Geophysical Research Abstracts
Vol. 16, EGU2014-11702, 2014
EGU General Assembly 2014

In situ measurement of thermal diffusivity in marine sediments

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The temperature of marine sediments depends on the interplay between heat flow from below and bottom water temperature above. The heat flow is controlled by the regional geological history and stable over long periods of time, whereas the bottom water temperature is subject to both seasonal and long-term climatic changes. The thermal inertia of the sediment determines how rapidly and to what depth temperature changes propagate from the bottom water into the seabed. The influence of seasonal changes is usually limited to shallow depths, while long-term trends may also affect deeper sediment layers. The thermal diffusivity of sediment is its ability to conduct thermal energy relative to its ability to store thermal energy. It is a measure of thermal inertia. While the thermal conductivity can be measured using regular heat flow probes, it is difficult to measure the diffusivity in situ. Hence, empirical relationships that link conductivity to diffusivity are widely used to characterize the thermal inertia of sediments.

Here, we present a new method for measuring the thermal diffusivity of marine sediments in situ, which is based on monitoring the changes in sediment temperature profiles over short periods of time. We report on a successful measurement from 400 m water depth on the western Svalbard margin, where we deployed a temperature probe by submersible. The "T-Stick" consists of a lance with 8 temperature sensors distributed equally over a length of 0.6 m and a data logger, which is attached to the upper part of the lance. Temperature profiles were recorded at a sampling interval of 10 seconds for a period of 10 days. The observations show that variations in the temperature profile were driven by changes in bottom water temperature. Inverse modeling of the recorded temperature profiles allowed us to determine the thermal diffusivity of the sediment. The new method will help to better characterize the heat exchange across the sediment-water interface and contribute to the understanding of seafloor warming as a consequence of climate change. The new data is particularly useful for modeling the response of marine gas hydrate occurrences to warming bottom waters.