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The thermal evolution of marginal basins: Results of thermo-mechanical numerical modelling

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The South Atlantic conjugate margins are the product of continental rifting and break-up of Pangea, which was made up of different crustal features prior to rifting. We investigate the thermal evolution of marginal basins from the moment of continental rift initiation until the early spreading phase. 2D numerical modelling techniques are used to explore the continental break-up with complex, model setups that consist of two segments characterized by different rheological strength and include various initial positions of thermal anomalies. Next, the thermal evolution of the various rift-to-spreading modes is calculated with a 1D heat flow equation.

The thermo-mechanical model results show that, depending on the initial location of a thermal anomaly (or plume) various modes of break-up develop, amongst which are 1) the classical 'central' or 'plume-centered' mode, where the break-up center develops directly above the plume-impingement point, 2) a 'distant' mode, where the lithosphere breaks far away from the plume-impingement point operating in quasi-passive regime, 3) a 'shifted' type of break-up, where break-up occurs offset from the plume-impingement point, but where plume-material still reaches the break-up center after migration along the base of the lithosphere and 4) a 'two-branch' break-up mode where two plume-induced rift-branches develop into spreading centers, separates through time and space.

These results are then used to simulate in more detail the thermal evolution of conjugate margin basins. Heat flow trends calculated for these break-up modes show that in absence of plume material at the spreading centre (so e.g. a 'distant' mode of break-up), heat flow rates are lower than when plume material does reach the spreading axis (e.g. 'central' or 'shifted' type of break-up). The models also show that it is possible to have different heat flow rates between different conjugate margins. For a basin that developed on the margin of a 'shifted' break-up mode where plume material migrates along the base of the lithosphere, heat flow values are generally higher than on its conjugate, where no plume material migrated along its base. The different heat transfer trends can directly be used as initial and boundary thermal conditions for basin modelling to investigate an impact of varied heat flow on basin scale processes e.g. hydrocarbon maturation and generation.