Earth and Life

Tibet: Berner's model of the carbon cycle

Voice Over
At this point enter an enterprising post graduate, Maureen Raymo, who was just starting her academic career. She looks back at that time ten years ago.

Maureen Raymo
Just putting the Plateau in the models didn't really cause any major global cooling, like you couldn't explain why an Antarctic ice sheet grew, so it seemed like there still was some other cause for global cooling. This was something that I was always thinking about and obviously thinking about the mountains too, and started going off in my own direction, and it started really with one of the first classes I took where I learned about Berner's model.

Voice Over
Bob Berner's model used the idea of the amount of carbon dioxide in the air controlled how warm the Earth's atmosphere was. This is the Greenhouse Effect: the more CO2 in the atmosphere, the warmer the Earth's climate. According to Berner's model the Earth works as a giant pump shifting the CO2 from the rocks to the atmosphere, to the oceans, and back to the rocks again. Carbon dioxide is pushed into the atmosphere from volcanoes and can combine with rainwater, making a weak acid which can dissolve silicate rocks on the Earth's surface through weathering. This removes CO2 from the atmosphere. The dissolved material washes into the oceans and is deposited on the sea floor. Eventually the sediment is dragged down a subduction zone and the CO2 is returned to the mantle. Global temperatures are determined through CO2 in the atmosphere, controlled largely by the rate of sea floor spreading.

Caption: Bob Berner, Yale University
The carbon cycle models ideally would give us CO2 in the past but the real benefit of studying these models is to evaluate the different processes that affect carbon dioxide, how you circulate carbon from one part of the surface of the Earth to another, and to the depths of the Earth, and we can learn more about geological processes by studying the carbon cycle, the goal of course of trying to get it, what controls carbon dioxide over geologic time.

Maureen Raymo
It was just an amazing model, I read the paper many, many times, I thought it was just so neat and to think about climate this way.

Bob Berner
I've been working on the whole problem of carbon and sediments for a very long time, maybe thirty years, but actually doing modelling of the carbon cycle. We started with my colleagues, Lasaga and Garrels thinking about the problem around 1980.

Voice Over
Through their model Berner and colleagues examined the fluxes of carbon that moved around the cycle. Most important for us he saw the role of mountains as a feedback mechanism. Periods of rapid seafloor spreading led to a hot CO2-rich atmosphere. This increases the rate of chemical weathering that takes place in mountains, thus drawing down CO2 from the atmosphere, and returning the Earth to cooler conditions. However something about the model was wrong. Maureen Raymo:

Caption: Maureen Raymo, MIT
It predicted that global cooling occurred between 150 million years in general, whereas most of the global cooling occurred actually much later so there seemed to be this mismatch between what the model predicted and what really happened in geologic history.