Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

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Geochemistry of planktic foraminiferal tests is an important archive to understand paleoenvironment. However, many biotic factors can affect the geochemical composition and thus may lead misinterpretation of the proxy signals. Photosymbiosis (endosymbiosis with autotrophic algae) is thought to give specific effects on foraminiferal test geochemistry such as $\delta^{13}C$ due to photosynthetic activity of the symbionts. This is because photosynthesis can alter the geochemical condition of the vicinity of the foraminiferal test where calcification takes place, and eventually elevate the $\delta^{13}C$ of the test. Therefore, whether foraminiferal species have photosymbiotic ecology or not, and how active the photosynthesis is are important information for precise paleoenvironmental reconstructions. However, photosymbiotic information of planktic foraminifers is still limited even for extant species which are often utilized to generate proxy records.
In this study, we investigated 30 species of modern planktic foraminifers covering four families; Globigerinidae, Hastigerinidae, Globorotaliidae, and Candeinidae, using active chlorophyll fluorometry (fast repetition rate fluorometry; FRRF). FRRF performs non-destructive and non-invasive measurements of algal physiology based on real-time variable fluorescence profiles. When it is applied to symbiotic consortia of planktic foraminifers, it enables us to quantify chlorophyll content of a specimen, and to qualify of photophysiological features that are useful diagnostics of symbiont photosynthetic fitness. It can provide us with convincing information on individual-based photosymbiosis.
Specimens were collected from various oceanic settings; from tropical to subpolar region, encompassing Pacific to Atlantic. We have sampled across much of the northern hemisphere tropical-subtropical gradient to get the endemic species and to replicate for the others. The detection rate of photosymbiosis in each species, the biomass of symbionts (indicated by chlorophyll content), and the state of symbionts (indicated by photophysiological parameters) were investigated. Using principal component analysis, species were ranked by their “strength” of photosymbiosis. This thorough investigation will provide a more systematic understanding of photosymbiosis in modern planktic foraminifers and will help us to choose which species to use to reconstruct paleoenvironment.

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