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# Multiple normal and reverse faulting along the Costa Rica margin – results from IODP Expedition 344 (CRISP 2)

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The primary objective of Integrated Ocean Drilling Program (IODP) Expedition 344 offshore the Osa Peninsula in Costa Rica was to sample and quantify the material entering the seismogenic zone of the Costa Rican erosive subduction margin. Fundamental to this objective is an understanding of the nature of both the subducting Cocos plate crust and of the overriding Caribbean plate. The Cocos plate is investigated trying to define its hydrologic system and thermal state. The forearc structures recorded within the sediments deposited on the forearc, instead, document periods of uplift and subsidence and provide important information about the processes of tectonic erosion.

Brittle structures within the incoming plate (sites U1381, U1414) are mineralized extensional fractures and shear fractures. Shear fractures mainly show a normal component of shear. Within the sedimentary sequence both types of fractures dip subvertically and strike NNE-SSW. Deformation bands trend roughly ENE-WSW, sub-parallel to the Cocos ridge. The Cocos Ridge basalt contains mineralized veins at various orientations. A preferred orientation of strike directions was not observed. Vein mineralizations mainly consist of carbonate, quartz and pyrite.

The top 150 m of the sediments in the prism-toe at about 2.5 km from the frontal thrust (Site U1412) are characterized by normal faults. These form distinct shear planes with little displacement and form conjugate sets with NW-SE and NNE-SSW trends. This reveals a subvertical orientation of the maximum principal stress, and a subhorizontal, ENE-WSE orientation of the minimum principal stress, indicating a stress regime of normal faulting. We interpret these faults as compaction-related features. As the stratigraphic age within this interval is Pleistocene, the formation age of the normal faults is younger than Pleistocene. Deeper in the sediment sequence of the prism toe, fault zones are localized between 330 and 342 mbsf, and between 358 and 365 mbsf.

Moving landward across the forearc, Site U1380 is located on the middle slope. 154 fault planes were identified throughout the whole cored interval. Domains of localized faulting, intense fracturing and brecciation were defined as fault zones. The lower part of Site U1380 is characterized by a downhole trend of decreasing bedding dip angles. Dip angles change from an average of 40° above 630 mbsf, to an average of 10° in the lower 100 m of the hole. The decrease of bedding dips is not linear, but shows steps associated with brecciated zones. This interval also corresponds to a relative increased frequency of fault planes. Faults with both normal and reverse sense of shear are common throughout the hole, equally present, and their abundance increases downhole. Strike-slip faults increase in abundance downhole as well. This section also includes well consolidated/cemented sediments containing mineral veins. The veins indicate that high fluid pressure was generated just below the cemented interval.

Site U1413 is located on the upper slope of the forearc. Faulting-related deformation is abundant from approximately 180 mbsf to the bottom of the drilled section. Normal faulting is usually more abundant than reverse faulting. Dip angles of normal faults and reverse faults vary from subhorizontal to subvertical with a maximum dip of 75°. Both normal and reverse faults are not homogenously distributed along the entire hole. The deeper parts are additionally characterized by high-angle reverse faults with steep dip angles (> 75°).

The structures within the mid- to upper slope of the Costa Rica forearc may therefore be associated with the development of an over-steepened slope margin, thrust-related anticlines, fault reactivation, structural inversion and over-printing, probably related to seamount impact. Faulting within the upper plate additionally controls the distribution of fluid seeps. Fluids released within the lower plate may migrate along the plate boundary and into the upper plate.