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by Umberto G. Cordani

Geology and our common future

Address by the IUGS President at the opening ceremony of the 29th International Geological Congress

Today, we are in the process of redefining the direction of further human development. We know the major problems that are threatening society, but we are still a long way from our goal of sustainable development on an equitable basis for all of humanity. Advances in science and technology will open new pathways toward this development that will be environmentally sound and sustainable. The geosciences have a fundamental role to play in addressing these global problems.

Over the last several years, the field of geology has had many technological advancements that have enhanced considerably our capacity to observe the Earth and to measure with increased precision more aspects of its internal dynamics and surface processes. More than ever before, geologists and specialists in the related sciences understand that our data have to be integrated in a complex, interdisciplinary way within the global science relating to the whole Earth system.

An atmosphere of global consensus and confidence in a better future seems to be evolving. As environmental and developmental issues are addressed in cooperative efforts worldwide, geologists will have a prominent role in this, our common future. (Ed.)

This is a very important turning point in the history of mankind, a time in which we are redefining the direction of further human development. The United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, has just finished, and the major problems that are threatening society, now and for the future, have been identified clearly. About 100,000 generations of Homo sapiens were needed to reach the present world population of 5 billion people, and yet, this number will double in the next few decades. Our planet is becoming smaller and smaller, some non-renewable resources are nearing exhaustion, the environment has been damaged and spoiled increasingly, and we are still very far from the idealized situation of sustainable development on an equitable basis for all of humanity.

Science and technology are accused of bringing about many of these problems that are confronting the world today. This is not correct! The problems arise from the manner in which the advances in knowledge have been used by people, companies, institutions, and

countries that are moved by ignorance and self-interest. Consequently, these groups of people employ pragmatic but predatory cost-benefit equations in their plans, do not take into account the environmental situation, and neglect the long-term damaging effects of their actions.

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Our hopes for a satisfactory common future are based indeed on further advances in science and technology that will open new pathways of development. These advances will call for the reduction and optimization of our use of resources, the recycling of industrial wastes, the employment of regenerative agriculture and social forestry, and other environmentally sound and sustainable mechanisms. We see that science has a great responsibility for humanity and that the difficulties are of a global nature, which necessarily calls for international and interdisciplinary efforts. The geosciences have a fundamental role to play in addressing these global problems, and we geologists are fully prepared, in fact, anxious, to play our part.

Geology is alive and well and has been very active over the last several years. At the opening ceremonies of the past few International Geological Congresses, the outgoing President of the International Union of Geological Sciences (IUGS) traditionally has summarized the major accomplishments of the past term. I will concentrate on only a few examples that I consider to be the main highlights. These examples are all associated with relevant technological developments that have enhanced considerably our capacity to observe the Earth and to measure with increased precision the manifestations of its internal dynamics and surface processes.

Let me start by citing the progress made in the field of mineral deposits and metallogenesis, where the evidence from sea-floor observations of submarine hot springs continues to show the remarkable hydrothermal discharge that forms metalliferous deposits in many of the world's oceans. In recent years, several such deposits have been discovered and were associated not only with midocean ridge systems but also with a variety of different tectonic settings, including subduction-plate margins. Studies of these modern deposits have shed much light on the formation of the ancient ones.

Great advances have been made in the observation and interpretation of past climates. From deep-sea sediments, Vostok ice cores, lacustrine materials, and so on, we can reconstitute the pattern of past ocean circulations, the past records of carbon dioxide abundance in the atmosphere, past surface temperatures, past records of solar radiation, precise regional sea-level variations, and other parameters.

We can say now that the Earth's internal dynamics play a big part in global climatic changes. The Milankovitch theory alone does not work.

In geodynamics, geologists, geochemists, and geophysicists working together have made improved interpretations of the deep Earth with the aid of numeric simulations and supercomputers. The conclusion is that probably the entire mantle of the Earth is, and has been, more dynamic than previously thought. Although still speculative, the notion of "megaplumes" is beginning to attract attention, and the importance of crust-mantle mixing in subduction zones has been demonstrated. Moreover, in the context of crustal evolution, the concept of agglutination and subsequent fragmentation of a few supercontinents during the Earth's history has been gaining strength.

Improvements in mass-spectrometric measurements have made possible the application of the rhenium-osmium method to geologic materials. The method has turned out to be an impressive tool in the investigation of old cratonic areas, a tool for tracing the recycling of crustal material. In the history of the Earth in the Early Archean, the isotopes indicate a strong depletion of the mantle, which implies massive formation of the crust; however, we have—up to this moment—no indication of a corresponding primitive crust that was enriched in incompatible elements. Zircon geochronology has developed further in recent years, along with improvements in the methods and interpretative techniques. A few months ago, the oldest known zircon of the solar system, a small crystal within the Vaca Muerta achondrite, was dated by the sensitive high-resolution ion microprobe (SHRIMP). The resulting date confirmed the 4.56-Ga age that already had been obtained by other methods for this very primordial event in the evolution of the meteorite parent bodies.

Spectacular advances in comparative planetology have been achieved with the great success of the USA's Magellan mission, which uncovered Venus and revealed many of its mysteries. Our sister planet has an extremely complex surface and widespread evidence of volcanism, as well as evidence of horizontal extension and compression. Tectonic features include mountain belts, ridge belts, large rifts, fracture systems, and trenches; however, no clear evidence is seen for Earth-style plate tectonics, in which the geodynamics features are concentrated in plate boundaries. Several hundred impact craters have been identified on Venus, and its average surface age is dated at about 500 Ma.

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A structure has been identified as the possible site for a large bolide's striking the Earth at the Cretaceous-Tertiary boundary. This is the buried Chicxulub structure in the Yucatan Peninsula of Mexico, and it has presented definitive evidence of its impact origin. Moreover, the target rocks include anhydrite, which could have released billions of tons of sulfur dioxide into the atmosphere and would have had devastating global effects that could easily explain the observed mass extinctions at the Cretaceous-Tertiary boundary.

In most subfields of the geosciences, technological developments have been continuous. The use of computers is worldwide, and geographic information systems are used extensively by the main mining companies and geological surveys. Geoscience information is being processed and disseminated at ever greater speed. The oil companies increasingly make use of mathematical simulations to

study the physical and chemical processes involved in the formation of sedimentary basins, their tectonic evolution, and the origin of their hydrocarbons. Geostatistics also are applied increasingly to reservoirs and their influence on fluid displacement, as well as to resource assessment.

The development of instrumentation in certain fields has been critical, as in experimental petrology where major advances have been produced in Japan, especially in the field of high-pressure instrumentation. In the monitoring of seismic events, I wish to mention the high-quality broad-band seismometers that have been developed by our California colleagues in the USA and that make up the TERRAscope project's network. This equipment is able to obtain instant data, in real time, of seismic parameters, including rupture propagation, speed, and direction, that enable seismologists to provide timely information about significant earthquakes. I will mention as well the surprisingly accurate results that have been obtained by our Greek colleagues in earthquake prediction by using the VAN (Varotsos-Alexopoulos-Nomicos) method. This method is based on geoelectric potential monitoring, and although there is no satisfactory theoretical explanation for it, it certainly deserves more attention.

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These few examples, as well as many others that I could cite, demonstrate our greatly improved capacity to observe the Earth, study it, and understand its dynamics. We geologists understand that we have to deal with a very large global science that concerns the whole Earth system. We also understand that all of our specialties in the solid Earth sciences, as well as the other specialties in the atmospheric and oceanographic sciences, are only pieces that have to be integrated in a complex, interdisciplinary way.

During my opening remarks at the Washington Congress 3 years ago, I urged the geological community to interact with our counterparts in the other sciences and to contribute to solving the many common problems related to the environment. I think that I can see a clear trend in this direction because most geological surveys in many countries already have adapted themselves to shift into environmental issues by following the interests of their own governments. In addition, undergraduate bodies in geology all over the world now include students who increasingly are interested in environmentally related subjects.

The IUGS itself has followed the mentioned trends as well through direct participation in the Global Change Program of the International Council of Scientific Unions, its strong involvement in the International Decade for Natural Disaster Reduction of the United Nations, and the creation of its special Commission on Geoscience for Environmental Planning, COGEOENVIRONMENT. This Commission has been very active in promoting effective links with policy makers and in trying to increase awareness among the general public and decision makers about the importance of earth science for the efficient management and protection of the environment and its resources.

Are there sufficient reasons now to hope that sustainable development can be attained in a few decades? Yes, I am sure. When I was in Rio for a few days during the United Nations Conference on Environment and Development, I felt the very special atmosphere of

global consensus and confidence in a better future. Environmental and developmental issues were made openly accessible to the public all over the world. Politicians and government executives in all countries are well aware of the problems that threaten the future of mankind, and despite the great difficulties involved in the proposed resolutions, there is no going back!

In cooperative efforts with our colleagues in other branches of science and with engineers, planners, and policy makers, we geologists have the advantage of being familiar with the observation and monitoring of the Earth's processes, as well as with map construction and interpretation. We will always play a prominent role in dealing with the exploitation and management of mineral resources, groundwater reservoirs, and nonrenewable sources of energy. We also will be of great value in comprehensive studies of soil degradation and erosion, in the prevention and mitigation of natural disasters, and in different types of research involving geotechnical and geoenvironmental fields.

However, the Rio conference is only a starting point, and the pathway is full of great difficulties that are presented by the various self-interests at every level—individual, local, regional, national, and supranational—self-interests that characterize human nature. More than ever, we need social solidarity among all of us, we peoples of different origins and different races.

Are we on the way to a better world?

At present, the distances that separate the rich and the poor are still increasing, but hope is evident that this tendency will reverse at

the beginning of the next century. Probably today's generation will not see a world that has social equality, in which all basic needs will be satisfied. But why not believe that our children or grandchildren could one day benefit from the successful results of the actions that we are starting now for our common future?

To conclude, science and scientists have a great responsibility to bring about sustainable development, and geologists have to play a prominent role. It is our responsibility to instruct politicians, educators, and the general public on the issues related to the Earth's processes. In doing so, perhaps geology will leave its present semi-isolation and will acquire a new human dimension. □



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