Geology

Restoration of Laramide right-lateral strike slip in northern New Mexico by using Proterozoic piercing points: Tectonic implications from the Proterozoic to the Cenozoic: Comment and Reply

Lee A. Woodward, Karl E. Karlstrom and Chris G. Daniel

Geology 1994;22:862-864
doi: 10.1130/0091-7613(1994)022<0862:ROLRLS>2.3.CO;2

Email alerting services  click www.gsapubs.org/cgi/alerts to receive free e-mail alerts when new articles cite this article
Subscribe  click www.gsapubs.org/subscriptions/ to subscribe to Geology
Permission request  click http://www.geosociety.org/pubs/copyrt.htm#ga to contact GSA

Copyright not claimed on content prepared wholly by U.S. government employees within scope of their employment. Individual scientists are hereby granted permission, without fees or further requests to GSA, to use a single figure, a single table, and/or a brief paragraph of text in subsequent works and to make unlimited copies of items in GSA’s journals for noncommercial use in classrooms to further education and science. This file may not be posted to any Web site, but authors may post the abstracts only of their articles on their own or their organization’s Web site providing the posting includes a reference to the article’s full citation. GSA provides this and other forums for the presentation of diverse opinions and positions by scientists worldwide, regardless of their race, citizenship, gender, religion, or political viewpoint. Opinions presented in this publication do not reflect official positions of the Society.

Notes

Geological Society of America
The late extensional history of the eastern margin of the Tyrrhenian Sea has been controlled by listric normal faults (Lavecchia, 1988). Offshore of the southern Apennines, basins formed in the Miocene, and activity continued through the Pliocene-Quaternary during west-southwest extension (Mariani and Prato, 1988). Basins off the coast of the southern Apennines were controlled by south-southeast displacement on low-angle normal faults from the late Miocene to the early Pliocene (Prencipe et al., 1987). Timing and structural style suggest that the southern basin-bounding faults, unlike those to the north, are correlative with the low-angle normal faults exposed in the southern Apennines.

The present seismotectonic framework of the southern Apennines is characterized by northeast-southwest extension, more or less orthogonal to the mountain chain (Cristofolini et al., 1985). To the south, the tensile axes derived from earthquakes gradually change from east-northeast to west-southwest (Cristofolini et al., 1985) but remain at a high angle to the belt. Structural analysis (Gars, 1983) shows that motion on young high-angle normal faults has a small northwest-southeast component, which is reflected in minor longitudinal extension. These displacements are all compatible with our kinematic model.

REFERENCES CITED


Restoration of Laramide right-lateral strike slip in northern New Mexico by using Proterozoic piercing points: Tectonic implications from the Proterozoic to the Cenozoic: Comment and Reply

COMMENT

Lee A. Woodward
Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

The "Nacimiento fault" is the westernmost of several north-trending faults along which Karlstrom and Daniel (1993) suggested there is 100-170 km of cumulative Laramide (Late Cretaceous-early Tertiary) right slip. Their "Nacimiento fault" actually consists of four separate, distinct, and overlapping faults (Woodward et al., 1992); for clarity and brevity these four faults (from south to north: Pajarito, Nacimiento, Gallina, and Tierra Montañosa) are referred to here as the Nacimiento fault system. Karlstrom and Daniel (1993, p. 1140) stated that "Baltz (1967) mapped a series of en echelon folds in Mesozoic and early Tertiary strata west of the Nacimiento fault and estimated ~5 km of Eocene right slip. However, we add 70-80 km of right slip on both this and a concealed western rift fault to accommodate the suggestion by Laughlin (1991) that the Sandia Granite 'correlates' with the Fenton Hill granodiorite encountered in drill holes beneath the Jemez Mountains some 80 km north of the Sandia Mountains and to match up the offset magnetic anomalies.'" This clearly implies that the Precambrian Fenton Hill granodiorite and the Sandia Granite are separated by the Nacimiento fault system. This is not so, as the Fenton Hill granodiorite and Sandia Granite are both east of the fault system. To demonstrate offset, the plutons must be on opposite sides of the fault. Also, no Precambrian rocks are exposed immediately west of the fault system (Woodward, 1987). Karlstrom and Daniel moved the initial location of their western rift fault (erratum, Geology, v. 22, p. 383), but even the new location cannot be reconciled with the seismic data noted by Russell and Snoeck (1990).

The Rio Puerco fault zone, the southern continuation of the Nacimiento fault system, was mapped in detail by Slack and Campbell (1976), who calculated a maximum of 2 km of right shift. Baltz (1967) noted that there is no geometric necessity for a large amount of lateral shift north of the Gallina fault. Subsequent detailed mapping by Hultgren (1986) demonstrated that displacement on the Ti-
erra Montañosa fault, north of the Gallina fault, is principally dip slip. Thus, right slip dies out at the north end of the Nacimiento fault system.

Cordell and Keller (1984, p. 22) noted that it is difficult to accommodate much strike slip to the north of the Nacimiento fault system because continuous gravity anomalies and structural features that trend northward from the Rio Grande rift cross the projected trend of the fault system. In Figure 3 of Karlstrom and Daniel (1993), the Nacimiento fault system is shown to continue north and connect with west-trending thrusts that bound the Uinta uplift. If the system were to do this and have significant Laramide right slip, it ought to be manifested in pre-Laramide strata and structures. I am not aware of any geologic map that shows a linear fault, a zone of faults, or echelon folds indicating right slip or shift connecting the Nacimiento fault system and Uinta uplift.

Karlstrom and Daniel (1993, p. 1141) stated, "[W]e propose that most of the right-lateral strike-slip occurred in the Laramide," although they also stated that "timing of movement(s) on these faults is not well constrained and probably involved various combinations of late Paleozoic, Laramide, and late Tertiary slip." As a matter of fact, the post-Cretaceous movement on the Nacimiento fault system is reasonably well constrained (Baltz, 1967) and indicates that offset of the northeast-trending band of magnetic highs vastly exceeds the post-Cretaceous right slip and shift on the fault system. The logical inference is that much of the offset on the band of magnetic highs occurred before the Laramide. The ancestral Nacimiento uplift (Pecos axis of Read and Wood, 1947) rose in the late Paleozoic and was probably bounded on the west by a steep fault (Woodward, 1987) that could have had a strike-slip component of movement (Kluth and Coney, 1981).

This discussion of Karlstrom and Daniel's (1993) paper does not, in itself, necessarily negate their major point concerning use of piercing lines defined by the intersection of an isotropic metamorphic surface with steep stratigraphic markers and regional structures in estimating Laramide right-lateral offsets on some of the faults in northern New Mexico. It does, however, point out that the Nacimiento fault system is not a likely candidate for ~80 km of Laramide right slip and that the relevant criteria should be used in estimating the slip and timing of motion on any fault.

REFERENCES CITED


Hultgren, M. C., 1986, Tectonics and stratigraphy of part of the southern Gallina–Archuleta arch, French Mesa and Llaves quadrangles, Rio Arriba County, New Mexico [M.S. thesis]: Albuquerque, University of New Mexico, 123 p.


REPLY

Karl E. Karlstrom, Chris G. Daniel
Department of Earth and Planetary Sciences, Albuquerque, New Mexico 87131

Kelly (1955) and Woodward and Callender (1977) were early proponents of dextral slip along the eastern edge of the Colorado Plateau. These studies were followed by the papers of Chapin and Cather (1981) and Chapin (1983) that proposed ~100 km of Laramide right-lateral strike slip across a series of faults in the area now occupied by the Rio Grande rift. Our paper supports these models and provides constraints on the amount of slip across several faults in northern New Mexico.

Woodward's Comment addresses the westernmost faults, ones for which our data from Proterozoic rocks provide no firm piercing lines. He discusses (1) the amount of slip on the Nacimiento fault system, (2) the position of our western rift fault, (3) the nature of northern extensions of the Nacimiento and western rift fault systems, and (4) the timing of dextral strike slip.

Woodward argues for only limited dextral strike slip on the Nacimiento fault system. However, according to Woodward et al. (1992), there are no piercing points to constrain the magnitude of slip. We quoted the work of Baltz (1967), who estimated up to 5 km of right slip based on tentative correlation of fold axes across the Nacimiento fault. The estimate of Slack and Campbell (1976) for the southern extension of the Nacimiento fault zone of "probably less than 2 km" was not constrained by piercing points. Neither of these studies provides firm constraints on the magnitude of strike slip, but both suggest that the strike-slip component is probably greater than the dip-slip component.

Our Figure 1 (Karlstrom and Daniel, 1993) shows a cumulative strike-slip displacement of 70–80 km along the Nacimiento fault and a hypothetical western rift fault that passes under the Rio Grande rift and the Jemez Mountains. This large magnitude of slip on a proposed western rift fault system is speculative but is consistent with (1) our interpretation of magnetic anomaly patterns; (2) a paper by Laughlin (1991), which suggests that the Fenton Hill granodiorite (intersected in deep drill holes located at about the "J" in Jemez in our Fig. 1) was displaced ~80 km northward relative to the Sandia Granite; contrary to Woodward's Comment, our Figure 1 does show that the western rift fault separates the Fenton Hill and Sandia granites; and (3) a possible structural control for the position of the Jemez caldera, at the intersection of a major northeast-striking Proterozoic lithospheric boundary and our hypothetical north-south–trending Laramide fault system.

Woodward questions whether our proposed 70–80 km slip on the Nacimiento and western rift fault systems can be accommodated farther north. He cites Cordell and Keller (1984), who noted that continuous northeast-trending gravity and magnetic anomalies cross the northern extension of the Nacimiento trend, suggesting minimal dextral slip. However, they also emphasize the probability of complex fault networks of Laramide age and the nonuniqueness of in-
terpretations of the origin and correlation of geophysical anomalies. Our model (following Chapin and Cather, 1981) suggests that north-south–trending transcurrent fault networks become transpressive as they change to northwest-striking structures. Baltz (1967), Gries (1983), Tweto (1979), and many others have mapped a complex system of structures (Salado-Cumbres discontinuity of Baltz, 1967) involving shortening and strike slip in northern New Mexico and Colorado. Our hypothesis is that this deformation was kinematically compatible with (and balanced) Laramide strike slip in the ancestral Rio Grande rift. This model must be tested in terms of regionally distributed deformation, not in terms of a single linear fault zone.

We stated that the timing of right slip is not tightly constrained. Our Proterozoic piercing lines only determine net slip since 1.4 Ga. However, Late Proterozoic and early Paleozoic deformation is unknown in the region. Pennsylvanian deformation, if due to northwest shortening during the Ouachita collision (Kluth and Coney, 1981), should have been sinistral on north-south–trending faults, and Tertiary deformation was mostly extensional. Thus, the Laramide seems the most likely time for substantial dextral strike slip. Nevertheless, Woodward’s cautions are important, and we share his desire to arrive at better constraints through continued work that attempts to distinguish the components of late Paleozoic, Laramide, and late Tertiary movements within reactivated fault networks.

As pointed out in his last paragraph, Woodward’s discussion does not pertain to the main points of our paper: (1) that piercing lines defined by the intersection of Proterozoic isobaric surfaces with steeply dipping stratigraphic and structural markers in the Tusas, Picuris, Truchas, and Rio Mora uplifts provide evidence for −50 km of right-lateral strike slip; (2) that these faults provided a weak zone that was reactivated in the mid-Tertiary to form the Rio Grande rift; and (3) that restoration of dextral strike slip on these faults provides insights into the geometry of Proterozoic provinces in the Southwest.

REFERENCES CITED


