

# The Rupture of the Pitáycachi Fault in the 1887 $M_w$ 7.5 Sonora, Mexico Earthquake (southern Basin-and-Range Province)

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## Abstract

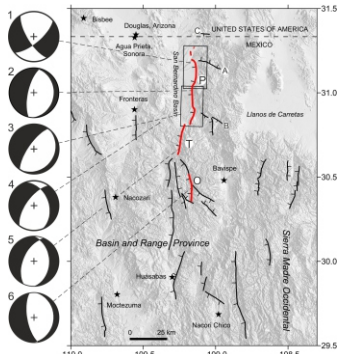
During the great 3 May 1887 Sonoran earthquake (surface rupture end-to-end length: 101.8 km;  $M_w = 7.5 \pm 0.3$ ), an array of three north-south striking Basin-and-Range Province faults (from north to south Pitáycachi, Teras, and Olatas) slipped sequentially along the western margin of the Sierra Madre Occidental Plateau. This detailed field survey of the 1887 earthquake rupture zone along the Pitáycachi fault includes mapping the rupture scarp and measurements of surface deformation. The surface rupture has an endpoint-to-endpoint length of 41.0 km, dips between  $60^\circ$  and  $86^\circ W$ , and is characterized by E-W extension, perpendicular to the fault trace. The maximum surface offset is 487 cm and the mean offset 260 cm. In the north, the rupture terminates against a major cross fault, whereas in the south, a 2.5-km-wide unbreached right step-over separates the Pitáycachi from the Teras segment. The 1887 along-strike surface offsets are proportional to the one order-of-magnitude larger along-strike offsets of a distinct Pleistocene alluvial fan surface, which suggests that the 1887 rupture dimensions are characteristic for ruptures along the Pitáycachi fault.

Whereas the Teras and Olatas segments have the typical 15–20 km length of normal fault segments, the Pitáycachi fault is unusually long because of being a composite of formerly independent fault segments. The former segment boundaries are linked by an échelon rupture scarp arrays with a local horizontal slip component. However, the former segmentation is not expressed in the 1887 along-rupture surface-offset profile, which indicates that the former segments are now linked at depth into a single coherent fault surface.

The Pitáycachi surface rupture shows a well-developed bipolar branching pattern suggesting that the rupture originated in its central part, where the polarity of the rupture bifurcations changes. Most likely the rupture first propagated bilaterally along the Pitáycachi fault, from where the southern rupture front jumped across a step-over to the Teras fault and from there across a major relay zone to the Olatas fault. Branching probably resulted from the lateral propagation of the rupture due to the unusual length of the fault, given that the much shorter ruptures of the Olatas and Teras segments did not develop branches.

## Location and Neotectonic Setting

- At western margin of Sierra Madre Occidental Plateau.
- Block faulting with ~10% E-W extension.
- Segmented fault array, mostly half-grabens.
- Faulting initiated ~25 Ma ago (as in Rio Grande rift).
- Peak subsidence between 25 and 18 Ma (Miocene) at ~0.5 mm/a.
- Crustal thickness ~50 km below plateau, ~25 km west of it.

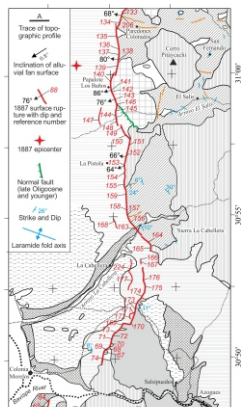
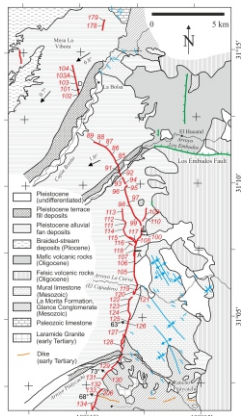


Shaded relief map of northeastern Sonora and northwestern Chihuahua (Mexico) and the adjacent U. S. border region showing the 1887 rupture trace (red, bars on hanging wall, P, Pitáycachi segment; T, Teras segment; O, Olatas segment) and the traces of interpreted Basin-and-Range Province faults. A, Los Embudos fault; B, La Cabeallera fault; C, Guadalupe Canyon fault. Dashed line: international boundary. Boxes: region covered by surface rupture map. The lower-hemisphere equal-area stereoplots represent striations measured on the rupture surface and focal mechanisms (P quadrants shaded in grey).



Contemporary photograph by Camillus S. Fly of the 1887 earthquake rupture, most likely near site 124. The scarp is subvertical, composed of alluvial gravel cemented by caliche, and its height is estimated here as 4.7 m.

## Surface Rupture Map

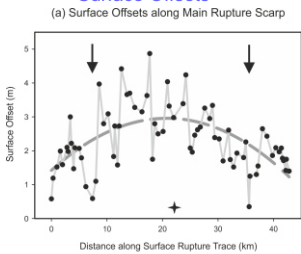


Geologic map showing the rupture trace of the 1887 earthquake along the Pitáycachi fault.

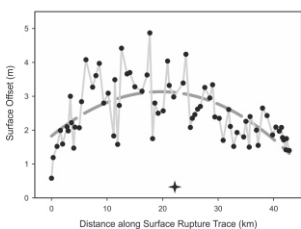


Surface rupture (white ribbon) along the central part of the Pitáycachi rupture segment, seen from the WNW. The scarp height is approximately four meters. Background: ignimbrites of the Sierra Madre Occidental; middle ground (foothills of the Sierra Madre): sediments of the Cretaceous Bisbee group; foreground: alluvial fan deposits of the San Bernardino valley.

## Surface Offsets

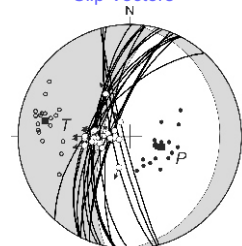


## (b) Compound Surface Offsets



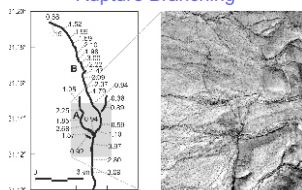
Surface offsets calculated for 71 scarp measurement sites along the main rupture scarp of the Pitáycachi segment. The mean surface offset is 232 cm. The maximum offset (487 cm) is located in the center of the segment. The dashed line is a quadratic best fit. The overall distribution is symmetric. Two local minima, indicated by arrows, are located where the slip is partitioned onto several branches or secondary ruptures. The star marks the latitude of the epicenter. (In this graph, the surface offsets from 11 sites on branches and secondary ruptures were added to the offsets along the main rupture. These compound offsets make the data on Figure 4 disappear and increase the values on the regression curve as well as the mean surface offset.

## Slip Vectors



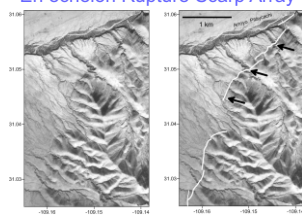
Lower-hemisphere equal-area stereoplots showing the 18 fault planes and striations measured on the Pitáycachi segment of the 1887 rupture surface. The striations generally indicate east-west extensional dip-slip with a minor left-lateral displacement component.

## Rupture Branching



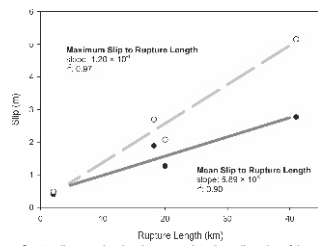
Map and vertical aerial photograph showing in detail the major surface-rupture branching-pattern in the northern part of the Pitáycachi segment, south of Cañón de los Embudos, and related slip partitioning.

## En échelon Rupture Scarp Array



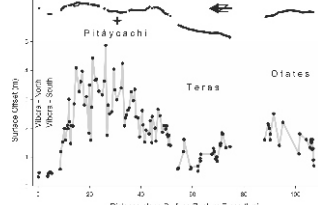
Vertical aerial photograph (in duplicate) showing in white the 1887 rupture trace south of Arroyo Pitáycachi, which forms here a left-stepping en échelon array composed of six segments. The three arrows point to right-laterally deflected drainage channels.

## Slip-to-Length Ratios of Individual Rupture Segments



Scatter diagram showing the rupture length-to-slip ratios of the major individual 1887 rupture segments and related linear regressions. The open circle represents the maximum slip, the closed circles the mean slip.

## Trace map (upper part of figure) and surface offset scatter diagram of the entire 1887 earthquake rupture. North is to the left. The star marks the epicenter.



## Related Previous Work by the Author

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