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Post-depositional alteration of benthic foraminifera in a methane seep environment

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Benthic foraminifera tests from the sediment cores taken from the Vestnesa Ridge, one of the northernmost known marine methane hydrate reservoir, were studied for their visual appearance, mineral and stable carbon isotopic composition in order to explore their indicator potential in a methane seep environment.

The Vestnesa Ridge is a sediment drift located in 1200m water depth at 79°N at Svalbard´s northwestern continental margin. Observations of gas flares originating from pockmarks that are aligned along the crest of the ridge show ongoing methane emission. A distinct sediment layer containing a fossilized assemblage of chemosynthetic bivalves indicates methane seepage activity at least in the late Pleistocene. We have examined the state of preservation and geochemical characteristics of foraminifera tests from this bivalve shell horizon.

Tests of the benthic foraminifera species *Cassidulina neoteretis* display a variable degree of post-depositional alteration and formation of diagenetic carbonate overgrowths on calcitic primary tests. Using binoculars, scanning electron microscope imagery and energy dispersive x-ray spectroscopy, we distinguish visually and mineralogically different diagenetic phases on the external and internal test surfaces. Pristine and smooth test surfaces act as nucleation templates for precipitation of authigenic Mg-calcite crystals causing complete filling of chambers and encrustation of the external test surfaces. The presence of Mg-calcite indicates the overgrowth is precipitating in sulfate-poor sediments.

In addition to benthic foraminifera, we have studied the mineralogical and stable carbon and oxygen isotope composition of authigenic carbonate nodules found in the bivalve shell horizon. The mineralogical nature of the carbonates and overgrowths on the foraminifera tests were found to be identical. The δ^{13}C value of the carbonate nodules is as low as -32.3‰ indicating their methane-derived origin. Authigenic carbonate coated foraminifera tests are also depleted in their δ^{13}C isotopic composition.

Our findings demonstrate that up to 55% of the δ^{13}C signal in the benthic foraminifera test record has been created after burial of the tests by overgrowth with isotopically depleted methane-derived authigenic carbon. Thus, the benthic foraminifera δ^{13}C composition in the presence of methane is a mixed signal comprising the δ^{13}C value of the pristine foraminifera test and of the authigenic overgrowth encrusting the test after burial in post-depositional diagenetic processes.

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