Nd isotopes in invertebrate skeletal calcite as a proxy of past seawater characteristics

The seawater of modern oceans exhibits a wide variation in neodymium (Nd) isotope composition. This allows us to identify the different water masses and track changes in ocean circulation. The main input of Nd to the ocean is from continental weathering through transport by rivers and wind, and from remobilization of Nd from river-transported coastal and shelf sediments. The Nd isotope system has the advantage of being independent of biological processes in the water column. Numerous studies have shown that Nd isotope information can be preserved in biogenic (skeletons of marine fauna) and abiogenic (e.g., authigenic carbonates, phosphates) minerals that precipitated from past seawater. Therefore, Nd isotopes recorded in marine precipitates can be used as a tool for distinguishing different water masses of past oceans and seas. However, isotopic studies on past seawater composition require that the geochemical information is recorded in marine minerals which should be common, datable, contain significant concentrations of Nd and remain chemically stable after their formation. Various marine authigenic and biogenic precipitates were proposed as accurate recorders of the Nd isotope composition of seawater but their practical applications usually have considerable limitations. Although shallow-water invertebrate calcites are widespread and very often common in various Palaeozoic to Cenozoic rocks and sediments, they have so far not been verified as suitable materials for the Nd isotope composition of past seawater.

The main aim of the proposed project is to test calcitic skeletons of invertebrates for their potential of retaining the original Nd seawater signal and thus for their potential in identifying different water masses and their temporal and spatial changes. The planned study is focused on the Nd isotope composition of shallow-water skeletal calcite from Neogene to Holocene peri-reefal carbonates in Egypt and Jamaica, and from the littoral zone of the Bay of Biscay in France and Spain. Research tasks should help: (1) to understand the stability of the Nd isotope system in invertebrate calcites over time, (2) to understand the role of vital effects on the Nd isotope composition of macrofossil calcite, (3) to identify benthic organisms whose calcite skeletons can serve as archives for the Nd isotope composition of past seawater, and (4) to determine analytical constraints which are necessary for the use of invertebrate calcites in paleoceanographic research. In addition, new data will be generated from relatively shallow-water environments of shelves which only in rare cases were focused on in the oceanographic studies of modern oceans. Macrofossil calcite as a material of Nd isotope signatures of past seawater can resolve and advance the research questions and fill gaps in understanding the hydrography of past shelf areas. Water masses of the shelves are not volumetrically dominant on a global scale but are crucial for reconstructions regarding the Palaeozoic and the Triassic, given that the oceanic spaces of this time were closed, and thus pre-Jurassic oceanic sediments are extremely rare in the fossil record.

The principal research technique used in the presented project will be the analysis of the isotope ratios of neodymium ($^{143}Nd/^{144}Nd$), performed by thermal ionisation mass spectrometry (TIMS). These measurements will be preceded by petrographic and geochemical tests, which will allow us to assess the possible secondary changes in the composition of examined skeletal material. The challenge will be to identify material that has preserved original seawater signatures of some or all geochemical parameters (trace elements, Sr isotopes, REE). Microtextural preservation, luminescence patterns and trace element contents will be the primary selection tools for identifying unaltered macrofossil calcites.