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Thermophysical properties derived from lab measurements and downhole logging at New Jersey Shallow Shelf (IODP Expedition 313)

A. Fehr (1), R. Pechnig (2), J. Inwood (3), J. Lofi (4), F.P. Bosch (1), and C. Clauser (1)

(1) RWTH Aachen University, Applied Geophysics and Geothermal Energy, Aachen, Germany (a.fehr@geophysik.rwth-aachen.de), (2) Geophysica Beratungsgesellschaft mbH, Aachen, Germany, (3) Department of Geology, University of Leicester, Leicester, United Kingdom, (4) Géosciences Montpellier, Université Montpellier, Montpellier, France

The IODP drilling expedition 313 New Jersey Shallow Shelf was proposed for obtaining deep sub-seafloor samples and downhole logging measurements in the crucial inner shelf region. The inner to central shelf off-shore New Jersey is an ideal location for studying the history of sea-level changes and its relationship to sequence stratigraphy and onshore/offshore groundwater flows. The region features rapid depositional rates, tectonic stability, and well-preserved, cosmopolitan age control fossils suitable for characterizing the sediments of this margin throughout the time interval of interest. Past sea-level rise and fall is documented in sedimentary layers deposited during Earth's history. In addition, the inner shelf is characterised by relatively fresh pore water intervals alternating vertically with saltier intervals (Mountain et al., 2010). Therefore, three boreholes were drilled in the so-called New Jersey/Mid-Atlantic transect during IODP Expedition 313 New Jersey Shallow Shelf. Numerous questions have arisen concerning the age and origin of the brackish waters recovered offshore at depth.

Here we present an analysis of thermophysical properties to be used as input parameters in constructing numerical models for future groundwater flow simulations.

Our study is based mainly on Nuclear Magnetic Resonance (NMR) measurements for inferring porosity and permeability, and thermal conductivity. We performed NMR measurements on samples from boreholes M0027A, M0028A and M0029A and thermal conductivity measurements on the whole round cores prior to the Onshore Party. These results are compared with data from alternative laboratory measurements and with petrophysical properties inferred from downhole logging data.

We deduced petrophysical properties from downhole logging data and compared them with results obtained with laboratory measurements. In water saturated samples, the number of spins in the fluid is proportional to sample porosity. NMR porosities were calculated from the zero amplitudes of the transverse relaxation measurements by normalizing the CPMG (Carr, Purcell, Meiboom, Gill) amplitudes of the measured samples to the amplitudes measured on a pure water cylinder which is equivalent to a porosity of 100 %. The NMR porosities fit well with porosities determined by Multi Sensor Core Logger (MSCL) and porosity measured on discrete samples using a helium gas pycnometer.

Using log interpretation procedures, the volume fraction of different rock types and their porosity can be derived. From the volume fraction of each rock type and its porosity, continuous profiles of thermal conductivity can be derived by using a suitable mixing law, e.g. such as the geometric mean. In combination with thermal conductivity measurements on cores, these continuous thermal conductivity profiles can be calibrated, validated and finally used to provide reliable input parameter for numerical models.

The porosity values from NMR seem to correlate well with porosities deduced from other measurements. In order to compare NMR permeabilities, we need permeability determined by an alternative method. The thermal conductivity derived from logs correlates with the measurements performed on cores.

In a next step, a numerical model will be set up and the measured thermophysical properties will be implemented in order to study transport processes in passive continental margins. This numerical model will be based on existing geological models deduced from seismic data and drillings.

References:

Mountain G. M., Proust J.-N. and the Expedition 313 Science Party (2010): The New Jersey Margin Scientific Drilling Project (IODP Expedition 313): Untangling the Record of Global and Local Sea-Level Changes, in Scientific Drilling No. 10, September 2010, p. 26-34. DOI 10.2204/iodp.sd.10.03.2010