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The Third Dimension

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Presidential Address Delivered by J. Alan Coope GAC President 1985-1986 At the Joint Annual Meeting of the Geological Association of Canada and Mineralogical Association of Canada Ottawa, Ontario 19 May 1986

Mr. Chairman, Mr. President, Dean Neelin, Mr. Tupper, Mr. Vice President, Ladies and Gentlemen,

An important privilege of a President of the Geological Association of Canada is the opportunity and, indeed, the responsibility to figuratively stand back, survey the scene, and analyse the various elements that constitute not only the earth sciences, but the importance, the fundamental significance and the potential and inevitable impact of geology on our scientific, political and social framework.

A cursory reflection on Man's record of discovery and understanding clearly indicates that we have progressed from a two-dimensional to a three-dimensional perception of the Earth.

For many centuries, there were voyages of discovery or conquest led by amazing and durable men who sought territory and power, metals, spices and silks or scientific facts. Geographically, Man found a two-dimensional world, even though it turned out to be round.

Then came an expanded awareness of geology and our resources. Within the last two hundred years — stimulated significantly by the Industrial Revolution — we have been embarked on a path of scientific growth, geologic understanding, and resource and technological development that has expanded exponentially through recent time. The father of geology in this country and a figurehead personality of this Association, Sir William Logan first came to Canada almost 150 years ago as a pioneer and a geologist propelled by the need for resources and knowledge of the Canadian Hinterland.

Progressively our two-dimensional geographic understanding became underlain and overlain by a thicker, but still two-dimensional, geological understanding of our continents and oceans. Through mining, through structural geology and then, beginning 100 years ago, through growth and investment in the petroleum industry we have, somewhat selectively, addressed the problems of the third dimension of our continents. High technology, computers and seismology since World War II focussed on sedimentary basins having hydrocarbon potential and provided us with a graphic understanding of structural and stratigraphic elements to depths of several kilometres.

Then came the Revolution. Very basic research on magnetic patterns over oceans provided the clues that spawned the theory of plate tectonics. Progressively over the past 20 years many of the mysteries of geological science have been replaced by some semblance of order in our understanding of the Earth. Dynamic processes connected with volcanoes, earthquakes, basins, mountains, petroleum and mineral deposits, now can be more accurately modelled. We know how the continents and oceans evolve and how they behave.

Today, plate tectonics is part of every geologist's perspective. For the **stratigrapher** and the **paleontologist**, intercontinental correlation became credible. For the **structural geologist** the advances in understanding were profound. For the **mineral deposit geologist**, the distribution of different families of deposits made sense and their presence became predictable.

Geology has matured and strengthened. Now, as a result of these revolutionary advances we have a framework in which to generate answers to many of the problems that confront us as we pursue our scientific knowledge and convert our advances into social and economic opportunities. Much speculation in geology has been replaced by prediction.

Historically, a major scientific breakthrough such as plate tectonics is followed by a period of technological development and application to resolve the problems and the opportunities revealed by the advance of science. This technological phase is already underway and is, in turn, stimulating further new concepts and ideas.

Underwater technology has been adapted to the investigation of plate margins in oceans and on our continental shelves. This led, in the 1970's, to the "black smoker" discoveries in the Pacific and more recently to the Juan de Fuca Ridge and Explorer Ridge discoveries in Canadian waters off the West Coast. The ongoing studies of these discoveries will be an immense and essential contribution to our knowledge of the formation, location and concentration of certain mineral deposit types in the mining areas of Canada leading to the identification of additional bodies of ore. These studies, too, will continue to illustrate to the world the high level of expertise and understanding of mineral deposits geology by Canadian scientists and also establish sovereignty in our extensive offshore areas.

The decade-old COCORP program involving deep, seismic profiling in various regions of the United States has added much new and exciting information to depths of as much as 40 km from all around this continent. Not only has this program illustrated major elements in accreted terrains, prominent mid-continental rifts, data on the history of the ancient Iapetus Ocean and valuable deep crustal information in areas of frequent earthquakes, volcanoes and other natural hazards, it has revealed possible significant interpretations of sources of deep natural gas in the South East and major structures in the West that may be correlative with the famous "Mother Lode" in the Sierra Nevada.

We have also witnessed the application of "Vibroseis" technology in Canada's own and very important LITHOPROBE program, and it is clear that our improved understanding of the origin of mineral deposits at plate margins and this important new data from deep seismic work, as illustrated so spectacularly by the LITHOPROBE results from Vancouver Island, will enable us to predict and locate new areas of mineralization and important new resources to sustain our country's growth.

In time we will be able to see even deeper. One of science's more dramatic breakthroughs is **seismic tomography**. Using earthquake-generated body and surface waves it will be possible to map the three-dimensional structure of the Earth's interior. Essential to these studies is a global network of broadband digital seismic instruments and the international collection and exchange of data. At this time this network is sparse, but we can look forward to maps of the Earth's interior on the scale of surface tectonic provinces and information on temperatures, compositions and convections throughout the mantle and, possibly, the core.

Seismic tomography is in the future. However, the next critical step for the earth scientist in this exciting advancement and discovery, will be the initiation of deep-penetrating continental drilling programs allowing the recovery of geological materials for examination and the testing of some of the features that appear to be of important geological and economic significance.

Modern drilling rigs are capable of penetrating to 12-15 km from the surface. Just as we have done with the Vibroseis, we can borrow the latest technology developed by the petroleum industry to bring those all-important samples to our laboratories for examination. This will allow us to develop and perfect down-hole technology to measure chemical and physical properties in this deeper continental frontier.

Information released by the Russians who have been involved with deep continental

drilling for some time has revealed many unsuspected facts. This includes data on porosities at greater depths that can significantly change some of our thinking on how fluids, including mineralized fluids, move around in the crust.

Drilling is expensive. We will have to choose our sites wisely. But deep scientific drilling is a critical phase in our quest to develop the more advanced understanding of continental tectonics that will unlock the secrets of continental formation, will tell us how mineral and energy resources have been concentrated, how the infrequent but especially destructive earthquakes take place and how other phenomena such as volcanism and fluid migration can be explained.

But the Third Dimension in geology is more than just looking deep.

It is not difficult for us as members of the Geological Association of Canada to comprehend the opportunities stemming from the exploration of the crust.

I ask though, do we all appreciate our full potential?

As members of the national geological community, I contend that by combining the many talents that you represent in your chosen disciplines, you can generate the initial horsepower needed to start the engine that will power Canada to economic prominence and all the social and scientific benefits that are well within our capability, and that go along with efficient management of our fantastic Canadian natural heritage.

LITHOPROBE, COCORP, Continental Diamond Drilling, Seismic Tomography all represent the **Third Dimension of Geology In Space.**

In geology, we have learned the Dimension of Time is of great importance.

Sir Charles Lyell, many years ago, clued us in to uniformitarianism as a guide to geological interpretation.

In mineral deposits geology, today's black smokers on the Juan de Fuca Ridge and further south in the Pacific, the Kuroko deposits of the Tertiary of Japan and the important massive sulphides of the Canadian Paleozoic and the Canadian Shield are part of a family of mineral deposits — part of an ongoing process explained by plate tectonics — that transgress geological time. As a result mineral deposit geologists, whose bread and butter is the Archean, improve their understanding by observing the Tertiary and what is happening today on the East Pacific Rise.

What is true for massive sulphides is true for other types of mineral deposits — including gold. Predictably, a better understanding of Canada's world-class gold deposits in the Canadian Shield — and perhaps more importantly, the better understanding of the potential of the Canadian Shield for those world-class gold deposits that have yet to be found — is to be gained from the study of Tertiary gold deposits and where gold deposits are forming at the present time.

I have expressed my views earlier about the arbitrary differentiation of "hard rock" and "soft rock" interests in geology. It is folly to separate younger rocks, their evidence, their processes and their properties from older rocks which have endured the mill of geological process for much longer. And, of course, the reverse is also true.

This topic leads me to another dimension of geology which can be justifiably classed as part of our Third Dimension. I talk of **Integration**.

Ending just this morning was a Symposium on Sediment-Hosted Stratiform Copper Deposits. This Symposium has brought together mineral deposits geologists from many different parts of the world to share their knowledge and experience.

The international geological literature continually reminds us that the understanding of certain geological phenomena by geologists abroad is not always the same as ours. This is quite understandable. Although our concerns in our different countries are commonly much the same, geologists in other countries have different training and, more importantly, observe different exposures and environments to the ones on our doorsteps. Interpretations, concepts and principles, therefore, follow different development paths and, invariably, there is something new to learn through communication with colleagues beyond our borders.

Prominent in the technical program of this same symposium on Sediment-Hosted Copper Deposits were geoscientists from other than the mineral deposits discipline speaking on fluid migration, diagenesis and other subjects. These are important in the understanding of Sediment-Hosted Mineral Deposits but are traditionally studied in the context of petroleum geology rather than mineral deposits geology. However, this integration of expertise from the mineral deposits, sedimentology and petroleum geology disciplines has the powerful potential of broadening and deepening our understanding.

In point of fact, **multidisciplinary activity in geology is a fundamental and necessary practice.** It is an effective and rewarding way of increasing the productivity of the individual and facilitating the advancement of geoscience.

Indeed, the benefits of integration extend beyond our own science. Microbiologists and geologists are working together in the black smoker environments of the East Pacific Rise investigating the activities of organisms in the fomation of massive sulphide deposits.

Closely co-ordinated studies between geochemists, marine geologists, other geoscientists and botanists and zoologists is contributing, and will continue to contribute, to the anticipation and resolution of environmental problems. The recognition of the Environmental Geoscience Division within the Association is testimony to these realities.

Repeatedly, in this exploration of the Third Dimension of geology, I have attempted to place in context the important contributions of plate tectonics, integration, international communication, and the exploration of continental shelves, the oceans and continental crust to the Canadian identity and the Canadian future.

The spectacular new data from the Earth's third dimension is continually illustrating features, relationships and processes which not only lead to a confirmation, re-evaluation, improvement and expansion of our geological understanding, but reveal basic, fundamental information on natural hazards, natural resources, the environment, and matters of sovereignty and sociology that are important to the future well-being of all Canadians and this country's political, social and economic development.

This is the **true Third Dimension** in geology.

This is what we must appreciate and this is what we should communicate, not only to ourselves, but also to those in industry, to those in politics and to those others whose short-term concerns deprive them of the opportunities to fully observe and appreciate the **long-term** fundamentals and **long-term** importance to Canada of the **long-term** expansion of our geological data base and its impact on our social and economic growth and maturity.

Canada is a resource nation. We are the world's second largest country, we have the world's longest coastline, we have diverse terrain, we have an immense natural heritage. Canada's **collateral** extends from the Archean to the Recent, Canada's **currency** is our natural resources and Canada's **credit** is dependent on our ability to exercise our expertise in the proper and orderly development of our geological heritage.

The Geological Association of Canada with its diverse representation of geological disciplines embraces this challenge.

In my term as your president, I have appreciated your talent, I have appreciated your abilities, I salute your potential, and I ask you to focus your expertise in Canada's best interests.

It is important that you create the Third Dimension.

The economists, the politicians, the industrialists, your fellow scientists, your colleagues, friends and loved ones will be very grateful.

I wish you well.