Fluid migration along a dense, intersecting array of faults on the outer-shelf of Southern Costa Rica: Insights from 3D seismic attributes and multibeam data

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We use 3D seismic reflection attributes and multibeam data to map and analyze fluid-flow along a dense network of intersecting normal faults imaged on the outer shelf offshore Southern Costa Rica. Faults were imaged on the seafloor using (i) high-resolvability EM122 multibeam data, and (ii) in 3D below the seafloor using seismic reflection data, both collected during the 2011 CRISP seismic survey. Multibeam bathymetry reveals a series of high-backscatter ridges on the seafloor cut by numerous faults with roughly N-S and E-W trends. Vertical profiles within the 3D seismic volume reveal that faults have normal displacements and extend deep into the sedimentary section, some of which cut through top of the margin. Numerous indicators of fluid-migration and fluid-rich sediments, such as bright spots, dim spots, and acoustic turbidity zones, are present along fault traces imaged on vertical inlines and crosslines. Within the seismic volume we use seismic discontinuity attributes (e.g., coherency and similarity) of a dip-steered seismic volume to reveal and map fault traces in horizontal time slices. We then use a neural network of multiple seismic attributes to create a 'fault cube' and a 'chimney cube' to detect high probability zones fluid leakage along faults. Indicators of seafloor seepage, such as high-backscatter pockmarks and mounds, are imaged on the seafloor along fault traces and above seismic indicators of fluid migration. Use of seismic discontinuity attributes massively improves 3D interpretability of a very complex set of intersecting faults, and provides insight into understanding the pathways of fluids and gas within the margin of Costa Rica.

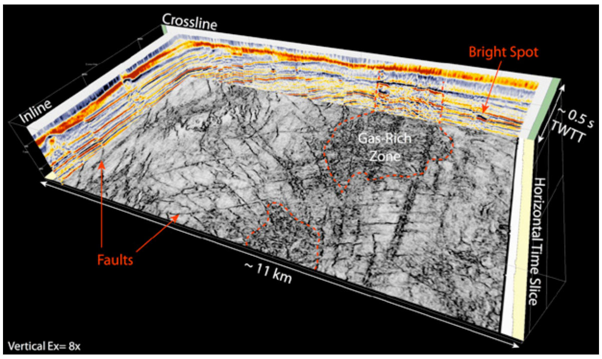

Figure 1. 3D perspective view of subset of 3D seismic data below the outer shelf of southern Costa Rica.

Constraints for the clumped isotope application in diagnetic environments involving high salt concentrations

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Carbonate clumped isotopes is a promising proxy for the reconstruction of mineral formation temperature and their parent fluid composition. Clumped isotopes has a wide range of potential applications, such as the reconstruction of the diagenetic history of sedimentary basins that involve fluids with a high salt concentration and elevated temperatures. As salt ion effects are known to impact bulk oxygen isotopes, here we assessed the influence of salinity on clumped isotopes in the temperature range from 20-90°C.

Samples were precipitated from a super-saturated $CaCO_3$ solution via N_2 bubbling. Prior to starting the carbonate precipitation the solution was equilibrated at the respective experiment temperature. Different salt ions (Na^+, Ca^{2+}, Mg^{2+}) were added to the solution and compared to samples without added NaCl, MgCl or $CaCl_2$ to evaluate ionic effects on ^{13}C-^{18}O clumping. No effects were observed for NaCl at temperatures between 23 and 90°C and salt concentrations up to 6 molal. Preliminary results indicate that moderate concentrations of $MgCl_2$ (0-0.4 molal) and $CaCl_2$ (0-0.5 molal) have no observable influence on ^{13}C-^{18}O clumping. Furthermore, polymorphism of $CaCO_3$ produced no observable effect. In summary, our results indicate that carbonate clumped isotopes can be applied to carbonates precipitated from saline parent fluids without the need to correct for salt ion effects in common NaCl brines or fluids containing moderate levels of $CaCl_2$ and $MgCl_2$.

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