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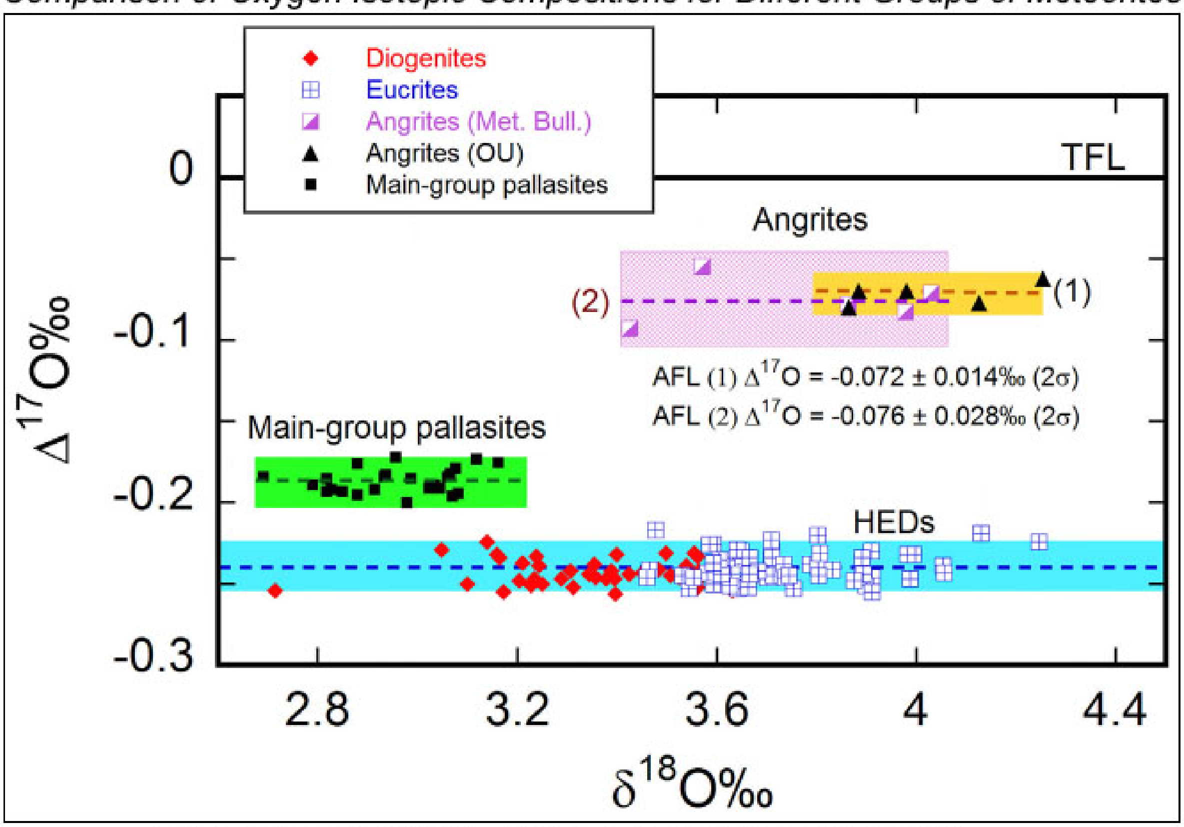
Revealing the Secrets of Asteroid Melting by Precise Oxygen Isotopic Analyses

The relative abundances of oxygen ***isotopes*** have long provided a fingerprint of how planetary bodies could be related to each other and to the extent to which they melted. Richard Greenwood (Open University, United Kingdom) and colleagues at the Open University and Mount Holyoke College (Massachusetts, USA) have written a review article about the techniques for measuring oxygen isotopes and how studies of oxygen isotopes have advanced our understanding of melting and ***differentiation*** in asteroids. Improvements in the techniques over the years have greatly enhanced the clarity of the oxygen fingerprints, allowing progressively more precise and accurate isotopic compositions to be measured.

One of the examples of how improved measurement capabilities have illuminated how ***meteorite*** types are or are not related to each other involves three prominent groups of meteorites: main-group ***pallasites*** (stony-iron meteorites), the Howardite-Eucrites-Diogenite (***HED***) group (which almost certainly come from asteroid 4 Vesta), and mesosiderites (mixtures of basaltic rock and metallic nickel-iron). Older oxygen measurements of oxygen isotopic compositions allowed for all three types of meteorites to come from one parent asteroid. It was a challenge for cosmochemists to devise reasonable geochemical/geologic models to show how these three types could be related to each other. Newer, more precise measurements show clearly that the pallasites must come from a different parent asteroid (see plot below).

Comparison of Oxygen Isotopic Compositions for Different Groups of Meteorites



(From Greenwood *et al.* 2016, *Chemie der Erde*, doi:10.1016/j.chemer.2016.09.005.)

This plot from Greenwood and colleagues shows the deviation of oxygen isotopic composition from the line defined by terrestrial samples ($\Delta^{17}O$, the y-axis) against the $^{18}O/^{16}O$ ratio normalized to mean ocean water and expressed in parts per thousand ($\delta^{18}O$, the x-axis). The main group pallasites (area shown in green) clearly have different oxygen isotopic compositions than do HEDs and another group of differentiated meteorites, the angrites.

Greenwood and colleagues relate other cosmochemical stories of how oxygen isotopic compositions allow us to understand the extent of melting and differentiation on the parent asteroids of numerous **achondrites**. An interesting conclusion is that when coupled with other data, the oxygen isotopic data indicate our terrestrial collections contain samples from about 110 different asteroids. This is still a small fraction of the original total number of asteroid-sized bodies in our Solar System, but not a bad sampling of the compositional range and melting histories of the original batch of asteroids.

See Reference:

· Greenwood, R. C., Burbine, T. H., Miller, M. F., and Franchi, I. A.. (2016) Melting and Differentiation of Early-Formed Asteroids: The Perspective from High Precision Oxygen Isotope Studies, *Chemie der Erde,* available online 14 NOV 2016, doi: 10.1016/j.chemer.2016.09.005. [**abstract**].

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