A bottom-driven mechanism for distributed faulting in the Gulf of California Rift

Patricia Persaud1, Eh Tan2, Juan Contreras3 and Luc Lavier4

1persaud@lsu.edu, Department of Geology and Geophysics, Louisiana State University, Baton Rouge, Louisiana 70803; 2 Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan; 3Centro de Investigación Científica y de Educación Superior de Ensenada, Ensenada, BC, Mexico; 4 University of Texas Austin, Institute for Geophysics, Austin, TX 78712

Introduction

Observations in the continent-ocean transition of the Gulf of California (GOC) show multiple oblique-slip faults distributed in a 200x70 km² area (Fig. 4). In contrast, north and south of this broad pull-apart structure, major transform faults accommodate plate motion. We propose that the mechanism for distributed faulting results from the boundary conditions present in the GOC, where basal shear is distributed between the southernmost fault of the San Andreas system and the Ballenas Transform fault.

We hypothesize that in oblique-extensional settings whether deformation is partitioned in a few dip-slip and strike-slip faults, or in numerous oblique-slip faults may depend on (1) bottom-driven, distributed extension and shear deformation of the lower crustal mantle, and (2) the rift obliquity. We explore the effects of bottom-driven shear on the deformation of an elastic-plastic layer with the help of pseudo-three-dimensional numerical models that include side forces.

Application to the Northern Gulf

• Our model with an obliquity of 0.7, and linear basal velocity boundary conditions reveals a delocalized fault pattern of contemporaneously active faults, multiple rift basins and variable fault dip is representative of faulting in the N. Gulf.

• The r=0.7 model is able to predict the broad geometrical arrangement of the two Upper Del Cerritos, Lower Del Cerritos and Wagner Basins as segmented basins with tilted fault blocks, and multiple oblique-slip bounding faults characteristic of incomplete strain partitioning. We also confirm with our numerical results that numerous oblique-slip faults accommodate slip in the study area instead of throughgoing large-offset normal transform faults.

Conclusions

1. Strain localization results in our models when the basal shear abruptly increases in a step-function manner while oblique-slip on numerous faults dominates for distributed basal shear (Fig. 7).

2. We show in a 2-layer numerical model that lower crustal flow can produce multiple faults in the overriding brittle crust in the case of distributed basal shear (Fig. 8). In this instance, the flow essentially drives the deformation.

3. We further explore how the faulting style varies with obliquity and demonstrate that the delocalized faulting is reproduced in models with an obliquity of 0.7 and distributed basal shear boundary conditions (Fig. 8 and 9), consistent with GOC observations.

References


DISTRIBUTED FAULTING IN A BRITTLE 5-KM THICK UPPER CRUSTAL LAYER OVERLYING A 15-KM THICK LOWER CRUSTAL CHANNEL

2+½D Numerical Models

Flow in a channel with a sloping wall

Shear stress at the base of the brittle crust for 1D Couette-Poiseuille flow with a constant channel thickness.

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Fig. 3. Models with varying obliquity labeled in the top left of each model. The time for each model runs, t, is indicated next to the obliquity. The vertical exaggeration of the topography is noted at the top right of each panel. The total plastic strain (x 100%) is shown in all cases with hot colors representing zones of high strain.

References


Obtaining the shear stress at the base of the brittle crust for 1D Couette-Poiseuille flow with a constant channel thickness.