Review of:

Triple-isotope composition of atmospheric oxygen as a tracer of biosphere productivity
Luz et al., Nature 1999

There are two primary controls on the triple-isotope composition (^{16}O, ^{17}O, ^{18}O) of atmospheric O_2:

1) photosynthesis and respiration (mass dependent fractionation: ^{17}O enrichment is about half ^{18}O enrichment)
2) photochemical reactions in the stratosphere (mass independent fractionation; ^{17}O and ^{18}O enrichment equal)

This paper describes a **terrarium experiment** used to simulate biological fractionation. Initially, air in the terrariums had the ^{17}O anomaly characteristic of ambient air. After 100+ days, the anomaly had been removed.

$\Delta^{17}O$ is deviation from normal MDF:
$\Delta^{17}O = \delta^{17}O - 0.521\ \delta^{18}O$

In terrarium experiment, **$\Delta^{17}O = 155 \pm 8$ per meg** with respect to HLA.

Now, entering the **stratosphere**…
UV photolysis of ozone in the stratosphere results in ^{17}O enrichment of CO_2 and ^{17}O depletion of O_2, leading to the 155 per meg anomaly.

The behavior of N_2O serves as a proxy for CO_2 distribution in the stratosphere and for CO_2 mixing into the troposphere. Pre-industrial ozone levels are estimated using existing models; Pre-industrial ozone CO_2 levels are obtained from ice cores.

Using this information, the production rate of $\Delta^{17}O_{O2}$ is calculated. Accumulation of anomalous O_2 determined from the calculated production rates is between **104 and 131 per meg**.

"… the magnitude of the atmospheric $\Delta^{17}O_{O2}$ anomaly reflects the ratio between two important global processes – biospheric O_2 production and stratospheric photochemistry involving O_2, O_3, and CO_2."

Application: **GISP2 Ice Core**

$\Delta^{17}O^*_{O2} = k[CO_2]/P$ (k is a constant relating anomalous O_2 production to $[CO_2]$)

$\Delta^{17}O^*_{O2} = \Delta^{17}O_{O2} - 155$ per meg

Normalized gross biosphere production, t is time before present, 0 is present.

$P_t/P_0 = k_t/k_0([CO2]_t/[CO2]_0) \times (\Delta^{17}O^*_{O2})_0/(\Delta^{17}O^*_{O2})_t$

Calculated values of P_t/P_0 range from 0.87 to 0.97 (Table 2)

12.491 Non-conventional Light Stable Isotope Geochemistry

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