Foraminiferal TE/Ca determination in thin section by LA-ICP-MS

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Trace element/Ca (TE/Ca) ratios derived from well-preserved tests of calcareous foraminifera are widely used in paleoceanographic studies as proxies of primary water mass characteristics (e.g., temperature via Mg/Ca). These proxies have exclusively been measured from isolated and cleaned foraminifera, either as pooled multi-shell dissolutions or from LA-ICP-MS spot ablations of external or internal chamber surfaces. However, physical extraction, cleaning, and selection of optimal foraminifera specimens is not always possible or practical (e.g., from highly indurated lithologies). At the same time, visibly well-preserved foraminifera (e.g., with intact microstructure) are commonly observed in thin section. Here, we assess the potential for extracting primary TE/Ca values from foraminifera chamber walls (≥10µm) exposed in thin section by LA-ICP-MS. LA-ICP-MS analytical parameters were optimized from thin sections of pristine modern foraminifera (Ontong Java Plateau, California Margin) and foraminifera-bearing intervals of the Miocene Monterey Formation (offshore California). Curvilinear square-aperture transects are optimally suited for whole-test cross-sectional sampling, allowing multiple transects to be made from the same chamber. Screening of the resulting geochemical time-series enable altered (or otherwise contaminated) intervals to be excluded. The accuracy of derived TE/Ca transect averages for individual chambers is independently confirmed by EPMA traverses made over the same chambers. Similar to LA-ICP-MS studies based on physically isolated planktonic foraminifera, we find consistent TE/Ca among traverses made within the same chamber, but that different chambers of the same specimen can vary systematically. TE/Ca variations in tests of visibly well-preserved Monterey Formation foraminifera generally fall within expected ranges from literature, whereas elevated Mg, Mn and Ba and low Sr distinguish dolomitized foraminifera. Benthic foraminifera from the same thin section show very similar Mg/Ca regardless of whether chambers are open or filled by secondary spar (with highly variable Mg/Ca). These findings support the analytical feasibility of measuring primary TE/Ca in foram test cross-sections by LA-ICP-MS. The research hypothesis that well-preserved benthic and planktonic foraminifera should preserve a record of cooling (Mg/Ca paleothermometry) associated with mid-late Miocene buildup of Antarctic ice sheets is considered.