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Interindividual differences in stable isotopes of benthic foraminifera: the profile of isotopic disequilibrium

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For more than 50 years, variations in stable carbon and oxygen isotopic compositions of calcium carbonate, especially foraminiferal shells, have been used for estimating paleoenvironments, such as global sea-level changes, paleotemperature, global deep-sea circulation, and huge methane release events from the seafloor. In particular, the stable isotopic compositions of calcareous benthic foraminiferal shells have been used as tracers to determine the paleoenvironment at the seafloor.

Several factors determine the isotopic values of benthic foraminiferal shells, including the isotopic composition and temperature of the bottom water, the organic carbon flux, and ”vital effects”. Major isotopic variations in some species of benthic foraminifera are already being utilized as paleoindicators of bottom water conditions, but recently researchers have begun to quantify in detail the relationship between the isotopic composition of benthic foraminiferal shells and ecological characteristics such as species' microhabitat and the organic carbon flux. Such precise calibration and validation of isotopic indicators in benthic foraminifera will broaden the range of their application as paleoenvironmental tracers. However, until recently, it has not been possible to analyze the stable isotopic compositions of small carbonate samples of less than 20 micrograms and obtain results with an acceptable error range, thus, each sample used for analysis included multiple individuals, resulting in isotopic values averaged across individuals. This limitation prevented precise association of shell compositions with microenvironments.

In this study, by using a custom-made analytical system to determine stable carbon and oxygen isotopes in specimens with submicrograms calcium carbonate; the quantity required by the system is less than 1/100 of that required by conventional analytical methods, we determined the stable isotopic values of small individual shells of deep sea benthic foraminifera from core-top samples from three sites in marginal seas of the northwestern Pacific to characterize the magnitude of interindividual variation in their stable isotope ratios. We expect the results to be useful for exploring which species are most appropriate to use as paleoindicators in paleoenvironmental studies.

Keywords: stable isotope, foraminifera, vital effect, proxy, microscale analysis, calcification