From microbes to mountains: Molecular signatures of life and its environment

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Biomarkers serve as a rich sources of information about ancient environments and provide important proxy tools for studies of past climatic change. Interpretations of molecular and isotopic signatures are grounded in studies of the habitat and growth of modern analogs to biologial sources for ancient compounds. Molecular signatures are rarely simple recorders of material or physical properties (like temperature), and can be influenced by variations in lipid and isotopic properties both within and between organisms. This presentation will highlight two examples of molecular proxies and the importance of ecological and physiological influences on their geochemical record.

The first example underscores the role of ecology on the molecular signatures of modern marine Archaea. Recent studies point to crenarchaeota as important agents in ammonium oxidation, consistent with an apparent affinity of these organisms with deeper habitats and upwelling regions. Archaeal lipid signatures in the modern ocean include inputs from both euryoarchaeota chrenarchaeota, and the relative importance of these inputs can vary with nutrients, especially nitrogen. Ancient archaeal lipid signatures will reflect ecological shifts in regions with variable oceanographic conditions, potentially complicating their utility for temperature reconstruction in such settings.

In the second example, we consider how plant lipids record deuterium abundance in waters in their growth habitat. Large isotopic fractionation associated with lipid biosynthesis can be attenuated by evaporative effects which yeild leaf waters enriched in D relative to precipitation. Thus the apparent (or net) fraction between plant lipids and environmental waters reflect both physiological and climatic properties. Understanding of such influences empowers better reconstructions of this emerging proxy for paleohydrologic signatures. We apply such insights to a lipid-based method for reconstructing uplift of the Tibetian plateau and explore implications for understanding tectonic and climatic interactions.

Provenance and genesis of the high Ti heavy mineral sand deposits of South Kerala, SW India: Constraints from CCSEM analysis

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Computer Controlled Scanning Electron Microscopy (CCSEM) is a new fully automated method for the chemical and physical characterisation of the heavy mineral fraction in sands (Frei *et al.*, 2005). For example, CCSEM allows to determine the chemical variation of individual mineral groups (e.g. garnet or ilmenite) and their modal abundance. In this contribution we demonstrate the capabilities of CCSEM for investigating the grade, genesis and provenance of Ti heavy mineral sand deposits.

The world-class heavy-mineral deposits occuring in beach sands around the town of Chavara in SW India are characterized by abundant ilmenite with elevated TiO_2 contents, often exceeding 60 wt. %. In order to determine the provenance and genesis of these high- TiO_2 ilmenite deposits, we have collected a large number of beach sediment samples from an approximately 800 km long stretch of coastline from northern Kerala state to well within the Tamil Nadu state. An additional set of river sediment samples was also taken, roughly covering the areas drained inland from the beach samples. The heavy-minerals in all samples were analyzed by CCSEM, providing both chemical analyses of individual grains as well as the modal composition of heavy-minerals in the sediment. The results show that the sediments in the Chavara high-Ti ilmenite deposits are distinct by minor elements in ilmenite and garnet chemistry as well as heavy mineral assemblage: ilmenite has high MgO and low MnO contents, garnets have low grossular components and the heavy-mineral assemblage is dominated by sillimanite-kyanite in addition to ilmenite. These features correlate with basement geology in the hinterland, and with the results for sediments from rivers, draining the basement. Based on these observations we conclude that high-Ti ilmenite from Chavara beaches is derived from the granulite-facies metasedimentary rocks exposed in the khondalite belt. Our study demonstrates that rapid mineral analyses in sediments by CCSEM is an efficient and powerful new tool for the characterization of mineral compositions and assemblages in sediments, the identification of their possible source regions and thus ultimately for refined exploration for industrial mineral resources.

Reference

Frei D., Rasmussen T., Knudsen C., Larsen M., Whitham A., and Morton A. (2005), *Annales Societatis Scientiarum Faeroensis* **43**: 96-108.