Geophysical Research Abstracts
Vol. 12, EGU2010-14217, 2010
EGU General Assembly 2010

Reconstructing the geological history of the Roer Valley Graben (Southern Netherlands) by integrating provenance and basin thermal history and apatite fission track thermochronology

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Apatite fission track thermochronology is a powerful analytical tool used to investigate thermal history and reconstruct geological history of sedimentary basins; especially where parts of the geological record are missing due to erosion.

We have used a combined approach of burial history models and apatite fission track analysis to reconstruct the thermal and geological history of the Roer Valley Graben. This is a Mesozoic-Cenozoic rift basin located in the southern Netherlands, which was inverted and partly eroded during the Late Cretaceous and the Paleocene. The main emphasis of this study is to quantify the amount of erosion during late Cretaceous and Paleocene basin inversion phases. The reconstructions are based on an apatite fission track dataset of 27 Carboniferous to Neogene samples taken from boreholes at 0.4 km to 3.5 km depth.

One of the challenges encountered during this study was to master a non-uniform distribution of single fission track ages,resulting from inherited thermal signals of multiple sediment source areas. A first analysis of samples buried at shallow depths (<1,300 m) that have not experienced fission track annealing after deposition show broad and non-uniform age distributions with the bulk of the apatite fission track ages ranging from 430 to 150 Ma. These ages can be explained by a mix of Caledonian, Variscan ages and a Jurassic exhumation event which was reported by earlier studies in the Brabant and Rhenish Massifs in Belgium and Germany which are the sediment source areas.

A new model was developed combining the various scenarios for the pre-burial history of samples with a 1D burial history model of the sedimentary basin. Comparison of observed and simulated fission track data allowed an estimation of the magnitude of late Cretaceous inversion of the basin. Samples from mildly inverted sections maintain a broad distribution of ages inherited from the Caledonian and Variscan source areas, while strongly inverted samples show a narrow age distribution due to the resetting of fission tracks. In addition, a number of samples show surprisingly old Pre-Cambrian ages and in a few samples apatite fission track ages have been reset in spite of their relatively shallow burial.

Our results have implications for the magnitude and distribution of the Late Cretaceous inversion as well as for the heat flow history of the basin. The results of this study demonstrate that integrating the provenance and burial thermal history expands the possibilities of apatite fission track analysis by enabling the use of heterogeneously distributed single grain ages to study the thermal and geological history of sedimentary basins.