DEEP TOW STUDIES OF THE TAMAYO TRANSFORM FAULT*

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(Accepted 13 February, 1979)

Abstract. The Tamayo transform fault occurs at the north end of the East Pacific Rise where it enters the Gulf of California. The two deep-tow surveys reported here show that the transform fault zone changes significantly as a function of distance from the spreading center intersections. At site 1, near the intersection, one side of the fault is young and the fault zone is narrow and well-defined. Strike slip occurs in a zone approximately 1-km wide suggesting a correspondingly narrow zone of decoupling between the Pacific and North American plates. On the young side of the strike-slip zone, normal faults occur along shear zones which are 45°–50° oblique to the transform strike. They occur parallel to the short axis of the strain ellipse for transform fault strain here, i.e., perpendicular to the least compressive stress. The transform walls are formed by normal faulting as has been pointed out in previous detailed surveys. Here, however, the age contrast of 2.5 m.y. across the transform valley is apparent in the morphology of the normal fault scarps. While the scarps are steep and well-defined on the young side, the scarps on the older side have gradual 10°–30° slopes and appear to be primarily talus ramps. Apparently, the scarps have been tectonically eroded by continued strike slip activity after the initial stages of normal faulting. Thus, transform valleys should be quite asymmetric in cross-section where there is a significant age contrast and one side is less than approximately 0.5 m.y. old. Also, along older sections of the transform valley walls, normal faulting may not be at all obvious due to degradation of the scarps by tectonic erosion. This phenomenon makes the likelihood of transform faults providing ‘windows’ into the oceanic crust most unlikely except in special cases.

The picture of transform deformation is more complex at site 2 in the central portion of the fault where both sides of the fault are greater than 1 m.y. old. Here the transform valley is wider (25–30 km as opposed to 2–5 km). There is no clear simple zone of strike slip tectonics. In fact, the only clear evidence for deformation is the intrusion of magmatic or serpentinite diapirs through the sediments of the transform valley floor. The diapirs have deformed the turbidite layers flooring the valley and in one carefully studied case the turbidite sequence has been uplifted, perched atop the diapir. The pattern of deformation on this outcropping diapir shows radial and concentric fractures which can be modeled by a vertical intrusion circular in plan view. Magnetic studies limit the possible composition to basalt or serpentinite. A 60-km-long median ridge is also likely to be the product of intrusion along the transform fault. The survey at site 2 pointed out the importance of vertical tectonics in the transform valley floor and in particular the importance of diapiric intrusions of either basaltic or serpentinite composition.

Based on initial boundary conditions and present tectonic elements in the Tamayo fault zone, a possible history of the mouth of the Gulf of California is outlined. The median ridge was emplaced starting approximately 0.8 m.y. ago by regional extension across the transform fault, the result of ‘leaky’ transform faulting. The diapirs occur along a possible ‘relay’ zone of extension midway along the fault which began approximately 0.15 m.y. ago. The extension in this case is parallel to the trend of the transform fault, is still occurring at present, and may evolve into a true spreading center.

* Contribution of the Scripps Institution of Oceanography, new series.

1. Introduction

A fundamental aspect of plate tectonics in the northeastern Pacific is that plate boundaries cut across portions of the American continent (Figure 1). The geologic history of western North America has been shown to be due to the continued interaction between the continent and the Pacific Ocean lithospheric plates (Atwater, 1970). For example, strike slip motion along the San Andreas fault system is directly related to the formation of new oceanic crust along the extension of the East Pacific Rise (EPR) crest into the Gulf of California. The Tamayo transform fault may be considered as the southernmost of a series of transform faults which cut across the continent connecting the EPR with the Gorda Rise. It is near 23°N at the entrance to the Gulf of California. It has an 80-km left lateral offset with right lateral relative motion of approximately 6.0 cm/yr (Larson, 1972). It is a well-defined, active ridge-ridge transform fault with clear fossil extensions on the continent on each side.

The purpose of this paper is to present the results of two detailed near-bottom geophysical studies of the Tamayo using the deep-tow instrument package of Scripps' Marine Physical Laboratory (Figure 2). The context of the surveys is defined in a discussion of the overall bathymetry and structure of the Tamayo transform fault based on surface ship data (see Kastens et al., 1979, for details). The observations at site 1 (near the intersection of the Tamayo with the EPR) are presented, focusing on the styles of faulting observed and their tectonic implications. This is contrasted with the observations at site 2 (midway between the adjacent spreading centers) where both sides of the transform fault are old (>1 m.y.) and the structure is quite different. Additional sections discuss diapiric structures at site 2 and develop possible models of intrusion. A brief history for the mouth of the Gulf of California is then outlined in terms of the tectonic patterns observed in this survey and the larger scale history of the Gulf.

2. Regional Structure

Three distinct morphologic elements characterize the Tamayo transform fault: the south trough, the transform ridge and the north trough (Figure 2). The south trough trends NW–SE and is approximately 10-km wide. The floor is approximately 2800-m deep and is covered with flat lying sediments up to 300-m thick. The south side of the trough is bounded by a 600-m-high scarp, the north side by the transform ridge. The latter is a 100 to 600-m-high structure which divides the transform valley. It extends from the northwestern intersection of

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Fig. 1. Regional setting for the Tamayo transform fault. The Figure 2 chart covers the area between the East Pacific and Gulf rises.