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HOLOCENE OFFSET AND SEISMICITY ALONG THE PANAMINT VALLEY FAULT ZONE, WESTERN BASIN-AND-RANGE PROVINCE, CALIFORNIA

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ABSTRACT

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Holocene right-slip along the central segment of the Panamint Valley totals 20 m and dip-slip is somewhat less. The most recent offset, about 2 m right-slip, probably occurred at least several hundred years ago. If a comparable amount of slip occurred during earlier earthquakes, mean seismic recurrence intervals would have been about 700—2500 years during the Holocene.

INTRODUCTION

The Panamint Valley fault zone, a major structural feature in the western Basin-and-Range structural province of California, extends 100 km northwards from the left-lateral Garlock fault along the steep western escarpment of the Panamint Range. Noble (1926) described and named the fault zone, which he felt belonged to a class of faults distinguished from those of the San Andreas type by the great amount of topographic relief across them. This suggested that most of the fault offset had been dip-slip. Subsequent workers (e.g. Hopper, 1947; Maxson, 1950) recognized a major right-slip component in the fault zone's Quaternary displacement. This paper describes Holocene displacement and seismicity along a 20-km segment where recent right-slip is several times greater than the dip-slip.

Evidence for Holocene faulting is seen best where faults transect Holocene fan segments. Along the segment of the Panamint Valley fault zone between Ballarat and Goler Wash (Fig. 1), Holocene alluvial fans envelop remnants of older surfaces into which were cut shorelines of the last shallow pluvial lake to occupy Panamint Valley. The age of these shorelines is probably latest Pleistocene (10,000—20,000 years B.P.), as judged by the degree of shoreline

Fig. 1. Index map of the central segment of the Panamint Valley fault zone.

degradation, dissection and deformation relative to older, better-dated shorelines of much deeper lake stands (Smith, 1975). Deposits of the shallow lake stand have yielded no material suitable for radiocarbon dating.

FAULT DISPLACEMENT

This segment of the fault zone, 1—3 km wide, is marked by discontinuous ground traces and by NW-facing range-front embayments (Fig. 1). Where parallel fault traces occur, right-slip seems largely confined to the westernmost trace and dip-slip characterizes all others, most of whose scarps face west. Some scarps along the westernmost trace face west and others face east.

Right-slip

Scarps attributed to right-slip are commonly lower and less distinct than those attributed to dip-slip. In some places, scarps are absent and the fault trace follows a shallow furrow or an indistinct line marked only by channel offsets and contrast in the textural character of materials on either side of the fault trace. Even the freshest fault trace cannot be followed continuously across the rough, bouldery surface of some young alluvial fan deposits.

Most observed right-slip falls into the range 2.0 ± 0.6 m, and the minimum seen is 0.9 and 1.4 m on opposite banks of the same channel south of Goler Wash. Although smaller offsets may have escaped notice, this 2-m figure probably characterizes the latest event of ground breakage along this segment. Larger offsets seem to have a common denominator of about 2 m, although the 1.2 m uncertainty in this figure precludes extrapolation of the common denominator to offsets of more than 6 m. The maximum observed right-slip is 20.0 m on mudflow levees at the mouth of Manly Peak Canyon.

Dip slip

Abundant fresh scarps attributed to dip-slip are 0.6—1.8 m tall and have maximum slopes of 27—31°, although tiny patches of vertical slope are preserved locally along some scarps, mostly under boulders (Fig. 2). In general, taller scarps are steeper than lower ones, probably because more debris must be moved to degrade a tall scarp than to degrade a low scarp by the same

Fig. 2. Two-meter fault scarp at the mouth of Manly Peak Canyon. Note the relict groundline band of desert varnish which marks the position of an earlier, gentler scarp profile. Note also the nearly vertical surface beneath the granitic boulder; the rock hammer resting against this surface gives scale.

amount. Many of these scarps do not lie along the main trace of the fault zone and probably represent single events of ground breakage subsidiary to, or incidental to, movement along the main trace.

Scarps between 2 and 6 m tall probably formed by repeated offset along the same line. Some granitic boulders on these scarps are marked by an inclined band which appears to represent the groundline band between the above-surface (back) and below-surface (orange) facies of desert varnish (Fig. 2). This suggests that the boulders lingered on scarps gentler than modern ones long enough for desert varnish to form, and that subsequent offset has heightened and steepened the scarps, whose retreat by erosion has exposed the older groundline bands. These 2—6 m scarps commonly retain larger patches of vertical slope than do lower ones. At the mouth of Coyote Canyon, some granitic boulders protruding from the upper part of a 3-m scarp display a nearly vertical relict groundline band which has been exposed by parallel scarp retreat. This relation indicates that some nearly vertical surfaces can persist long enough in the same position for desert varnish to form. Precipitous scarps taller than several meters may persist from one episode of offset to the next, to be renewed and heightened by each succeeding episode of offset.

SEISMICITY

The age of the youngest event of offset is not known. No offset is recognized in fan deposits adjacent to modern channels. At the mouth of Goler Wash, a well-defined trail of unknown age shows probable right-slip of 1.8 m, suggesting possible historic offset. However, three nearby trails show no convincing evidence for offset where they cross the fault trace, nor does an adjacent road shown on the Searles Lake one degree topographic sheet surveyed during 1911 to 1913. These relations and the absence of historical reports of any damage to buildings at Ballarat, some made of adobe, suggest that the earthquake of November 4, 1908 in the Death Valley region did not occur along this segment of the Panamint Valley fault zone. Richter (1958, p. 469) assigned a queried location in the southern Panamint Range and a queried magnitude of $6\frac{1}{2}$ to this earthquake.

Scarp morphology suggests that dip-slip has not occurred on most scarps for hundreds of years or more. This estimate is based on the paucity of retained surfaces steeper than the angle of repose. Wallace (1977, pp. 1272—1273 inferred that some patches steeper than the angle of repose ("free faces") would linger for at least 300 years, perhaps for 1000—2000 years. He based this on a study of the degradation of scarps, 3—6 m tall, produced during the 1915 and 1954 earthquakes in Nevada. These findings can be applied only loosely to the lower scarps of Panamint Valley where the climate is more arid.

The mean recurrence interval between earthquakes along this segment of the fault zone can be estimated roughly by comparing the magnitude of the youngest offset with the magnitude of the greatest observed Holocene offset. If the latest and all earlier events each produced right-slip of 1.4—2.6 m, the 20-m total offset represents 8—14 events during the interval since the oldest deposits buried the 10,000—20,000-year shoreline of pluvial Lake Panamint. These relations suggest that the mean recurrence interval between earthquakes along this segment is on the order of 700—2500 years. Recurrence intervals along the entire 100-km length of the fault zone may be shorter if the ground did not break along the zone's entire length during each earthquake.

Evidence from scarp morphology and from relict groundline bands of desert varnish is imprecise, but suggests recurrence intervals of the same order of magnitude. Once some scarps formed, no subsequent offset occurred along them until they were degraded and desert varnish formed on their surficial boulders. Desert varnish may take as little as 25 years to develop under ideal conditions, but probably takes hundreds to thousands of years in most cases (Blackwelder, 1948; Engel and Sharp, 1958; Hunt, 1961). This interval, added to the hundreds to thousands of years probably required to degrade scarps, suggests that dip-slip along these scarps has recurred only every 1000 years or more. Recurrence intervals along tall, steep scarps may be somewhat shorter.

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