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Gas hydrates in the Eastern Mediterranean: occurrence and biogeochemical environment compiled from detailed sampling of the Anaximander Mountains

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Within the framework of the EU Project ANAXIMANDER, two expeditions with R/V Aegaeo allowed an extensive investigation of the Anaximander mud volcanoes in May 2003 and November 2004. Gas hydrates (GH) have been encountered and sampled at three mud volcanoes (MV), namely Amsterdam, Kazan, and the newly discovered Thessaloniki MV. At Amsterdam MV we did not only encounter GH within the crater but also on the mud flow of the southern slope.

These sites span a considerable range of water depths, from 2236 m (A'dam MV) to 1263 m (Thessaloniki MV), the latter depth being close to the upper boundary of the hydrate stability zone (bottom water temperatures of about 14˚C). Gas hydrates recovered from gravity cores were either stored in steel vessels and kept at -80˚C or put into gas tight bottles filled with brine solution where the gas from the dissolving hydrate is captured, simultaneously replacing part of the brine. The first deployment of a newly developed autoclave piston corer in this area allowed the recovery of the total gas volumes from the gas hydrate-bearing sediments of the three MV. These data lay the base for the determination of the in situ methane and hydrate content in the shallow sediments. Additionally, gas analyses on sediment samples (dissolved and adsorbed gas) have been performed. With this extensive data set, we were able to draw a solid picture of the gas hydrate occurrence at the specific sites. This picture is refined by geological studies and microbiological description of the gas hydrate environment.

Whereas the gas hydrates at Amsterdam MV appear in distinct pieces of several cm in diameter, hydrate crystals at Kazan MV are dispersely distributed and only several mm in size. The latter were therefore hard to recover and dissolved to a large extent in the sediment matrix before and during pore water sampling. This results in a stronger chlorinity minima at Kazan MV (as low as 10 per mil) compared to Amsterdam MV.

At both sites, GH occurred at various sub-surface depths, ranging from the maximum penetration (mainly about 150 cm) to near the seafloor. Related methane concentrations are up to 1000 μmol/l wet sediment at shallower depth (box corer samples), and reach values of almost 5000 μmol/l wet sediment close to larger pieces of hydrate (gravity corer samples). The total gas volumes which were retrieved from pressurized cores were about twice as much at Amsterdam than at Kazan MV.

In both mud volcanoes, the bacterial and archaeal communities were dominated by representatives of the δ-Proteobacteria and ANME-1 group. Methanogenic archaea, however, were only found in Kazan, at the lower limit of the inferred zone of anaerobic oxidation of methane.

At Kula MV (where GH had been sampled on earlier cruises) we found only evidence of GH (gassy texture of the sediment), however, salinities are rather low here, too (down to 21 per mil). Because of the oxic surface of these sediments (which implies no recent MV activity) and the very stiff sediment matrix towards the base of some of the cores, the reason for the observed salinity decrease remains puzzling and will be subject to further studies using specific proxies to trace a possible source.