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PERSPECTIVES

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Cesare Emiliani (1922–1995): the founder of paleoceanography

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Cesare Emiliani was born as a son to Luigi and Maria (Manfredidi) Emiliani on December 8, 1922 in Bologna, Italy. He studied geology at the University of Bologna, specializing in micropaleontology. He received the D.Sc. from the University of Bologna in 1945. His earliest publications concerned philately, an interest that continued throughout his life. After graduation he worked as a micropaleontologist with the Societa Idrocarburi Nationali in Florence from 1946–48. During this time he published several papers on taxonomy and stratigraphy of foraminifera of the Cretaceous argille scagliose near Bologna, and from Pliocene sections near Faenza.

In 1948 he received the Rollin D. Salisbury Fellowship in the Department of Geology at the University of Chicago and obtained the Ph.D. in 1950. It was in Chicago that he met, and on June 28, 1951, married his wife, Rosita. They had two children, Sandra and Mario. From 1950 to 1956 he was Research Associate in Harold Urey's Geochemistry Laboratory in the Enrico Fermi Institute for Nuclear Studies at the University of Chicago. It was in this laboratory that the pioneering work was being done to establish relationships between stable isotopes and environmental variables. The early work of Urey and his students had involved studies of the relation between oxygen isotopes and temperature in recent molluscs, and the application of this relationship to the determination of paleotemperatures in the Cretaceous. Emiliani initiated use of this technique to the shells of foraminifera in ancient sediments from the ocean floor and concluded that the deep waters of the ocean had been much warmer in the early Tertiary. The discovery that the deep ocean was not the constant unchanging environment that had been assumed marked the beginning of a new field of science: paleoceanography.

Further major discoveries followed rapidly. Using the piston corer developed by Kullenberg, the Swedish Deep Sea Expedition (1947–1949) and the Lamont Geological Observatory had taken long cores in the deep-sea carbonate oozes of the Pacific and Caribbean. Emiliani took on the job of applying the oxygen isotope technique to the tests of planktonic foraminifera sampled at 10 cm intervals down the length of the cores. He found a systematic periodic variation in the ratio of ^{18}O:^{16}O following a characteristic sawtooth pattern. It was known that the changing ratios reflected two major factors, the temperature of the seawater and the volume of glacial ice. Cooler temperatures and greater ice volumes both

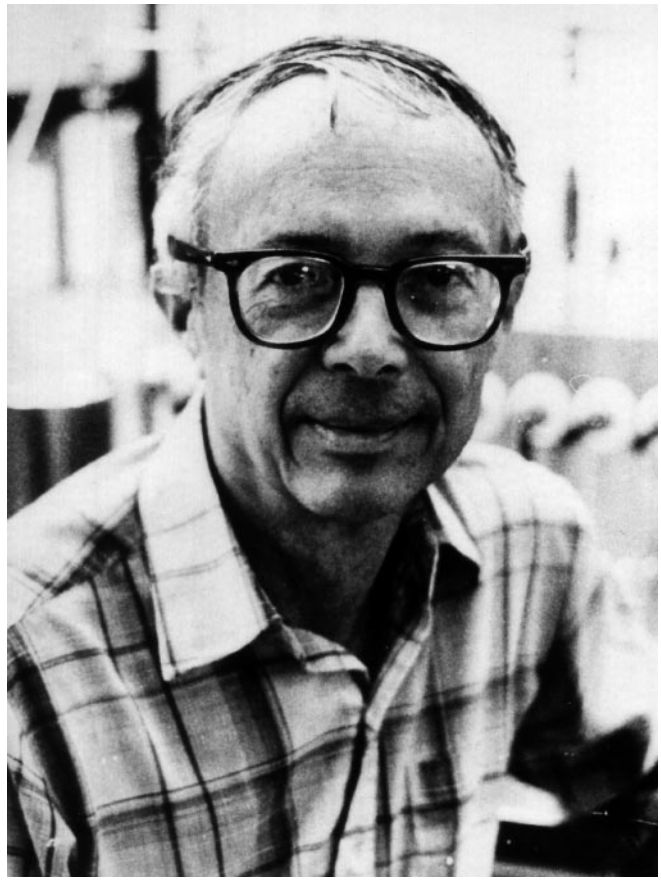

Fig. 1 Cesare Emiliani (1922–1995)

result in more positive ^{18}O:^{16}O ratios. He supposed that 60% of the signal was due to the temperature effect, 40% to the ice effect. He concluded that equatorial and tropical ocean surface temperatures had been several degrees cooler during times of glaciation. At the time he did this work, it was thought that there had been only four major glaciations during the Pleistocene. Emiliani's analysis indicated that there had been many more cycles of glaciation; he found seven, extending to the base of the Caribbean cores and fifteen in the Pacific cores. He concluded that the cyclic glaciations were related to orogenic uplift, changing insolation (Milankovitch cycles), ice-albedo feedback, and the effect of isostatic adjustments to the loading of continental crust by glacial ice sheets—all topics still being actively discussed today. His discoveries revolutionized ideas about the history of the ocean and of the glaciation.

In 1957 Emiliani moved to the University of Miami's Institute of Marine Science, later to become the Rosenstiel School of Marine and Atmospheric Sciences. There, he organized the program in marine geology and geophysics, built a major laboratory for isotope geology, and continued to develop the ideas about the nature and cause of the Quaternary glaciations. At this time, a major activity in American science was "Project Mohole", the effort to drill a hole to the Mohorovicic Discontinuity, the surface separating the Earth's crust from mantle. Cesare Emiliani, however, was convinced that much more could be learned from recovering long cores which would record the history of the ocean. As the cost projections for "Project Mohole" escalated and the project collapsed, Emiliani submitted a proposal termed "LOCO" (for Long Cores) to the U.S. National Science Foundation. A suitable ship, the SUBMAREX, was chartered for test drilling of cores on the Nicaragua Rise. The success was such that it was immediately recognized that the recovery of drilled cores from the deep sea would provide evidence of the history of the ocean and also serve to test the hypotheses of sea-floor spreading and plate tectonics. The result was formation of JOIDES (Joint Oceanographic Institutions for Deep Earth Sampling) and its three sequential projects, the JOIDES drilling on the Atlantic continental margin off Jacksonville, Florida (1966), the Deep Sea Drilling Project (1967–1983) and the Ocean Drilling Program (1984–2003).

In 1967 he organized the Department of Geological Sciences on the main campus of the University of Miami and remained its Chairman until his retirement in 1993. He was an extraordinary, exciting teacher; he used Earth Sciences as a focus for introducing large numbers of students to the sciences as a whole.

Cesare Emiliani was a renaissance scientist in the truest sense. He was a scholar familiar with classical languages, and extraordinarily well versed in history. His interests were very broad, ranging far beyond the field of stable isotope geology to tectonics, catastrophes, extinction, evolution, human history and human impact on the planet. Among other innovative ideas, he proposed drilling to the oceanic Mohorovicic Discontinuity from land (Eleuthera Island in the Bahamas), controlling earthquakes by the use of nuclear explosions, that viruses might be responsible for extinctions, and that evolution might be more a process of niche-filling after extinctions rather than direct competition.

He worked to introduce calendar reform, in part to eliminate the BC-AD chronology hiatus caused by the lack of a zero year, but more importantly to eliminate the use of religion-based systems in a multicultural context. He was also very much concerned about the unrestrained growth of the human population and its effect on the environment of the planet.

He was very much concerned that scientists and the public in general were losing touch with the development of knowledge as a whole. To combat this he wrote *The Scientific Companion* (1988) which is a broad review of science that makes entertaining and excellent reading for specialists and laymen alike. Much of his extraordinary character and his broad interests are revealed in *Planet Earth* (1992) which is a fascinating introduction to mathematics, physics, chemistry, and biology, and as well as earth science, all set in the historical context of the development of ideas.

Cesare Emiliani was honored by having the genus *Emiliania* erected as home for the taxon *huxleyi*, which had previousiy been assigned to *Coccolithus*. He was further honored by receiving the Vega Medal (Sweden) in 1983, and the Agaasiz Medal of the U.S. National Academy of Sciences in 1989. He died unexpectedly of a heart attack on July 20, 1995 at his home in Palm Beach Gardens, Florida.

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