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Variability of non-silicate authigenic minerals in anoxic Baltic Sea sediments reflects changes in local biogeochemical environment

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The purpose of the study was to evaluate the effects of biogeochemical processes on mineral composition of anoxic sediments in the Baltic Sea pockmarks. Pockmarks are circular or elongated depressions in the bottom filled with unconsolidated sediments affected by the outflow of biogenic methane sometimes associated with freshwater seepage. Anaerobic conditions and processes such as methanogenesis, anaerobic oxidation of methane and dilution by freshwater make chemical composition of the waters and mineral composition of the sediments different from the typical sediments around them.

The top 100 cm of sediments were sampled from three sites differing in environmental conditions: (i) a pockmark (80 m bsl) with methane seepage and infiltration of freshwater; (ii) a shallow-water site (50 m bsl) with large regular accumulation of methane, and (iii) a reference site (100 m bsl) with no methane nor freshwater in the sediments. A comprehensive description of biogeochemical systems was carried out, as well as sediment mineralogy and chemistry, pore water chemistry and hydrogeochemical modeling. The sediments were characterized using X-ray diffractometry, light microscopy, electron microscopy, thermal analysis, X-ray fluorescence spectroscopy, Mössbauer spectroscopy, and chemical extractions. The 16S rDNA metabarcoding to assess variability of microbial communities was applied as well.

All the sediments are fine-grained and rich in organic matter. Their mineral skeleton is generally similar and includes phyllosilicates (muscovite, biotite, illite, chlorite, kaolinite and mixed-layer clay minerals), alkali feldspars and quartz, accompanied by accessory minerals (titanium oxides, zircon, apatite, barite etc.). On the other hand, authigenic minerals occur in small concentrations but seem to differ in terms of their proportions. These minerals include amorphous silica, carbonates (calcite, Mg-calcite, dolomite and siderite) and sulphides (predominately pyrite). Observed differences in the proportions of authigenic minerals between the sites can be explained by variability of biogeochemical processes (i.e. transformations of organic matter, production of CH_4 and H_2S) that shape local physicochemical conditions of the sites. A conceptual model of microbial processes affecting mineral composition of sediments in pockmarks with periodic freshwater inflow has been developed.

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