CENOZOIC STRESS ROTATION, NORTHEASTERN COLORADO PLATEAU (ABSTRACT)

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Six periods of fracture in Cenozoic rocks of the Piceance basin, on the northeast edge of the Colorado Plateau, show that Late Laramide and post-Laramide stresses in that region rotated about a vertical axis with time. All of the fractures are vertical and perpendicular to bedding, and all are Mode I (extensional) fractures as shown by plumose structures and twist hackle. Thus, when each set formed, the minimum principal compressive stress (σ_3) was horizontal and perpendicular to the fracture planes, and the maximum horizontal compressive stress (σ_{hmax}; $\sigma \leq_{hmax} \sigma_1$) was parallel to fracture strike. From oldest to youngest the fracture record of the basin's stress history is as follows. (1) Late Eocene hydraulic fractures created by intrusion of clastic dikes show no preferred strike, indicating that horizontal stresses were nearly isotropic. (2) Local F_1 joints striking north-northwest record a minor fracture event. (3) F_2 joints striking west-northwest (Fig. 1) are the major set of the northern part of the basin but are sparse farther south, where stresses presumably remained too low to produce pervasive fracture. (4) F_3 joints striking east-northeast are abundant in the southern part of the basin, where F_3 corresponds to the major fracture event, but are less common farther north. (5) Local left-lateral shear, common on F_2 joints and rare on F_3, indicate σ_{hmax} trending approximately northeast. (6) Regionally pervasive F_4 joints striking north-northeast correspond to a major fracture event during or after regional uplift about 8-10 Ma. (7) Rare, geologically young F_5 joints striking west-northwest have orientations compatible with formation in the contemporary stress field.

The data show that σ_3 remained nearly horizontal but rotated counterclockwise with time (Fig. 2). Although stresses between fracture events are conjectural, evidence exists that the 50° rotation spanning events 3 through 5 was continuous, with no reversals in direction. In any case, statements that stresses in and near this region remained essentially unchanged from Laramide time to the present are in error.

Figure 1. A well-developed set of west-northwest striking F_2 joints along the eastern edge of the Piceance basin. The joints strike away from the observer and indicate horizontal extension within the plane of the photograph (north-northeast to south-southwest).

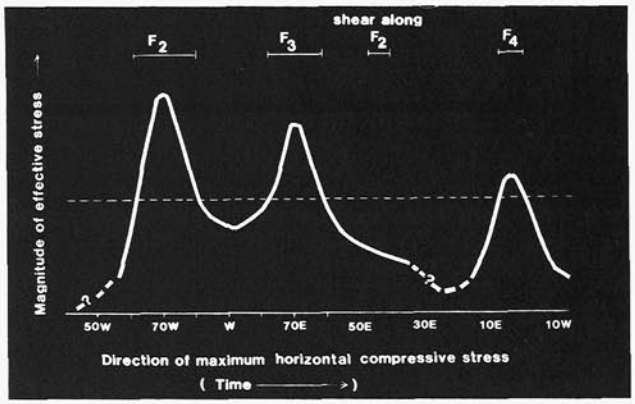

Figure 2. Partial stress history for the northern Piceance basin showing counterclockwise rotation of the stress field with time. The dashed line (ideally, a zone) represents the magnitude of effective stress that, if exceeded, would cause fracture in common lithologies in the basin. The three peaks in the stress-magnitude curve correspond to the three periods of jointing F_2, F_3, and F_4. Between F_3 and F_4 the stresses were sufficient to cause shear along older joints (as shown by fibrous calcite within the joints) but were not great enough to form a new joint set. The graph is schematic only and is not linear either in stress or in time.

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