THE BLUE CUT FAULT, SOUTHEASTERN CALIFORNIA

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Abstract.—The Blue Cut fault is one of several east-west faults in a region south of the Mojave Desert and east of the San Andreas fault. Between 3 and 4 miles of left-lateral strike slip accumulated along the Blue Cut fault sometime between the Jurassic and the Quaternary. At its western end, displacements along the fault were probably translated to the Dillon fault which strikes northwest, dips northeast, and has had at least minor reverse-slip movement. At the eastern end, the Blue Cut fault may be displaced more than 11 miles right laterally by the northwest-trending Sheep Hole fault.

In the part of southern California east of the San Andreas fault, the major faults as well as the mountain ranges and valleys generally trend north to northwest. This trend is broken south of the Mojave Desert by the east-west Transverse Ranges (fig. 1, see also Jahns, 1954, p. 11). The shapes of these ranges and the intervening basins are in part due to the presence of several west-trending faults. Reconnaissance mapping indicated that crustal blocks had shifted a mile or more left laterally along several of these faults (Hope, 1966). Two of the longest faults have been studied in more detail. One of these, the Blue Cut fault, is described in this article; the other, the Pinto Mountain fault, has been mapped and described by T. W. Dibblee, Jr. (1967a, 1967b, 1967c, 1968).

EXTENT AND PHYSICAL FEATURES

The Blue Cut fault (Pruss and others, 1959), is named for the Blue Cut, a straight east-west canyon eroded along the fault zone where it crosses the Little San Bernardino Mountains (fig. 1). At its western end, the fault curves slightly and merges with the northwest-trending Dillon fault. East of the Blue Cut, the fault zone is buried under the alluvium of Pleasant Valley, but reappears in El Dorado Canyon in the Hexie Mountains. East of El Dorado Canyon, the position of the Blue Cut fault becomes less certain.

The only good exposures of the fault zone are in and west of the Blue Cut. Here the fault zone is several hundred feet wide and contains interbranching breaks, as well as breaks which splay northwestward (not shown in figure 1 because of the scale of the map). Individual fault surfaces appear to be almost vertical in the Blue Cut, although to the west, steep northward dips occur. In the Blue Cut, gouge zones a few tens of feet thick border the more continuous faults. The two main rock types (foliated quartz monzonite and granodiorite) show differing types of deformation within these gouge zones. The quartz monzonite and associated aplites and pegmatites have been pulverized to produce a loose mixture of very fine white powder and small angular fragments. The granodiorite is more sheared than pulverized, and occasional slickensides can be found.

DISPLACEMENT IN THE LITTLE SAN BERNARDINO AND HEXIE MOUNTAINS

Figure 2 shows the structure and lithic units of the north and south walls of the Blue Cut fault west of Pinto Basin (between points *A* and *B* in fig. 1). The fault surface in figure 2 is assumed to be a vertical plane. Pairs of circled numbers (1 and 1′, 2 and 2′, and so forth) on figure 2 identify corresponding traces formed by the intersection of the segments of an offset geologic surface with the fault surface. Subsurface interpretations have been made by extrapolating surficial orientations of traces at depth (their actual orientations may differ markedly). Corresponding traces in the two walls are nearly parallel, at least at the surface, indicating a lack of significant rotational fault slip. Figure 2 also shows the numbered pairs of offset traces transposed so that the traces in the south wall all intersect at a point. If the two blocks of the fault had behaved rigidly while sliding past one another, the traces in the north wall should intersect at a second point in the diagram of figure 2, and the position of these two points would determine the orientation and magnitude of relative slip along this segment of the fault. The traces in the north wall,

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however, intersect within a small area rather than at a point, which suggests that the two blocks did not behave in this ideal manner. Of course, the uncertain orientation of the traces at depth also affects the size of the area of intersections.

Along this segment of the fault, then, the north block slid westward and slightly upward (the average slip line plunges 7°E. in fig. 2 diagram) relative to the south block, and the magnitude of displacement was about 3.7 miles.

WEST END OF THE FAULT

The Blue Cut fault merges to the west with the Dillion fault—a northwest-trending, steeply northeast-dipping fault. Little is known about the time, direction, or magnitude of displacement along the Dillon fault. It dies out at both ends, although one branch terminates at the San Andreas fault at the northwest end. The trace is about 36 miles long, and the Blue Cut fault joins it near the middle. At the northwest end, local reverse slip on the west branch of the Dillon fault has carried gneiss southward over Tertiary fanglomerate (Dibblee, 1967b). This meager evidence suggests that the net displacement on the Dillon fault has not been great—probably amounting to several thousands of feet rather than many miles.

The question is how these two faults have interacted. No offset extension of the Blue Cut fault is found farther west, although exposures are adequate and the terrane has been examined by several geologists. The most reasonable interpretation is that displacements were translated from one fault to the other at their juncture. In order for this to happen, the slip direction along both faults near their juncture must nearly parallel the line of intersection. From the assumed orientations of the two faults (the Dillon fault striking N. 60° W. and dipping 55° NE., the Blue Cut fault striking due west and dipping 90°), the slip direction should trend about due east and plunge 35°. This would require that the movement along the Dillon fault have components of reverse slip and left slip. About 5 miles farther east on the Blue Cut fault, the slip vector apparently plunges only about 7°E. (fig. 2). Such a change in plunge requires a considerable rotation of the north block along the westernmost 5 miles of the fault, and, if this interpretation is correct, the rotation should be found with more detailed mapping.

As the north block of the Blue Cut fault was shoved upward along the Dillon fault, increased horizontal compression may have been partly relieved by east-west shortening in the westernmost part of the block. This could explain why the strike slip measured between traces 5 and 5′ is less than that measured between the traces farther east, and also why the width of the foliated quartz monzonite measured along the fault trace is about 1½ miles less in the north wall than in the south wall (fig. 2). This shortening could easily have been accomplished by small displacements along the numerous shear zones in the north block which more or less parallel the Dillon fault.

EAST END OF THE FAULT

The Blue Cut fault zone extends under Pleasant Valley and through El Dorado Canyon (fig. 1); it may be represented by the Quaternary fault scarps that bound the Hexie Mountains east-southeast of El Dorado Canyon. This branch seems to die out about 10 miles east-southeast of El Dorado Canyon.

Two pieces of evidence suggest that another branch—and probably the main one—extends eastward under Pinto Basin from El Dorado Canyon: (1) A northeast-trending pendant of metasedimentary rocks (fig. 1) appears to be offset at least 3.5 miles left laterally from the central Pinto Mountains to the Eagle Mountains. (2) A west-trending fault bounds low dune-draped hills of late Cenozoic lacustrine beds in the western Pinto Basin and lies approximately on the eastward projected strike of the Blue Cut fault. If a continuation of the Blue Cut fault eastward under Pinto Basin exists, the fault has not moved as recently as the zone of faults which trends east-southeast from El Dorado Canyon, because there are no older alluvial breaks trending due east from this canyon.

The Blue Cut fault probably underlies the western part of Pinto Basin, but it definitely does not cut through the Coxcomb Mountains to the east. At least four hypotheses can explain the eastern termination: (1) The fault dies out under the alluvium of the eastern Pinto Basin (this would mean that 3 to 4 miles of strike slip diminished to zero within 12 miles or less). (2) The fault terminates against the Sheep Hole fault and displacements have been transferred between the two faults, perhaps in a manner similar to that of the Dillon-Blue Cut fault intersection. (3) The fault went through the site of the present Coxcomb Mountains, but prior to emplacement of the granodiorite and uplift of the Coxcomb Mountains (as yet, no extension of this fault has been mapped in the adjacent ranges to the east). (4) The fault is older than the Sheep Hole fault and has been offset by it, perhaps right laterally.

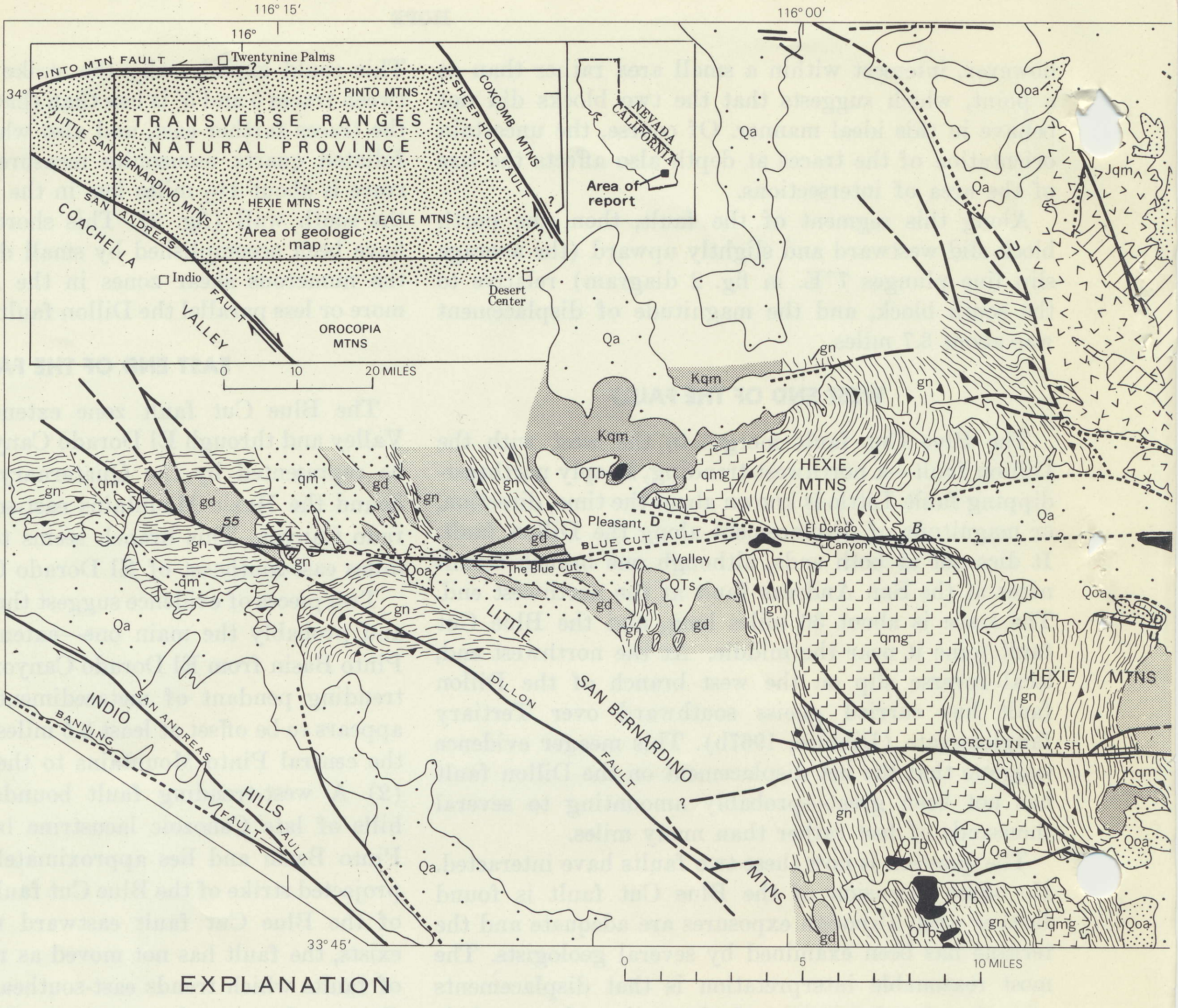
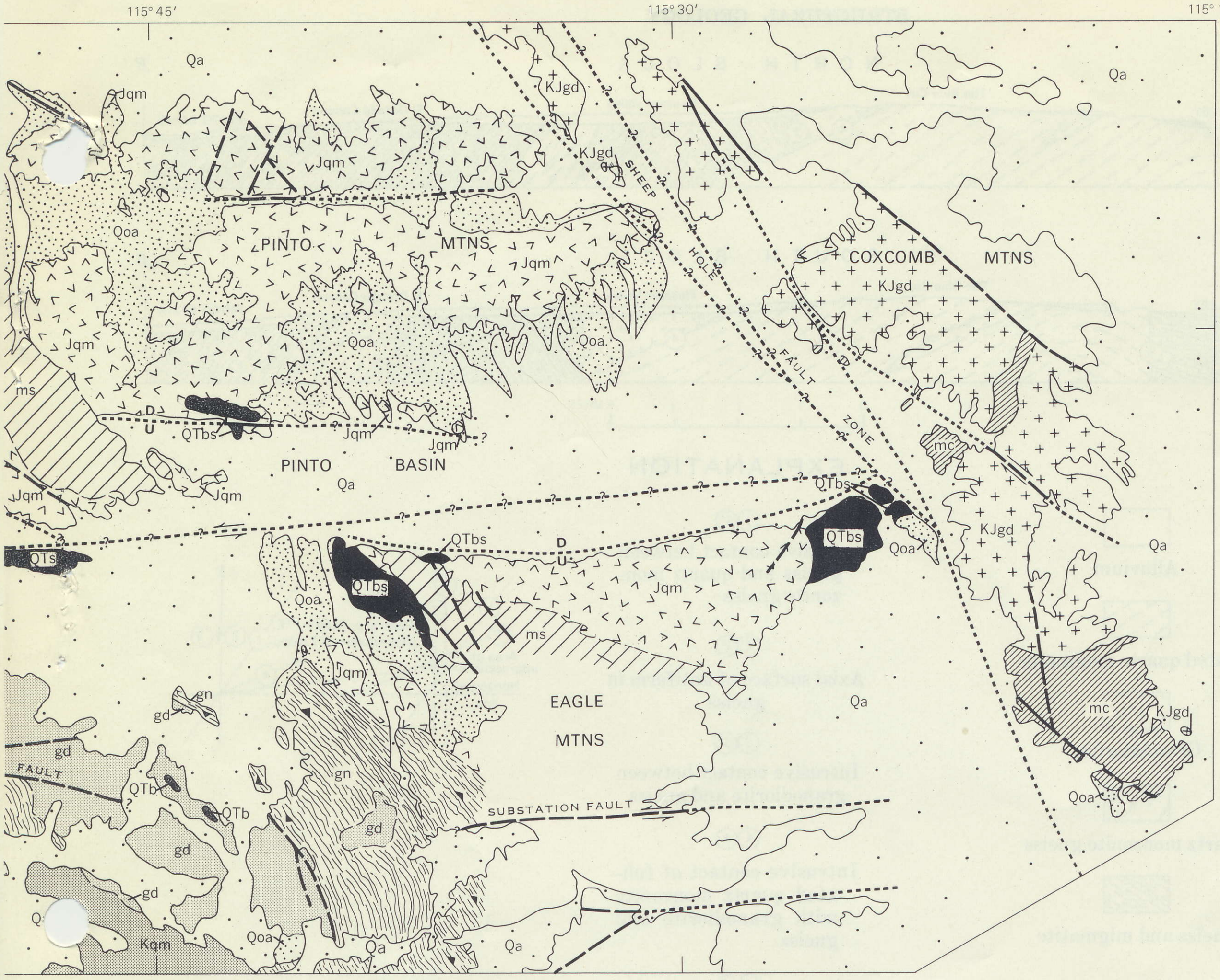


FIGURE 1.—Generalized geologic map of part of the showing opposing fault-plane



METAMORPHIC ROCKS

mc

McCoy Mountains Formation of Miller (1944)
Metavolcanic and metasedimentary rocks

ms

Metasedimentary rocks, mainly quartzite and marble

PALEOZOIC OR MESOZOIC

qmg

Quartz monzonite gneiss and associated metahornfels

gn

Gneiss, migmatite and minor quartzite, irregular broken lines show general strike of foliation

PRECAMBRIAN ?

Unmapped bedrock

Contact
Dashed where approximate

55 U D ?

Fault, showing dip
Dashed where approximately located; queried where doubtful; dotted where concealed. Arrows and letters show relative displacement

eastern Transverse Ranges. See figure 2 for cross sections surfaces between points *A* and *B*.

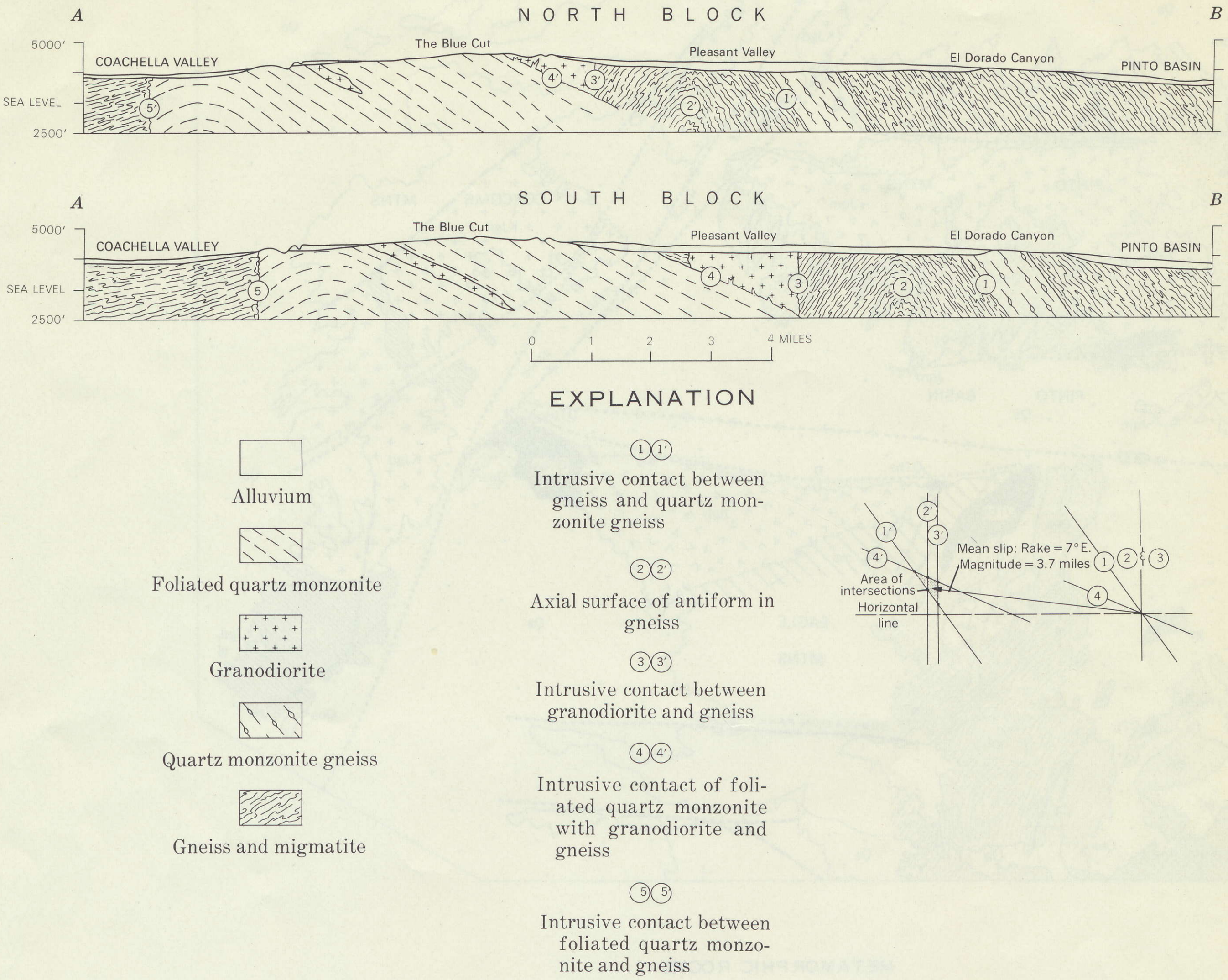


FIGURE 2.—Cross sections along western half of Blue Cut fault (between points *A* and *B* in fig. 1), and diagram of slip orientation and magnitude. Pairs of traces shifted so that all traces in south block intersect at a point. Distance and direction from this point to area where traces intersect in north block gives slip. Sections and diagrams are drawn at the same scale.

From what is now known, the fourth explanation seems most likely. The Sheep Hole fault forms a major lithologic boundary. The belt of quartzite and marble in the Eagle and Pinto Mountains trends eastward toward the southern Coxcomb Mountains, but does not occur there or anywhere else to the east (unless it is the equivalent of the post-Cambrian Maria Formation of Miller, 1944). The McCoy Mountains Formation of Miller (1944), a Paleozoic or Mesozoic unit containing metamorphosed clastic and volcanic rocks, is widespread to the east, but absent to the west. Faults which probably belong to the Sheep Hole fault zone cut the Coxcomb Mountains, and one of the faults offsets a steeply dipping septum of metasediments in a right-lateral sense by 0.8 mile. If we assume the displacement on the Sheep Hole fault to be mainly right lateral, and if the fourth explanation is correct, the eastern extension of the Blue Cut fault would exist farther south. Since the Blue Cut fault does not cut through the Coxcomb Mountains, it must have been offset at least 11 miles right laterally. There are some east-west faults farther southeast at the south tip of the Palen Mountains (see Jennings, 1967), but until more details are known, these bits of evidence are merely suggestive.

MOVEMENT HISTORY

The offsets described above must represent the net slip along the Blue Cut fault. This is so because traces formed in late Mesozoic time (the contact between metasedimentary rocks and Jurassic quartz monzonite, and quite possibly the pair 4 and 4′ in fig. 2) are offset roughly the same amount as traces which probably existed during the Precambrian (the pair 1 and 1′ in fig. 2). The initial movement along the Blue Cut fault must have been later than the emplacement of the Jurassic quartz monzonite and earlier than the deposition of the older alluvium.

At only five places along the fault have late Cenozoic deposits been disturbed: (1) on an old alluvial fan east of the Blue Cut, stream channels bend in crossing small fault scarplets, but in no consistent direction; (2) hillocks at the east end of Pleasant Valley are underlain by Tertiary or Quaternary sedimentary rocks tilted as much as 90° and striking east-west; (3) just northeast of these hillocks, a ridge of fanglomerate has been formed by relative uplift of the south block of the fault; (4) the faults along the boundary between Pinto Basin and the Hexie Mountains are possibly a part of the Blue Cut fault zone; they cut older alluvium, but stream channels in the older alluvium are deflected in no systematic sense; (5) a cluster of low hills in western Pinto Basin outlines a north-northwest-trending anticline in Tertiary or Quaternary sedimentary rocks. This anticline could be considered a drag fold formed by left slip, but in the absence of any stronger evidence, it can only be said that there was faulting of unknown direction and amount after deposition of the Tertiary or Quaternary rocks, and of unknown direction and minor amount after deposition of the older alluvium.

OTHER WEST-TRENDING FAULTS

There is evidence for left slip on several other west-trending faults in the eastern Transverse Ranges. The Pinto Mountain fault, which forms the boundary between the eastern Transverse Ranges and the Mojave Desert to the north (fig. 1), has had a maximum of about 10 miles of left slip since the Late Cretaceous (Dibblee, 1967a). Along the Porcupine Wash fault in the central Hexie Mountains, a near-vertical contact between gneiss and granodiorite has been offset left laterally by 1.8 miles. Due east of here, in the central Eagle Mountains, the Substation fault has offset a swarm of Late Cretaceous or Tertiary dikes by about 2 miles left laterally. An unnamed fault in the eastern Pinto Mountains appears to have a 1-mile left-lateral offset, as measured on an albite-rich phase of the porphyritic quartz monzonite. Other faults and lineaments in this region are known, but more work is needed to determine their displacements.

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