Sea-level Change during Glacial Cycles

Kurt Lambeck

2012 Balzan Prize for Solid Earth Sciences, with emphasis on interdisciplinary research

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Affiliated Institution: Australian National University
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Kurt Lambeck is Emeritus Professor at Australian National University. He is currently (2018) also visiting professor at both the Instituto Nazionale di Geofisica e Vulcanologia in Rome, Italy, and at the Department of Geology, Lund University, Sweden. The research component of the second part of his Balzan Prize addresses three important elements of the broad subject of sea-level change.

The first involves geophysical modelling of interactions between ice sheets, the solid earth and sea level. One of the goals of the project is to develop a version of the numerical models suitable for use by 'non-experts', so as to make the methodology available to geologists and archaeologists. Another goal is to develop the next iteration of ice sheet models with a particular focus on the Antarctic ice sheet, which up to now has played a rather passive role in the discussion of past sea levels, despite its being important in assessing the future of this ice sheet in a framework of a warming planet. Other targets include an improved ice sheet model for southern Greenland and improvements in the North American ice sheet model. These models provide improved reference points for testing climate models under conditions very different from today as well as the basis for palaeogeographic reconstructions during recent glacial cycles to explore possible constraints on human migrations. A major step forward has been the publication of the new ice-sheet model for North America from the time of the last Glacial Maximum to the end of deglaciation. The significant outcome has been the establishment of operational models for the mantle viscosity. Current related research includes the analysis of geodetic data pertinent for understanding the earth's response to this glacial system, and continuing work on the Antarctic ice history.

The second element, dealing with past interglacials as analogs of the present interglacial, has been temporarily suspended because of a shift in priorities, but it remains important. Of these, the most significant is the Last Interglacial some 120,000 years ago because its traces are best preserved in the geological record. Its climate was similar to today, but possibly a few degrees warmer, and sea levels were 4-6 meters higher than today. But the precise timing of this occurrence and any variability within the interglacial interval remains poorly constrained. Yet this information is important in the context of current climate change debate for understanding the sensitivity of ice sheets to changes in temperature. Field sites for which the team had collected new information include: Western and Northern Australia, the Seychelles, and the Mediterranean. Currently Lambeck's researchers are examining some new evidence from southernmost South America.

The third theme is the present interglacial (the Holocene). Ocean volumes have remained approximately constant during the past 6,000 years, but periodically the argument arises that large amplitude (1-2 m) changes have occurred within relatively short time periods (a few hundred years). If correct, this has major implications for the instability of the climate system when the planet is not in an ice age. There are many reasons why this question remains debated. One is of the nature of the observational evidence. Another is land movement caused by tectonic and global dynamic processes. A third is the ongoing interaction between the past ice sheets and the solid earth and oceans. New observational evidence from Tasmania has been collected. Along with a re-analysis of Roman-epoch archaeological data from the Mediterranean, this evidence will address the question of the sea-level (and hence climate) stability or instability during the current interglacial period that forms the background to any anthropogenic contributions.

Lambeck's Balzan Prize funding has provided for the support of two researchers at the Australian National University (ANU) to work on the modelling aspects of the various components of the earth-ocean-ice system. One is the mid-career researcher Dr. Anthony Purcell; the other, a more junior researcher Dr. Helene Rouby. Purcell has developed a good track record as an independent researcher who is able to attract his own research funds. For Rouby, Balzan funds have mainly been used to partly fund her first two years in France at the École Normale Superiéure, a number of extended visits stays in Canberra, participation in workshops, and support of on-going research. She has been able to successfully interact with archaeologists and geologists on questions of how the past changes in sea level impact on the interpretation of their

observations, as well as with geodesists on understanding some of the earth-ocean-ice system's processes that impact observations of the Earth taken from satellites. Both scholars exemplify the interdisciplinary research recognized in Lambeck's Balzan Prize.

Funding has also been directed towards supporting young researcher fieldwork in several areas: the Seychelles; support for Ms. Y. Sun for an extended stay in Canberra to learn about extracting earth-information from observations of sea-level change; field support including laboratory work to support Ms. Brigid Morrison for the Tasmanian work; laboratory dating work in support of archaeological-geological investigations in the Red Sea as part of a project to determine environmental conditions in this area during pre-history times of exodus from Africa (run by York University); and support for a young student to attend a summer school on underwater archaeology (run by the University of Geneva, where Lambeck has been lecturing) that will lead to ongoing work in Greece.

As mentioned, current work includes a reexamination of the Mediterranean evidence, including new fieldwork integrating geology and archaeology. With a portion of the funds still available, Lambeck will make a renewed attempt at organizing a meeting of young archaeology and geology researchers working in the Greek and Italian parts of the Mediterranean.

Publications

Underlined names refer to recipients of Balzan funding for research support or salary.

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Prendergast, M.E., Rouby H., Punnwong P., Marchant. R., Crowther, A., Kourampas, N., Shipton. C., Walsh, M., Lambeck, K., Boivin, N.L. 2016. Continental island formation and the archaeology of defaunation on Zanzibar, eastern Africa. *PLOS One,* 11(2).

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