Journal of Foraminiferal Research, v. 51, no. 1, p. 1–3, January 2021

2020 JOSEPH A. CUSHMAN AWARD TO ELLEN THOMAS

Ellen Thomas is the recipient of the 2020 Joseph A. Cushman Award for Excellence in Foraminiferal Research for her lifetime dedication to the study of foraminifera and her outstanding contributions in this field. She is a leading authority on deep-sea benthic foraminifera, especially their taxonomy and curation, evolutionary history, and multiple applications. Additionally, the award recognizes her multiple collaborative studies that have been at the forefront of international efforts to reconstruct past climates.

Ellen completed her education at the University of Utrecht with a general background in classical geology and micropaleontology and finished her doctoral thesis (1979) on the evolution of *Uvigerina* in the Cretan Mio-Pliocene under the guidance of Prof. Cor Drooger, the 1991 recipient of the Cushman Award. Upon finishing her Ph.D., Ellen worked with various research institutions in the United States and Europe and was also involved as a staff scientist on the Deep Sea Drilling Project (Scripps Institution of Oceanography). She worked with Nick Shackleton in Cambridge (U.K.) for several years in the '90s. Ellen is currently a Senior Research Scientist at Yale University, Research Professor at Wesleyan University, and Harold T. Stearns Professor of Integrated Sciences. Over the course of her remarkable career, her name has become synonymous with professional excellence, leaving a long trail of high-quality scientific achievements, mainly using benthic foraminifera. This track record, together with her participation in several scientific ocean drilling expeditions (DSDP Legs 85 and 94; ODP Legs 113 and 208) and her uncanny ability to carry out multi-disciplinary research, has culminated in Ellen breaking new ground and shining new light in the fields of paleoclimatology and paleoceanography.

Driven by her strong curiosity in all fields of geological and biological sciences, Ellen has addressed a wide variety of questions related to the climatic, geochemical, and biological evolution of the last 70 million years, investigating the impact of changes in environment and climate on living organisms on various time scales from millions of years to decades with focus on benthic foraminifera and geochemical studies on their shells. She has focused on biotic crises triggered by environmental stressors, such as the last major greenhouse climate interval in the Earth's history. In the early '90s, her studies were instrumental in the discovery of a greenhouse global warming event of 5–6°C, which started at what is now recognized as the boundary between the Paleocene and Eocene epochs (56 million years ago). This transient warming event, now known as the Paleocene-Eocene Thermal Maximum (PETM), was first documented in two marine sediment cores taken near Antarctica where Ellen recognized the largest mass extinction of deep-sea fauna within the last 90 million years. The stable carbon isotope ($\delta^{13}C$) record from that core indicated an abrupt change in the oceanic $\delta^{13}C$ budget consistent with the release of a massive amount of carbon. The PETM represented a hitherto unprecedented analog for modern climate change, though possibly at a slower rate than current anthropogenically induced change, and represented the first opportunity to directly investigate the implications of 5–6°C of global warming. Her collaborative studies with a large group of researchers, including Jim Zachos, contributed to a decades-long, international effort to constrain the timing and magnitude of global carbon emissions during the PETM. Given the fact that the modern ocean is absorbing anthropogenic CO_2 which lowers the pH of seawater, a process referred to as ocean acidification, they aimed at constraining changes in ocean carbonate chemistry (pH) to estimate the mass of carbon released. Massive emissions in the past would have caused ocean acidification, the extent of which should scale with the mass and rate of carbon emission. To test this hypothesis, they designed and implemented Ocean Drilling expedition Leg 208 in 2003 to recover sediment cores to reconstruct the magnitude of ocean acidification during the PETM and thus estimate the total mass of carbon released. They concluded that the magnitude and rate of C emissions for this event was on the scale of current and projected anthropogenic emissions. Subsequently, they used the PETM as a road map for understanding future climate change, making important contributions toward reconstructing its potential effects on biota and supporting the hypotheses that modern greenhouse carbon emissions are invariably changing Earth's climate, that its impacts will be severe, and implications long lasting. Ellen first presented

the hypothesis that the PETM was not unique, thus opening a new line of research, the study of less intense warming events which she named "hyperthermals", now a major focus of research for the paleoclimate community. She has participated in a great number of the most significant papers in this field, contributing data sets and exploring novel hypotheses, and placing these anomalies within the context of longer-term global temperature trends of the past 65 million years. She collaborated with Kate Darling and Chris Smart to establish that some biserial planktic foraminifera are genetically identical to benthic species, the so-called tychopelagic lifestyle, and collaborated with Laia Alegret in a long series of papers on deep-sea benthic foraminifera across the Cretaceous/Paleogene boundary.

Her research interests include the reconstruction of various aspects of past climate, such as the study of cold intervals, the origin of Antarctic ice sheets, and their effects on deep-sea biota. She has proven to be versatile in research, through the study of living foraminifera and the geohistorical record of anthropogenic-related change. In major contributions to understanding of anthropogenic impacts on the ocean she teamed up with her husband (Johan Varekamp) to study the causes of profound changes in the shallow-water benthic foraminifera within the last millennium in Long Island Sound (CT, NY); they were also pioneers (early 1990s) in the use of the foraminiferal record to document latest Holocene sea-level rise in Connecticut and Massachusetts salt marshes. Ellen has additionally undertaken collaborative research with her husband in volcanology and igneous geochemistry. More recently, she has pioneered a 3-D technique for imaging and printing microfossils for education and outreach. She is always a most welcome speaker in workshops and symposia.

Ellen has published more than 160 frequently cited papers in peer-reviewed journals [including the paper in *Science* by Zachos et al. (2001) which was identified by Thomson Reuters in 2008 as one of the most highly cited papers in geosciences—now over 8000 citations), and more than 400 abstracts. She is one of the most cited living scientists in her field with an h-index of 62 and a remarkably innovative and productive scientist. She has an extensive service record in professional societies, boards of directors, and editorial boards along with many other panels (e.g., NSF, ODP, and IODP) and external committees. She was honored as Exceptional Reviewer by Geology in 2007 and received the Editor's Citation for Excellence in Refereeing by Paleoceanography in 1995. Her unfailing capacity and contribution to our discipline as an editor can be seen in the number of terms as editor of major journals such as Marine Micropaleontology (2003–2010), Geology (2012–2015) and Paleoceanography and Paleoclimatology (2015–2019). Her scientific accomplishments have been recognized with the 2016 Brady Medal (The Micropalaeontologial Society, U.K.), the 2013 Association for Women Geoscientists' Professional Excellence Award in academia/research, and the 2012 Maurice Ewing Medal (AGU and ONR). She is a Fellow of the American Association for the Advancement of Science (2011), the American Geophysical Union (2012), and the Geological Society of America (2019).

Many students, young researchers, and junior faculty have benefitted from Ellen's courses and mentorship and enjoyed working with such an enthusiastic and dedicated scientist who masters both basic and applied micropaleontology and naturally blends it with high-quality geochemistry to advance many fields, notably paleoceanography. Ellen's role as an educator has been internationally recognized, and in 2013 she was honored as Leverhulme Visiting Professor, School of Earth Sciences, University of Bristol, U.K.

In summary, Ellen Thomas is a remarkably innovative, productive, and passionate scientist who has established a vibrant, interdisciplinary, and internationally recognized high-quality research program in micropaleontology and paleoceanography. Her collaborative contributions in paleoclimatological research have provided a historical context through which modern climate change may be evaluated, documented the effects of climate change in the largest habitat on Earth, quantified a clear relationship between atmospheric CO_2 concentrations and global warming, and illustrated the impacts that modern climate change will have on ocean pH. Ellen has strongly influenced generations of micropaleontologists, and she will continue to do so in the years to come.

SELECTION OF ELLEN THOMAS' SIGNIFICANT PUBLICATIONS

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