Geophysical Research Abstracts, Vol. 8, 08046, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08046

Numerical modelling of the geothermal and structural evolution of the Astrakhan crest, SW-Pricaspian salt basin (Russia)

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The Astrakhan crest is one of the largest sub-salt structure of the Pricaspian basin containing a huge carbonate massif. The giant Astrakhan gas field is situated within the crest and associated with the carbonate reservoir, which is located in the Carboniferous deposits. Numerous indications on possible locations of oil-and-gas fields in the older sediments were found during the exploration of the Astrakhan gas field. Therefore, the study of the geothermal and structural evolution of the region plays an important part in the understanding of the possible origin of hydrocarbons in the Devonian-Carboniferous sediments. To understand the geothermal history of the Astrakhan crest region, we have developed two-dimensional (2D) geothermal models associated with the structural evolution of the region. The geological profile along the Astrakhan crest is back-stripped using constraints on the duration of erosion and paleo-water depths. To rely on the model results, we employ two different numerical techniques to compute the heat conduction in the original and restored profiles. The first technique is based on a finite element method applied to solve a 2D steady-state heat diffusion equation. The second technique is a high-order finite difference method applied to solve a 2D non-stationary heat diffusion-advection equation. A present geothermal model contains 11 sedimentary layers: salt, 4 layers of its overburden, and 6 sub-salt layers. The heat flux at the lower model boundary and temperature at the upper boundary are estimated such a way to fit the measured temperatures in several drilled boreholes. The time between 370 Ma and 270 Ma is marked by the presence of the

Caspian sea water in the region. The water thickness varies laterally, and hence temperature is lower beneath the sea and higher beneath the dry land. Such changes in the geothermal regime due to presence of sea water in the region may have an implication for understanding of hydrocarbon generation in the region. In the post-Kungurian (post Late Permian) times, when seawater is withdrawn from the region, the temperature depends primarily on depth with the maximum temperature of about 200C in the Devonian deposits. If our major assumptions, concerning the constant heat flux at the lower model boundary during the basin evolution and the absence of fluid influx into sediments since the Devonian times, are valid, hydrocarbons are most likely to be generated in the post-Kungurian times rather than before it.