$\delta^{18}O$

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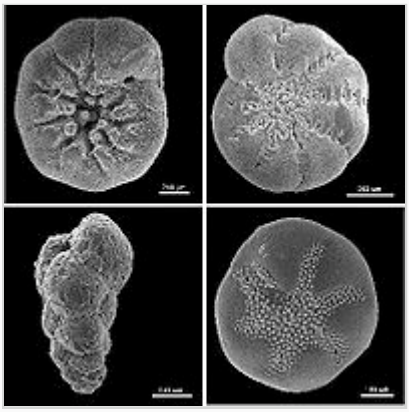
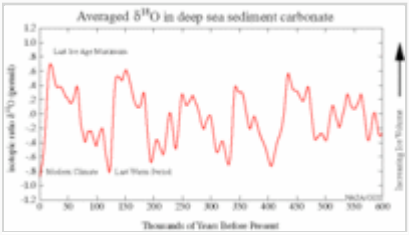
In geochemistry, paleoclimatology and paleoceanography **$\delta^{18}O$** is a measure of the ratio of stable isotopes **^{18}O:^{16}O**. The definition is $\delta^{18}O$ (in per mil) = $10^3[(R_{sample}/R_{standard})-1]$, where R_x = $(^{18}O)/(^{16}O)$ is the ratio of isotopic composition of a sample compared to that of an established standard, such as ocean water. It is commonly used as a measure of the temperature of precipitation, as a measure of groundwater/mineral interactions, as an indicator of processes that show isotopic fractionation, like methanogenesis. In paleosciences, foraminifera and ice core data ^{18}O:^{16}O is used as a proxy for temperature.



Foraminifera samples.

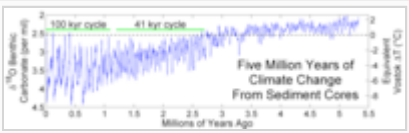
Contents



$\delta^{18}O$ ppm in deep sea sediment foraminifera carbonates over time from 0-600,000 years. Averaged over a large number of cores in order to isolate a global signal.

Mechanism

Foraminifera shells of calcium carbonate ($CaCO_3$), having oxygen in them, and being found in many common geological features, are most commonly used to do tests on. The ratio of ^{18}O to ^{16}O is used to tell the temperature of the surrounding water of the time solidified, indirectly. The ratio varies slightly depending on the temperature of the surrounding water, as well as other factors such as the water's salinity, and the volume of water locked up in ice sheets.



Climate record of Lisiecki and Raymo (2005) constructed by combining measurements from 57 globally distributed deep sea sediment cores. The measured quantity is oxygen isotope fractionation (δ18O) in benthic foraminifera.

$\delta^{18}O$ also reflects local evaporation and freshwater input, as rainwater is ^{16}O enriched - a result of ^{16}O's preferential evaporation from seawater. Consequently, the surface ocean contains greater amounts of ^{18}O around the subtropics and tropics where there is more evaporation, and lesser amounts of ^{18}O in the mid-latitudes where it rains more.

Similarly, when water vapor condenses, heavier water molecules holding ^{18}O atoms tend to condense and

precipitate first. The water vapor gradient heading from the tropics to the poles gradually becomes more and more depleted of ^{18}O. Snow falling in Canada has much less $H_2{}^{18}O$ than rain in Florida; similarly, snow falling in the center of ice sheets has a lighter $\delta^{18}O$ signature than that at its margins, since heavier ^{18}O precipitates first.

Changes in climate alter global patterns of evaporation and precipitation therefore change the background $\delta^{18}O$ ratio.

Calculations

If the signal can be attributed to temperature change alone, with the effects of salinity and ice volume change ignored, a $\delta^{18}O$ increase of 0.22‰ is equivalent to a 1 °C cooling.[1] Temperature can also be calculated using the equation:

$$T\ (°C) = 16.9 - 4.0(\delta^{18}O_{calcite} - \delta^{18}O_{seawater})$$

During the Pleistocene, a 0.11‰ $\delta^{18}O$ signature correlates to 10m of sea level change as a consequence of changing ice volume.

See also

- $\delta^{13}C$

References

1. **^** Visser, Katherine (2003). "Magnitude and timing of temperature change in the Indo-Pacific warm pool during deglaciation". *Nature* **421**: 152. doi:10.1038/nature01297.

- Clark, Ian D. and Peter Fritz (1997) *Environmental Isotopes in Hydrogeology,* CRC Press: 1997, ISBN 1566702496
- Schmidt, G.A. (1999). "Forward Modeling of Carbonate Proxy Data from Planktonic Foraminifera Using Oxygen Isotope Tracers in a Global Ocean Model *Paleoceanography* **14**,": 482-497.