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^{18}O tracer shows diagenetic isotope exchange in biocalcites to be fast, pervasive and species-dependent

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Ocean paleotemperatures have been reconstructed for almost the entirety of the Phanerozoic using the oxygen isotope compositions of calcium carbonates formed by marine organisms and preserved in ocean sediments. However, the isotopic composition of these calcitic tests and shells can be substantially altered through diagenetic processes. Here, we used ^{18}O as an isotopic tracer in controlled experiments designed to simulate early diagenesis of modern benthic foraminifera tests to investigate how fluids penetrate into and exchange oxygen isotopes with these biogenic calcites. Initially pristine tests of *Ammonia sp.*, *Haynesina germanica*, and *Amphistegina lessonii* were immersed in an ^{18}O-enriched artificial seawater at 90 °C for hours to days. High-resolution SEM images of the tests before and after the experiments were indistinguishable yet the bulk oxygen isotope compositions of reacted tests revealed rapid and species-dependent isotopic exchange with the water. Correlated SEM, TEM and NanoSIMS imaging of ^{18}O intra-test distributions showed that fluid penetration and exchange is ubiquitous yet heterogenous, and is intimately tied to test ultrastructure and associated organic matter. Species level differences in ultrastructure, quantified through image analysis, explained the observed species-dependent rates of isotopic exchange. Consequently, even calcitic skeletons considered texturally pristine for paleo-climatic reconstruction purposes may have experienced substantial isotopic exchange and hence a critical re-examination of the paleo-temperature record is warranted.