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Methane seep-related carbonates from the Dolgovskoy Mound and the Batumi Seep Area in the eastern Black Sea: two case studies

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We investigated mineralogical, petrographical and geochemical characteristics of carbonate precipitates recovered from two locations of different water depth in the Black Sea: the Dolgovskoy Mound (north-eastern Black Sea), and the Batumi Seep Area (eastern Black Sea off Georgia). Although similar with regard to strong ^{13}C-depletions (δ^{13}C = -25 to –41 per mill PDB) typical for methane-derived carbon, carbonates from both sites exhibit strong differences reflecting the site-specific environmental conditions, especially with respect to seepage rate and the presence of gas hydrates.

At the Dolgovskoy Mound, located in 2000 m water depth, carbonates vary in shape from simple pavements to complex cavernous structures with thick microbial mats attached to the lower side and within cavities of the build-ups. The shape of the carbonates is characterised by plastic deformation of the primary sediment prior to cementation through sustained, but not vigorous, fluid seepage. The internal carbonate structure is dominated by three lithological facies, i.e. finely laminated coccolith

ooze and homogeneous clay layers, both cemented by micritic high-magnesium calcite (HMC), and pure, yellowish low-magnesium calcite (LMC) grown as rims on the lower side and inside cavities of the precipitates, in direct contact with microbial mats. $\delta^{18}O$ values suggest that the authigenic HMC precipitated in equilibrium with bottom water while the yellowish LMC rims have been growing in slightly ^{18}O-depleted interstitial waters. Compelling evidence for the influence of dissociating or forming gas hydrates on the precipitation of these carbonates has not been found. Lipid biomarker patterns show that AOM-performing communities were characterized by ANME1-dominated consortia in all carbonate facies irrespective of their lithologies. Compounds attributable to non-AOM associated terrestrial and marine organisms are only present in the calcite-cemented coccolith ooze and micritic layers.

Carbonates sampled in 850 m water depth from the Batumi Seep Area, a site of near-surface gas hydrate presence and vigorous methane seepage, also mainly comprise LMC-cemented coccolith ooze with pure, yellowish rims along fractures and cavities covered by cm-thick microbial mats. In this case the yellowish carbonates mainly consist of aragonite and contain only minor amounts of high-Mg-calcite. Homogenous layers as observed for the micritic layers from the Dolgovskoy Mound carbonates, have not been found. Computerised tomographic imaging showed that carbonates from the Batumi Seep Area are generally heavily deformed, fractured and brecciated probably due to the presence of gas hydrates and the impact of overpressurized fluids. The involvement of gas hydrates during the formation of these carbonates is evidenced by a relative enrichment of ^{18}O derived from hydrate water in the calcite-cemented coccolith ooze, while the $\delta^{18}O$ signatures of the yellowish aragonite rims point to their precipitation in equilibrium with the Black Sea bottom water.