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In-situ sediment temperature and geochemical porewater data suggest highly dynamic fluid flow at Isis mud volcano, eastern Mediterranean sea

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The Nile deep-sea fan is the most important sedimentary accumulation in the eastern Mediterranean. During two geophysical mapping campaigns conducted in 1998 (Prismed II) and 2000 (Fanil), several mud volcanoes were discovered on the upper slope of the eastern province. Up to a few kilometers in diameter and generally showing a low relief of a few tens of meters, they have been described as surface expressions of deep-seated gas chimneys. Isis mud volcano (Isis MV) is located at a water depth of approximately 1020 m. In contrast to the more complex structure of the neighboring Osiris and Amon mud volcanoes, Isis MV shows a very distinct camenbert-shaped morphology with relatively steep flanks and a gently domed top elevated between 20 and 40 m above the surrounding seafloor. Detailed geothermal and geochemical investigations of Isis MV have been carried out during the Nautinil (2003) and Mimes (2004) cruises within the framework of the Euromargins/Mediflux project. Sediment temperatures of more than 40 °C at 10 m below the seafloor at the center of the mud volcano indicate an exceptionally high level of activity. Rapidly decreasing temperature gradients away from the center support the hypothesis of an axisymmetric dynamic functioning of Isis MV. At the center, pore water profiles show a rapid decrease of chlorinity within the uppermost meter of the sediments, whereas the chlorinity of cores taken at short distances away is equal to bottom water values.

The data obtained during the two cruises reveal significant changes in both the sediment temperature profiles and the geochemical porewater profiles of cores from the center of the mud volcano. In 2003, in-situ measurements revealed a slightly convex-

upward temperature profile with a gradient of up to 2.78 °C/m at depths between 2 and 7 m below the seafloor. When the measurements were repeated at the same location in 2004, the sediment temperatures had decreased by more than 5 °C at approximately 7 m below the seafloor and the previously observed convex-upward curvature of the profiles had disappeared. The temperature gradient did not exceed 2.3 °C/m, corresponding to a decrease in heat flow of about 17 percent with respect to the measurements in 2003. The chlorinity profile of the piston core that was sampled during the Nautinil cruise in 2003 showed a rapid decrease from the seawater concentration of about 608 mmol/kg to less than 170 mmol/kg less than 1 m below the seafloor. An equally sharp transition was observed in the chlorinity profiles of the cores that were sampled during the Mimes cruise in 2004. However, at this time the chlorinity decrease was shifted to a sediment depth of 0.5 to 1 m and the transition zone was overlain by normal seawater concentration in the upper part of the cores.

A one-dimensional coupled model of heat transfer and solute transport in the upper sediment column has been developed to analyze the observed changes and to characterize the associated processes. The model results indicate that the variations in the temperature and chlorinity profiles exceed the effects that may be expected from simple heat conduction and solute diffusion. Neither the rapid temperature decrease nor the downward shift of the chlorinity step observed between 2003 and 2004 can be explained by varying rates of upward fluid flow. Instead, the model suggests the presence of an additional process that leads to cooling of the sediment column and flushing of the upper meter of the sediment with seawater at the same time. In order to identify this process, the role of gas ebullition and the possibility of seawater circulation within the upper meters of the sediment column are investigated.