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1300-m-high rising bubbles from mud volcanoes at 2080 m in the Black Sea: Hydroacoustic characteristics and temporal variability

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Abstract

A mud volcano area in the deep waters (>2000 m) of the Black Sea was studied by hydroacoustic measurements during several cruises between January 2002 and June 2004. Gas bubbles in the water column give strong backscatter signals and thus can be detected even in great water depths by echosounders as the 38 kHz EK500 scientific split-beam system that was used during the surveys. Because of their shape in echograms and to differentiate against geochemical plumes and real upwelling bubble-water plumes, we call these hydroacoustic manifestations of bubbles in the water column 'flares'. Digital recording and processing of the data allows a 3D visualization and data comparison over the entire observation period, without artefacts caused by changing system settings.

During our surveys, we discovered bubble release from three separate mud volcanoes, Dvurechenskiy (DMV), Vodianitskiy (VMV) and the Nameless Seep Site (NSS), in about 2080 m water depth simultaneously. Bubble release was observed between 9 June 2003 and 5 June 2004. The most frequently surveyed, DMV, was found to be inactive during very intensive studies in January 2002. The first activity was observed on 27 June 2002, which finally ceased between 5 and 15 June 2004 after a period of continuously decreasing activity. This observed 2-yr bubble-release period at a mud volcano may give an indication for the duration of active periods. The absence of short-term variations (within days or hours) may indicate that the bubble release from the observed mud volcanoes does not undergo rapid changes. The recorded echograms show that bubbles rise about 1300 m high through the water column, to a final water depth of about 770 m, which is ~75 m below the phase boundary of pure methane hydrate in the Black Sea. With a release depth from 2068 m and a detected rise height of 1300 m, the flare at VMV is among the deepest and highest reported so far, and gives evidence of highly extended bubble life times (up to 108 min) in deep marine environments.

To better understand how a methane bubble (gas analyses of the pore water and gas hydrate gave 99.4% methane) can rise so high without dissolving, we applied a recently developed bubble dissolution model that takes into account a decreased mass transfer due to an immediately formed gas-hydrate rim. Using the hydroacoustically determined bubble rising speeds (19–22 cm/s at the bottom; 12–14 cm/s at the flare top) and the relation between the rising speed of 'dirty'/gas hydrate rimmed bubbles and the bubble size, we could validate that a gas-hydrate-rimmed bubble with a diameter of 9 mm could survive the 1300-m-rise through the water column, before it is finally dissolved. A diameter of about 9 mm is reasonable for bubbles released at seep sites and the

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