End of Cretaceous (65 My BP)

Weathering Heights

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James Hansen

In 2007 Bill McKibben asked me whether 450 ppm would be a reasonable target for atmospheric CO_2, if we wished to maintain a hospitable climate for future generations. 450 ppm seemed clearly too high, based on several lines of evidence, but especially based on paleoclimate data for climate change.

We were just then working on a paper,[1] *Climate sensitivity, sea level and atmospheric carbon dioxide*, that included consideration of CO_2 changes over the Cenozoic era,[2] the past 65 million years, since the end of the Cretaceous era. The natural source of atmospheric CO_2 is volcanic emissions that occur mainly at continental margins due to plate tectonics ("continental drift"). The natural sink is the weathering process, which ultimately deposits carbon on the ocean floor as limestone.

David Beerling, an expert in trace gas biogeochemistry at the University of Sheffield, was an organizer of the meeting at which I presented the above referenced paper. Soon thereafter I enlisted David and other paleoclimate experts to help answer Bill's question about a safe level of atmospheric CO_2, which we concluded was somewhere south of 350 ppm.[3]

Since then, my group at Climate Science, Awareness and Solutions (CSAS), has continued to cooperate with David's group at the University of Sheffield. One of the objectives is to investigate the potential for drawdown of atmospheric CO_2 by speeding up the weathering process. In the most recent paper, which will be published in *Nature* tomorrow, David and co-authors report on progress in testing the potential for large-scale CO_2 removal via application of rock dust on croplands.

A press release on the paper is available here.

Weathering, nature's process of removing CO_2 from the air, can be sped up by grinding silicate materials into fine dust and spreading it on soils that can otherwise benefit from the addition. Many farmers are accustomed to liming their fields, and have equipment for such purpose. The silicate particles will dissolve slowly, react with CO_2, forming carbonates. Much of this carbonate will eventually find its way to the ocean, ending up as limestone on the ocean floor.

In order for enhanced weathering to play an important role in CO_2 drawdown it will be necessary to demonstrate that it provides a significant benefit in increased soil fertility and crop yield. If governments also provide a financial incentive via a carbon market, the chances of obtaining large-scale buy-in by farmers will be much increased.

Other CO_2 drawdown approaches, such as reforestation, are important, but require management to assure that the carbon sink is maintained. We will need the combination of reforestation, enhanced weathering, and other techniques to draw down atmospheric CO_2 to a safe level.

Of course, the most important action required to avoid dangerous climate change is to phase over to carbon-free energies as rapidly as is economically justified. In that event, it should be possible to bring down atmospheric greenhouse gas levels before slow amplifying climate feedbacks occur, the most dangerous climate impacts need never occur, and we can bend the climate curve back toward the climate within which that humanity and nature lived during the Holocene.

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[1] Hansen, J., M. Sato, P. Kharecha, G. Russell, D.W. Lea, and M. Siddall: Climate change and trace gases. *Phil. Trans. Royal. Soc. A*, **365**, 1925-1954, 2007.

[2] Volcanic CO_2 emissions were large in the early Cenozoic as the Indian plate subducted carbon-rich ocean crust while moving north through the present Indian Ocean and colliding with Asia. Since then, over the past 50 million years, CO_2 has declined and Earth has been in a long-term cooling trend, albeit with many climate oscillations, especially climate change associated with perturbations of Earth's orbit.

[3] Hansen, J., M. Sato, P. Kharecha, D. Beerling, R. Berner, V. Masson-Delmotte, M. Pagani, M. Raymo, D. Royer, and J.C. Zachos: Target atmospheric CO_2: Where should humanity aim? *Open Atmos. Sci. J.*, **2**, 217-231, 2008.