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Presentation of the Mineralogical Society of America Award to Guillaume Fiquet

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President Rumble, Members of the Society, and guests:

It is a special pleasure to be giving the citation for Guillaume Fiquet as the recipient of the 2003 MSA Award. As both a scientist and as a person, he is someone who I admire. Guillaume's research record includes a number of landmark papers on the most basic materials of the deep Earth, and numerous technological innovations that are true milestones in high-pressure mineral physics. His published research reflects a broad range of interests, from subduction and recycling of material into the mantle, to the composition of Earth's central core. Guillaume has established himself as one of the preeminent experimentalists in mineral physics, and his work has greatly influenced our view of the Earth's interior.

Guillaume's career began as that of many Europeans: a geologist who was fascinated by the Alps and the other geology around him in France. Perhaps it was his love of skiing and hiking that initially steered him into structural geology. His first publications were on the topics of block rotation in the brittle crust, and fault kinematics deduced from sandbox experiments. However, he soon switched fields to high-temperature mineralogy, and the loss to the fields of structure and tectonics was definitely our gain. His thesis research involved the structural and thermodynamic properties of upper mantle minerals with Philippe Gillet at the University of Rennes. After finishing his Ph.D. and serving his military obligation as a post-doc in Germany, he returned to France to take up a CNRS position in Lyon. His interests had evolved towards understanding the deep Earth and building an experimental program in this area. His approach was to measure mineral properties under in situ high *P-T* conditions that simulate those in the Earth as closely as possible, and to do this more quantitatively that had been done in the past. His efforts to address these problems were enormously successful, and dramatically expanded our understanding of the major components of Earth's interior. Using the diamond anvil cell with laser heating at the ESRF synchrotron, Guillaume and his collaborators (including Bruno Reynard, Denis Andrault, Isabelle Daniel, Daniel Hausermann, Mohamed Mezouar) conducted measurements on Earth constituents, including MgO, iron, and silicate perovskite, at simultaneous high pressure and temperature conditions. These were technically demanding measurements that required the design of new equipment and techniques. They also provided crucial information for resolving a number of basic issues in the Earth Sciences, including the stable mineral assemblage of Earth's lower mantle, and the composition of Earth's crystalline inner and liquid outer core. For example, his measurements on magnesium silicate perovskite provided a compelling demonstration that the orthorhombic perovskite structure is stable throughout most of the *P-T* range of Earth's lower mantle, thus confirming that $MgSiO_3$ perovskite is, in fact, the most abundant phase in the planet. Moreover, he derived the *P-V-T* equations of state for perovskite and periclase to 94 GPa and temperatures of 2500 K. This allowed him to estimate the ratio of Magnesiowustite to perovskite and, thus, the Si/Mg ratio in the Earth's lower mantle. This result is vital not only for mineralogists, but also for a spectrum of Earth scientists from seismologists to geodynamicists and geochemists. The early measurements by this group remain as the definitive work on the subject; a gold standard of sorts for equation of state measurements in the laser heated diamond cell.

While Guillaume was helping to establish the Ecole Normale Superieure of Lyon as one of the world's leading institutions in high *P-T* X-ray diffraction, he also pursued other innovative applications of high-pressure techniques. In particular, his work utilizing inelastic X-ray scattering to resolve the vibrational (phonon) spectrum of iron at ultra-high pressures represented a novel means of determining sound velocities from synchrotron X-ray measurements with the diamond cell, an unprecedented feat within the earth sciences. Not only was this another technical "first," but the implications for earth sciences are profound: His results indicate that the inner core of the planet is unlikely to be pure iron, but instead contains about 5% of a lighter alloying constituent. Thus, experimental innovation provided mineralogic results of direct relevance to the bulk composition of the Earth and the state of material at its center. Similarly, with Christèle Sanloup and co-workers he produced among the first constraints on the high-pressure structural behavior of liquid iron and iron-sulfur alloys. Again, these X-ray diffraction and absorption measurements, obtained using a Paris-Edinburgh cell on a synchrotron, of first-order importance for understanding the structural behavior of the most abundant liquids within terrestrial planetary interiors. Another milestone achievement is his work on characterizing the *P-T* environment in the diamond cell. Although laser heating in the diamond cell has been done for many years, it is quite another issue to accurately know the temperature and pressure environment of laser heated samples. This is due to the thermal pressure effect, which makes it difficult to characterize the pressure under laser heating. The possible magnitude of this effect had been calculated, but had not been measured despite its obvious importance. Guillaume and his collaborators quantitatively assessed the thermal pressure effect by actually measuring it in X-ray diffraction experiments on the *P-V-T* equation of state of MgO. It was shown that laser

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heating has a very significant effect on the true pressures in diamond cells, resulting in an erroneous equation of state if this effect is not measured and accounted for. This research has had far-reaching consequences for the way in which equation of state experiments are now conducted with the diamond cell, and set a new standard for accurate *P-V-T* measurements.

Several years ago Guillaume moved to the Laboratoire de Minéralogie et Cristallographie (University Paris 6 and 7, Institut de Physique du Globe de Paris) where he has established a new laboratory for high pressure diamond cell studies. He has continued to innovatively apply an ever-expanding range of techniques to make new discoveries. Most recently, James Badro and Guillaume identified a high-pressure high-spin to low-spin transition in magnesiowüstite by synchrotron X-ray fluorescence measurements. This work may have far-reaching implications for element partitioning and the structure of the lower mantle. In fact, it could effectively separate the lower mantle into two geochemically distinct parts.

In addition to studying the materials in Earth's deepest interior, Guillaume was also working on the properties of volatile-rich phases. His results document an unexpectedly large stability field for $MgCO_3$-magnesite at high pressures, implying that magnesite could be a major reservoir for carbon retention in the deep Earth. Similarly, his collaborative work with Isabelle Daniel on lawsonite, perhaps the most important mineral in transporting water from the near-surface into the deep Earth, revealed a phase transition and unexpected volume behavior at high pressures and temperatures. Guillaumes's continuing work on volatiles has provided fundamental insights into the manner in which carbon and hydrogen are transported to depth and retained within the planet.

In summary, Guillaume Fiquet has produced new insights into mineral properties through innovative, careful experimentation. His numerous, often unique experimental results provide a basis for understanding the mineralogy and chemistry of the deep Earth. His creative output continues to grow with time, and his research is at the center of essentially every major issue dealing with the mineralogic properties of the deep Earth. I should also mention that his talents and interests extend far beyond the earth sciences, and he brings the same intensity shown in his research into these other areas as well. For example Guillaume is an outstanding cook. In fact, I heard that at a young age he struggled trying to decide whether he would be a chef or a geologist. He is also quite a formidable opponent on the squash court and he skis in places where I will never dare to go.

It is an honor and my pleasure to present Guillaume Fiquet as this year's recipient of the Mineralogical Society of America Award.