THE NORTHERN SAN ANDREAS FAULT: LOCATION, PALEOSEISMICITY AND GEOMETRY

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The Northern San Andreas fault: location, paleoseismicity and geometry

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INTRODUCTION

The location, character and history of movement of the northern end of the San Andreas fault have been sources of great controversy for a number of years (Merritts, 1996). The fault zone forms the boundary between the North American and Pacific plates, but like many such boundaries involving continental lithosphere, its precise location is not everywhere clear. The fault strand which broke from the San Francisco area northward in 1906 goes offshore at Point Arena (Figure 1).

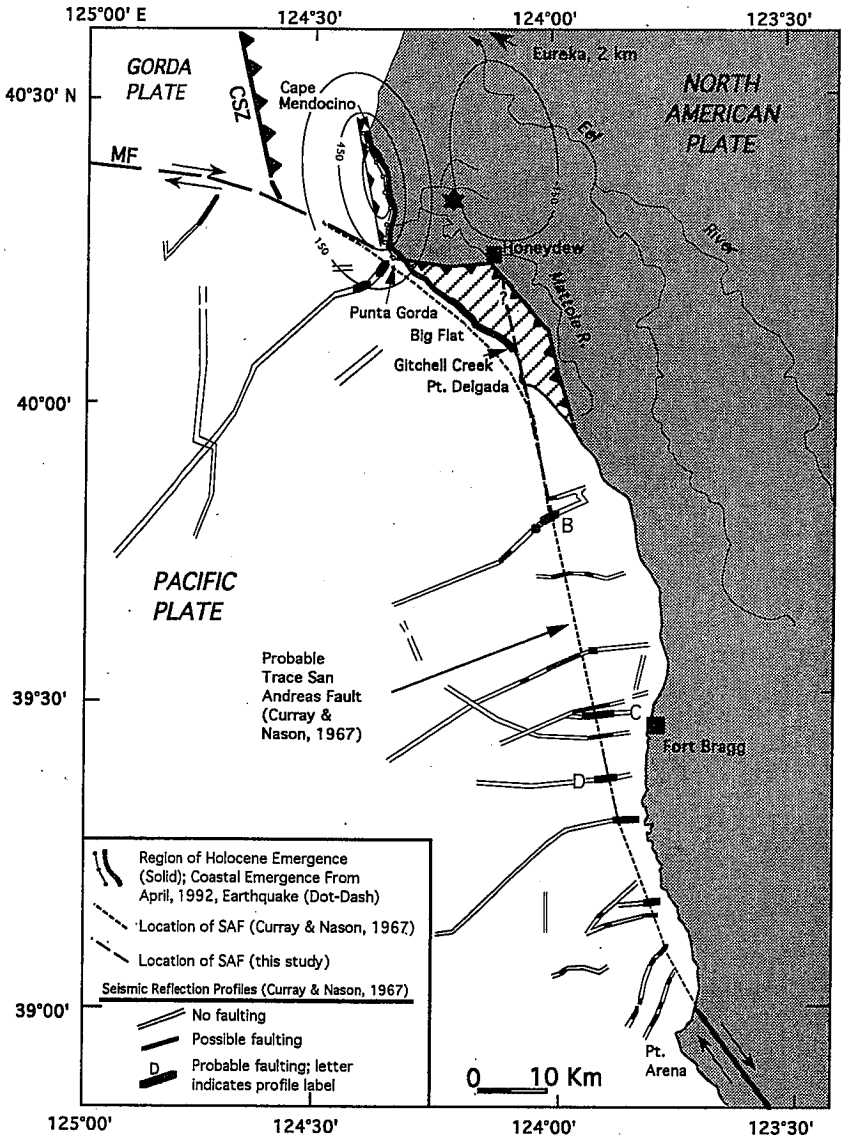

Figure 1. Location map and tectonic setting of the northern end of the San Andreas fault. Asterisk is epicenter of 1992 Cape Mendocino earthquake; contour lines (in mm.) represent modeled displacement from this earthquake. Hachured area is King Range terrane. (from Merritts, in press)

The path of the San Andreas from Point Arena to the point ~180 km to the northwest where it interacts with the Mendocino fracture zone and the Cascadia subduction zone to form the Mendocino triple junction is not well defined. North of Point Arena, Curray and Nason (1967) detected on marine seismic reflection profiles a linear belt of disturbed strata which could be traced NNW toward Point Delgada. However, they suggested that the fault remains offshore very near the coast.

In contrast, recent geologic and geophysical studies suggest that the San Andreas may come ashore south of Cape Mendocino and that the triple junction is onshore. (McLaughlin et al. 1993). The area surrounding Cape Mendocino has high seismicity and has undergone Holocene uplift, including substantial coseismic uplift during the 1992 Cape Mendocino earthquake. The questions which this project addressed are simple: does the San Andreas come ashore at Shelter Cove on the south side of Point Delgada, and if so, what is its expression, where does it go from there and what has been its influence on the distribution of lithologic units and on the formation, preservation and deformation of marine terraces?

The Keck project benefited from being dovetailed with two other ongoing research projects with which the faculty are involved. Dorothy Merritts and Ed Beutner, together with Carol Prentice of the USGS, are working on a project funded by the NEHRP program of the USGS; Carol directly advised one of the Keck students and aided several others. In addition, Dorothy and Paul Bodin from the University of Memphis have an ongoing project funded by the National Science Foundation aimed at modeling the deformation associated with the northern end of the San Andreas fault. Paul spent most of the project period with us and had input on a number of student projects.

LOCATION OF THE NORTHERN SAN ANDREAS

Part of the inspiration for this project came from the discovery by R. Brown (Brown, 1995) of the photos of Francois Matthes in the archives of the U.C. Berkeley library. Matthes was with the U.S. Geological Survey and as part of the team sent out to survey the San Andreas following the 1906 earthquake, he examined the coastal terrain north of Point Arena. He discovered, photographed and mapped a 3 km-long trace of ground breakage crossing Point Delgada, coming onshore at Shelter Cove and disappearing near Kaluna Cliffs. His work was summarized in the Lawson report on the 1906 earthquake, but its significance was lost over the years and the ground breakage he reported was attributed instead to earthquake-induced landsliding on the steep slopes of the Point Delgada area. A prinicpal goal of this Keck project was to test the hypothesis that Matthes was correct in locating the northern strand of the active San Andreas fault in the Point Delgada area.

A major NNW-trending fault crosses Point Delgada and separates two portions of the King Range terrane (Franciscan complex); the Late Cretaceous Point Delgada subterrane is on the west and the Miocene King Peak subterrane is to the east (McLaughlin et al, 1993). This fault had been a candidate for being the active San Andreas, but McLaughlin discovered adularia-bearing veins crossing the fault that have yielded K-Ar ages of 13.8 ± 0.4 my, and thus the two subterranes have been locked together since that time. The three likely paths for the modern San Andreas are thus the immediate offshore, through Point Delgada east of the fault just described, and crossing the coast near the mouth of Whale Gulch and extending up Whale Gulch and down Bear Creek, where a pronounced shear zone is known (Beutner, et. al, 1980). The offshore possibility could not be investigated, but the other two hypotheses were foci of student projects.

STUDENT PROJECTS

We began with a field trip to examine the San Andreas fault at a number of classic areas where fault-related landforms are particularly well developed. Ramon Arrowsmith (Arizona State University) led us south from San Francisco to sites where we examined the fault at Mission San Juan Bautista, Hollister (Calaveras fault), and Parkfield, where the fault monitoring array was visted. The following day was spent in the Carrizo Plain where we studied the fault at Washburn Ranch, Wallace Creek, Soda Lake and the Dragonsback. The next day was spent driving northward to the Point Arena area, where Carol Prentice guided us through the intricacies of San Andreas-related landforms in a much more humid venue. We then headed northward toward Point Delgada, which was to be home for the following 4 weeks.

After several days of orientation, the students were spread out along 35 km of coast and their work began. Two students, **Jim Heyes** and **Thea Depetris**, worked on the stretch of coast from the mouth of Whale gulch southward, in the Sinkyone Wilderness State Park. Thea concentrated on the older structures in the bedrock (King Peak subterrane and Coastal Belt of the Franciscan), with the intent of documenting the structures which formed during Cascadia subduction prior to the propagation of the San Andreas into the area. Jim worked on younger faults which cut the Cascadia fabric, marine terraces and deposits on the terraces. **Nathan Brooks-English** tackled the wall of Shelter Cove, an enigmatic exposure of the materials overlying a Quaternary marine terrace. His project involved everything from blue goo to fossil

beetles. **Scott Pease** worked on the well developed Quaternary marine terraces which are one of the landmarks of Point Delgada. An important part of the project was our attempt to relocate the fault where it was mapped and photographed by Matthes crossing the Point. With enthusiasm undampened even when the backhoe dug up a water main, **Allison Schill** and Carol Prentice trenched several sites and surveyed the land surface along the proposed path of the fault. **Erin Gorman** and **Alan Troup** mapped the exposures of the Point Delgada subterrane on the coastal platform in order to characterize the terrane and to see whether it was possible to match the lithologies with other Franciscan terranes along the San Andreas fault to the southeast. Erin worked on the southern portion of the exposure where the rocks are largely sedimentary, whereas Alan had to deal with voluminous pillow lavas and a wonderfully enigmatic sequence of shallow intrusives. **Ron Griffiths** and **Greg Schorr** studied the area along the coast north of Point Delgada. Ron concentrated upon the Holocene terraces which appear between Telegraph Creek and Gitchell Creek and become a striking shoreline feature northward toward Big Flat. Greg's project was aimed at defining the sequence and geometry of Cascadia subduction zone-related structures and the younger faults which overprint the subduction-related structures in the King Peak subterrane along this segment of coast. **Jordan Muller** was supported by NSF funds but worked alongside all of the Keck students as he attempted to trace the San Andreas into the King Range.

And where is the San Andreas? A steep shear zone with right slip was found cutting a <11,000 ybp landslide in the Shelter Cove wall in an exposure which had been washed clean of sand and modern landslide debris by winter storms. Interestingly, by the end of our field work, this fault had again been covered by a small debris flow and the sand of the summer beach. It was traced northward (Figure 2) across Point Delgada, where it is marked by distinctive landforms and deformation observed in a trench. It continues across Kaluna Cliff on a course of ~N 10°W into the King Range. We are confident that this represents the most recently active trace of the San Andreas fault.

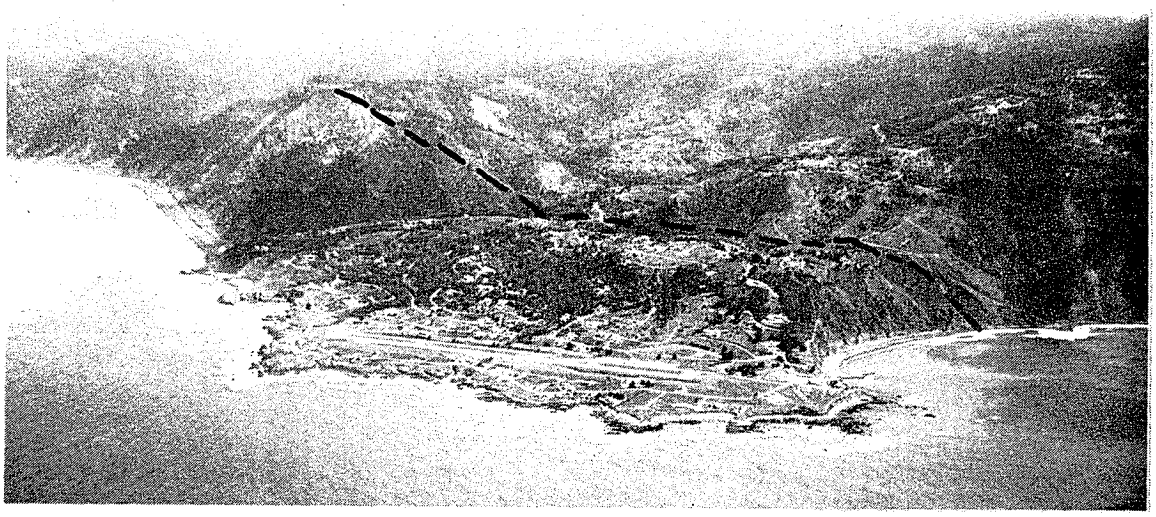

Figure 2. The dashed black line represents the trace of the San Andreas fault as it crosses Point Delgada.

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