Geomorphologic Impact on the Climate Record of Santa Cruz Basin, CA

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Abstract

Part of the California Borderlands, the Santa Cruz Basin is located off the southern California coast approximately 87 km west of Los Angeles. The basin reaches a depth of 1957 m and covers an area approximately 1735 km^2, trending northwest to southeast. Similar to the anoxic Santa Barbara Basin, the Santa Cruz Basin contains varves with a foraminiferal climate record dating to the Miocene. During March 2011 the NOAA Ship *Okeanos Explorer* collected multibeam sonar data of the basin using a Kongsberg EM302 multibeam sonar system. CARIS HIPS 7.1 software was used to create a high-resolution CUBE BASE bathymetric surface and three dimensional map of the basin's geomorphology, which revealed slumps and turbidity flows from the nearby Santa Cruz Canyon. The drainage system, canyon turbidity flows, and slumping have potentially disturbed the climate record along the edge of the basin floor. As with nearby basins, the right-lateral movement caused by transform faults of this region may be responsible for the slumping along the western rim of the Santa Cruz Basin. Along the eastern rim of the basin, a dendritic drainage system was identified as an outlet for the Pilgrim Banks which divides the Santa Cruz Basin from neighboring Santa Monica Basin.

Geologic Background

The Santa Cruz Basin is representative of other basin morphologies in the Borderland region off the coast of southern California (Fig. 1). The Borderland includes many basins, trenches and submarine canyons (Covault and Romans, 2009). These geomorphologic units result from the right-lateral strike-slip faulting in the region (Howell et al., 1974). Due to its complex bathymetry, the Borderland experiences extreme currents and turbidity flows (Covault and Romans, 2009). Much of the geologic history of the California Borderland is recorded in basinal environments. Thus, basins like Santa Cruz often contain well preserved climate paleo-climate records within their anoxic water (Resig, 1958). However, turbidity flows and other sedimentation processes may disrupt the climate record in these basins (Howell et al., 1974).

The Borderland includes many basins, including the Santa Cruz and Santa Barbara Basins. Santa Cruz Basin is one of many in the surrounding area off the coast of California. Located 87 km west of Los Angeles, the Basin reaches a depth of 1,957 m and covers an area of approximately 1735 km^2 (Fig. 2). The basin contains similar characteristics to the Santa Barbara Basin, as both contain a foraminiferal paleo-climate record of the last 8,000 years (Resig, 1958; Pisias, 1978). Although the laminated sediments of the Santa Barbara Basin appear mainly undisturbed, they are subject to rapid sedimentation (Pisias, 1978; Covault and Romans, 2009). Much of the sediment formations of these basins are due to submarine canyon systems which transport sediment from the surrounding islands and continental shelf to the seafloor (Covault and Romans, 2009).

Because of the potential for detailed climate studies of this region, a better bathymetric model was created to study the basin geomorphology, and to identify areas where core samples may not be suitable, as the sediments are not those originally deposited, but have been subjected to bulk emplacement of slump and turbidite deposits. This project provides such a model and examines the processes of Borderland climate preservation and destruction.

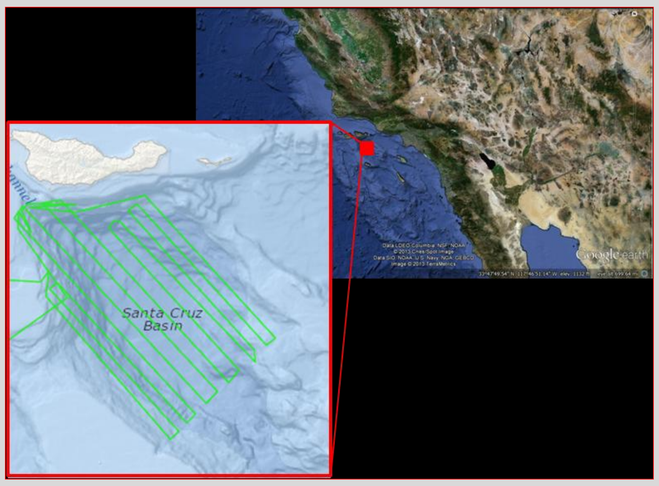

Figure. 1. Location of Santa Cruz Basin, California, USA (119.7° W, 33.8° N). Track lines of survey EX1101 collected by NOAA Vessel *Okeanos Explorer*.

Methods

- Multibeam data acquired on the *NOAA Ship Okeanos Explorer,* March 24-26, April 26, 2011
- Hull-mounted Kongsberg 302 multibeam sonar system
- A 10 m CUBE BASE surface was created using CARIS HIPS 7.1, along with a 2000 m surface as an underlay.

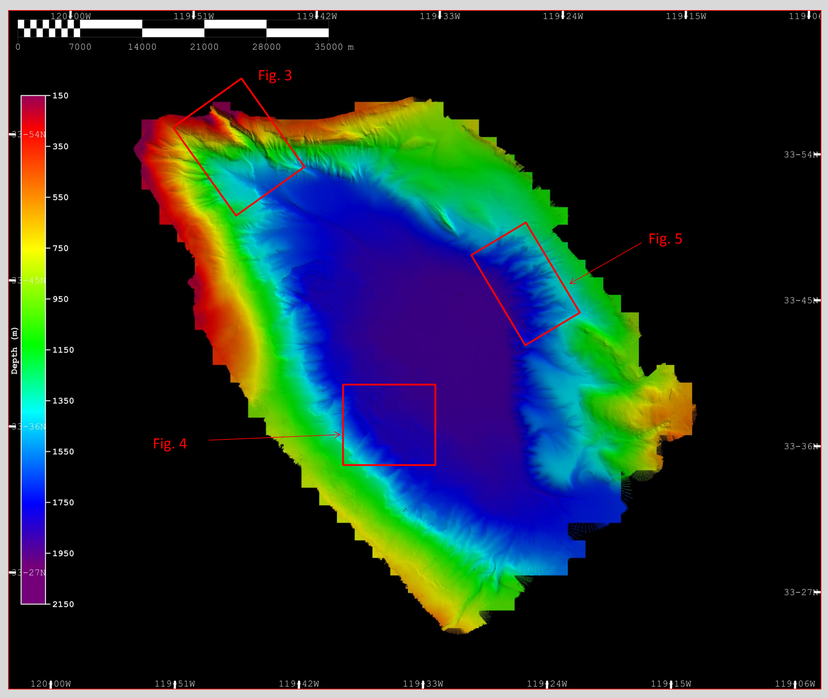

Figure 2. CUBE Base Surface of Santa Cruz Basin. Insets designate the Santa Cruz Canyon (Fig. 3), an area of slumping on the southwest flank (Fig. 4), and a dendritic drainage system from the Pilgrim Banks (Fig. 5).

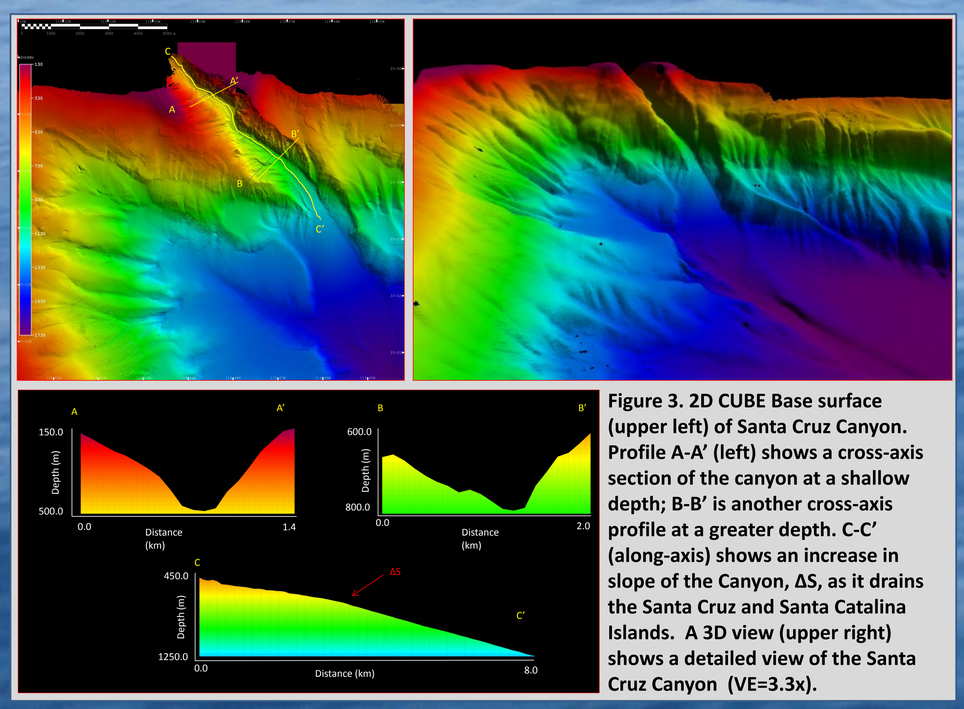

Figure 3. 2D CUBE Base surface (upper left) of Santa Cruz Canyon. Profile A-A' (left) shows a cross-axis section of the canyon at a shallow depth; B-B' is another cross-axis profile at a greater depth. C-C' (along-axis) shows an increase in slope of the Canyon, ΔS, as it drains the Santa Cruz and Santa Catalina Islands. A 3D view (upper right) shows a detailed view of the Santa Cruz Canyon (VE=3.3x).

Discussion

- The Santa Cruz Canyon in the northern section of Santa Cruz Basin is congruent with turbidite morphology (Covault and Romans, 2009). The narrow channel of this canyon and change in gradient cause rapid transportation of sediment from Santa Cruz Island to the seafloor, likely destroying any laminated bedding that has developed at depth.
- This basin has undergone multiple slumping events, probably as a result of active regional tectonics (Howell et al., 1974).
- A significant decrease in slope as sediment is transported off the basin wall accounts for the deposition of multiple slump mounds immediately adjacent to the wall.
- The increase in mound frequency as distance from the western wall increases may be a result of either (a) more active tectonics earlier in the geologic development of the basin, or (b) mound erosion over time, dividing a single slump event into multiple mounds. The second option seems more likely as mound height decreases significantly from B-B' to C-C'.
- These slumping episodes also decrease the likelihood of discovering an undisturbed paleoclimate record in the sediment of the Santa Cruz Basin.
- The dendritic drainage system deposits sediment transported from the Pilgrim Banks in alluvial fans at the base of the system.

Results

- Santa Cruz Canyon (Fig. 3) provides drainage from the Santa Cruz Island to the seafloor, transporting sediments through the steep channel (Fig. 3D). The canyon begins with a narrow channel and walls approximately 350 m in height (A-A') and empties into the basin with a wider channel and lower relief walls (B-B'). The slope of the canyon increases significantly at approximately 3.5 km from the head of the canyon (C-C').
- Prominent slumping exists on the western rim of the Santa Cruz Basin (Fig. 4). Slumping events appear to be episodic, forming long sinuous mounds of sediment (Fig. 4E). The numbers of slumping events and deposits seem to increase as distance from the basin wall increases, indicated by an decrease in the intervals from profiles A-A' through C-C'. The slumping area covers a distance of 11.0 km from the western basin wall and has a water depth change of approximately 600 m, with a distinct change from very steep slope to shallow slope (D-D').
- An intricate dendritic drainage system exists in the eastern portion of the basin (Fig. 5), transporting sediment from the Pilgrim Banks to the basin floor. The drainage channels have fairly unchanging slopes and undergo an elevation change of approximately 700 m (A-A', B-B'). The system contains multiple wide-mouthed channels positioned adjacent to one another over approximately 9 km (C-C'). Significant alluvial fans were produced at the mouth of this system (Fig. 5D).

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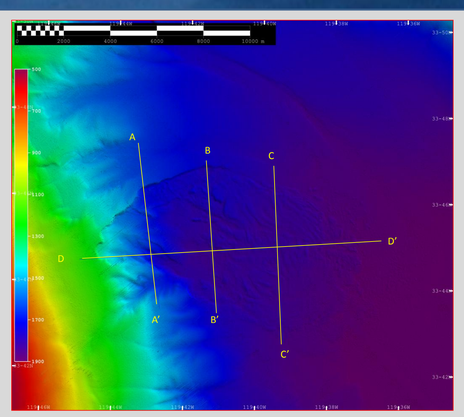


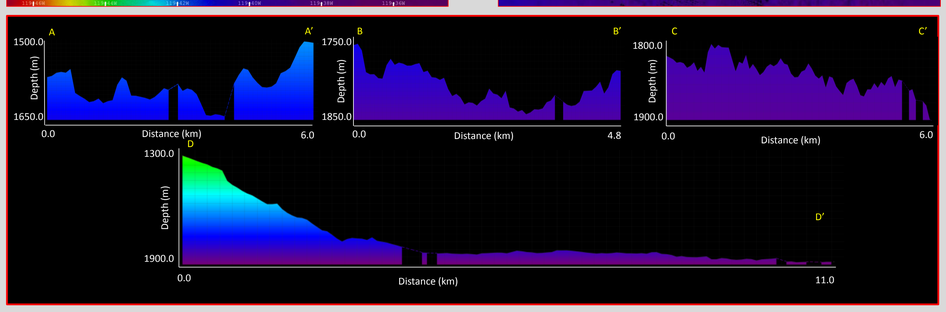
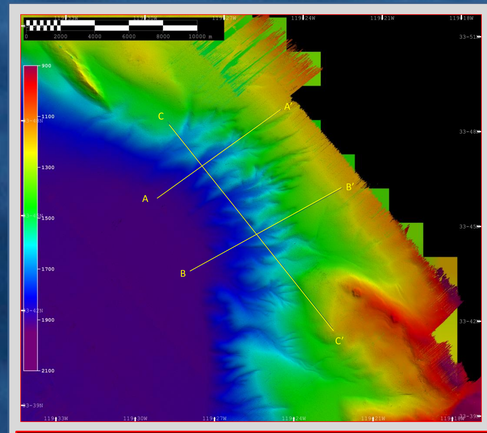


Figure 4. 2D surface of a slumping area on the southwest basin wall. Profiles A-A', B-B', and C-C' show increasing occurrences of shallow slumping and slump deposits along the entire slope of the eastern basinal boundary (D-D'). The 3D view (upper right) shows a detail of the slumping zone at (VE=3.3x).



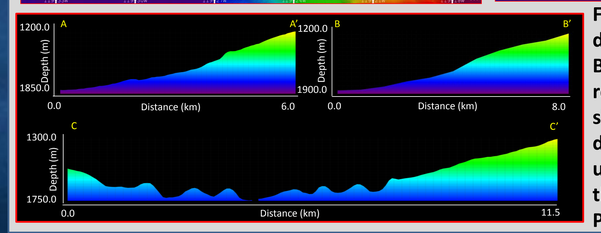


Figure 5. 2D surface of the eastern drainage system emptying the Pilgrim Banks. Profiles A-A' and B-B' show the relief of the drainage system. C-C' shows the number of dendritic drainage patterns within the area. The upper right image shows a 3D view of the entire drainage system from the Pilgrim Banks (VE = 3.3x).

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