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Thermo-hydrodynamic modeling of Isis mud volcano based on heat flow measurements and geochemical pore water analysis

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During the MIMES expedition of the multidisciplinary Euromargins project MEDIFLUX in June 2004, Isis mud volcano on the Nile Deep Sea Fan was the site of a particular focus of heat flow measurements. Temperatures as high as 35 °C at 10 m below the seafloor and temperature gradients of up to 2.2 °C per meter at the center of the volcano indicate an exceptionally high level of activity, although apparently in decline with respect to an even higher gradient of 2.7 °C per meter measured during the NAUTINIL expedition in September 2003. Measurements taken at increasing distances away from the center in several directions reveal an axisymmetric temperature distribution in the mud pie. Rapidly decreasing temperature gradients from the center to the outer part of the mud volcano, with no apparent influence of the direction, are consistent with the hypothesis of a narrow feeder channel and an axisymmetric dynamic functioning and growth of Isis mud volcano.

The results of heat flow measurements and geochemical pore water analysis have been combined to provide a three-dimensional insight into the fluid flow and to constrain a thermo-hydrodynamic model of the recent activity. The pore water profiles of cores from the center of the mud volcano show a rapid decrease of salinity to near-freshwater values within the uppermost meter of the sediments, whereas the pore water salinity of cores taken 200 m away from the center is equal to bottom water salinity throughout the entire core. Geochemical transport models and models of heat transfer indicate that

both the pore water composition and the temperature distribution in the mud conduit are strongly influenced by fluid flow and suggest that the observed decline of heat flow with time is accompanied by a reduction of the flow rates.