Is CO_2 the Phanerozoic climate driver?

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There are good reasons to suspect that atmospheric pCO_2 has been a primary climate driver in the geologic past, but the evidence is not conclusive. Numerical carbon cycle models and pCO_2 proxies generally support the suspected relationship between climate and atmospheric pCO_2. However, the oxygen isotope paleotemperature record from 600 Ma to the present displays notable intervals for which temperature and inferred pCO_2 are not correlated. One of these occurred during the early to middle Miocene (about 17 Ma), a time well established as a warm interval but with proxy evidence for low atmospheric pCO_2. Moreover, whereas climate models predict warming at all latitudes in response to elevated pCO_2, geologic data, in particular the oxygen isotope record, indicate muted warming or even cooling at low latitudes while higher latitudes warm.

Is the CO_2-climate relationship refuted by these and other apparent mismatches between climate and CO_2 proxies? Not necessarily. The "cool tropics paradox" and the longer-term mismatch between pCO_2 and temperature proxies could be artefacts, the consequence of inevitable blurring of the signal by diagenesis. Even if the proxies survive further scrutiny and the mismatches remain, we shouldn't necessarily expect highly correlated records of atmospheric pCO_2 and climate. A pCO_2 increase whose radiative forcing drives a slowly changing climate component (e.g., the extent of continental ice sheets during glaciation), or triggers the release of other greenhouse gases (e.g., CH_4) could produce a proxy climate record (e.g., ice-sheet volume as expressed in the oxygen isotopic composition of the ocean) that was poorly correlated with the CO_2 forcing, as in the Miocene.

Through fossil fuel burning, we have made the natural world our laboratory, but the experiment is inadvertent and thus not designed to yield easily decipherable results. Focused research in climate modeling and paleoclimatology may provide us the tool we need to make confident predictions and thus wise policy decisions that ward off what may be dire consequences of our global experiment.

Noble Gases from the deep mantle: new evidence from oceanic volcanism

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The "standard model" for terrestrial helium isotopic evolution is that high $^3He/^4He$ ratios reflect undegassed deep mantle reservoirs having high He/(Th+U) ratios. High $^3He/^4He$ ratios from oceanic islands such as Hawaii, Iceland and Galapagos would then reflect relatively undegassed reservoirs brought to the surface by mantle plumes. This model has been challenged on a number of grounds, as geochemists and geophysicists increasingly attempt to explain the geochemical diversity of oceanic basalts by recycling processes. In order to address this important issue, we report new helium and neon data from submarine glasses of the Galapagos archipelago, and compare them to the most recent noble gas data from Hawaii. The new Galapagos samples come from the submarine western flank of the archipelago, and were collected during a 2001 cruise of the R/V *Revelle* which combined multibeam bathymetry, sonar mapping, and dredging. The highest Galapagos $^3He/^4He$ ratios, up to 30 times atmospheric, are found at Fernandina, and on the seafloor directly to the west of Fernandina. The geometry is similar to Loihi Seamount, Hawaii, in the sense that Fernandina is at the leading edge of the archipelago with respect to plate motion. We interpret the high $^3He/^4He$ ratios, coupled with active volcanism, as an indication that the plume melting center presently lies beneath Fernandina. The Galapagos submarine glasses have less radiogenic $^{21}Ne/^{22}Ne$ ratios than MORB or Loihi seamount, and the neon isotopes are consistent with the helium isotope systematics in suggesting relatively undegassed mantle. Overall the helium-neon systematics are consistent with the correlation identified by Moreira *et al*. (*EPSL* **185**(2001) 15-23) and demonstrates that Loihi seamount does not adequately characterize high $^3He/^4He$ mantle sources. Correlations between helium and other radiogenic isotope systems, at Galapagos and Hawaii, provide some important arguments in favor of the standard model for noble gases. The most plausible explanation for high $^3He/^4He$ ratios remains undegassed deep mantle reservoirs, perhaps from the core-mantle boundary; the noble gas data cannot be explained by recycled material.