by Umberto G. Cordani

# "Nature to be commanded..."

## *Address by the IUGS President at the opening ceremony of the 28th International Geological Congress*

*The past five years have brought many significant achievements in the geological sciences that contribute new data about Earth. Noteworthy are planetary data, especially from Venus, that provide a better understanding of Earth's early history, as well as new isotopic and analytical results that demonstrate that plate tectonic processes comparable to those known today have probably operated since the Archean.*

*Increasing quantification of earth-science disciplines and the shift to a global, earth-system perspective provide new opportunities, new responsibilities, and new challenges for professional geoscientists to contribute to societal needs. Major problems and concerns transcend national jurisdiction and include catastrophic natural hazards, global change, man-induced environmental damage, and sustainable economic development. IUGS, with its emphasis on multidisciplinary international scientific collaboration, can play a fundamental role in addressing these problems and concerns. (Ed.)*

Dear Colleagues, Ladies, and Gentlemen:

At the opening ceremony of the International Geological Congress, tradition calls for the outgoing President of the IUGS to summarize recent accomplishments in the geosciences on a global scale. Because of Dr. William W. Hutchison's untimely death in 1987, I stand before you not as the "outgoing" President, but as the "ongoing" one. If luck prevails, I will see you again at the closing ceremony and in Japan at the opening ceremony of the 29th session of the Congress, by which time we will certainly know one another very well indeed!

Let me begin my account of accomplishments by paying tribute, first and foremost, to Dr. Hutchison's accomplishments. His boundless energy, his fantastic capacity to bring out the best in people, his enthusiasm and optimism were a boon to international cooperation around the world. His was a life dedicated to geology and to the IUGS. It is a great privilege for me to follow in his footsteps.

Let me also pay tribute to Canada for putting forward people of the caliber of Dr. Hutchison, Dr. Harrison, and their colleagues. The Geological Survey of Canada, in particular, deserves a special note of recognition for its generosity in supporting the IUGS and international scientific collaboration—through Hutch's terms as Secretary General and President, through the editorial office of our successful newsmagazine *Episodes*, and through the difficult transition period following Dr. Hutchison's death. Both Eugen Seibold, Hutch's predecessor and acting President before my election, and I, as well as the Union, are very much indebted to the Canadian support.

Geology and geologists have been active during the past five years. Although there were no breakthroughs comparable to the plate tectonic revolution of the late 1960's, there was certainly excellent progress in several fields. I will highlight just a few examples based on many excellent submissions received from friends and colleagues around the world.

The largest of the IUGS Commissions, the Commission on Stratigraphy, has been defining, properly, some of the more important stratigraphic boundaries, like the Precambrian-Cambrian and the Cretaceous-Palaeogene. On the latter, it cooperates with the Commission on Global Sedimentary Geology in correlating global events recognizable more or less worldwide in the sedimentary record.

You may be interested to know that in parts of the Cretaceous, geologic evidence demonstrates that the average surface temperature of the Earth was some 10 °C higher than today and that palm trees grew at very high latitudes. This demonstrates that our planet can reach such extreme conditions naturally, even without a greenhouse effect produced by man!

Significant progress was made in comparative planetology after analysis of the radar images obtained by the Soviet Venera 15 and 16 space probes. Venus seems to be more similar to Earth than any other planet of the solar system, and the processes operating today may be similar to the Earth's Early Archean in terms of upper mantle temperature, lithospheric behavior, tectonic styles, and processes of crustal thickening. America's recently launched Magellan mission to Venus is expected to provide higher resolution radar images, as well as altimetric and gravimetric data. We look forward to a better understanding of Venus and, by comparison, the early history of Earth itself.

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Paleontology has experienced a revival in recent years when molecular paleontology developed considerably. Cooperation between biochemists and paleontologists is producing spectacular results in the understanding of the phylogenetic relationship between living and extinct animal taxa. This understanding demonstrates that man is actually closer to the great apes than previously believed. In addition, important new fossils discovered recently have refined our understanding of the evolution of man.

We have advanced geological interpretation of deep seismic profiles, such as those produced by the French "ECORS," the American "COCORP," the Canadian "LITHOPROBE," and other projects. Cooperation between geologists and geophysicists has led to the correlation of observed discontinuities in the records with geologic structures observed at the Earth's surface, and if we take into account the probable rheological behavior of the material, such evidence impacts our understanding of the origin and evolution of folded belts. They can now be regarded as orogenic floats that separate crustal fragments from the underlying lithospheric roots. The Global Geoscience Transects project, with its emphasis on large-scale geological interpretation of the crust, is the most visible and impressive product emanating from the International Lithosphere Program.

The tridimensional view of the continental lithosphere has fantastic potential. Eventually, we geologists must recognize the need for 3–D subsurface mapping and modeling of rock materials, reservoirs, fluid circulation, and so on. The tools are now being developed, and resource management of the subsurface will likely become a crucial issue for the geosciences in the future.

Deep seismic surveys will benefit from the results of deep continental drilling, the only direct access to the crystalline crust under *in situ* conditions and, by consequence, the only possible way to calibrate the nature of the deep seismic reflectors. The technology involved in superdeep boreholes is very complex. A number of continental drilling projects are underway or in the planning stage, with the Soviet Union leading in that field.

Among the recent advances in petrology, inclusions of small diamond crystals in garnets of a metasedimentary gneiss from north Kazakhstan, USSR, have demonstrated that carbon representing former organic matter was present in the original sediment. In addition, it was subducted to mantle depths of at least some 130 km.

In my own fields of research, isotopic geochemistry, geochronology, and crustal evolution, we have made significant analytical improvements on mass spectrometers, ion probes, and single-zircon dating. We also have had several important discoveries, including precise dating that identified the Earth's oldest known minerals, a few grains of detrital zircon in metasediments of western Australia that have apparent ages of about 4,300 Ma. The ages mean that probable granitic material existed very early in Earth's history. Moreover, extensive work with neodymium isotopes suggests that substantial amounts of continental crust formed in the Archean. On the other hand, one of the largest juvenile crust-formation episodes in the Earth's history was identified in middle Proterozoic times in North and South America, and ophiolites dated about 1,900 Ma were discovered in Scandinavia, Canada, and near Lake Baikal, USSR. This evidence demonstrates that sea-floor spreading and plate tectonic processes comparable to those of today operated well back in time—probably since the Archean.

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Let me focus now on our profession in general. Professional geologists, especially those involved with mineral deposits and economic geology, were affected seriously in the 1980's by a worldwide recession. With the exception of gold, industrialized countries reduced their consumption of mineral commodities. Metal prices declined, and mining companies reduced exploration activities and budgets. The results were both severe unemployment and discouragement.

These effects were probably most drastic in the industrialized countries, where the system forces producers to compete openly for world markets. In the Third World, where mineral production is more controlled by government, activities continued because income earned from production simply could not be foregone, whatever the price. But the overall result was continued oversupply, reduced income, and consequent economic difficulties. At present, the depressed situation seems to be easing, at least for some commodities like nickel, copper, and zinc, and this is resulting in some renewed exploration for these metals.

As a representative of the developing world, I must stress the importance of mining, not only in economic terms but in the role that exploration geologists can play in advancing north-south cooperation. Genuine cooperation between industrialized and developing nations can reverse the present, very adverse situation for the Third World. The developed nations, having about one-quarter of the world's population, use more than 80 percent of the world's mineral wealth, no matter what sources. As a result, the mineral potential of the Third World has been beneficial practically only to the industrialized nations and a very small minority within the developing countries.

*"Geology is shifting to a global, earth-as-a-system perspective."*

I believe that we geoscientists have a responsibility to understand the social and economic factors that control the development of mineral resources and to estimate their effects. It is our duty to identify the appropriate balance, the division of responsibilities between governmental and private interests, that best will meet the different needs of all involved, while providing the necessary material to industry.

Finally, a few words of "crystal ball gazing" into the future of our profession.

Geology is becoming a more quantitative science, as broader application of information technology and modeling is made to the geologic processes bearing on the nature and evolution of the Earth. Basin analysis using computers, seismic tomography of the interior of the Earth, numerical simulation for exploitation of oil and mineral deposits, remote sensing, digital data bases, and digital cartography are all examples of this tendency.

Geology is shifting to a global, earth-as-a-system perspective. New initiatives in the IUGS family alone reflect this development: the Global Sedimentary Geology Program, the Global Geoscience Transects project and the World Stress Map of the International Lithosphere Program, and the recently launched environmental programs.

This brings me to what I consider the most important role of the geosciences in the next decades: to contribute in a holistic view, in cooperation with many other branches of science, to achieve sustainable development as it was characterized in the United Nations "Brundtland Commission" report, "Our Common Future."

Damage to the environment and the many related problems are now a major worldwide concern. The challenges cut across the divides of national jurisdiction. Political decisions on the management of resources and land-use planning are crucial.

Sustainable development will give rise to an unprecedented demand for information, advice, and technology that only an integrated approach can satisfy. In many countries, the focus of the challenge ahead is shifting from protection and restoration to planning and prevention, as the possible solutions to environmental issues become more and more complex and dependent on the cooperation of a multitude of sectors–but first and foremost that of science.

Soil degradation, desertification, deforestation, acid rain, water pollution as a result of excessive use of fertilizers and pesticides, major technological hazards in nuclear plants or large chemical plants, mining wastes, and seawater pollution from wastes and oil spills—all these demonstrate that our planet is in an environmental crisis. Most of these problems are related to the growing human population, which is starting to reach saturation. Human activities now involve an annual flux of earth materials that is equal to that of plate tectonics.

In addition to the local or regional environmental problems, concern grows about possible changes in the whole global ecosystem, which may have a long-term adverse effect on mankind. And, finally, there are the catastrophic natural hazards—earthquakes, volcanic eruptions, typhoons, floods, landslides, and the like—that so frequently cause death and destruction.

The geosciences have a fundamental role to play in addressing all of these problems. The geologic record of past global changes provides the baseline against which to assess the nature and significance of contemporary and future changes. The elucidation of the dynamics of the solid earth provides a framework for the mitigation of catastrophic natural hazards.

IUGS, having its emphasis on multidisciplinary international collaboration, can contribute in a major way. We can contribute through the International Council of Scientific Unions program on global change and through the "International Decade for Natural Disasters Reduction." As geologists, we are custodians of our Earth. Let us mobilize and start bridging the knowledge gaps to address these vital global threats to our planet's survival and our own survival.

Let us not shy away from communicating with policymakers and planners. Geology is not, at present, part of their culture. All of us know how important geology is for society. Let's make sure that educators too share that knowledge. It is our responsibility to reintroduce earth-science curricula into educational programs, preferably at the secondary school levels when students are introduced to the environment and the very serious problems that face it.

Francis Bacon in the 17th century wrote, "Nature to be commanded, must be obeyed."

We live in a challenging world with many uncertainties. We hold a great responsibility for future generations. We must keep faith in our capacity and remain organized to accomplish our goals, and we must make use of the tremendous potential of international collaboration. Let us start right now to respond to the signals that nature is sending us. Let us obey in order to command again. □

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