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Detecting time-averaging and spatial mixing using oxygen isotope variation: a case study

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Abstract

In principle, bivalve mollusks living at the same time and in the same place will experience the same temperature and salinity regimes and will have identical annual oxygen isotope ($\delta^{18}O$) profiles. Bivalve mollusks living at different times or in different places are more likely to have different annual $\delta^{18}O$ profiles. Thus, differences in annual $\delta^{18}O$ profiles can be used to detect temporal or spatial mixing.

We devised eight metrics to quantitatively compare sclerochronologically calibrated annual $\delta^{18}O$ profiles from different shells: difference in maximum value, difference in minimum value, difference in amplitude, the number of non-contemporaneous isotopic enrichment events (NNEE), the average fortnightly difference (AD), the standard deviation of the average fortnightly differences (SDD), the maximum fortnightly difference (MaxD) and the number of fortnights separating the minimum values.

These metrics vary among northern Gulf of California shells from four temporal and spatial categories: (1) same time and same place; (2) same time and different place; (3) different time and same place; and (4) different time and different place. Different time/different place comparisons include comparisons of live-collected shells with shells alive during times of Colorado River flow and shells from a Pleistocene interglacial deposit. The same time/same place comparison has the most similar metric values, whereas comparisons among the different time/different place shells are usually the least similar.

Between-shell oxygen isotope differences can reveal temporal or spatial mixing of shells that would be undetectable with radiocarbon or amino-acid racemization dating. Application of the technique to a Holocene deposit with shells in life position reveals that the bivalves were alive at different times, despite indistinguishable radiocarbon ages. Two adjacent but disarticulated Pleistocene shells appear to be both temporally and spatially mixed. The method can detect temporal or spatial mixing in any shell material unaffected by diagenesis, regardless of the age of the specimens.

Keywords: Taphonomy; Time-averaging; Spatial-mixing; Oxygen isotopes; Gulf of California; Mollusks

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