LONG-TERM SEDIMENT TEMPERATURE OBSERVATION REVEALS RAPID COOLING AFTER A RECENT ERUPTION AT NORTH ALEX MUD VOLCANO ON THE WESTERN NILE DEEP-SEA FAN

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Abstract

The West Nile Delta Project at IFM-GEOMAR aims to analyze the relationship between deep gas reservoirs and mud volcanoes on the western Nile deep-sea fan. Long-term monitoring of sediment temperature as an indicator of fluid seepage and mud expulsion at North Alex mud volcano revealed that infiltration of cold bottom seawater accelerates the cooling of the sediments after an eruption and points to rapid transitions between extremely active and dormant stages of this mud volcano.

Keywords: Mud Volcanoes, Nile Delta, Temperature, Models

North Alex mud volcano (MV) is located on the upper slope of the western province of the Nile deep-sea fan at a water depth of around 500 m. It is a circular structure with a diameter of less than 2 km and an elevation of nearly 50 m above the surrounding seafloor at its highest point. The central plateau is characterized by gentle slopes towards a steep edge of about 40 m height, which separates the central mud pie from a surrounding moat. Based on a geophysical mapping campaign, North Alex MV was described as a deep-rooted active gas chimney that may have triggered slope destabilization associated with significant northward sediment flows and slumps, following the local slope gradient [1]. Further investigations in 2003 showed a moderate sediment temperature anomaly of around 0.8 °C/m and sporadic gas ebullition at the center [2], indicative of a minor level of activity.

More recently, North Alex MV has been the focus of the West Nile Delta Project at IFM-GEOMAR, aiming to study the relationship between deep gas reservoirs and mud volcanoes on the Nile deep-sea fan. A first detailed assessment of the sediment temperatures in the mud volcano during the P362-2 cruise of R/V Poseidon in February 2008 revealed extremely high temperatures of up to more than 70 °C at around 6 m below the seafloor (mbsf) at the center, corresponding to temperature gradients of more than 10 °C/m [3]. The focus of the temperature anomaly was found at the highest point and the temperature gradients decreased rapidly towards the flanks of the mud volcano, such that the temperature gradient generally correlated with the morphology. Particularly in the central area, however, the sediment temperature distribution was heterogeneous, which suggested a very recent eruption.

A second assessment of the sediment temperatures at North Alex MV was conducted during the 64PE298 cruise of R/V Pelagia in November 2008 [4]. While the sediment temperatures at the center had remained as high as 9 months before, the outer parts of the plateau had cooled significantly and the lateral extent of the main temperature anomaly had decreased by around 50 percent. Using an ROV, numerous gas seeps were observed in the central area of the mud volcano, where a very rough morphology of the seabed with fresh cracks and superficial faults pointed to recent mud eruptions. During the same cruise, an uncabled seafloor observatory was installed close to the center of North Alex MV. Bottom water temperature and pressure, temperature at the seabed, and sediment temperature down to a depth of 5 mbsf is recorded at an interval of 30 minutes in order to monitor the activity of the mud volcano.

The first data from the observatory was obtained via an acoustic link to the R/V Poseidon during the P388 cruise in July 2009 [5]. Unfortunately, due to a malfunction in the modem software, the time series could not be downloaded completely. However, the currently available sediment temperature data documents clearly that the temperature of the sediments decreased more rapidly than by simple conductive cooling in contact with the relatively cold bottom seawater. The most likely explanation for the accelerated cooling is the infiltration of seawater into the mud volcano sediments. This hypothesis is supported by several concave-upward shaped sediment temperature profiles measured on the central plateau, which also indicate downward flow of porewater. In addition, the time series revealed small temperature fluctuations over time scales of several days to months, suggesting that intermittent pulses of rapid fluid expulsion interrupt the general cooling trend.

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