Geophysical Research Abstracts
Vol. 21, EGU2019-5642, 2019
EGU General Assembly 2019

Measuring and modeling the thermal effect of breakup at the continent-ocean transition

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Continental breakup is one of the most important processes in geology. In order to correctly model and understand continental breakup it is essential to define key physical parameters and know how these parameters have changed over time. Changes in thermal regime are still poorly understood, but play a pivotal role in rifting, breakup and post breakup phases. Therefore, our aim is to measure thermal maturity at the Continent Ocean Transition (COT) and use this data to model the thermal evolution of this complex domain.

In that respect, the recent International Ocean Discovery Program (IODP) expeditions 367-368 along the South East China margin provide an excellent case study, with recent studies suggesting that the SCS rift represents the “missing link” between magma-poor and magma-rich margins.

Here, we draw on data acquired from four holes drilled along a transect spanning the COT, in order to record different ages and stages of rifting (i.e. pre-rift, syn-rift and post-rift sediments). Thermal models were calibrated by means of vitrinite reflectance, Raman spectroscopy of organic matter and fossil-lipid biomarker analyses. Direct measurements of the present-day heat flow (HF) indicates elevated values in the area (HF > 100mW/m^2). Thermal models incorporated diffusive heating from a magmatic intrusion, and when considered over the rifted margins geological history allow us to determine the palaeotemperatures experienced by sediments prior, during and after the continental breakup.

Our data indicate very low thermal maturity for the post-rift sequence and a thermal maturity jump moving from the pre-rift to the syn-rift sediments. The 1D heat flow models that explain these observations in all four holes show:

1) A peak in heat flow occurred subsequent to the Oligocene with a maximum heat flow of 150 mW/m^2.

2) Radiogenic heating affected sediments closest to the continental margin the most, sediments overlying oceanic crust not all, and sediments between the two positions less the closer that they are to the oceanic margin.

3) A magmatic intrusion is necessary to explain the thermal maturity profile recorded in syn-rift and pre-rift sediments in a hole drilled over extremely thinned continental crust (6 km thick).

In combination vitrinite reflectance, Raman spectroscopy and biomarker thermal parameters can cover the range of thermal regimes encountered in post rift sediments (pre-catagenesis), and sediments found near magmatic intrusions (high thermal maturities). Magmatic intrusions are needed to explain the thermal maturities measured in the oldest sediments. As dykes and sills are not equally distributed over the COT, we expect that the thermal maturity found in distal sedimentary basins is heterogeneous, and that therefore the thermal effect of breakup is complex to integrate within basin models.