Reconstructing the history of the Earth's climate using oxygen isotopes

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Growing out of work on the chemical properties of isotopic substances in the 1930s and 1940s by Harold Urey, Harry Thode and their students and colleagues, natural variations in the isotopic abundances of oxygen, hydrogen, carbon and sulfur have been increasingly used to infer conditions of formation of minerals in the natural environment. The preponderance of such applications depends upon the small but readily measurable change as a function of temperature of the partitioning of the isotopes among phases in thermodynamic equilibrium with one another. For example, in the case of calcium carbonate that forms in equilibrium with ocean water, the fractionation factor, α,

$$\alpha_{CaCO_3-H_2O} = \frac{\left({}^{18}O/{}^{16}O\right)_{CaCO_3}}{\left({}^{18}O/{}^{16}O\right)_{H_2O}}$$

is temperature dependent, as are the fractionation factors for equilibrium between liquid water and water vapor

$$\alpha_{liquid-vapor} = \frac{\left({}^{18}O/{}^{16}O\right)_{liquid}}{\left({}^{18}O/{}^{16}O\right)_{vapor}} \quad \text{and} \quad \alpha_{liquid-vapor} = \frac{\left(D/H\right)_{liquid}}{\left(D/H\right)_{vapor}}$$

In this talk we will examine the inferences about the evolution of the earth's climate drawn from isotopic records of calcium carbonate microfossils deposited in deep sea sediments during the past 100 million years and of Greenland and Antarctic ice accumulated over the last 1 million years. We will then look at current concerns about global climate change in the context of the long-term geologic record.