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Numerical simulation of transient temperature logs of borehole Yaxcopoil-1, Chicxulub impact structure, Mexico

J. Safanda (1), H. Wilhelm (2), P. Heidinger (2) and V. Cermak (1)

(1) Institute of Geophysics, Prague, Czech Republic, (2) Geophysical Institute, University of Karlsruhe, Germany (jsa@ig.cas.cz)

The geothermal research of the Chicxulub impact structure on the Yucatan Peninsula, Mexico, included repeated temperature logs of the 1.5 km deep borehole Yaxcopoil-1, which were done following 0.3-0.8, 15, 24, 34 and 50 months after shut-in of drilling operations. A gradual distortion of the linear temperature profile by a cold wave was detected propagating downward from 145 m to 317 m within the observational period of 50 months (March 2002 - April 2006). The amplitude of the cold wave was increasing with depth and time in the range of 0.8 -1.6 °C. As an explanation of this unusual phenomenon, the hypothesis of downward migration of drilling mud, accumulated within the overlying and cooler highly porous and permeable karstic rocks during the drilling, was proposed. The thermal effects of the migrating fluid have been evaluated by solving numerically the heat conduction-convection equation in appropriate geothermal models. The best coincidence between the observed data and the simulations was yielded by the model of the drilling mud migrating as an isolated large drop. Parameters of this model are constrained by the measured temperature logs relatively tightly.

Namely: 1) the vertical extent of the downward migrating fluid body is about 10 m, maybe increasing within the observational period of 33 months by a factor of 2 2) the horizontal extent of the body must be at least 5 - 10 m, i.e. by order(s) of magnitude larger than diameter of the borehole 3) the average speed of the migration is about 5 m/month 4) the fluid must migrate through a highly porous rock (70% - 80% porosity

or more). This high porosity, which is necessary for the model to fit the observed data, and the observed relatively stable velocity of the migration indicate the existence of a well-developed system of interconnected karstic cavities.