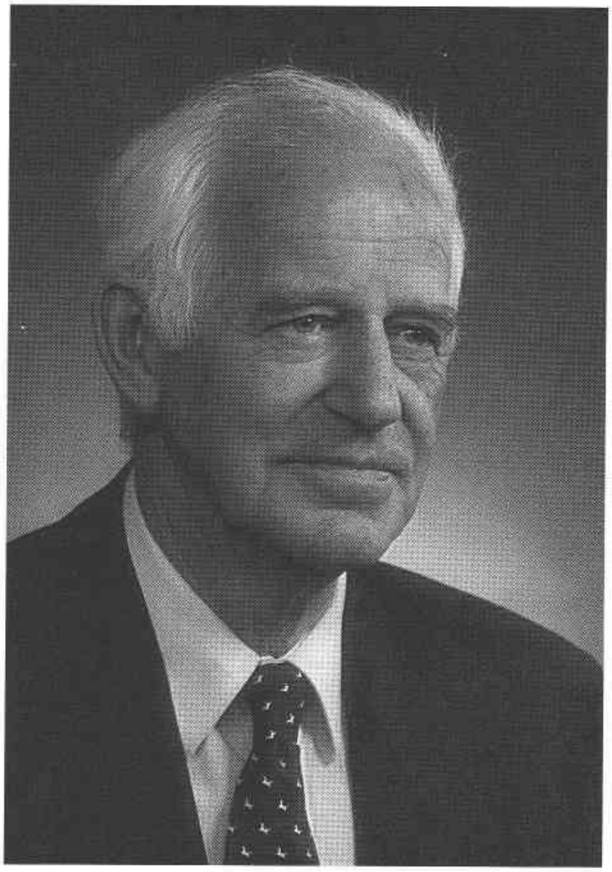
American Mineralogist, Volume 81, pages 773–774, 1996

Acceptance of the Roebling Medal of the Mineralogical Society of America for 1995

William S. Fyfe

Department of Geology, University of Western Ontario, London, Ontario N6A 5B7, Canada



Mr. President, members, and guests:

I am deeply honored to receive the award of the Roebling Medal from the Mineralogical Society of America. I thank Bernard Evans for his very (perhaps overly) generous remarks. When things like this happen, I always remember the words of Sir Andrew Huxley, a former president of the Royal Society, London, when he spoke to Royal Society research workers. He said, to succeed in science, one must have moderate intelligence, one must work hard, and one must be lucky. He meant by the latter remark that one should tackle significant problems at the right time. Personally, I had great luck, good fortune, in my association with wonderful earth scientists, teachers, colleagues, graduate students, and all the other staff who make our laboratories operate and our departments function well. (I was amazed to see that I joined the MSA 50 years ago and that you published one of my first papers in 1951.)

For me, it all started at Otago University, New Zealand. I took chemistry to get a job, and geology because I was curious and, as a child, milked cows while looking at the Southern Alps. At Otago, Colin Hutton and Frank Turner were my teachers (they were to leave later for Stanford and Berkeley), and people like Douglas Coombs were my fellow students. Later, while at Berkeley, UCLA, and Manchester, I got to know many others, like Adolf Pabst, George Tunnell, Scott Mackenzie, Leslie Orgel, and, yes, I even visited Linus Pauling. And, at the same time, I had a wonderful group of graduate students and associates, like Bernard Evans and the late Roger Burns. Over the past decade, Kazue Tazaki of Japan has introduced me to the power of the modern electron microscope.

Today, our techniques for describing minerals are quite fantastic in comparison with those available when I was a student. We can observe structure and chemistry on a submicron scale, with X-rays, electrons, neutrons, etc. We can watch atoms on a surface with great resolution with the new array of surface techniques. We can watch the interactions between geofluids and the crystal surface, observations critical in the megaproblems of water quality, soil quality, and the management of waste, including nuclear wastes (on which the world will spend tens of billions of dollars in the next decades). Long ago, I remember hearing a famous chemist call the surface of a reacting solid "terra incognita."

The earth sciences are in trouble today. I think we have partly failed to explain to our society what we do and why it is so important. Mineralogy is the science of earth and planetary materials. The exact description of minerals reveals the history of all aspects of planetary evolution. Minerals contain the library of changes on this planet, and the processes that form them are vital to our understanding of resources, from ore materials to soils and even clean water resources.

We live in an amazing period in the history of the development of Homo sapiens. After Christ, it took 1500 years to double human population. Now it takes less than 40 years, and population has doubled twice in my lifetime. The present nearly six billion will grow to at least ten billion next century, and some even talk of 20 billion, and most of these people will live in urban areas in the developing world. There is going to be, there must be, vast development on this planet if there is to be any social stability. What are the megaproblems? Some include the following: (1) Finding adequate energy resources for ten billion people, for our quality of life is related to energy. While North Americans waste energy, most of the world's

0003–004X/96/0506–0773$05.00

people have far too little for their needs. (2) Understanding climate and all factors that cause fluctuations in the Sun-Earth system. (3) Providing adequate clean water for all purposes (already 40 nations are limited by their water supply). (4) Preserving soil quality and the remediation and remineralization of degraded soils. (5) Managing waste products, including urban wastes, nuclear wastes, combustion gases, etc. (6) Providing the raw materials for construction, fertilizers, metals, etc., which, next century, could involve moving about 100 km^3 of rock per year. And we must improve our mining technologies. It is interesting to note that the British journal *The Economist* recently reported a world shortage of high-purity silicon. Where is the purest SiO_2 in large quantities?

Are there any items on the above list that do not need exact mineral science? To find intelligent solutions to such global problems requires new structures and new teams of experts who can communicate. As King and Schneider of the Club of Rome recently stressed, specialists have failed.

In recent years, and here I acknowledge the wonderful influence on me of Heinz Lowenstam of the California Institute of Technology, we have come to appreciate that the 1000 km^3 or so of living cells (particularly the microbugs) synthesize a vast and complex array of minerals near surface and now down to 4.2 km and over 100 °C. It is these biomineralization products that contain much of the record of global environmental change. More mineralogists must become involved in problems like understanding the global carbon cycle, the sulfur cycle, etc., the understanding of which at present, I am sure, is very imperfect. Recent work we have been doing in the great caves of Hawaii has revealed incredible basalt-organic interactions involving carbon fixation mediated by microorganisms. Such deep-biosphere processes are hardly discussed in the modern literature. And these observations show that it may be possible to dispose of CO_2 from stationary power plants in appropriate rocks (and the reactions are exothermic, so one gains a geothermal energy bonus!).

Our techniques are wonderful, and problems of great significance to the thing we call sustainable development abound. Exact earth materials science, mineralogy, has never been so urgently needed for the intelligent use of our planet, as our population continues to explode. And again, thank you for this great honor.