Geochemical un-mixing of multiple sources of aluminosilicates in marine sediment cores with multivariate statistics

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Reconstructing the depositional history of distinct, yet compositionally similar, aluminosilicates (e.g., dust and ash) in marine sediments is key to understanding eolian, volcanic, fluvial, and climate processes through time. We differentiate multiple aluminosilicate sources mixed into bulk sediment by examining the covariance and proportions of many elements downcore. This comprehensive approach ensures that the outcome is not unique to only a few elements, and is beholden to the geochemical composition of the sediment.

Applying multivariate statistical techniques to bulk sediment element concentrations, analyzed by ICP-ES and ICP-MS, can un-mix the chemical composition(s) of bulk sediment and fingerprint multiple different aluminosilicate sources. Using a targeted subset of elements selected from a dataset of ~50 major, trace and rare earth element bulk sediment concentrations, we apply Q-Mode factor analysis, total inversion (TI), and iterative constrained least squares (CLS) multiple linear regression techniques to simultaneously test all possible combinations of given geochemical end-members for sediment provenance mixing models. The QFA and CLS models are developed and interpreted in the context of other geochemical discrimination approaches (e.g., ratios, x vs. y plots, ternary diagrams).

Here we summarize these statistical techniques and their application to several different temporal scales and environmental regimes, including ash input in the Izu-Bonin and Mariana Subduction zones, the evolution of the South Pacific Gyre, and terrigenous provenance of marine sediment in the East China Sea deposited under the influence of the East Asian Monsoon. We highlight the chemical differentiation of ash from dust to emphasize the importance of volcanic ash in marine sediment on a global scale, and to stress the importance of differentiating between dust and volcanic ash when tracking climate records and subduction zone budgets and processes.