The Study of Submerged Shorelines of the Southern California Borderland Areas Focusing on the Northern Channel Islands Platform and Pilgrim Banks.

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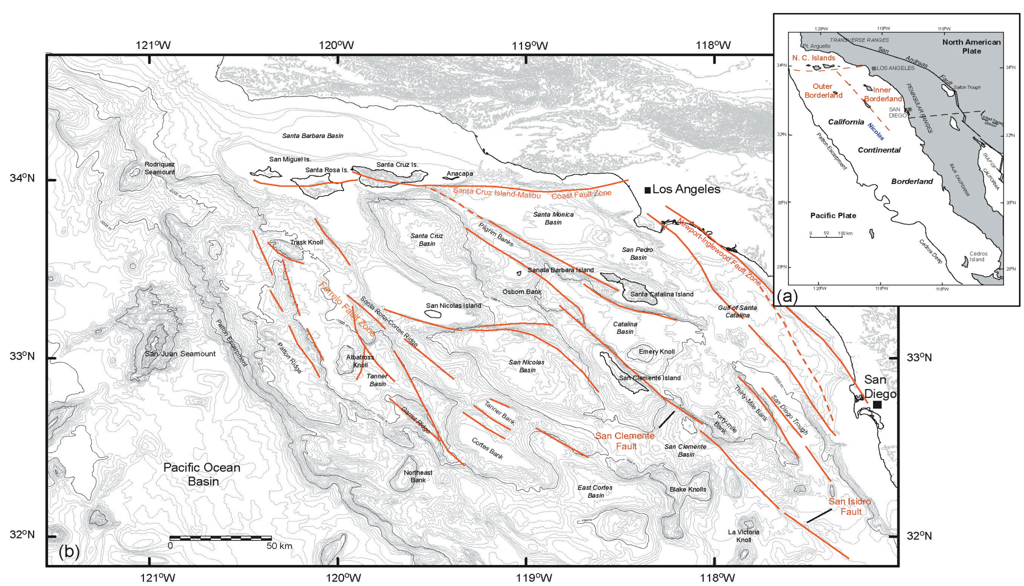
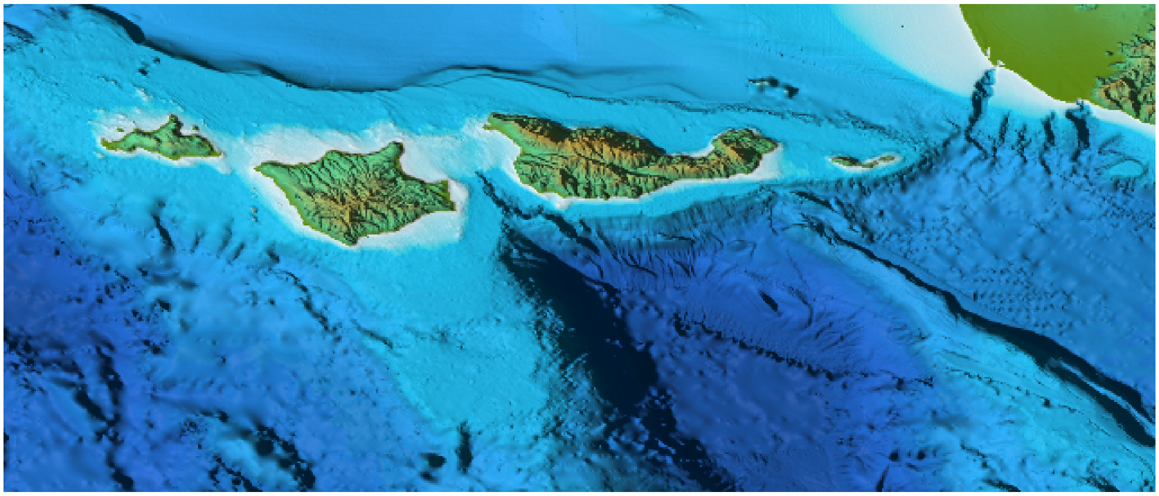
Abstract

Submerged shorelines preserved around the Northern Channel Islands platform within the Southern California Continental Borderland provide a unique datum for determining vertical tectonic motion. Last Glacial Maximum (LGM) and younger paleoshorelines are well preserved due to low frequency erosional forces that occur in the region and as such act as excellent strain markers, recording deformation over the last 18,000 years (about the time of LGM). These shorelines were originally formed close to sea level, but through time they have been submerged and deformed due to sea-level change, local vertical tectonic movement, and faulting. The purpose of this project was and continues to be to map potential paleoshorelines around the Northern Channel Islands and Pilgrim Banks to the south, using the information gained to investigate the Transverse Range – Peninsular Range intersection. The interaction between these two major provinces has created a structurally and tectonically complex area, which we have only just begun to investigate and understand. As we study the paleoshorelines and their relevance to vertical strain rates, in addition to the distortion of them that has taken place due to the faulting in this area, we will be able to gain further insight into the nature of the associated faults. This information can then be used to further understand the tectonics processes operating in southern California and the earthquake hazards they pose to coastal communities and the larger metropolitan areas.

Along the coast of California there are very distinct geologic features called marine terraces. Marine terraces are reasonably flat platforms cut out by wave action against the shoreline. As land is lifted due to tectonics, new platforms are created and the old platforms are left as terraces. Offshore, similar evidence exists along the continental shelves in the form of low-stand shorelines cut during glacial maxima. After the platform is cut and sea level rises again, the terrace becomes submerged and it is now considered a submerged shoreline. The paleoshorelines offer a preserved record of any deformation that has occurred due to low frequency erosional forces that occur in the region. Paleoshorelines will be able to give details about any faulting, folding, or tilting that has occurred in the area since they were formed. Submerged shorelines exist in the Southern California Borderlands and in this study the Channel Islands Platform and Pilgrim Banks are emphasized.

Below is a map of the entire Southern California Borderland region and the area where we called particular attention to this summer, the Channel Islands. Most of our study this summer was on the northern and southern regions of Santa Cruz Island and Santa Rosa Island. Santa Cruz Island is a main topic of our study because a major fault runs through the island and distorts most of the zone on the southeastern side of the island. As paleoshorelines are revealed, we can examine the type of deformation that has occurred due to the fault and at what rate.

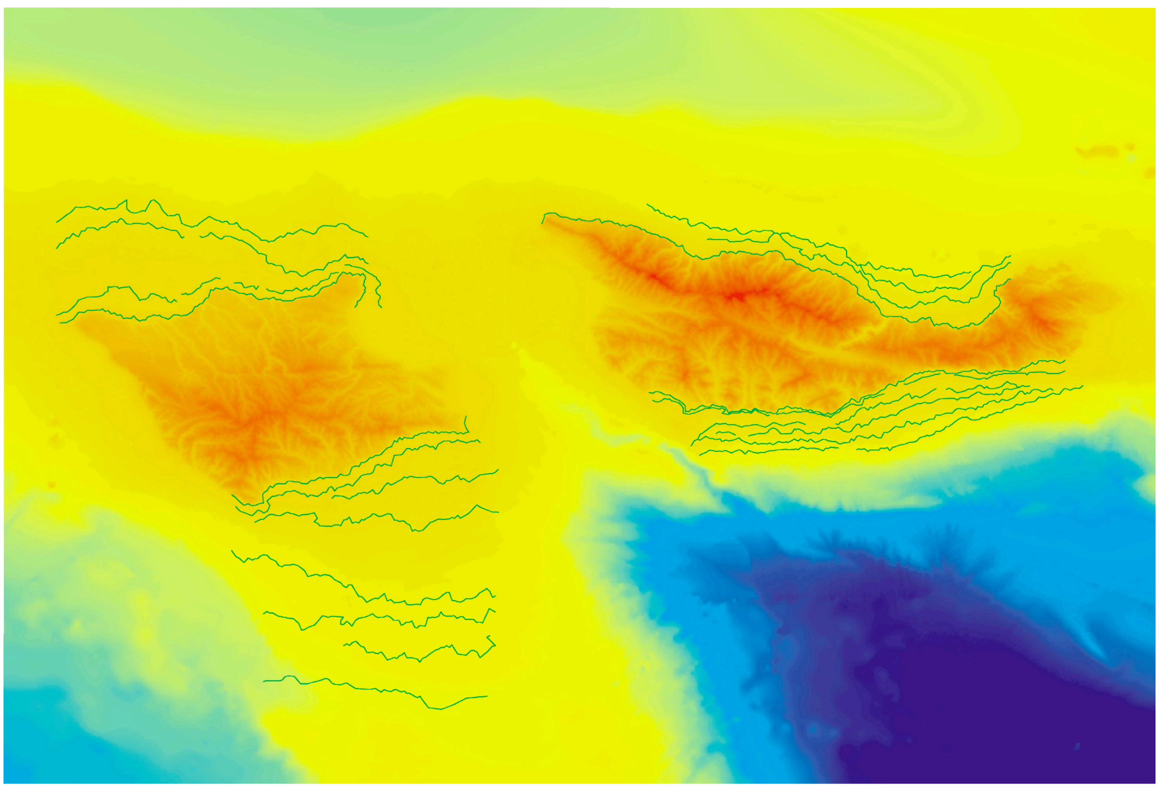




Region of Study in Greater Detail

In order to map the paleoshorelines in detail, we used a bathymetric map that was created from data collected by the use of multibeam sonar on previous offshore cruises. The map was used in a GIS program called Erdas Imagine to create profiles across the region. The profiles were examined for characteristics of submerged shorelines such as relatively flat platforms at various levels offshore, and sharp breaks of slope. A mark was made at each instance when a platform met a sharp slope and the depth was recorded. The marks were then superimposed onto a 3D map of the region created on ArcView GIS and then examined to see if any of the marks correlated with each other. After extensive examination, a line was made where there was thought of a possible paleoshoreline. After all of the possible shorelines were created, they were superimposed onto the 3D bathymetric map again to see if the paleoshorelines agree with the image of the sea floor.

Examining the marks and comparing them to their corresponding depth was very intensive because the idea that a shoreline should be about the same depth in its entirety keeps resurfacing in the mind. However, these shorelines have been deformed due to some sort of tectonics and the entire shoreline will not necessarily be at the same depth. When looking at the 3D ArcView map, a very large exaggeration was used to be able to see slight differences in the possible shorelines. These differences could be a result of the deformation that has taken place in the area since the formation of the paleoshorelines. Another issue that must be kept in mind is that paleoshorelines would not be straight. Most shorelines today are not straight lines down the coast; instead they hug the outline of the shore, which can be very uneven. Paleoshorelines follow the same principle therefore, when looking at the possible paleoshorelines, straight lines are not necessarily practical. Both of these factors were considered when mapping the possible shorelines nevertheless, a predetermined thought of what the shorelines should look like was never used in the process.

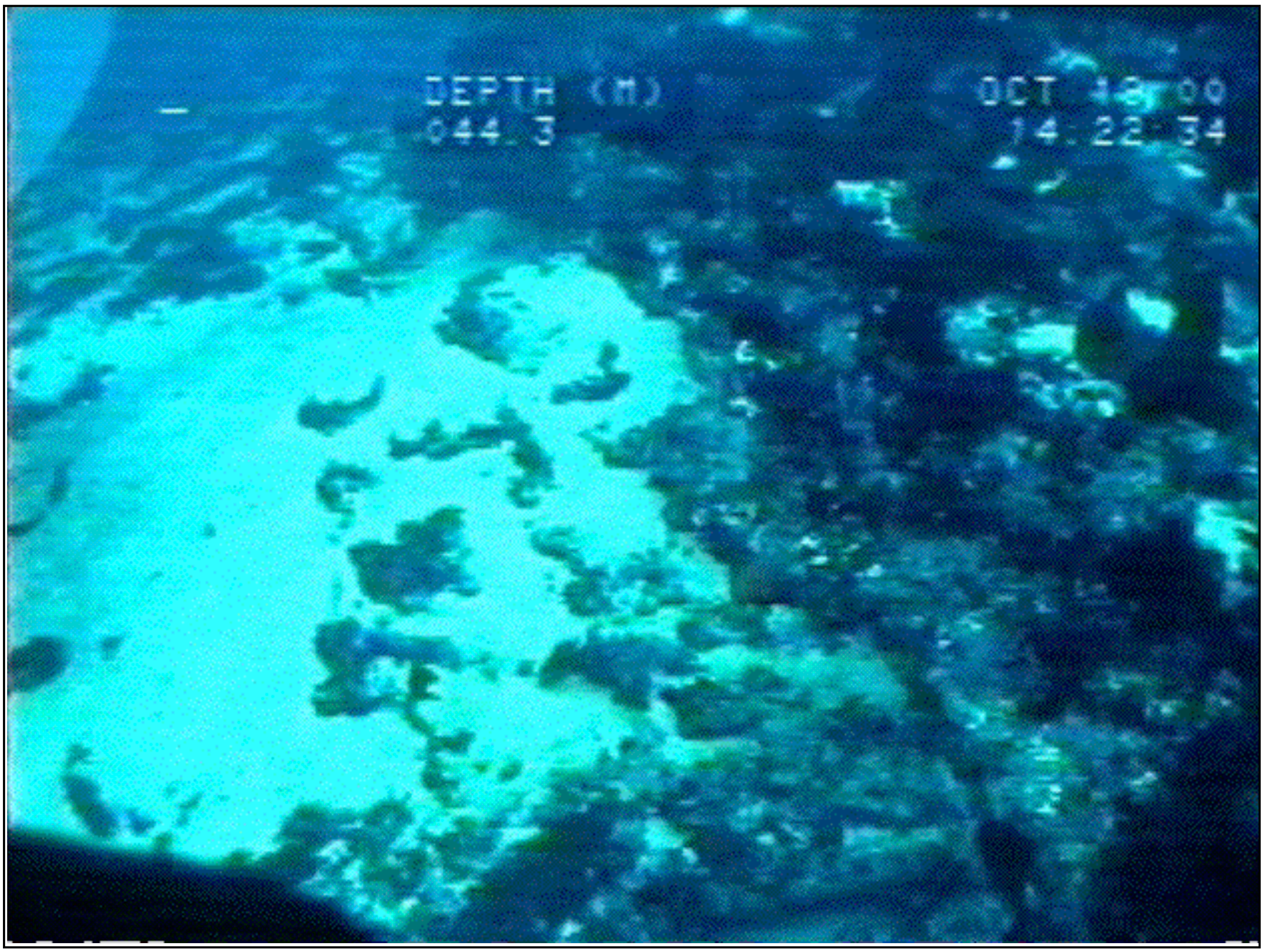


Potential Shorelines Mapped During the Summer

Last Glacial Maximum (LGM) and younger paleoshorelines provide excellent strain markers, precisely recording deformation over the last 18,000 years (about the time of the LGM). The study of paleoshorelines will help to decipher what type of deformation occurred and at what rate. This knowledge will help to investigate the Transverse Range – Peninsular Range intersection. The information learned through the study of the paleoshorelines surrounding this region would gain further insight into the nature of the associated faults. The interaction of these two major provinces has created a structurally and tectonically complex area, which has only just begun to be investigated and understood. The Transverse Range – Peninsular Range intersection is important because part of the boundary is offshore, and well preserved, while the other part is onshore, but difficult to investigate because of urbanization. If the offshore boundary is understood, then the information can be used to understand the boundary onshore. What is known is that these submarine faults are located just a few miles off the coast of Los Angeles and that they are active, as they have relatively frequent earthquakes. These faults pose both a seismic and tsunami hazard to the coastal communities of Los Angeles. However, because the slip rate and direction of motion of these faults is not known then the extent of the hazard is also unknown.

The shorelines that have been mapped in this project will further the investigation of these faults by giving a reference point for future dives in either a submersible or with the use of the ROPOS ROV (remote operated vehicle). During the dives, a shoreline can be confirmed with the presence of shell hash beaches, preserved ripple marks, wave-cut sea caves, and intertidal fossils that can be dated with AMS 14C techniques. Once the shoreline is confirmed, resultant dives can search for tectonic deformation along the shoreline such as scarps, vertical or horizontal displacements, and possible offset paleostream channels. The investigation of the tectonic deformation will allow scientists to gain knowledge of the slip rate and direction of motion of the faults surrounding the Los Angeles Basin. Furthermore, with every new breakthrough in the seismic activity found in the Southern California Borderlands, the citizens of Los Angeles can feel more secure about the place they call home.

On September 11, 2004 we set out for an eight-day cruise to collect more data for our investigation. We were able to plan dives in the Delta submersible to places that were thought to have shorelines. We used the findings from the summer project to plan these dives. We were able to confirm at least three shorelines mapped in this project. Below is an example of what a shoreline would look like diving in the Delta submersible. We also collected more sidescan sonar data and will be processing this data at a later date to help confirm shorelines we were unable to dive to on this cruise.



Shoreline Seen on a Past Dive