Geophysical Research Abstracts,
Vol. 11, EGU2009-10556, 2009
EGU General Assembly 2009

Numerical modelling of the thermal effects of groundwater flow during the evolution of the Roer Valley Graben, the Netherlands

E. Luijendijk (1), M. Ter Voorde (1), R.T. Van Balen (1), M. Person (2), and P.A.M. Andriessen (1)

(1) Faculty of Earth and Life Sciences, Vrije Universiteit, Amsterdam, (2) Department of Earth and Environmental Science, New Mexico Tech, Socorro, NM, USA

As numerous studies have demonstrated, groundwater flow can have a significant impact on subsurface temperatures, and therefore also on exhumation histories derived from thermochronological studies. Our research aims to quantify this influence by including fluid flow in numerical models for the thermal behaviour of the crust and sediments, and validating these models using apatite fission track thermochronology. Our study focusses on the Roer Valley Graben. This is a Mesozoic rift system which, after Late Cretaceous and Paleogene inversion events, was reactivated during the Neogene, forming the northwestern extension of the European Cenozoic Rift System. Here we report first results of 1) inverse modelling of thermal history using a vitrinite reflectance and apatite fission track dataset, and 2) a set of model scenarios of the thermal influence of groundwater flow during the evolution of the graben.

As a first step the thermal history of the Roer Valley Graben was reconstructed using inverse modelling of apatite fission track and vitrinite reflectance data of the basin fill. The method took into account the uncertainty of provenance ages of the apatite samples, and of long-term fission track annealing rates. First results suggest a number of thermal anomalies: 1) regional, but not basin-wide, enhanced heat flow during the Triassic to Jurassic rifting phase, 2) lower than expected thermal gradients during or after Late Cretaceous basin inversion, and 3) highly localized enhanced thermal gradients during the Cenozoic. Anomaly 1) can be attributed to thinning of the lithosphere. In this setting, the most obvious source of anomalies 2) and 3) is the thermal effect of topography-driven flow and free convection of groundwater.

The potential thermal influence of groundwater flow during rift development was simulated using RIFT2D, a numerical model of heat and fluid flow in evolving sedimentary basins. The model was applied to assess the long term thermal evolution of the basin. In addition we simulated model scenarios focussing on the effect of topography driven flow during late Cretaceous basin inversion, and on the potential of convection through permeable faults during the Triassic-Jurassic and Neogene extension phases.

One of the specific advantages of RIFT2D is that it includes solute transport, which is absent in most other basin modelling codes. Here we show the strong influence of a salinity gradient on topography-driven flow and free convection. Knowledge about the distribution of salinity from wells can thus provide constraints on the extent of groundwater flow.

A new model of fault permeability evolution, which takes into account the anisotropy of the fault zone, allowed an assessment of both local and basin scale flow through faults. We show to what extent the uncertainty and heterogeneity of the permeability of lithologies and faults determine the scale of thermal influence.