The role of pCO_2 during the eocene-oligocene climate transition

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In general, long- and short-term global temperature changes are commonly ascribed to parallel changes in pCO_2. Support for this CO_2-climate relationship can be found in the decline in alkenone-based pCO_2 estimates from the mid-Eocene to the Miocene, which generally tracks increasingly colder bottom-water, ice volume, and global temperatures. However, published pCO_2 records for the Eocene-Oligocene (E-O) climate transition—an episode of rapid and massive ice accumulation on Antarctica—appears to defy our expectations. Coarsely resolved CO_2 estimates associated with the E-O suggest that an increase in CO_2 occurred prior to global cooling, while the largest drop in CO_2 during the Cenozoic followed the climate transition. This introduces the paradoxical proposition that an increase in pCO_2 was responsible for Antarctic glaciation, while the climate shift and changes in weathering regimes was responsible for the subsequent pCO_2 decrease.

The devil appears to be in the details. The long-term record for the Paleogene derives from a composite of DSDP sites 516, 511, 513, 612, and ODP site 803. However, continuous alkenone records from the Eocene to Oligocene that encompass the E-O are not represented. Instead, the period across the E-O climate transition is predominantly represented by data from high-latitude sites.

We have begun to expand the details of the interval from high-latitude and tropical sites that capture the E-O climate transition in greater detail. Our preliminary data from Site 277 (Southern Ocean) and 925 (western equatorial Atlantic) indicate a clear divergence in the carbon isotopic composition of alkenones between high-latitude and low-latitude sites. In general, high-latitude sites are characterized by more negative δ^{13}C values and thus yield higher calculated CO_2 values. Such differences could be attributable to differences in CO_2 equilibrium between localities, or to effects related growth rate. As a consequence of these influences, it is preferred to select stable, well-stratified ocean localities when constructing CO_2 records. Accordingly, elimination of high-latitude sites from the long term record, in conjunction with new results from Site 925 indicate that CO_2 fell sharply across the E-O climate transition coincident with global cooling and ice accumulation.

Further, alkenone-based SST estimates across the E-O climate transition reveal strong differential latitudinal responses, with little to no change in tropical temperatures during the event. Data collection continues and more detailed temperature and CO_2 records will be presented.

Volatile loss Following the Moon-forming giant impact

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Among the most striking observations made of the Apollo samples is the dearth of volatile elements in lunar materials [1], including moderately volatile elements that condense from the solar nebula at relatively high ($T > 1,000$ K) temperature. Although such an observation is generally thought to be consistent with the energetic events associated with a giant impact, no quantitative chemical and dynamical scenario has been put forward to explain it.

The energy released in the Moon-forming giant impact is sufficient to melt and partially vaporize both the Earth and the impactor. The timescale to eliminate this heat by radiation is $\sim 10^3$ years [2]. Hence, the Earth-Moon system is expected to be in a molten, partially vaporized state for the first thousand years following the giant impact. Because the amount of mass loss necessary to explain the lunar volatile depletion is small (<1% lunar mass), thermal escape is an attractive possibility from the standpoint of energy considerations. Furthermore, the similarity of K isotopes [3] between lunar and terrestrial samples does *not* argue against extensive devolatilization after the giant impact [4].

We investigate the conditions necessary for the loss of volatile elements in a hydrodynamic wind, and explore the chemical consequences of such a wind. It has been known for decades that hydrogen – in molecular form – is gravitationally unbound in the circumterrestrial lunar disk [2]. However, the speciation of hydrogen in the post-impact silicate vapor atmosphere depends on the redox state, which in turn depends on the behavior of the major elements: the FeO-MgO-SiO_2 liquid solution, liquid metallic iron and the co-existing vapor. We will present model calculations that explore physical and chemical conditions necessary for devolatilizing the lunar material after the giant impact.

[1] Ringwood, A.E. (1979) *Origin of the Earth & Moon*. Springer-Verlag, New York. [2] Stevenson, D.J. (1987) *Annu. Rev. Earth Planet. Sci.* **15,**271-315. [3] Humayun, M., Clayton, R.N. (1995) *Geochim. Cosmochim. Acta* **59** 2131-2148. [4] Pritchard, M. Stevenson, D.J. (2000) *Origin of the Earth & Moon* Ed. R.M. Canup, K. Righter The University of Arizona Press, Tucson, 179-196.