural disaster to another and how can we develop and create new local and global protection techniques?

• What are the barriers, for each natural disaster that prevents or raise difficulties to governments from using risk and vulnerability information to create policies and plans to reduce them?

In Brazil, the great natural disaster is still the drought in our Northeast region (and now in the South too), which destroys crops and pastures and directly affects the lives

of people in these regions and the country. However, one cannot forget the disasters caused by the rains on the slopes of Rio de Janeiro, Santos, Petrópolis, the floods of São Paulo and cities of Minas Gerais and Espírito Santo states, as well in the riverside towns of the Amazon River and the Pantanal Matogrossense, among others. A research conducted by IBGE, published in 2018, indicated that "the number of Brazilians in areas with natural risks is 8 million, in 872 municipalities".

The intensity of these phenomena has brought together Brazilian researchers and engineers in discussing these problems and ways to solve them and minimize them. The Geological Survey of Brazil (CPRM), after some studies carried out in the decade of 1990 under the "Social Geology Program", aiming mainly at the mapping areas with probable landslides and flood forecasting, has been taken again. It is doing geological-geotechnical surveys and inspections in support of some of the municipalities that are historically affected by intense rainfall, with a large number of landslides, such as in the cities of Rio de Janeiro, Angra dos Reis, Nova Friburgo, Petrópolis, Teresópolis, Cantagalo, in addition to others in Minas Gerais, Pernambuco, Mato Grosso do Sul as showed by the Geological Survey of Brazil through the National Map of Natural Risks, this year.

The National Laboratory of Scientific Computing (LNCC), of the Ministry of Science, Technology, Innovations, and Communications (MCTIC) was recently researching mathematical modeling for prediction of landslides in the mountainous region of Petrópolis (Rio de Janeiro state), as well as some other groups such as the Institute for Technological Research (IPT), the University of Campinas (Unicamp), in São Paulo, which also develop geotechnical studies with this purpose. The Brazilian Association of Geology of Engineering and Environment (ABGE), one of the members of the National Committee for the IYPE, organized, with other institutions, the National Symposium on Natural Disasters, which took place in the city of São Paulo in 2018. It is important to record the important role of the National Center for Monitoring and Alerting of Natural Disasters (Cemaden) in predicting and monitoring severe storms, composing a fundamental partnership with the Geological Survey of Brazil and the teams of Civil Defense of the aforementioned localities.

Other debates, recommendations, suggestions, and conclusions of research on this subject have been more and more frequent, in light of the accelerated increase of these disasters.

Fortunately, our country, despite not suffering gigantic natural disasters such as volcanic eruptions and severe earthquakes, has been a global benchmark in the evolution of works carried out by other disasters. In 2017, the country received the International SASAKAWA Award from the UN for the project to strengthen the national strategy for integrated risk management in natural disasters – GIDES, granted to Cemaden (Revista Brasil no Ar, June 2017).

## 7. Oceans

The oceans are invariably regarded as an inexhaustible source of wealth and well-being for mankind. As knowledge of them deepens, it is verified that they also include high vulnerability to man's action. In fact, the oceans are the great dump of mankind! And this is especially noted in coastal areas, where occupation is not always rationally planned, causing irreparable damage, resulting from real estate speculation, intensive fishing, poorly planned harbor constructions, and tourism, in addition to the growing waste from human activities. (Chen et al., 2005)

It is estimated that, around 2025, 75% of the world's population will be living in a range of 100 km from the sea, compared to 60% from the beginning of this 21st Century (CNRS, International Magazine, 2016). Global warming will be largely responsible for increasing the level of the oceans, jeopardizing this immense population.

The International Year of Planet Earth focused on two key issues under the theme Oceans:

• How do the lithosphere, hydrosphere, and biosphere interact in the mid-ocean chains and what role does this interaction represent for the origin of life on Earth?

• What earthly processes affect the formation and evolution of continental margins, and what are the benefits and threats they offer to mankind?

But other questions can't be forgotten:

• How can the pollution of the oceans caused by increasingly larger and diversified vessels be rapidly reduced?

• How can we reduce the use and disposal of plastic materials that so many deaths of marine animals have been causing and whose presence is already being identified in tiny particles even in the oceans near the Arctic and Antarctica?

• What technologies have to be developed for harbors to become less polluting the seas?

• How can the processes of utilization of the oceans as "clean" sources of energy production for mankind be more economical and effective?

The answers to these questions still require studies on deep structures, sediments, mineral and fluid resources, maritime currents, natural disasters, data assimilation, technological advances, etc., even having passed a decade of these recommendations.

## 8. Natural Resources (minerals) and Energy

It can be said that since the early periods of mankind human beings have employed rocks and various mineral goods directly or indirectly for their welfare. It is not for another reason that prehistory is divided into the Chipped Stone Age, the Polished Stone Age and the Age of Metals (Iron, Copper, and Bronze sub-ages) and history begins with the development of writing by the Sumerians for more or less 4,000 years B.C., in clay plates, papyri, limestone porches and so on.

Practically all the objects, equipment and constructions made by man and almost all the forms of energy used by mankind today have the participation of mineral goods, as well as the agriculture that needs fertilizers and soil correctives, in addition to water. Society is more and more dependent on these assets for their survival and well-being, as the world's population grows and technology develops. Biodiversity itself depends on geodiversity.

However, these are non-renewable goods with erratic distribution, which increases the cost of extraction and exploitation. (Sinding-Larsen et al, 2006)

In the International Year of Planet Earth, the theme focused on three key issues:

• How can the accumulated knowledge of geology and mineral and energy resources provide better planning,

governance, stability, and social advancement in a sustained development situation?

• To what extent can methane gas and methane-hydrates contribute to global energy production and what will be the environmental impact of its use?

• Can the growing industrial use of mineral resources develop through new sustained productions?

Other basic questions are currently imposed:

• How can we quickly reduce the environmental damage caused by mining through innovation in the utilization of its tailings, the best use (reuse) of the water needed for the activities and the safe construction of dams to avoid disasters such as those that occurred in Mariana in 2016 and Brumadinho in 2019, both in Minas Gerais state, and those often occurring in China?

• How can we solve the problem produced by illegal mining, without causing a greater number of unemployed people, as it happens in Brazil and in several countries in Africa and in some countries of Asia?

• How can we develop cheaper methods for discovering and use essential mineral goods, in view of the ever-increasing difficulties in detecting world-class deposits, with the consequent decline in industrial performance? (SRK Consulting in Mining.Com, 2019)

• How can we continue to promote mining with increasingly minor environmental impacts?

• What can we do to make society understand that it cannot live and evolve without the rational exploitation and use of mineral goods?

• How can the metals and minerals of the deep ocean be extracted with environment safety?

These are some of the subjects that deserve a deep reflection and intense debate.

## 9. Soils

Soils are the best systems to support human life and their welfare. We build on them, we plant in them and we reap much of our food. Millions of organisms and microorganisms are responsible for biochemical reactions of great importance in the soils, from the fixation of nitrogen from the atmosphere to the decomposition of organic matter that will feed other organisms. Its proper use only brings benefits, but if removed, the problems can be very large. (Dent et al., 2004)

The excessive use of chemical pesticides in agriculture can compromise the future of many soils. And the tendency is of great risk in this sense, especially in the less developed countries, when the world population tends to almost duplicate at the end of this Century, demanding more food in quantity and quality.

According to the Food and Agriculture Organization of UN (FAO), the estimate of the increase in world food demand is 60% for the year 2030, most of them from developing countries. Of this demand, 20% will come from the expansion of land, 10% of the most frequent harvests, and 70% of the highest productivity. This will result in the disruption of many soils in the world and the increase in cost *per unit* produced, bringing consequences to the environment. In addition to this, there still is deforestation, without vegetation replacement, in many countries such as Brazil, China, India, and almost all African nations.

On this topic, four key questions were placed in the International Year of the Planet Earth:

• How can we expand the soil knowledge base for the greatest benefit of society and the environment?

• How can we associate the basis of soil science with the various disciplines of earth sciences?

• How can we communicate and educate politicians and society to better use the soils?

• How can we maximize the use of knowledge about natural soils?

In Brazil, an agricultural country by nature, the Brazilian Agricultural Research Corporation (Embrapa) has been developing excellent research and work on the issue of soils and throughout the production chain, constituting a worldwide reference. Just remember that by the mid-80 of the last century, the Brazilian Midwest region was considered unproductive for agriculture, given the lateritic coverage of its soils. Today it constitutes one of the largest, if not the largest, grain producers in the world, thanks to the intensive research of that institution.

This Brazilian position, however, is dependent on enormous importation of the two main agricultural fertilizers: phosphate and potassium, although the country has large deposits of both in the states of Minas Gerais, Goiás, and Santa Catarina, in the first case, and in Sergipe and Amazonas states, in the second mineral. In view of this, it has been fairly increasing research in remineralizers (including mining tailings) by Embrapa, CPRM, the Center of Mineral Technology (CETEM), and universities such as the University of Brasília.

## 10. Earth and Health (Medical Geology)

Until three decades ago, few professionals from the area would risk issuing concepts about the relationship between geology and human health, except that obvious referring to the use of water and mercury used by prospectors in the extraction of gold. However, from the food we consume to the dust and gases we often breathe everything is related to the mineral particles contained in them. Man himself and other living beings are repositories of mineral goods, without which they would not exist.

The excess or deficiency of certain elements can cause serious damage to the health of men, animals, and plants, with great economic and social impacts. Fluoride deficiency, for example, can cause fluorosis, as well as that of iodine, may be the cause of goiter (e.g. some regions of Goiás state), and iron results in anemia. It is presumed that the absence of lithium in the body may result in increased cases of suicide. Their excesses, however, are also troublesome. Fluoride is a result of severe damage to the children's dentitions (case of the Ribeira River valley in São Paulo and Paraná states, a region rich in fluorite occurrences); arsenic brings serious consequences for the skin, membranes, mucosae, nervous system, liver, and heart. It is the study of this relationship – geology and health – that Medical Geology or Geomedicine proposes to develop (Selinus et al., 2004, Davies et al. 2005).

Two key issues were proposed for the International Year of Planet Earth:

• Can we identify the environmental causes for known health problems and, in collaboration with biomedical researchers and public health institutions, find solutions to prevent or minimize these problems?

• How can we safely identify "high" and "low" geochemical concentrations in soils, sediments, rocks, and water that can

cause direct or indirect health impacts, and what are the critical links between these and human and animal health?

But other issues of political order are also crucial for reflection:

• How can we reassure the public about the problems caused by geological materials and processes?

• How can we take advantage of mining tailings such as the lead ore of Santo Amaro da Purificação (Bahia state), rich in highly harmful elements to health, such as arsenic, bismuth, cadmium, or even quarries in general located near or within cities? (Fernandes et al, 2018).

• How can cooperation be established between developed and developing countries in the search for solutions to common health problems arising from mining?

## 11. Earth and Life

In the last 500 million years, the Earth experienced at least five major events of mass extinction of beings, of which the best known is that of the dinosaurs, as already mentioned, and we are now observing a new mass extinction caused by our own species, according to Barbault, 2001. The reasons in the past were the most diverse, from asteroid shocks, to climate change, to plate tectonics, to global levels of volcanism, to the elevation of the sea level. The next consequences of the ecological imbalance that will come in the near future can be estimated based on past studies. (Reichenbackeret al., 2006)

The International Year of Planet Earth has put two major issues to be reflected:

• How can we better understand the dynamic processes of the biosphere?

• How can our current knowledge assist in the sustainability of our planet's life systems?

To answer these questions further investigations needs to be related to the environmental and dynamic changes of biodiversity, paleobiological evolution, the development of life on Earth, geobiology (interrelationship biosphere-geosphere), stability, and variability in ancient ecosystems, among others.

## 12. Conclusion

When analyzing these issues in light of the current situation of ten years of experience and recommendations, it is observed that three of them had an appreciable evolution. This is the case with the themes "Climate", "Earth Crust and Core" and "Natural Resources and Energy".

It is bigger and bigger the number of news, scientific papers, congresses, and symposia on the Climate issue, or rather, on Climate Changes. These meetings show significant examples of gigantic floods observed in India, China, Brazil, rigorous winters, and summers in various parts of the planet besides prolonged droughts above normal, acceleration of the defrost mainly in the polar ice caps and their vicinity. If there are still no complete solutions for these problems, at least they have evolved in the international debates and meetings that will lead to their minimization someday in the future.

The geological researches (or rather, geodiversity) of our planet has also evolved in a very satisfactory way, and much in light of major natural disasters, particularly in developing countries. The evolution of information technologies, remote sensing instruments, techniques of collecting, treating, and interpreting geophysical data, and geotectonic theories have been fundamental for this development.

The same can be said for advances in knowledge of biodiversity, mineral goods, and, above all, on the issue of energy diversification. It is remarkable the increase in the use of wind and solar sources, all over the world, and especially here in Brazil, as alternatives to the employment of coal, oil, and natural gas. Even in the USA, where coal mining was resumed recently, alternative energy sources surpassed those coming from this ore for the first time in 2018 (Mining. com, Jun. 2019). As it begins to proliferate the manufacture of electric cars and the use of anti-pollutants mineral goods in various equipment and machines, such as tires of motor vehicles, the world begins to understand how bad are the air and rivers pollutions. Relatively little has evolved in the researches of other sources, such as tides, methane gas (for example, waste), and hydrogen. But it is a relief to know that mankind today is much more concerned with environmental issues than 30, 40 years ago.

In the theme Energy Brazil is a privileged country. Besides the enormous amount of rivers, which can still provide energy, its enormous territorial extension allows the use of the sun, the winds, the tides as safer sources in the defense of the environment. Bioelectricity is also registered, mainly from the available biomass resulting from the utilization of sugarcane. In 2018, the domestic electricity supply (OIEE) in the country was estimated at 632.1 TWh, showing an increase of 1.3% compared to the previous year. From this availability, hydroelectric power corresponded to 67%, followed by natural gas with 8.5% and biomass with 8.3% (including uses in vehicles). Wind power was in the fourth position, representing 7.7% of the offer, although it grew rapidly (Monthly Energy Bulletin, MME, 10, 2018). But fossil fuels still have a big participation in the use of energy, mainly oil and gas, and in some countries, the use of coal as an energetic source is also significant, such as in China, Russia, and Australia.

In the other seven themes, no great evolution has been observed. Particularly in those equally crucial and are dependent on political will and social education. This is the case for issues involving Groundwater, Natural Disasters, Oceans, and mainly Megacities.

However, only a few questions raised by scientists for researching at the International Year of Planet Earth were properly answered, proving that one decade is still not enough for mankind to get to know its own place and solve the big problems that it caused and continue to cause. Is there hope for that?

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