



In-situ sediment temperature monitoring reveals complex fluid flow patterns at North Alex mud volcano on the western Nile deep-sea fan

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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. Located on the upper slope at a water depth of around 500 m, North Alex mud volcano 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.

Data obtained during previous investigations in 2003 and 2004 showed a moderate sediment temperature anomaly of around $0.8\text{ }^{\circ}\text{C/m}$ at the center, which pointed to a minor level of activity. A first detailed assessment of the sediment temperatures in the mud volcano during the P362-2 cruise of R/V Poseidon in February 2008, however, revealed extremely high temperatures of nearly $70\text{ }^{\circ}\text{C}$ at around 6 m below the seafloor at the center, corresponding to temperature gradients of more than $10\text{ }^{\circ}\text{C/m}$. 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. 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. The most likely explanation for this 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 indicate downward flow of porewater.

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 data collected by the observatory can be accessed via an acoustic link to a surface vessel. Due to a malfunction in the modem software, the time series could not yet be downloaded completely. The currently available sediment temperature data 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.