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Obituary: Nicholas Shackleton (1937–2006)

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Abstract

A founding father of palaeoclimatology, and an avid clarinettist.

Much of what we have learned about the dynamics of Earth's climate system has come from the study of ancient climates. In the early 1960s, Nick Shackleton, then a graduate student at the University of Cambridge, UK, developed a mass spectrometer that could analyse the oxygen isotope ratios ($^{18}\text{O}/^{16}\text{O}$) in small numbers of foraminifera, tiny calcareous creatures that can be found fossilized in deep-sea sediments. This innovation triggered a revolution in our understanding of ice-age cycles and provided a cornerstone for the relatively new discipline of palaeoclimatology.

Throughout his career, and until his death on 24 January 2006, Shackleton remained at the forefront of the field, supported by his lab manager Mike Hall. He was elected a Fellow of the Royal Society in 1985 and was knighted in 1998. Among his many awards were the Crafoord prize in 1995 and Japan's Blue Planet prize in 2005. He remained at Cambridge as Professor of Quaternary Palaeoclimatology until his retirement in 2004.

Nicholas John Shackleton studied physics at Clare College, Cambridge, graduating in 1961. In 1967 he received his PhD for a thesis entitled 'The measurement of palaeotemperatures in the Quaternary era'. With his mass spectrometer, Shackleton was able to routinely measure oxygen isotope ratios of both planktonic and the much rarer benthic foraminifera. Given the isotopic co-variation of these organisms in the ocean surface and abyss, Shackleton realized that the dominant control on oxygen-isotope variations was not temperature, as suggested by Cesare Emiliani in the 1950s, but instead was changes in the isotopic composition of the oceans caused by preferential removal of the lighter ^{16}O in the water that makes up continental ice sheets. He had thus discovered a method for reconstructing the history of global (mainly Northern Hemisphere) ice volume through the succession of ice ages.

At the end of the 1969 meeting of the International Quaternary Association in Paris, Shackleton found himself the only person in the audience at a talk given by John Imbrie, a palaeontologist. Imbrie presented a statistical method for estimating temperatures using census information on the same species of surface-dwelling foraminifera that Shackleton had been measuring. Shackleton and Imbrie realized that their methods could be combined — Shackleton's isotopic method allowed for the establishment of a temporal framework based on ice volume, whereas Imbrie's statistical methods would yield the temperature information. Thus, in effect, was born the CLIMAP Project, a multi-institutional programme that in the 1970s produced the first global map of sea surface temperatures during the Last Glacial Maximum, around 21,000 years ago.

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In 1973, Shackleton made the fundamental discovery that the dominant ice-volume cycle revealed by the oxygen isotopes lasted roughly 100,000 years. He analysed a sediment core from the western tropical Pacific in which Neil Opdyke had identified the signature of the most recent reversal of Earth's magnetic field, an event that occurred about 780,000 years ago. With an improved timescale that could now be applied to other deep-sea records, Shackleton, together with James Hays and Imbrie, were able to rigorously test the Milankovitch hypothesis — the idea that the great ice ages of recent Earth history were caused by subtle changes in the distribution of solar radiation across Earth's surface, in turn caused by orbital variations well known to astronomers.

They managed to use oxygen isotope and other records to detect the anticipated changes in orbital periodicities — of 19,000 and 23,000 years (precession), 41,000 years (obliquity) and 100,000 years (eccentricity) — in continuous sediment sequences. This provided the benchmark evidence that orbital changes act as a 'pacemaker' of climate change. Shackleton recognized that the orbital pacing of climate change made it possible to calibrate climate records from sedimentary sequences using the timing of the orbital cycles. Applying this principle, he gradually extended the orbitally tuned age-scale back some 30 million years. This has provided accurate dates for reversals of Earth's magnetic field, and for the evolution and extinction of marine organisms. It is a technique that has revolutionized the practice of stratigraphy.

Shackleton also pioneered the use and interpretation of carbon isotopes in palaeoclimate studies, an undertaking in which he moved on from studying the orbital forcing of glacial cycles to the positive feedbacks that amplify this forcing into dramatic changes in climate. He recognized that the carbon isotopic composition of the oceans is affected by the amount of carbon stored in forests and soils. And he was the first to use carbon isotope ratios in benthic foraminifera to assess the changing land reservoir of carbon between glacial and interglacial times. Shackleton also provided data that confirmed Wallace Broecker's proposal that the carbon isotopic difference between the surface and deep ocean could provide insights into the cause of the glacial–interglacial changes in carbon dioxide reconstructed from ice cores. Later, by combining deep-sea and ice-core records, he demonstrated that orbital eccentricity, the least well understood of the orbital forcings, probably affects climate through its influence on atmospheric carbon dioxide.

Shackleton, in his trademark sandals, was spirited and curiosity-driven. He let his students and an entire community share in his brilliance and vision. Through his meticulous work — he inspected every sample analysed in his lab — he was a champion of 'small science', showing by example that the most important data and the best ideas do not necessarily require high-priced enterprises.

It is revealing that Shackleton was an avid clarinettist, and taught a course on the physics of music at Cambridge. Music, more than any other art form, reveals itself through time and cyclic change. We owe a debt of gratitude to Nick Shackleton for his efforts to read the complex score of the Pleistocene climate symphony, and for helping to identify its composer — the variations in Earth's orbit and rotation. The challenge remains to reconstruct the orchestral players: the factors within the Earth system that work together to produce alternately the deep freeze of ice ages and the equable climates of interglacial periods, the last of which hosted the rise of human civilization.

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