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The effects of fluid flow on the morphology of continental margins at subduction zones

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The circulation and expulsion of fluids in subduction zones has a strong influence on the morphology of continental slopes. This influence can be direct through the formation of structures related to fluid expulsion such as mud volcanoes, mud mounds and chemoherm structures, or indirectly through the alteration of slope sediments or their properties. These alteration can be the formation of gas hydrates cementing slope sediments (or destabilising them during dissociation) or the precipitation of carbonates crusts that will change the resistance to erosion of the slope sediments.

Bathymetric and sidescan sonar data from offshore Costa Rica and Nicaragua document these effects of fluid flow in various ways. Widespread fluid expulsion occurs on the continental slope in water depths ranging from 400 metres to about 2000 metres. They form a number of morphological expressions of up to 250 metres relief height, which we here neutrally call 'mounds'. The mode of formation of these mounds is still unclear, but there is no evidence for recent mud flows precluding them to be mud volcanoes. Instead, the mounds show signs for active or recent carbonate crust precipitation, as do other sites without morphological expression. The results of active fluid venting at these sites, however, is imaged as high backscatter areas in sidescan sonar data. These mounds and backscatter anomalies can be isolated but several fields or alignments of these structures have been observed. Alignments of fluid escape structures are supposed to follow underlying faults that act as conduits for the fluids. These faults are generally not imaged with geoacoustic data, but two main sets of slope-parallel and across-slope faults have been described in the past based on seismic profiles.

The continental slope offshore Costa Rica and Nicaragua is dissected by a dense set of canyons. Downslope erosional currents forming these canyons would preferentially follow faults with similar orientation. In this case however, the faults act as conduits for fluid-flow structures and actually form ridges between the canyons. At present there are no indications for fluid seepage on the canyon floors or canyon walls. Erosive gravity currents and by extension the canyons they form will avoid areas of extensive carbonate cemented sediments due to fluid seepage. This effect is particularly well imaged offshore Costa Rica and Nicaragua because the continental slope there is mostly sediment starved, a fact that is already shown by the absence of trench-fill turbidites. As a result much of the slope morphology is dominated by structures resulting from fluid seepage together with large scale sediment failures. However, a few areas of smooth slope topography suggesting intra-slope basins are present offshore Costa Rica. Mounds and fluid-flow structures are mostly absent in these areas indicating a link between the dissipation of fluids and slope lithology. It is possible that coarse-grained gravity-current deposits allows for diffusive instead of focussed fluid emission.