New data concerning uplift rates at Point Delgada, Mendocino County, California--Possible implications for the position of the San Andreas Fault

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INTRODUCTION

Point Delgada is a low relief promontory extending westward from the otherwise steep, high relief, and relatively straight coastline of the King Range, south of Cape Mendocino, California (Figure 1). Topography and bedrock lithology suggest that the Point may have a significantly different Quaternary tectonic history from the King Range, and some workers (Beutner and Merritts, personnel commun., 1995) have suggested that the northern trace of the San Andreas fault passes between the two. If the San Andreas fault does pass between Point Delgada and the King Range, then a significantly different uplift history of the two areas might be expected. McLaughlin (1983) suggested that the prominent marine platform at Point Delgada formed during an interstadial of the last glaciation, probably marine isotope stage 3, and that subsequent uplift of the platform has been rapid, ca 1.0 m/ka. This rate is little different from that of nearby portions of the King Range (ca 1.2 m/ka - Merritts and Bull, 1989). An alternative interpretation, however, suggests an isotope stage 5 age for the Point Delgada platform, a much lower uplift rate (ca 0.2 m/ka), and an uplift history very different from the King Range. This interpretation suggests that a fault, possibly the San Andreas fault, exists between the King Range and Point Delgada.

This study concerns the depositional and deformational history of the Quaternary sediment deposited atop the marine platform at Pt. Delgada. Dating of the Quaternary sediment provides a limiting age for the underlying platforms. This age is used to determine the maximum uplift rate, which can be compared to the nearby King Range and perhaps shed light on the position of the San Andreas fault. Deformed Quaternary sediment indicates continuing tectonic activity at Point Delgada.

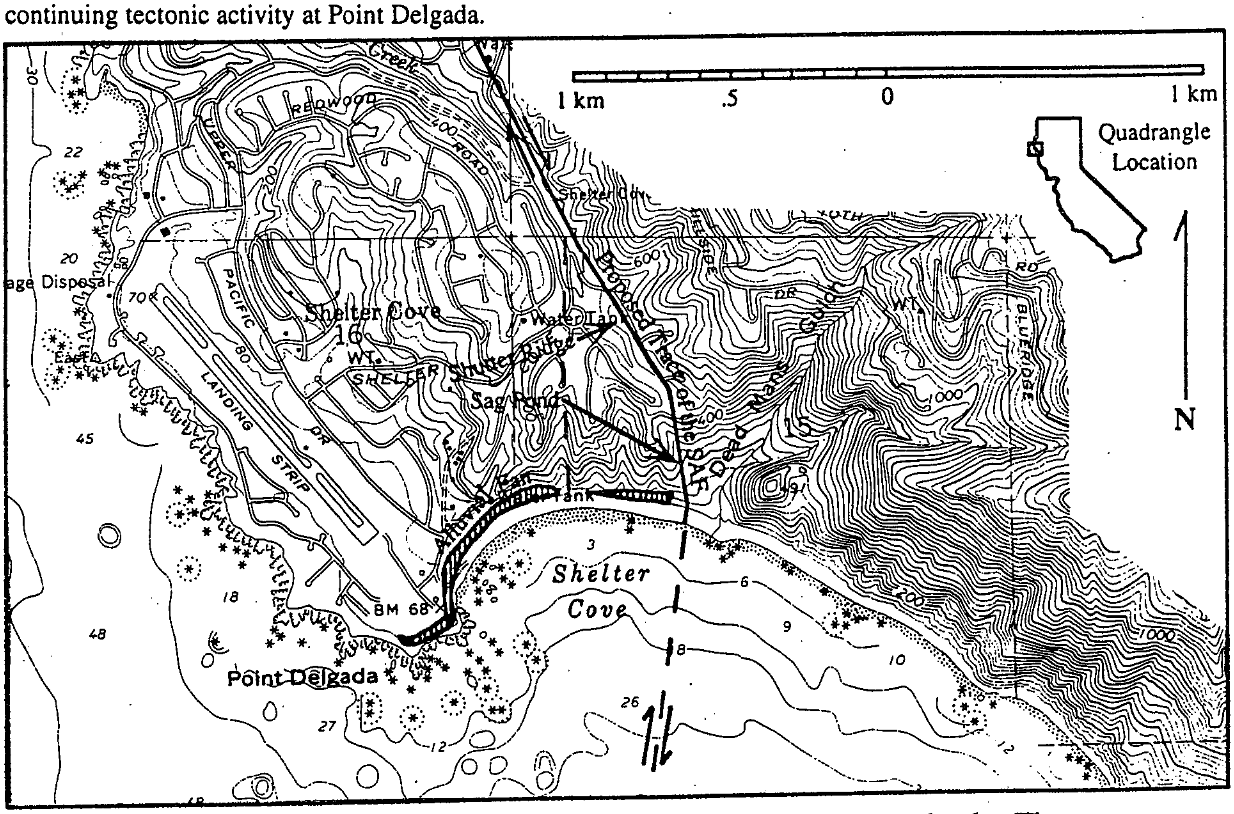


Fig. 1: USGS topographic map of Shelter Cove and Point Delgada. The relationship of the San Andreas Fault and the study area can be seen.

METHODS

Organic material from littoral and terrestrial sediment capping the platforms was sampled for radiocarbon dating and paleoecological analysis (incomplete at the time of publication). Accelerator mass spectrometry (AMS) and conventional radiocarbon techniques were used to date the samples (Figure 2). The paleoecological study uses beetles found in an organic rich lacustrine layer ~2 m above the marine platforms. The beetles have established temperature ranges and can be used to infer the temperature at the time of deposition. Inferred temperature ranges may help to determine whether the underlying platforms formed under interglcial (stage 5) or interstadial (stage 3) conditions. Using an electronic total station a detailed survey was made of the cross section of a deformed alluvial fan visible in Shelter Cove.

PREVIOUS WORK

Although the Mendocino triple junction has been located using seismologic data, the location of the less seismically-active northern trace of the San Andreas fault has been elusive. In 1906, Matthes (Lawson and others, 1908) photographed recent scarps along the trace of the San Andreas fault. He observed and photographed a 1 m scarp at Point Delgada that continued northward towards Telegraph Mountain. His photographs strongly suggest that the San Andreas fault comes onshore in Shelter Cove and continues north. The photographs show the fault scarp beside the sag pond and on the shutter ridge (Fig. 1).

Using seismic continuous reflection profiling off the coast north of Point Arena, Curray and Nason (1967) located the northern trace of the San Andreas fault trending N12°W. However, their seismic interpolation of the fault trace ends just offshore and south of Point Delgada, although it appears to head straight for it along the eastern edge of the Tolo Bank, a raised, elongate bathymetric feature ten miles long and two miles across trending southwest from Point Delgada. The study did not determine whether the San Andreas fault passed to the east, west, or crossed over the Tolo Bank.

McLaughlin (1983) found woody material in the sediments above the platform that yielded a radiocarbon age of 44,800±,1300 yr. BP. McLaughlin used this age to correlate the underlying marine platforms with the stage 3 high sea-level stand. Given this age for the platforms, McLaughlin calculated an uplift rate of 1.0 m/ka for Point Delgada.

QUATERNARY SEDIMENTS

The marine abrasional platforms at Pt. Delgada and Shelter Cove are capped by a 5-0.5 m thick layer of well sorted, matrix–supported, wave–winnowed gravel with well rounded to subrounded argillite or graywacke clasts from 2-15 mm in diameter. The contact of the littoral gravel with the wave-cut platforms is very irregular with up to 0.5 m of relief and at some points overlain by 40 cm to 2 m of boulder-cobble lag gravel. This gravel is identical in lithology and character to those of the modern beaches present at Point Delgada. Within this layer are large pieces of wood, one of which yielded a radiocarbon age of >43,900 yr. BP (Beta-84208) (Fig. 2).

A sandy mud 1.3 m thick at Point Delgada and gradually decreasing to 3 cm thick in Shelter Cove is found above the littoral gravel. The layer is dark gray to light blue and weathers to a brownish-tan color. The thickest layers at Point Delgada contain large amounts of well preserved biological detritus, including flattened Brewers Spruce (*Picea breweriana*) cones, twigs and branches, seeds, charcoal, and beetle fragments. In Shelter Cove, only charcoal fragments have been found. A radiocarbon age of >47,620 yr. BP (Beta–86187) (Fig.2) was obtained from a piece of wood and a pine cone (combined sample) in this horizon. The sandy mud is probably the distal toe sediments of an alluvial fan deposited landward of a large berm of littoral gravel in a freshwater lagoon like those present along the modern beach.

At Point Delgada and in Shelter Cove, angular gravel deposits overlie the lacustrine mud and littoral gravel and are the most prominent unit. The angular gravel deposit is poorly sorted, crudely bedded, and weakly graded. The deposit is not present on the west end of Point Delgada but is up to 22.5 m thick in Shelter Cove. The few beds that can be observed at the top of the angular gravel are .5 to 1m thick and inter fingering. The clasts are blocky–angular to subangular greywacke and argillite ranging from a few 5-6 cm cobbles to abundant 1 cm pebbles. The gravel is clast supported with a matrix of medium sand and grit. Two tabular crossbed sets 25 cm and 45 cm thick occur at Point Delgada but crossbedding is absent in Shelter Cove. Foreset dip directions N30°E 34°NW (three measurements) indicate a paleocurrent in the west-northwest direction (oblique to seaward). A piece of charcoal near the top of this deposit (Fig. 2) yielded a conventional radiocarbon age of 11260 ±60 BP (Beta–86188). This unit is easily recognizable as a prograding alluvial fan deposit very similar to alluvial fans present along today's coastline.

Large block rotational landslides and small, local sedimentary layers derived from from those slides overlie the alluvial fan gravels. The landslides are pulverized argillite (affectionately called "Blue Goo") with intact blocks argillite layers exhibiting folds.

Fig. 2 Stratigraphic columns with radiocarbon and paleoecological sample horizons (McLaughlin (1983) radiocarbon ages are marked with a †). A: Generalized stratigraphic section of Point Delgada B: Detailed column of section above Shelter Cove Boat ramp C: Detailed column at Point Delgada).

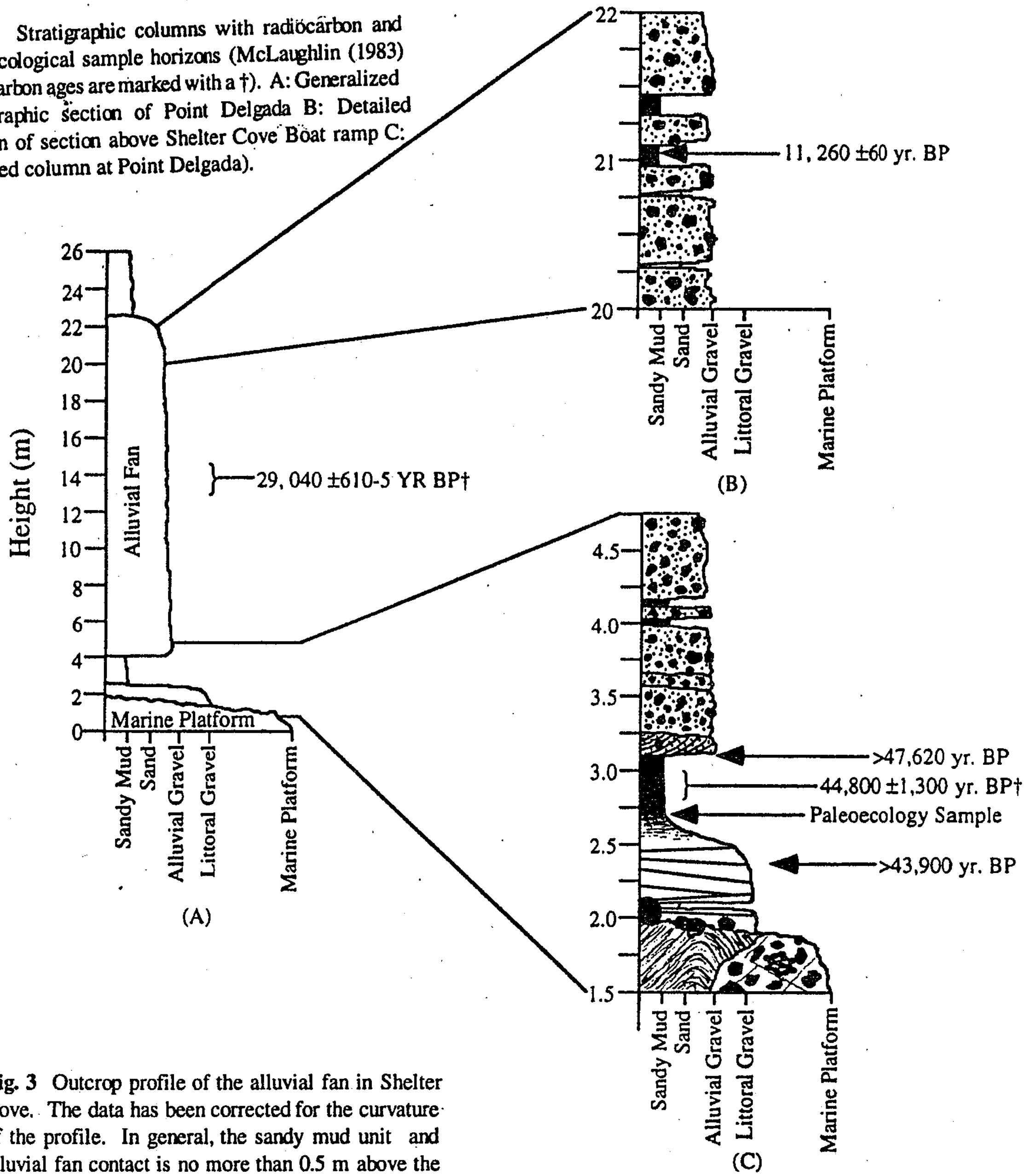
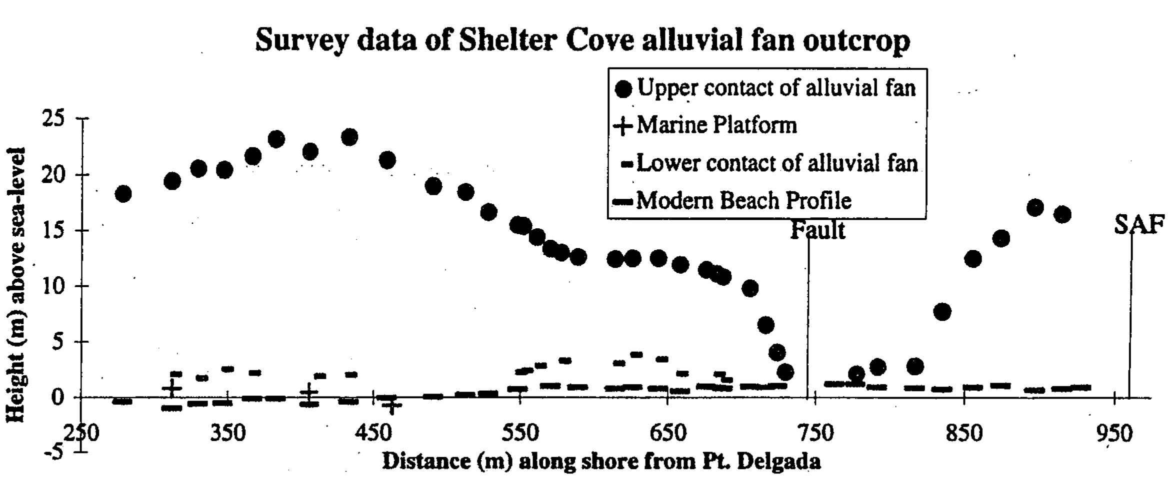


Fig. 3 Outcrop profile of the alluvial fan in Shelter Cove. The data has been corrected for the curvature of the profile. In general, the sandy mud unit and alluvial fan contact is no more than 0.5 m above the littoral gravel and sandy mud contact.



STRUCTURAL DEFORMATION

Both the marine platforms (Pease, personal commun., 1996) and the Quaternary sediments have been tectonically deformed (Figure 3). The marine platform is tilted no more than a 3 degrees towards the south and disappears beneath modern sands in Shelter Cove. Small normal faults with up to 14 cm of offset are present in the littoral gravel beneath the alluvial fan but do not extend into the alluvial fan itself. Low angle normal faults with meters of offset are present in the alluvial fan and littoral gravel all along Shelter Cove and are associated with modern slumping . The alluvial fan and underlying sandy muds and littoral gravel begin to dip steeply eastward at 700 m and disappear completely beneath modern landslides and beach sands at 730 m (Fig. 3). McLaughlin (1983) mapped a fault in this location although it is presently covered by landslide material. The fan reemerges 20 m to the east dipping shallowly to the west and continuing for another 190 m before it is abruptly truncated at the eastern end of Shelter Cove by a shear zone (N13°W 85°W) exhibiting right lateral drag. This shear zone is the proposed northern trace of the San Andreas fault. Directly north of this point are the sag pond and shutter ridge (Schill, 1996) that Matthes photographed in 1906 (Lawson and others, 1908).

DISCUSSION

A radiocarbon age of greater than 47,620 yr. (Beta-86187) from sandy mud immediately overlying the littoral sediment and 2 m above the marine platform provides a minimum limiting age for the platform, consistent with, but slightly older than previous ages from this section. As these ages are near the limit of the radiocarbon method, they are consistent with either an early stage 3 or a late stage 5 age for the platform, although the platforms may be older. If the platforms are stage 5, than the uplift rate is equal to or less than 1 m/ka.

Curray and Nason (1968) work suggests that the San Andreas might follow the eastern edge of the Tolo Bank and come onshore in Shelter Cove where deformation of the alluvial fan occurs. Deformation of the alluvial fan in Shelter Cove indicates that tectonic activity has occured during the last 11,200 yr. BP. Matthes' (1906) photographs and the presence of a sag pond and shutter ridge on steep slopes in an area of intense erosion from heavy rainfall suggest that the San Andreas fault is still active at Point Delgada.

Fluvial overbank deposits contain a rich beetle fauna. A pending paleoecological study of this sediment will help to resolve questions of the age and uplift rate of the platform by indicating whether it was formed under interstadial (probably stage 3) or interglacial (probably stage 5) temperature conditions. This data will help in determining the rate of uplift at Pt. Delgada and shed light on the question of a fault between Pt. Delgada and the King Range.

CONCLUSIONS

There is strong evidence to suggest that the northern trace of the San Andreas fault comes onshore in Shelter Cove and is still active there today. Evidence of a youthful, strike–slip fault at Shelter Cove include 1) structural deformation and truncation of a young alluvial fan in Shelter Cove; 2) geomorphological features along strike north of Shelter Cove. Forthcoming paleoecological data should help resolve the age of the marine platform, the uplift history at Point Delgada and Shelter Cove, and the question of differential uplift between the King Range and Point Delgada.

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