Understanding Future Sea Level Rise: the challenges of dating past interglacials

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The aim of PALSEA (http://www.climate.unibe.ch/~siddall/working_group.html) is to extract information about ice sheet response to temperature change by examining the history of sea level over the Quaternary, particularly interglacial periods, with a range of temperatures bracketing the modern. A better understanding of the relationship between global temperature and sea level is crucial for projections of future sea level rise expected from global warming. Currently, substantial uncertainty exists for such projections, primarily due to a lack of understanding about ice sheet dynamics. The 2nd PALSEA workshop meeting focused on challenges in U-Th coral dating, and was funded by IMAGES, PAGES, and WHOI's Ocean and Climate Change Institute. The discussion centered on three themes: technical issues in U-Th mass spectrometry, open-system behavior of U-series nuclides, and development of a Quaternary sea level database.

Analytical developments

New developments in mass spectrometry continue to improve coral age precision and extend the range of the U-Th geochronometer (Andersen et al. 2008). As a result, assuring comparability of ages reported by different labs becomes a crucial issue. Ideally, all measurements should be traceable to the same set of reference standards. Unfortunately, internationally recognized standards are not currently available. A widely used U/Th uraninite reference standard, HU-1, is now in short supply and may no longer be suitable as a reference standard, as different aliquots appear to have different isotope ratios when measured at current levels of precision and the assumption of radioactive equilibrium no longer appears valid. The time is ripe for the development of such standards. As a result of workshop discussion, a strategy for their production and distribution has been initiated in collaboration with the NERC Geosciences Laboratory, UK, and drawing on the experiences of the EARTHTIME project (http://www.earth-time.org). As part of our meeting we ran an informal U-Th dating inter-lab comparison involving 14 labs. Aliquots of mineral solutions (aragonite, uraninite) and powder (carbonate) were distributed and measured. The insight gained from this exercise was extremely useful, and a more comprehensive inter-comparison is being planned.

Open-system effects

The impact of open-system behavior of U-series isotopes on the quality of coral ages has long been recognized, and both sample screening (Gallup et al. 1994) and age correction (Thompson et al. 2003) methods are employed to alleviate this problem. While practices for sample screening and/or age correction are still keenly debated, workshop participants

agreed on a number of key points: 1) It is clear that many corals yield ages that do not agree within the analytical uncertainty when several individual pieces of the same coral are measured, so it is crucial that ages be replicated to establish the level of age uncertainty associated with sample heterogeneity. 2) The stratigraphic context of corals provides a key constraint on relative ages that has been largely underutilized. Publications should include the stratigraphic context of samples, rather than just their elevations. 3) Both sample screening and age correction approaches rely heavily on the $^{234}U/^{238}U$ ratio of seawater; yet the history of ocean uranium isotopic composition is not well known. Furthermore, $^{234}U/^{238}U$ values for screening and correction are not consistent between different lab groups. It would be highly desirable to adopt a uniform history of ocean $^{234}U/^{238}U$ for quality and correction criteria, and to incorporate seawater $^{234}U/^{238}U$ uncertainty into error estimates for the ages.

Compilation

One of the key goals of PALSEA is to establish a comprehensive Quaternary sea level database. This data is presently scattered across the scientific literature with widely varying reporting formats, screening and correction criteria, and decay constants. Stratigraphic information is often incomplete, and elevations are not tied to consistent benchmarks. It would be highly desirable to compile existing data in a uniform format that can be made available to the wider community, and to adopt a uniform set of standards for future data reporting. An effort to compile existing data is underway by PALSEA. Data reduction and archiving software has been developed as part of the EARTHTIME project, and discussions are underway to adapt this software for the U-Th chronometer.

Ice sheet recommendations

Relative sea level histories permit the reconstruction of former ice sheets – a fundamental boundary condition for modeling past climate. PALSEA suggests the following ice sheet guidelines for the Paleoclimate Modeling Intercomparison Project (PMIP): (1) Alternative ice sheet boundary conditions, generated by independent glacial isostatic adjustment (GIA) models must be considered. (2) An existing database (Dyke et al. 2002) that uses evidence of ice-sheet extent should be used. (3) GIA models use different relative sea level databases, many with inconsistent or outdated reconstructions. To address this problem PALSEA aims to develop an open-access, quality-controlled, and self-consistent database of relative sea level for use in isostatic models.

Public Outreach

The meeting included a public outreach event: *Where land and sea meet: managing shoreline change over the next 100 years*, funded by the WHOI Morss Colloquium. This well-attended event brought together PALSEA scientists with economic, legal, and policy experts for a series of brief presentations and a panel discussion responding to audience questions.

References

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