PENROSE MEDAL

Presented to Walter Alvarez

Walter Alvarez

Citation by Eldridge Moores

President Naldrett, Vice President Burchfiel, ladies and gentlemen. It is my privilege and honor to introduce to you Walter S. Alvarez, the 2002 GSA Penrose Medalist. Walter is a true renaissance man who has made outstanding contributions to the field of geology.

Walter and I go way back—we were graduate students together at Princeton in the early 1960s; we got married within a week of each other, and we had a joint bachelor party, a subject on which we have a mutual pact of "omertà" (the Italian word for the Mafia's "code of silence").

In the 35 years since receiving his Ph.D., Walter has been a prolific researcher and writer on a variety of subjects. His geologic work includes contributions to South American geology, Mediterranean tectonics, structural geology, magnetostratigraphy, and, of course, impacts. Walter's Ph.D. work was on the Guajíra peninsula, Colombia, the northernmost tip of South America. He was one of the last students of the Caribbean Research Project of Harry Hess and John Maxwell (1963 and 1974 GSA Presidents, respectively). After receiving his Ph.D., Walter worked for a time for the American Overseas Petroleum Company, exploring in the Mediterranean and North Sea regions. Out of this work came several contributions to the tectonics of North Africa, Sicily, and Corsica-Sardinia, one of which was a co-edited book entitled *The Geology and History of Sicily*.

Walter moved to Lamont-Doherty Geological Observatory in 1971 and to UC Berkeley in 1977. During this time Walter continued his work in the Mediterranean with a series of important papers on paleomagnetism, magnetostratigraphy, Cretaceous-Tertiary stratigraphy, and upon structural features observed in the complexly deformed rocks of Italy and the Alps. Walter was one of the first workers to document the rotation of Corsica and Sardinia during the Neogene, a work which presages the now well-known complex microplate interactions that characterize the entire Alpine-Himalayan belt, as well as other collisional plate margins. His work on the application of fold distortion to transport direction determination and on the origin and significance of solution cleavage stand as landmark contributions. More recently he has worked on the Quaternary volcanic province around Rome.

Walter's research on Cretaceous stratigraphy and magnetostratigraphy in northern Italy led to his discovery with his coworkers, his father Luis Alvarez, Frank Asaro and Helen Michel, of an iridium-rich layer at the Cretaceous-Tertiary boundary. When they published this discovery in 1980, they provocatively suggested that the layer resulted from a meteorite impact that caused the mass extinctions at the end of the Cretaceous. This originally revolutionary, controversial hypothesis has been corroborated by an enormous amount of detailed field, laboratory, and modeling work. An iridium layer at the Cretaceous-Tertiary (K/T) boundary reportedly has been discovered in more than 100 sites around the world, as has the "smoking gun"—an impact site in Yucatán, and "splash" deposits around the Gulf of Mexico and in the Atlantic east of Florida. Several other extinction events in earth history have been ascribed to impacts.

The original paper has been cited more than 1100 times. Four interdisciplinary, so-called "Snowbird" conferences have focused on the subject of global catastrophes and earth history. The first two of these conferences were held in Snowbird, Utah, in 1982 and 1988, the third in Houston in 1994, and the most recent in Vienna in 2000. (All these conference proceedings have been published as GSA Special Papers.)

Walter has been directly involved with much of this work. It has been interesting to watch him handle the notoriety, as well as the controversy, that this issue has generated. He has become a master of what he calls "the gentle art of scientific trespassing." This he defines as working in a profoundly interdisciplinary field and overcoming the problems caused by differences in the training of one's co-workers, different scientific cultures, and different perceptions of a scientific hierarchy or pecking order, not to mention judging the quality of work in different fields and overcoming the barriers of disciplinary-specific jargon. Through it all, Walter has remained a cheerful, hard-working, extremely versatile, imaginative, and very well organized geologist. This work has placed Walter at the forefront of a revolution in geology every bit as important as the plate tectonic revolution of the 1960s; that is, the planetary revolution—our ideas of Earth's place in space. We now know that there have been and will be periodic catastrophic collisions between the Earth and asteroids or comets. And these collisions have significantly af-

fected the evolution of the Earth and its life.

Walter has received many awards and recognitions for his work, including membership in the National Academy of Sciences and the American Academy of Arts and Sciences. In addition, he is the recipient of the G.K.Gilbert award of the GSA Planetary Geology Division, and an honorary citizenship of the towns of Gubbio and Piobbico, Italy.

Walter is a man of many talents and interests. He is a multilinguist, speaking Italian, Spanish, German, and French. He is an accomplished pianist, a pilot, and an enthusiastic raconteur.

In summary, I believe that Walter Alvarez's contributions have been of great importance in a number of fields including Caribbean and Alpine-Mediterranean geology, structural geology, and magnetostratigraphy and global impact events. His impact work has fundamentally changed the way we view the history of the Earth and its life. He is highly deserving of this award. Ladies and Gentlemen: Walter Alvarez.

Response by Walter Alvarez

Thank you so much, Eldridge. It is such an honor to receive the Penrose Medal not only from a lifelong friend, but from someone who has done as much for our science and our Society as you have. And my deep thanks to GSA, as represented by President Tony Naldrett and Vice President Clark Burchfiel. And to so many other friends and colleagues that I could not begin to name them all.

I grew up in northern California, where the occasional geological violence of the San Andreas fault and the incomprehensible confusion of the Franciscan mélange contrasted with the benign climate and the subtle, almost imperceptible seasons.

All that changed — reversed, even — when I went off to college at Carleton, in Minnesota, where the horizontal Paleozoic strata and the glacial deposits are orderly and well behaved. But in exchange, Minnesota taught me about seasons, and especially about winter, where two-week stretches of 20-below-zero reminded us that the glaciers were not long gone, and would soon be back.

In a certain sense, it was then the winter of Geology as well, and as a student, I absorbed two venerable dogmas that held our science as icebound as the upper Mississippi in January. The continents, I learned, have always been exactly where they are today, and there was no merit in the foolish ideas of an eccentric German meteorologist named Alfred Wegener. And I also acquired a reverence for the doctrine of uniformitarianism — the view that nothing in the past has ever happened at a faster rate, or by a different process than we can observe today.

In 1962 I went to Princeton as a new grad student. Through an uncommonly fortunate blind date, I met Milly, a most remarkable young woman from Virginia, and we fell in love in Washington DC, where she was a grad student, among the blossoming cherry trees that brighten the banks of the Potomac in the spring.

Springtime was bursting forth in geology as well, and Princeton was its source. During my first year there, Harry Hess published his revolutionary paper with the very first statement of sea-floor spreading. By good fortune I became Uncle Harry's grad student, and was able to do my doctoral research in the Guajira Peninsula of Colombia, following in the footsteps of older grad students Bill MacDonald and Jack Lockwood. Milly and I had our honeymoon there, living in the back room of a desert trading post run by a Guajiro Indian named Robertico, who was in the smuggling business. And I discovered that I had married the perfect geologist's wife — the worse the conditions, the better she liked it.

Uncle Harry's idea of sea-floor spreading was gaining support, and the springtime of a new geology was sweeping across the world. I simply watched from my ringside seat at Princeton. But friends of mine made major contributions, like my roommate Eldridge Moores, whose studies of Mediterranean ophiolites convinced Harry Hess that ocean floor was made of basalt, not of serpentinite, as he had originally proposed.

I emerged from Princeton in 1967, into the summer of a revitalized geology, fully merged with geophysics, and pouring forth a stream of new discoveries about a dynamic Earth on which continents move about, just as Alfred Wegener had said they do. In the summer of young adulthood, Milly and I lived an adventurous life, first in Holland and then in Libya.

And then, to follow up on a growing interest in Mediterranean microplates and archeological geology, we moved to Italy, which soon became a second home. There, for many years, I have found the fascination of the Apennine Mountains matched only by the kindness of the geologists of Italy, who took me into their friendship and shared their country and its geology with me. I have the fondest memories of what the Italian geologists call "geogastronomic excursions," in which hard days of field work are followed by dinners in little mountain villages, after which we would sit around in the evening, singing the old traditional songs of the Apennines and the Alps.

In the Apennines, around Gubbio and Perugia and Assisi, we stumbled onto the pelagic limestones that provide the best record anywhere of 150 million years of Earth history, from the Jurassic to the late Tertiary. By

then I was based at Lamont-Doherty Geological Observatory and, while trying to do tectonic paleomagnetism, my Scottish Lamont colleague, Bill Lowrie and I serendipitously discovered that the pelagic limestones of the Scaglia Rossa contain a complete record of the reversals of the Earth's magnetic field.

That record matched the pattern of sea-floor magnetic anomalies, in rocks packed with planktic forams that allowed us for the first time to date the reversals. Bill and I joined forces with Al Fischer, Giovanni Napoleone, Isabella Premoli Silva, Mike Arthur and Bill Roggenthen, and for several summers in the 1970s we systematically dated a hundred million years worth of geomagnetic reversals. It was finally a contribution to the plate tectonic revolution that Uncle Harry had started, which had broken the stultifying grip of continental fixism — one of the two dogmas of my early student days.

But plate tectonics was a decidedly uniformitarian theory, with continents separating at about the rate your fingernails grow. Geologists were so fascinated by plate tectonics that few paid any attention to the impact research of Gene Shoemaker and Bob Dietz, or the evidence for impact at Sudbury that Tony Naldrett has just described, or the results of lunar exploration, where the evidence of non-uniformitarian, catastrophic impacts was becoming undeniable.

Little did I imagine that the Apennine limestones would hold the clues that would demolish the uniformitarian dogma as well. But Isabella taught me to recognize the Cretaceous-Tertiary boundary in the field, and Al Fischer pointed out the crucial significance of the KT extinction in the history of life on Earth. In the summer of 1977, Terry Engelder and I carefully collected a sample of the thin clay bed sandwiched between top Cretaceous and basal Tertiary Scaglia limestones, and I took it with me when Milly and I moved to Berkeley. Using the sample as bait, I lured my physicist father into an unaccustomed interest in geology. We decided to use iridium, depleted in the Earth's crust, as a measure of cosmic dust, to see if the clay layer had been deposited quickly (thus incorporating little cosmic dust) or slowly (so that there would be substantial dust-borne iridium).

Our Berkeley colleagues Frank Asaro and Helen Michel made the measurements in their neutron activation lab, and to our shock, they found far more iridium than either scenario could explain. It was the second serendipitous discovery in the Apennine limestones. We finally concluded that the unexpected iridium anomaly was due to the impact of a 10-km asteroid or comet at the time of the Cretaceous-Tertiary extinction — what became known as the Berkeley Theory.

In Holland, quite independently, Jan Smit had just received chemical data on a KT boundary section he had discovered in Spain, which immediately confirmed our results, so I have long thought of Jan as the co-discoverer of the iridium anomaly.

The impact theory flew in the face of uniformitarian doctrine, enraging a large number of geologists and paleontologists. The debate was intense and exhaustive, as it should be in science. Together, Jan and I and a growing number of colleagues and friends, including my Berkeley postdocs, Sandro Montanari and Philippe Claeys, defended our catastrophic challenge to uniformitarianism through the decade of the 1980s.

Finally, in the early 1990s, the Chicxulub Crater, in the subsurface of Mexico's Yucatán Peninsula, was recognized and shown to date from precisely the KT boundary. Hard-core, absolutist uniformitarianism was finally dead. Today no geologist doubts that much of Earth history did take place through slow, gradual processes, but now Earth scientists are free to consider catastrophic events, like impacts, when the evidence supports them.

But now it is autumn. The days are shorter, the air is a little chilly, and the leaves are turning to colors on the misty slopes of the Apennines.

Of the two dogmas I learned as a student, I have watched as one was demolished, and participated in correcting the other. Their demise has made it possible for geologists and paleontologists to acquire a deep, rich understanding of Earth history, inconceivable when I was a student.

And although new challenges await, perhaps it is a good time to pause and breathe in the fresh, cool air of October, to thank you all for the honor of the Penrose Medal, and then perhaps to gather up Milly and a few old friends, and go and find the Italian geologists in a little trattoria, in some village way back in the Apennines. The day's field work is done. The local wine is waiting, the pasta sauce with the freshly gathered fall mushrooms fills the air with its irresistible aroma, and sausages are sizzling on a grill in the fireplace.

And if you listen, you can hear the soft, sweet harmonies of an old Italian song the geologists like to sing, in the evening.