Linking the mechanics of polygonal faults with hydrothermal activity and marine biosphere – the Guadeloupe geothermal system

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Polygonal faults are ubiquitous features, commonly observed in seismic images of fine-grained sedimentary successions along many passive margins. They are characterized by covering large parts of the basin with a typical polygonal pattern. In the last decade, different mechanical models for the generation of polygonal faults have been proposed; however, as they are commonly formed at depth and not directly observable at the surface, their formation remains a matter of debate. As part of the GEOTREF Program (ADEME – Investissement d’avenir) we found polygonal fault structures exposed close to the surface in marine soft sediments at 5 m water depth at the western coast of Guadeloupe. The structures are associated with fault-bound thermal springs and clearly visible at the sea bottom due to preferential precipitation of sulfur minerals and concentration of diatoms. In a multidisciplinary study involving a team of hydrogeologists, marine micro-biologists, and structural geologists, we study the genesis of polygonal faults in this setting. We analyzed the sediments in which the polygonal faults formed structurally and geochemically. First results suggest that SiO2 precipitated from hydrothermal fluids increases the cohesion of the most permeable soft sediments. Dewatering of the underlying layers causes the formation of polygonal faults at a depth of <1 m. These polygonal faults then act as channels for hot fluids, resulting in accumulation of sulfur favoring the establishment of diatoms at the surface. This study offers the unique opportunity to study the formation of polygonal faults in situ. We compare the observed geometries of polygonal faults with GEOTREF cruise 2-D seismic data offshore Guadeloupe, and 3-D seismic data of polygonal faults in New Zealand and Australia with the goal to understand the variability of polygonal fault geometries, as well as their comparability across different scales of observation. On a more local scale, this study provides insights how fracture dynamics guides fluid flow, which in turn interacts with the marine biosphere.