Effect of the interplay between ultra-slow spreading ridge and transform faults on seafloor morphology

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Slow and ultra-slow spreading systems give way to complex seafloor morphologies characteristic of different modes of tectono-magmatic activity at the ridge: crust accretion by episodic magma supply, low-angle brittle/ductile normal faulting and high-angle normal faults leading to the formation of oceanic core complexes (OCC). Previous studies have established that the magma supply acts as a first-order control on the tectono-magmatic activity at ultra-slow ridges (Howell et al., 2019; Lavier et al., 2000). However, other parameters are likely to play a significant role in the mode of spreading and therefore the seafloor morphology. For instance, transform faults are ubiquitous in slow spreading systems and are therefore likely to impact the mode of spreading by redistributing the stress field in the oceanic lithosphere. This seems to be supported by the observation that OCC are typically occurring in the inside corners of intersections between the ridge axis and major transform faults (Tremblay et al., 2009). Yet, little work has been done to investigate this question, leaving a significant gap in the understanding of slow and ultra-slow spreading systems.

This contribution investigates the interaction between ultra-slow spreading ridge and transform faults within the framework of a case study of the Fram Strait using high-resolution 3D numerical modelling. This study rely on the latest advances in geodynamics, namely the grain-damage rheology (Bercovici and Ricard, 2012) – which allows for internally consistent modelling of long-lived transformed faults. Numerical experiments are compared to the tectonic history of the Fram Strait over the last 10 Ma. A significant amount of geophysical and geological data available in the region allows us to assess how well the models reproduce observable structures in near-surface. Results show that ridge obliquity and ridge-transform interplay strongly affect the ridge spreading mode. Oblique ridge favour the formation of OCC over low-angle detachment fault and are systematically formed in the vicinity of major transform faults. Overall, results are in accordance with the highly complex seafloor morphology of the Fram Strait, in particular in the vicinity of the Molloy ridge. This study opens the way for a better understanding of complex ridge and abyssal hills structures in ultra-slow and slow spreading systems.

Bibliography

