

How I Learned to Stop Worrying and Embrace Isotopic Disequilibrium in Carbonate Minerals

Mathieu Daëron

Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif-Sur-Yvette, France

Abstract:

Oxygen-isotope thermometry played a critical role in the rise of modern geochemistry and is now extensively used in (bio-)geoscience. Its theoretical foundations rest on the assumption that $^{18}\text{O}/^{16}\text{O}$ partitioning among water and oxygen-bearing minerals, such as carbonates, primarily reflects thermodynamic equilibrium constants. However, after seven decades of research, there is mounting evidence that natural carbonate minerals truly formed in isotopic equilibrium with their parent waters are the exception rather than the rule. This has far-reaching consequences because instead of relying on relatively simple relationships between crystallization temperature and isotopic composition which remain uniform through geologic time, accurate interpretations of the isotopic signal in diverse natural carbonates may require a more quantitative description of the processes driving isotopic disequilibrium between water, dissolved inorganic carbon, and the mineral phase as a function of other parameters (e.g., water chemistry, precipitation rates). The study of these effects will likely benefit greatly from combining traditional $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ measurements with other isotopic tracers applicable to DIC and carbonates, such as ^{17}O anomalies ($\Delta^{17}\text{O}$) or clumped isotopes (Δ_{47} , Δ_{48}).