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Acceptance of the 2023 Roebling Medal of the Mineralogical Society of America

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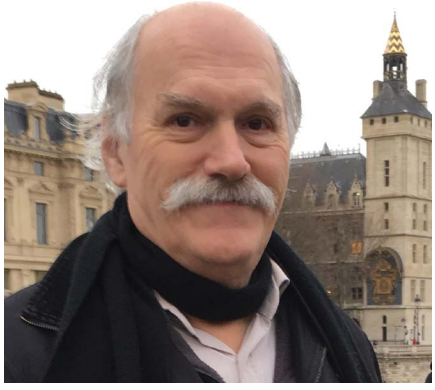
Thank you, Gordon, for your generous words, by which you underline the scientific vision, mutual encouragement, and friendship that we have shared over several decades, both in our professional and personal lives. Thank you for your continuous support. I particularly appreciate the fact that it is you who is introducing me to this most prestigious distinction.

It is a great honor, totally unexpected, to have been nominated and even more surprising to have been chosen for the prestigious Roebling medal and I am deeply honored. I warmly thank the MSA Council, the members of the Roebling Committee, and all those who nominated me for their confidence. Thank you also to those who have come to this luncheon or attended the Sunday symposium on "Molecular-scale approaches in Mineralogy: bridging the gap from microscopic to macroscopic." The great talks presented during this meeting demonstrated the topicality of molecular-scale approaches. But also, this honor makes me very humbled, particularly when I look at the list of previous recipients extending back to 1937, including so many legendary people. As a special mention, as I am the second French to be awarded this honor, I should mention Raymond Castaing, the father of the electron microprobe, who was the first French scientist to receive the Roebling Medal in 1977.

I have been attracted to minerals since middle school. After being admitted at Ecole Normale Supérieure (ENS) de Saint-Cloud-Lyon and following Geology classes at the Sorbonne, I began a series of internships in the historical Mineralogy-Crystallography Department of the Sorbonne, founded at the time of Napoleon 1st in 1809 and probably one of the oldest laboratories of France. It is now the Institut de Minéralogie, Physique des Matériaux et Cosmochimie (IMPMC) of Sorbonne Université. At this time, I was fascinated by mineral colors, unfortunately, considered a marginal topic in a laboratory mostly working on crystal structures. I had a bright professor, Hubert Curien (1924–2005), who explained clearly and simply the most recent concepts in crystallography, including crystal physics and point defects. Curien, a life fellow of MSA, occupied the most important positions in the French scientific system, including as Minister of Research and Technology in several French Governments (Calas 2007). After a first work on the superb colors of natural fluorites, I succeeded in a competition to become a high school teacher while obtaining at the same time a research fellow position at the Centre National de la Recherche Scientifique (CNRS). I took the second possibility with pleasure and started to investigate the structural properties of glasses using the spectroscopic properties of the transition elements they contain. In 1980, I was appointed full professor at University of Paris 7



(now University Paris-Cité). At the same time, a major change in my activities occurred with the access to synchrotron radiation sources. Indeed, the first operational synchrotron radiation centers were developed at the end of the 1970s both on the campus of Orsay and Stanford. The first results published were about the speciation of transition elements in glasses. And we were the first with Gordon Brown and Jacqueline Petiau, a physics professor in the Mineralogy-Crystallography Department of the Sorbonne, to publish this type of information.

William Bassett (the 1994 Roebling Medal) invited me to the 1982 AGU Fall Meeting, which hosted the first meeting devoted to the applications of synchrotron radiation in Earth sciences. This started a continuous and fruitful collaboration with Gordon Brown on topics of mutual interest: structure of glasses and melts, environmental mineralogy, speciation of contaminants in soils, etc. I have been a Cox Visiting Professor at Stanford on these topics. The contribution to environmental mineralogy, including the impact of mining activities (As, U), was reinforced by two bright soil scientists, Philippe Ildefonse and Jean-Pierre Muller, later joined by Guillaume Morin, Thierry Allard, and Etienne Balan. Sadly, Philippe died dramatically in the laboratory on the evening of October 26, 1999. In 2001, I moved to Sorbonne Université. In the 2007–2017 period, I was selected for a senior membership at the University Institute of France. In addition to relieving professors from a large part of their teaching, this major institution provides specific funding to encourage the transmission of experience to younger colleagues. During this time, I was chairing a funding network on oxide materials in the Paris region. My election at College de France in the 2015 annual chair on "Sustainable environment: Environment, Energy, Society" reinforced my motivation for the questions raised by mineral resources. Within the activity of the chair, I gathered experts from several countries in a meeting, "Mineral resources, a major issue in the context of sustainable

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development," podcasted on the website of College de France. My more recent activities include the investigation of medieval glasses in order to deepen our knowledge of the technological processes used during the Middle Ages to elaborate these fascinating witnesses of the former centuries. After the catastrophic fire of Notre Dame Cathedral on April 15, 2019, I was nominated to the working group on the restoration of the glasses from the Cathedral.

The guiding thread of my scientific life was rationalizing structure-property relationships. How strong is the link between physicochemical properties and molecular scale structure of minerals, glasses, and multicomponent natural and technological materials? I was also attracted by the original information these links provide on the formation conditions of minerals using substituted impurities and radiation-induced defects. Mineral spectroscopy provides some independence relative to mineralogy: it allows us to demonstrate the presence of different mineral generations with their distinct histories. For instance, radiation defects are of interest for tracing radionuclides in the geosphere. This topic was a natural collaboration field with Rod Ewing (the 2015 Roebling Medalist).

Molecular-scale information on gels and glasses demonstrates the universality of the basic laws of crystal chemistry: whether materials can be periodically organized or amorphous, there is a strict obedience to Pauling's rules (Linus Pauling was the 1967 Roebling Medalist). The original geometry of cation sites in glasses, with well-defined relationships with glass structure, provides evidence of their heterogeneous structure, as demonstrated by Laurent Cormier and Laurence Galoisy. This is a major result of the structural properties of glasses and gels demonstrating a short-range order, even in the absence of a long-range order. When working at this scale, mineralogists are in a good position to interact with scientists outside of the Earth and planetary sciences and with other fields of science and technology, e.g., environmental sciences, materials science, cultural heritage, and so on. These collaborations broaden the scope of our research and attract a large diversity of students in our laboratories.

I have been living in a time that has seen an explosion of instrumental, experimental, and theoretical approaches in mineralogy and geochemistry. Among these tools, spectroscopic methods and the fast-emerging synchrotron radiation facilities deserve special attention. Their fast development contributed to cross fertilization of mineralogy, geochemistry, and environmental and materials sciences. This interdisciplinarity illustrates the concept of "Geochemistry of solids," advocated by Bill Fyfe (the 1995 Roebling Medal) in his enlightening book more than 50 years ago. Such an approach provides direct access to a unified molecular scale vision of the structure of geomaterials, including nanos and mineral surfaces and "amorphous" materials. A similar approach has provided clues on structure-property relationships of technological materials, and this has been, for me, the occasion of a long-term collaboration with major industrial R&D centers and various branches of the French Atomic Energy Commission. I am glad that about half of my students found a position in these areas, some of them at top executive levels.

I was lucky to be at the right place at the right time. Indeed, such a broad diversity in my research activity over several decades results from team efforts and strong student motivation that were, for me, of the highest importance during all my professional life. I was in a laboratory located in the center of Paris, an attractive place for students, postdocs, and collaborators, driving a unique population of eminent scholars from the major universities and colleges that constitute the Quartier Latin.

Despite the fact that research was the main goal of my professional activity, I always felt concerned by the management of public affairs and the societal and economic implications of Mineralogy. I had several positions at University and CNRS and occupied a halftime position as a scientific advisor at the Ministry of Research and Higher Education. I was also involved in the management of public research and Universities, at a time when environmental concerns were rising fast, in the teaching programs as well as in research activities. Finally, service to our community, to our mineralogical societies and associations, and to our journals has always been an important component of my professional activity. In particular, I retain fond memories of having served as *Elements* Principal Editor. Without any similar example in our community for guidance, *Elements* has built a unique and worldwide link between mineralogical, petrological, and geochemical communities, 20 years after its launch. Sharing our experiences and our interests results in original issues of a journal that captivates our community. We hope that this will continue for the years to come, attracting interest for our fields and for science in general.

Once again, I thank the MSA for this great honor.

Reference cited

Calas, G. (2007) Memorial of Hubert Curien, 1924–2005. American Mineralogist, 92, 448–449.