Tuesday, May 11, 2004

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by ***Gerald R. Dickens, PhD***
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Rethinking the Global Carbon Cycle with Gas Hydrates and Seafloor Methane Throughout Time

Prominent negative ^{13}C excursions characterize several past intervals of abrupt (<100 kyr) environmental change. These anomalies, best exemplified by the >2.5% drop across the Paleocene/Eocene thermal maximum (PETM) ca. 55.5 Ma, command our attention because they lack explanation with conventional models for global carbon cycling. Increasingly, Earth scientists have argued that they signify massive release of CH_4 from marine gas hydrates, although typically without considering the underlying process or the ensuing ramifications of such an interpretation. At the most basic level, a large, dynamic "gas hydrate capacitor" stores and releases ^{13}C-depleted carbon at rates linked to external conditions such as deep ocean temperature. The capacitor contains three internal reservoirs: dissolved gas, gas hydrate, and free gas. Carbon enters and leaves these reservoirs through microbial decomposition of organic matter, anaerobic oxidation of CH_4 in shallow sediment, and seafloor gas venting; carbon cycles between these reservoirs through several processes, including fluid flow, precipitation and dissolution of gas hydrate, and burial. Numerical simulations show that simple gas hydrate capacitors driven by inferred changes in bottom water warming during the PETM can generate a global ^{13}C excursion that mimics observations. The same modeling extended over longer time demonstrates that variable CH_4 fluxes to and from gas hydrates can partly explain other ^{13}C excursions, rapid and slow, large and small, negative and positive. Although such modeling is rudimentary (because processes and variables in modern and ancient gas hydrate systems remain poorly constrained), acceptance of a vast, externally regulated gas hydrate capacitor forces us to rethink ^{13}C records and the operation of the global carbon cycle throughout time. ■

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Biographical Sketch

Gerald R. Dickens, PhD, is Associate Professor, at the Department of Earth Sciences, and the Shell Center for Sustainability, Rice University, Houston, TX. He received his BS degree from the University of California, Davis in 1989 and went on to the University of Michigan to earn his MS and PhD in 1993 and 1996, respectively. In only a few short years he has become one of the world's preeminent researchers in paleoceanography, marine geology and low-temperature geochemistry (^{13}C, etc) as a result of his brake-through research on methane hydrate, Permo-Triassic deep-ocean warming and its relation to the one of the world's great mass extinctions. Over less than 10 years, Dr. Dickens has prepared more than 30 papers, made numerous presentation around the world and contributed chapters to books and other publications on the general subject. He is serving as a member of the Editorial Board, *Geo-Marine Letters,* Springer-Verlag, and *Geology*, for the Geological Society of America. He also serves as an Associate Editor for the journal *Paleoceanography*, published by the American Geophysical Union. He also serves as panel member on the Earth Systems History (ESH) Science Steering Committee of the National Science Foundation and as the 2002/2003 Distinguished Lecturer of the Joint Oceanographic Institutions. He guides and supports a number of graduate students on a variety projects and teaches courses in oceanography, paleoceanography and biogeochemical cycles.