The northernmost San Andreas fault: Evidence of youthful strike-slip faulting near Point Delgada, California

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INTRODUCTION

Following the 1906 San Francisco earthquake, Francois Matthes, a topographer with the United States Geological Survey (USGS), reported a 3-km-long zone of surface rupture near Point Delgada, CA (Fig. 1). He interpreted this zone as the continuation of San Andreas fault (SAF) surface displacement seen 117 km to the southeast, entering the ocean near Point Arena (Fig. 2). If his hypothesis were correct, the rupture length associated with the 1906 earthquake would be at least 435 km, rather than merely 375 km. Later workers questioned this interpretation based on mapping bedrock units at Point Delgada, and concluded that ground breaks could have resulted from coseismic landsliding and ground shaking. The objective of this project is to map in detail the area where the SAF returns to shore south of Point Delgada, and to constrain the location of the active trace of the fault at its northern termination.

METHODS

Mapping. Strike-slip fault surface features along this section of the SAF were identified using field reconnaissance combined with analysis of topographic maps, low-altitude, low sun-angle photographs, historical aerial photographs, and maps and previously unpublished photographs produced by Matthes in 1906 (Lawson, 1908). Results of this mapping indicate the presence of a youthful strike-slip fault along the N 1-37° W trend mapped by Matthes.

Excavation. The fault trace was further constrained by detailed logging of two excavations made along the fault trace (Fig. 1). The first trench, dug at the beginning of Landis Road, is termed Lower Landis Trench (LLT). The walls of this excavation showed only undisturbed fluvial stratigraphy and a high water table. The second trench, dug south of LLT, is termed Upper Landis trench (ULT). This excavation, located on a shutter ridge mapped by Matthes, yielded an exposure of a steeply-dipping, strike-slip fault and several smaller, corollary faults. Based on the orientation of the fault exposed in ULT, the fault trends close to the east end of LLT.

Survey. A total geodetic station and electronic data logger were used to survey key features in the topography from the Cove wall exposure north to Shelter Cove road, roughly 20 meters north of the LLT (Fig. 1). The data will be used to generate detailed maps of the areas sketched by Matthes in 1906.

HISTORY OF FAULTING

The history of faulting in the Point Delgada area can be divided into three separate episodes based on fault characteristics and orientation. The oldest episode is recorded by large reverse faults with mineralized gouge zones which formed more than 1-2 m.y. ago during deformation associated with the Cascadia subduction zone. The next episode of faulting, less than 1-2 m.y. ago, produced reverse faults with moist gouge zones but no mineralization; this represents deformation from the leading edge of the SAF which propagated at an approximate rate of 5 cm/yr (Castillo and Ellsworth, 1993). The most recent episode of faulting is characterized by young, high-angle, right-lateral and reverse-oblique faults. This is the record of activation of an on-land trace of the SAF.

LOCATION OF TRACE

The Cove Wall. Point Delgada, CA, is a low, broad, nearly planar, seaward-dipping headland located on the coast 80 km south of Eureka and about 45 km southeast of Cape Mendocino (Fig. 2). Eroded bedrock at the point forms a surrounding sea cliff of late Pleistocene wave-cut marine platforms that are overlain by rounded near-shore marine cobbles, which in turn are overlain by fluvial sediments (McLaughlin et al., 1983)(Fig 3). Overlying these sediments are a thick section of Cretaceous argillites that have slid over the Quaternary deposits by mass movement during the Holocene Epoch. The argillites were deformed during Cascadia subduction, and contain convoluted lenses of granulated quartz in their fabric. On the sea cliff, southeast of Shelter Cove and about 200 m west of Deadmans Gulch, a young strike-slip fault and resultant shear zone cuts the argillites exposed in the Quaternary landslide (Fig. 1).

A sample was taken from the gouge in the fault exposure. A thin section cut in a plane oblique to the suspected direction of displacement showed grains sheared in a right-lateral sense. A thin section cut in a plane in the suspected direction of movement shows little to no sheared grains.

Strike and dip readings were taken of the argillite fabric on either side of, and within, the Cove wall shear zone associated with the SAF exposure. These readings, along with the orientations of the quartz lenses, show that the right-lateral fault contains a small component of vertical movement with relative motion up on the west.

Surface Features. From south to north, a list of key observations along the nearly-continuous fault trace begins at the Cove wall. Northeast and upslope of the wall exposure is a west-facing scarp and sag pond, originally mapped by Matthes. Half of a west-facing scarp, photographed by Matthes, has been bulldozed to become the end of Landis Road, at the top of the Cove wall slope. Along the west side of this road is a two-meter-long west-facing scarp; this marks the southern beginning of the shutter ridge. Near the crest of the shutter ridge, trending approximately east-west, is the ULT, through the east end of which the fault is exposed. Near the northern termination of the shutter ridge is the LLT; the fault trace passes close to the east end of this trench unrecorded by the excavation. Approximately 5 m north of this trench is a second, smaller sag feature. North of this feature, for approximately half of one mile, the fault trace is located northeast of, and sub-parallel to, Shelter Cove Road, until it runs alongside the town's largest water tank. The next prominent feature is an offset in Telegraph Creek that mesures 8 m, based on channel geometery and reconstruction. Features to the north of this scarp include a long scarp traceable up the southern slope of Telegraph Hill, two faults in Kaluna Canyon, a swail on either edge of Kaluna Canyon, another long scarp along Horse Mountain, and a fault at the Notch.

CONCLUSIONS

Prior to 1906, the location and characteristics of the northern termination of the SAF were unknown. Following the San Francisco earthquake in 1906, Francois Matthes proposed that the active trace of the SAF returned to land near Point Delgada and continued on land for at least several kilometers. Later workers favored a watery termination for the strike-slip fault (Fig. 2).

After detailed mapping and analysis using a number of different methods, this study concludes that the active trace of the northernmost section of the SAF is onland and complies with the map produced by Francois Matthes in 1906.

REFERENCES CITED

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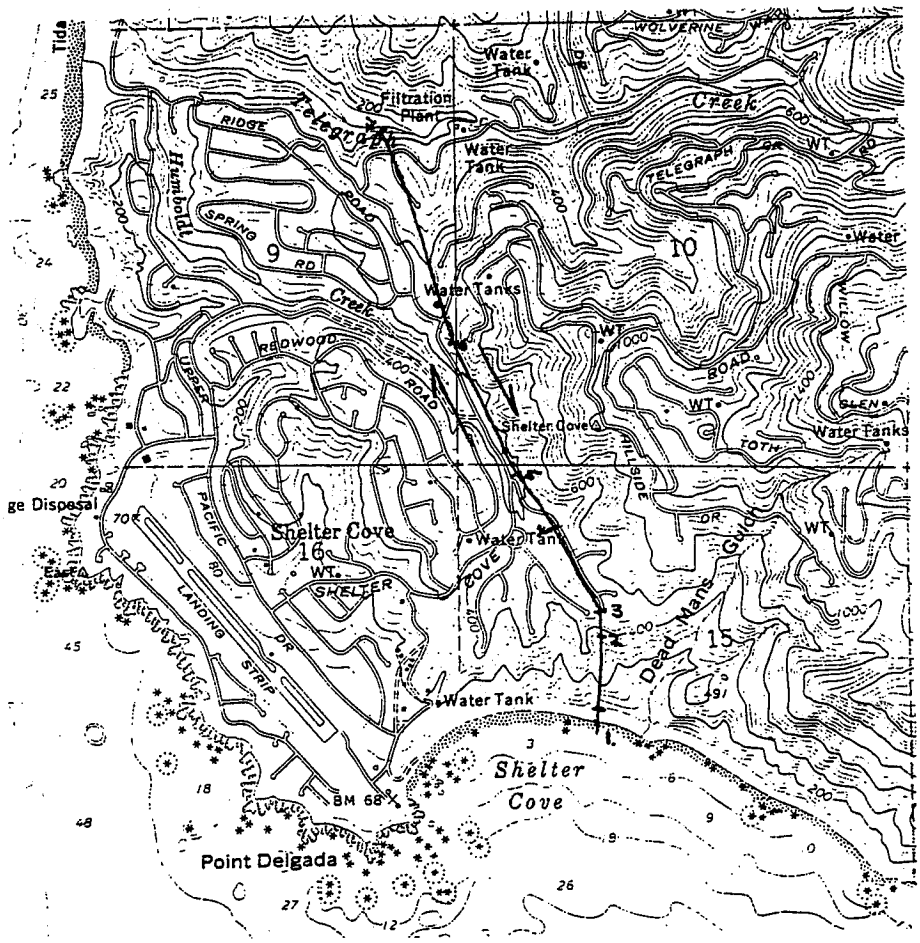
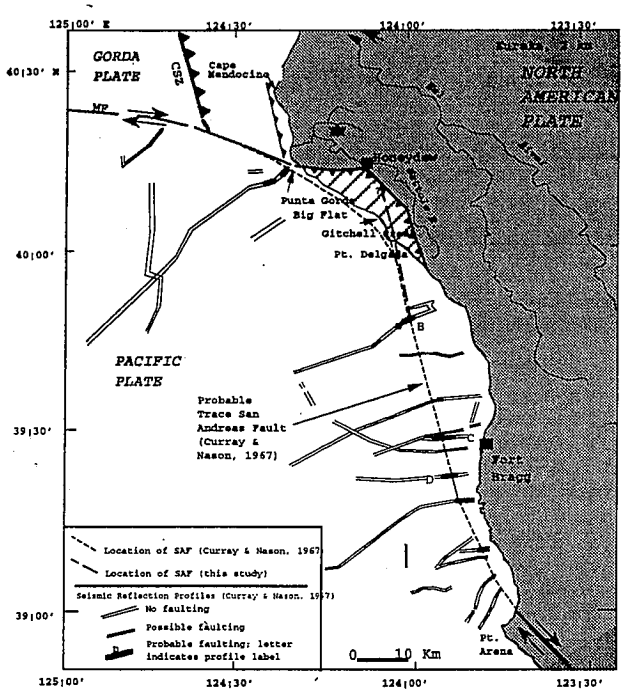
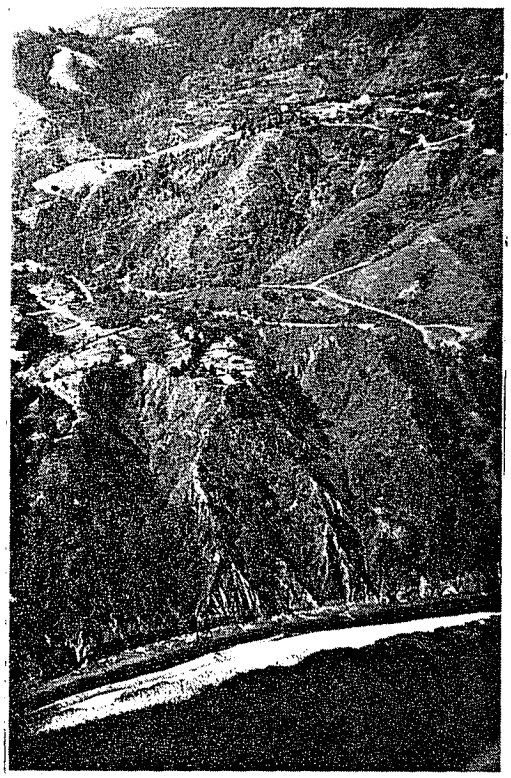


Figure 1. Topographic map of Point Delgada, California. Northern trace of the SAF is represented by the black line. Key features from south to north along the trace are 1) the Cove wall shear zone exposure; 2) the sag pond mapped by Matthes in 1906; 3) a west-facing scarp at the end of Landis Road; 4) ULT, located on a shutter ridge; 5) LLT; 6) a west-facing scarp mapped from aerial photographs; 7) 8 m of right-lateral offset in the channel of Telegraph Creek.

Figure 2. Seismic lines (Curray and Nason, 1967) illustrate constraints for the offshore location of the SAF north of Point Arena. In 1906, F. E. Matthes (see Lawson, 1908) mapped a scarp at Point Delgada that formed during the 1906 San Francisco earthquake. He attributed the scarp to shear along the SAF, similar to that which he mapped at Point Arena. Later workers concluded that the scarp was the result of mass movement (c.f. McLaughlin et al, 1983). This study has determined that the SAF returns to shore at Point Delgada and continues northward along a strike of N 13° W into the King Range, toward the town of Honeydew, where it joins the Mendocino fracture zone.





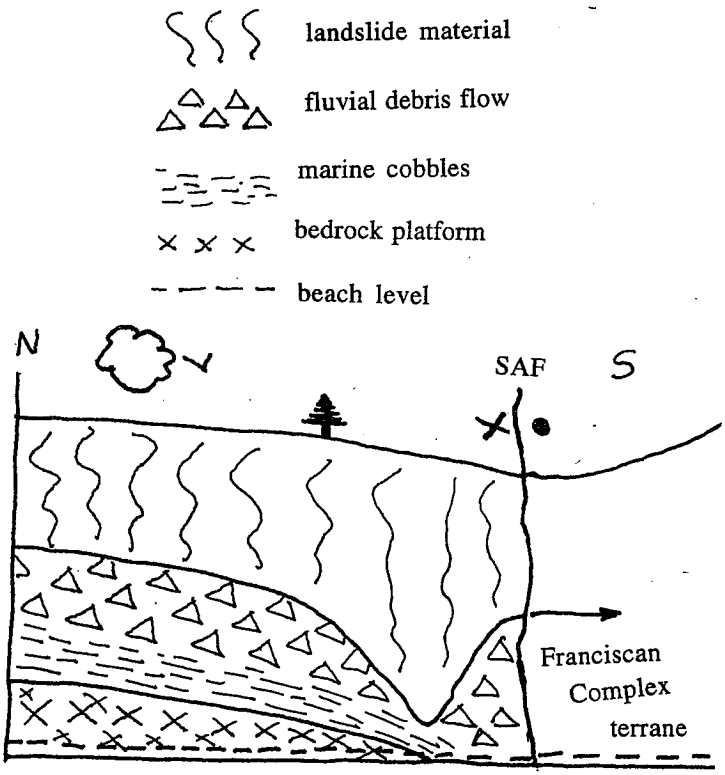


Figure 3. The stratigraphy of the sea cliff. **a.** Photograph of the Cove wall, 1995; **b.** Generalized stratigraphic section of the sea cliff materials shows a warped bedrock platform and warped alluvial fan gravel. SAF shear zone is marked by a black line.