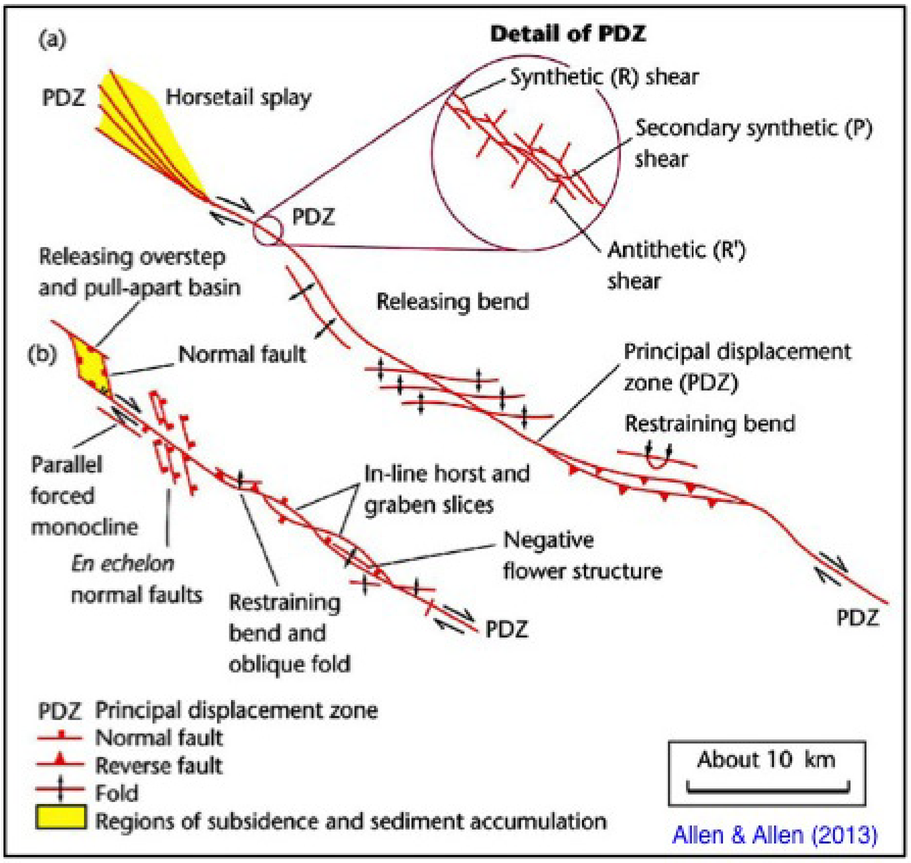
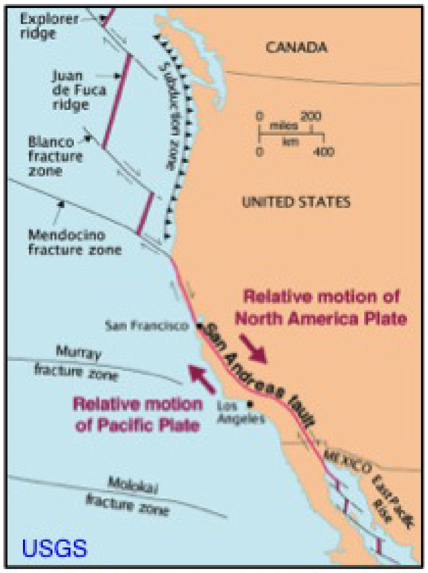
Strike-Slip Basins

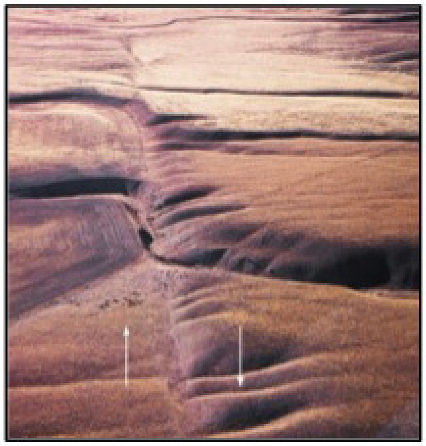


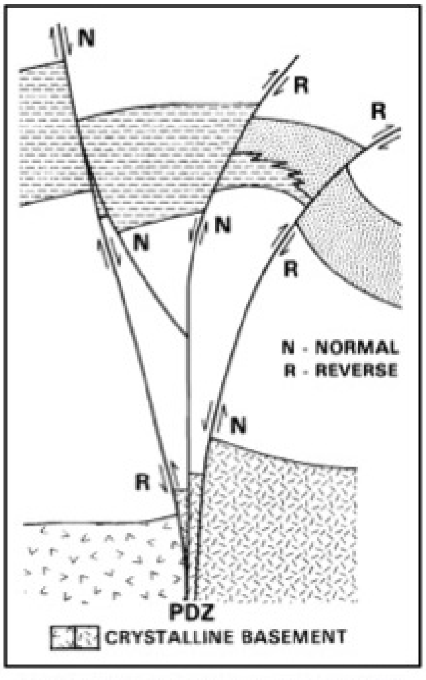
Allen & Allen (2013)

Figure 6.10 (a) structures associated with an idealised right-lateral strike-slip fault. **(b)** Adaptation to slightly divergent setting. Mod. from Christie-Blick & Biddle (1985).

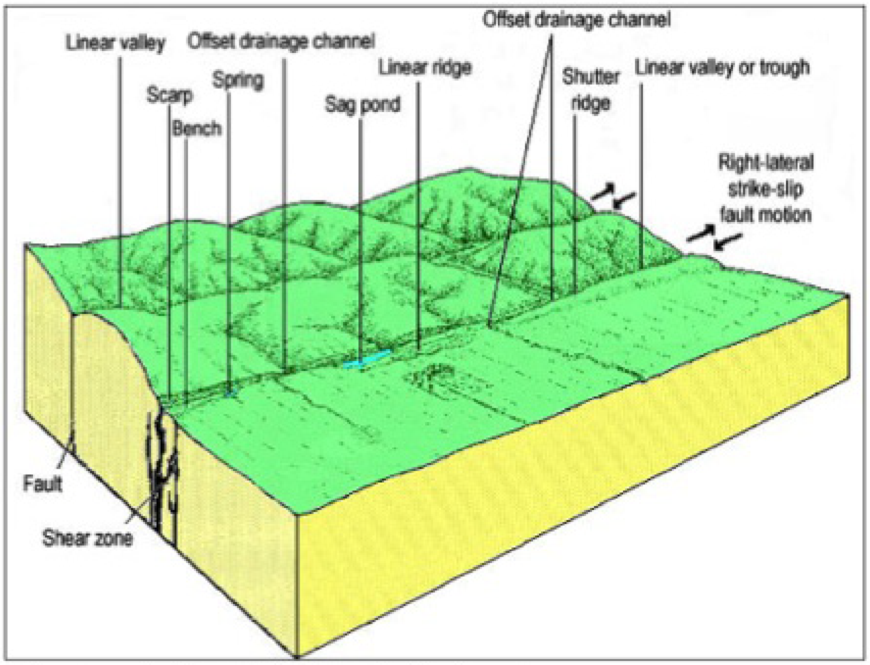


USGS





Structures **of strike-slip fault zones** (Christie-Blick and Biddle, 1985)

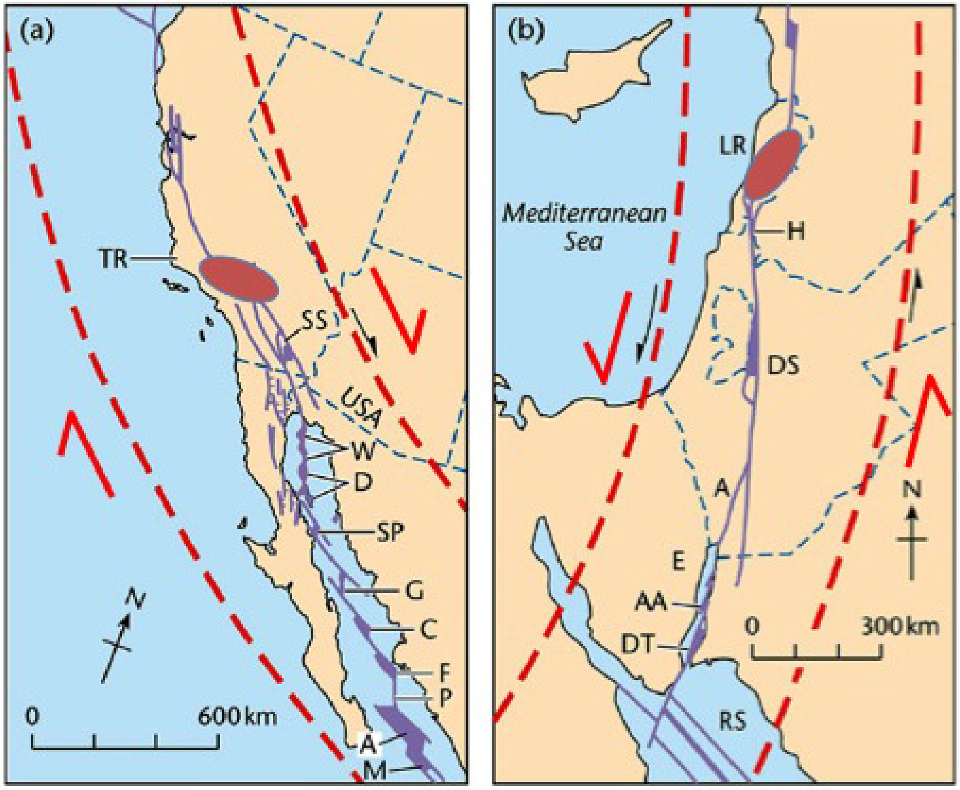


Geomorphology **of strike-slip fault zones** (Vedder and Wallace, 1970; Wallace, 1990)

Major Characteristics

- BASEMENT - INVOLVED
- PDZ SUB-VERTICAL AT DEPTH
- UPWARD DIVERGING & REJOINING SPLAYS
- CONTRASTING BASEMENT TYPE
- ABRUPT VARIATIONS IN THICKNESS & FACIES IN A SINGLE STRATIGRAPHIC UNIT
- NORMAL- & REVERSE-SEPARATION FAULTS IN SAME PROFILE
- VARIABLE MAGNITUDE & SENSE OF SEPARATION FOR DIFFERENT HORIZONS OFFSET BY THE SAME FAULT
- INCONSISTENT DIP DIRECTION ON A SINGLE FAULT
- VARIABLE MAGNITUDE & SENSE OF SEPARATION ON A SINGLE FAULT
- VARIABLE PROPORTIONS OF NORMAL- & REVERSE-SEPARATION FAULTS
- TIME-STRATIGRAPHIC UNIT WITH VARIABLE SEDIMENTARY FACIES

Compression and Extension Along Transform Plate Boundaries



Pacific-North America pl. boundary

Arabia-Sinai plate boundary

Fig. 6.3 Regions of compression and extension along strike-slip boundaries between rigid continental plates related to the orientation of the fault zone with respect to the plate slip vector. After Mann et al. (1983).

(a) Pacific–North American plate boundary. The dashed lines are theoretical interplate slip lines from Minster et al. (1974). ... Pole of rotation is in eastern Canada (near Montreal).

(b) Arabia–Sinai (Levant) plate boundary zone (Garfunkel 1981; Ben-Avraham et al. 1979). Theoretical interplate slip lines are from Le Pichon & Francheteau (1978). The prominent area of compression is the Lebanon Ranges push-up block ... Most of the pull-apart basins are in the Dead Sea and Gulf of Aqaba regions where the fault zone is locally 'divergent' with respect to the interplate slip lines.
© Journal of Geology 1983.

Allen & Allen (2013)

Strike-Slip Basin Types

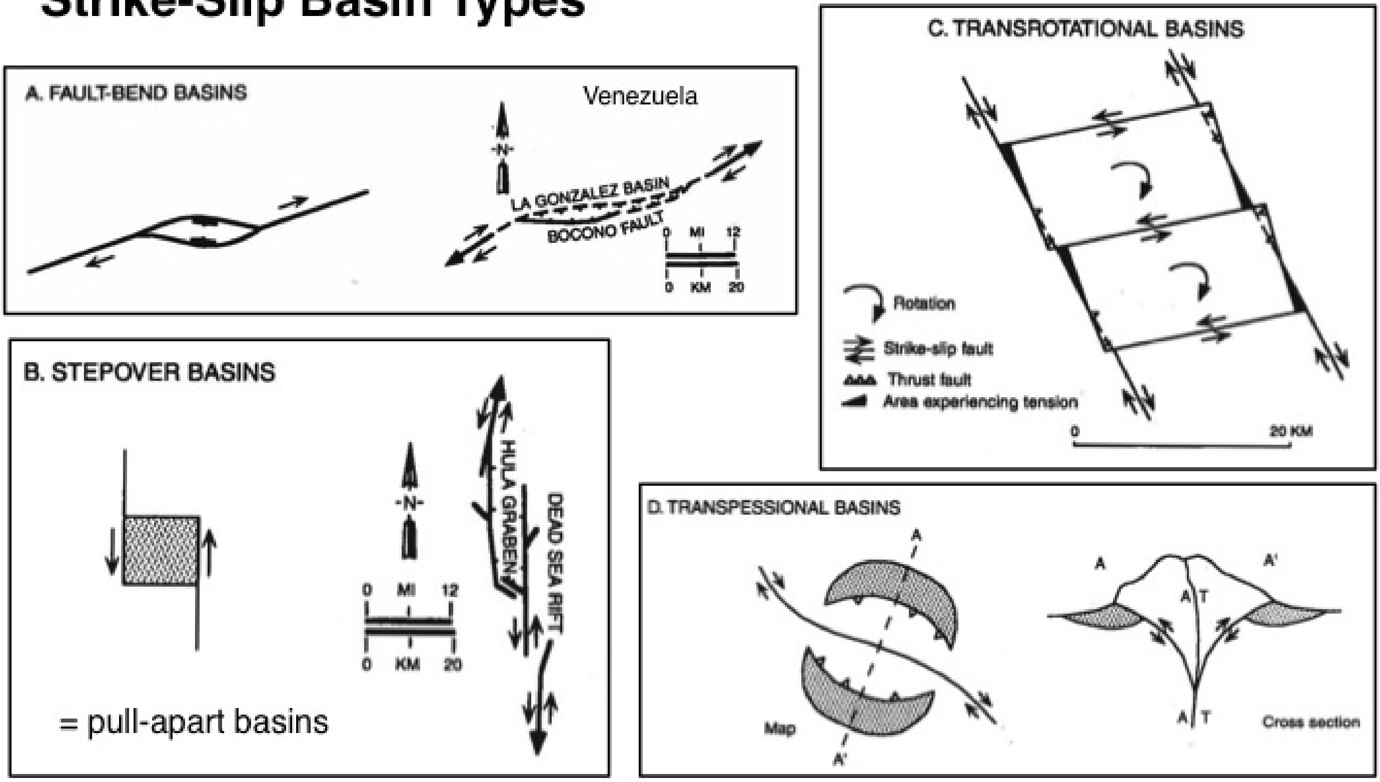


Fig. 12.3 Diagrammatic maps of strike-slip basin types ... (Nilsen and Sylvester, 1995)

Fig. 12.4 Small fault-bend basin from Superstition Hills earthquake zone. Fault strikes away from viewer, from bottom of photograph to tower on horizon. Axis of basin is about 25° to fault strike. Net right-lateral strike-slip at this site was 1.5 m (photograph by A. G. Sylvester).

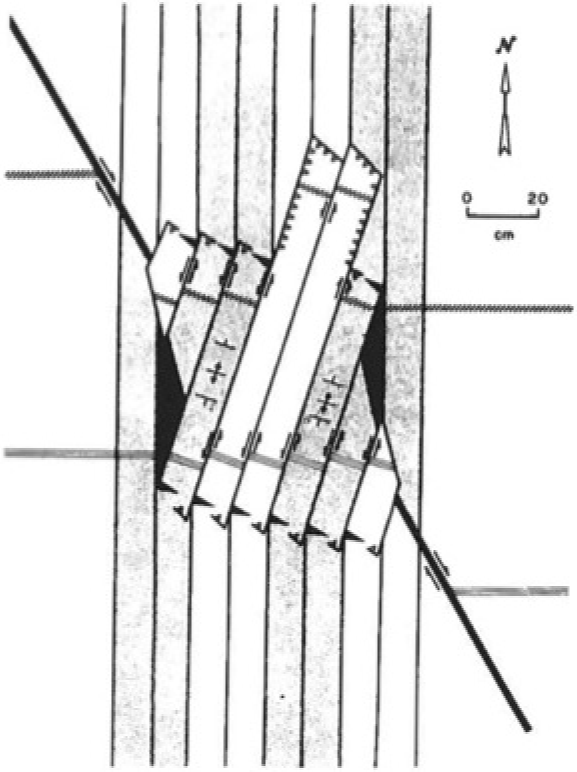
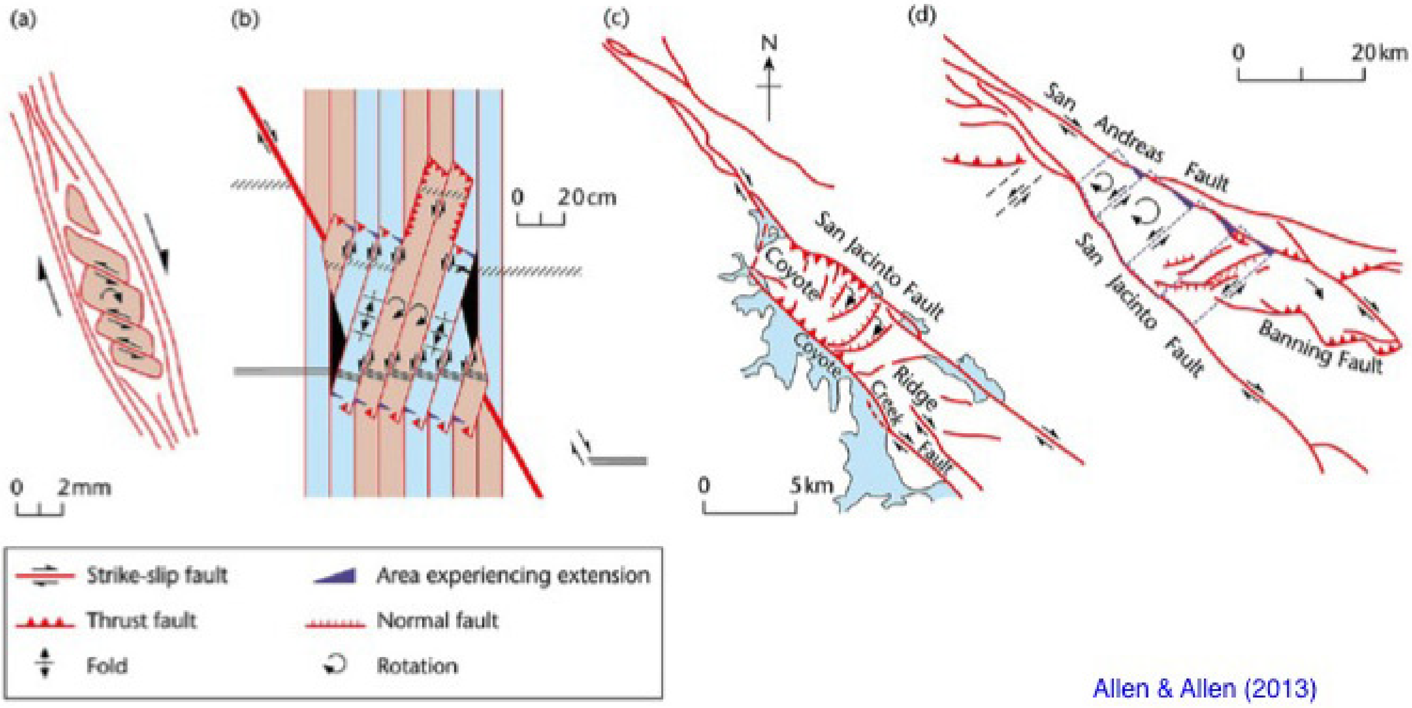


Fig. 12.5 Idealized diagram of gaps or basins (black areas) among rotated blocks in a right-simple-shear couple (Reproduced with permission from Terres and Sylvester, 1981). Hachures are on overthrust parts of blocks.

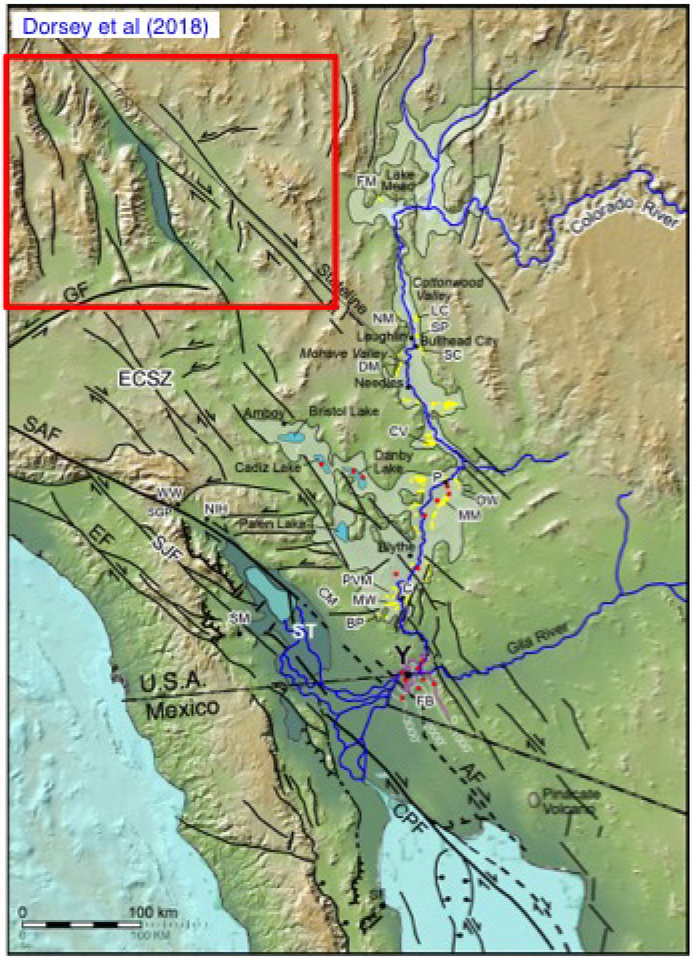
Nilsen and Sylvester, 1995



Allen & Allen (2013)

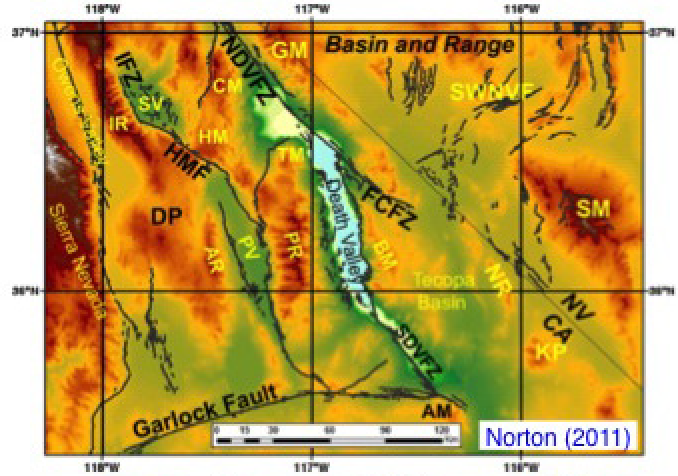
Fig. 6.5 Examples of block rotation by strike-slip faulting at scales from mm to km (after Nicholson *et al.* 1986a). (a) Fracture and rotation of a feldspar crystal along cleavage planes in a ductile matrix. (b) Rotation of a hard surface soil layer as a result of the Imperial Valley earthquake of 1979. The ruled lines are the evenly spaced furrows of a ploughed field. (c) Rotating blocks defined by secondary cross-faults between an overlapping right step from the Coyote Creek Fault to the San Jacinto Fault. (d) Block model for rotation near the intersection of the San Jacinto and San Andreas faults inferred from geology and seismicity. Reproduced with permission of John Wiley & Sons, Inc.

San Andreas Fault and ECSZ

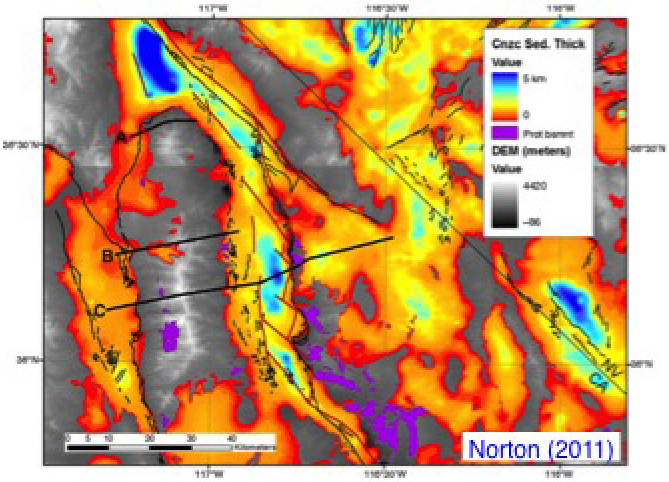


Dorsey et al (2018)

Death Valley



Norton (2011)



Norton (2011)

Death Valley: classic example of a modern pull-apart basin

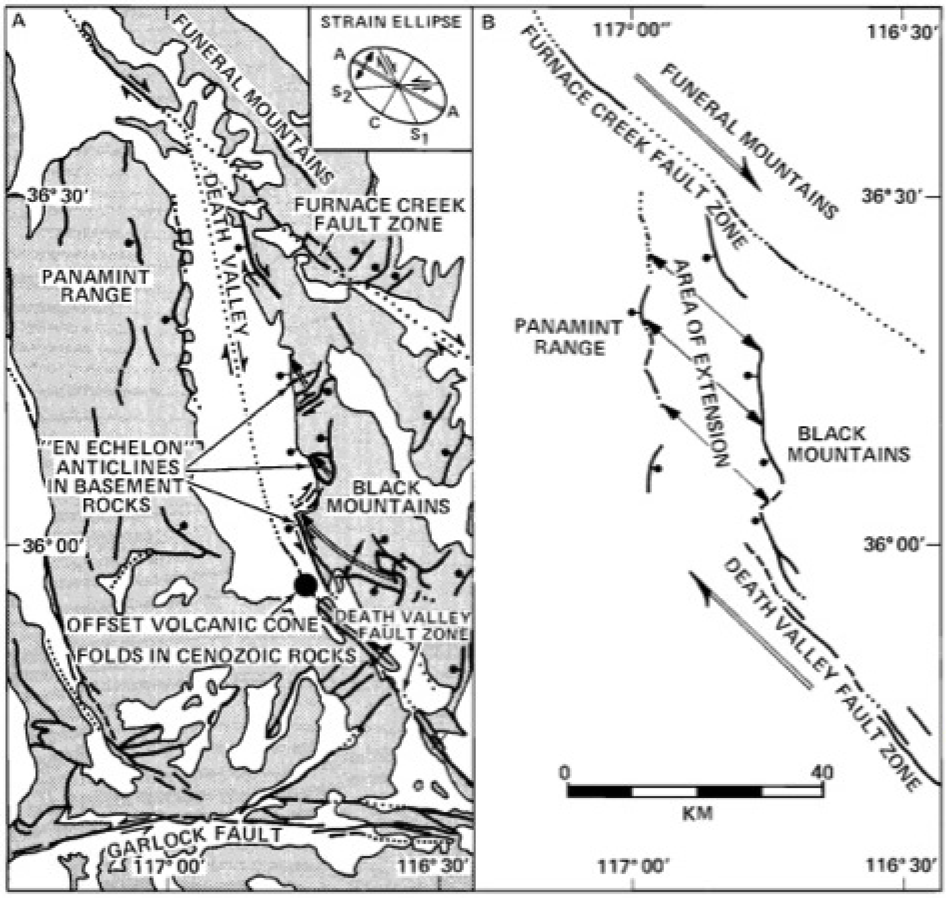


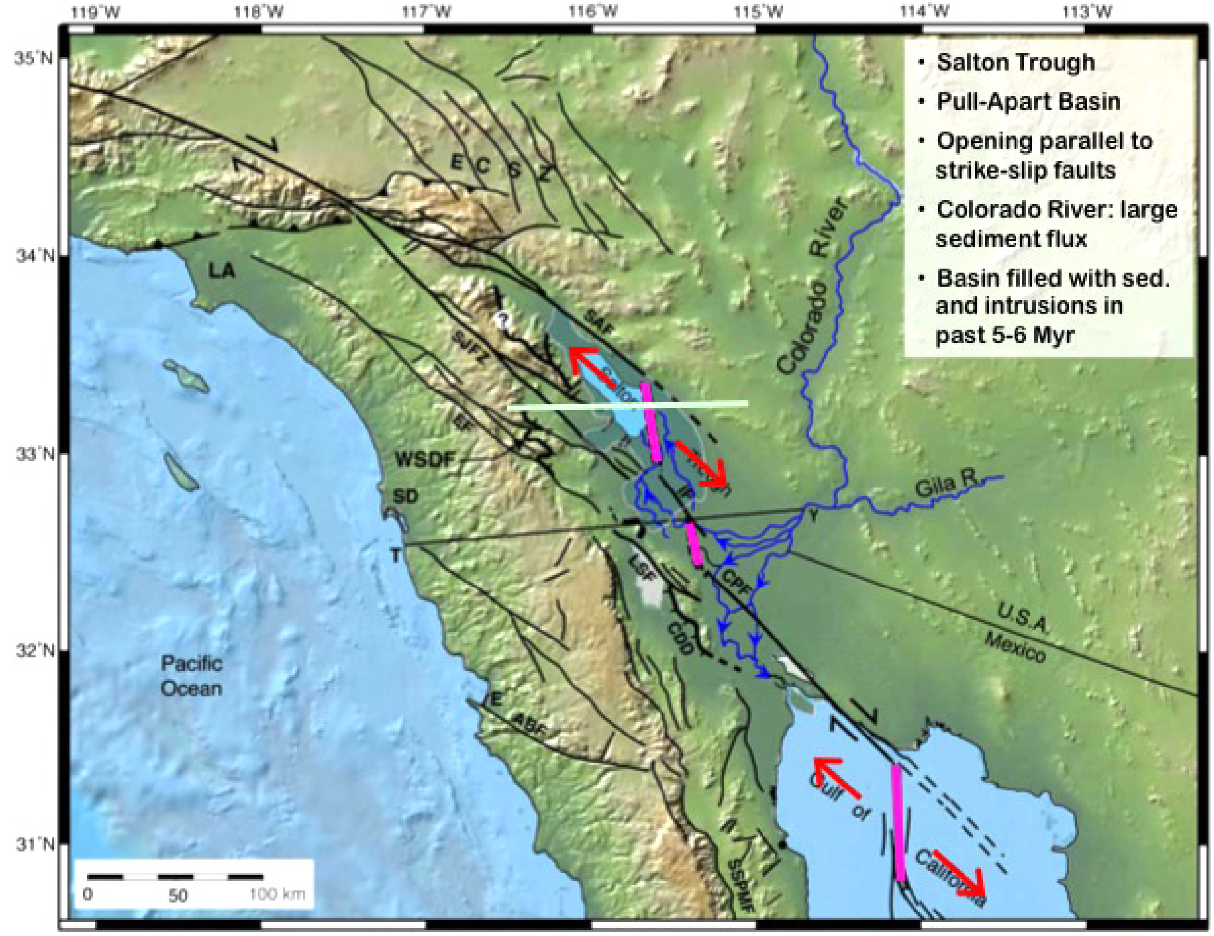
FIG. 9. Major fault zones in the Death Valley area, showing interpretations of (A) Hill and Troxel (1966), and (B) Burchfiel and Stewart (1966).

(A) A buried strike-slip fault is inferred in the central north-trending segment of Death Valley on the basis of oblique striae on fault surfaces in the Black Mountains, and "en echelon" anticlines in basement rocks (Hill and Troxel, 1966). Insert compares the orientations of observed structures with an idealized strain ellipse for the overall deformation ...

(B) Death Valley interpreted as a pull-apart along an oblique segment of a strike-slip fault system (Burchfiel and Stewart, 1966). Indicators of crustal stress and regional seismicity indicate continued extension in an approximately northwest-southeast direction parallel with the Furnace Creek and southern Death Valley fault zones (Sbar, 1982).

From Christie-Blick and Biddle (1985)

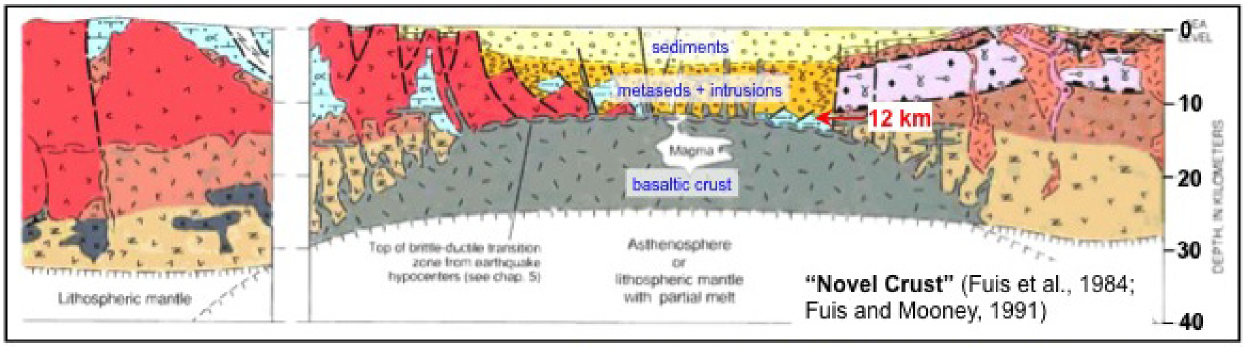
Oblique Rifting and Sedimentation in the Salton Trough



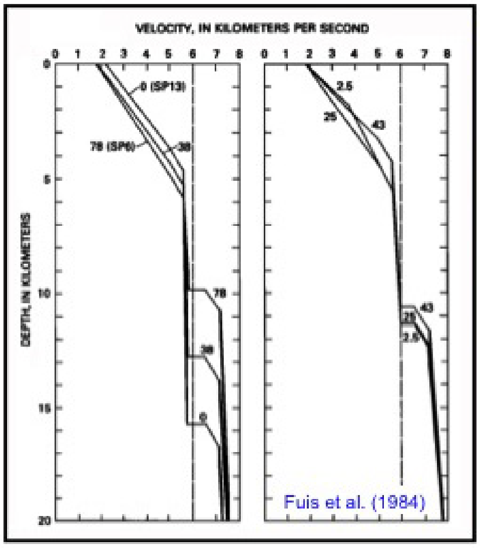
- Salton Trough
- Pull-Apart Basin
- Opening parallel to strike-slip faults
- Colorado River: large sediment flux
- Basin filled with sed. and intrusions in past 5-6 Myr

Crustal Model for Salton Trough (Fuis et al., 1984) – Seismic Refraction:

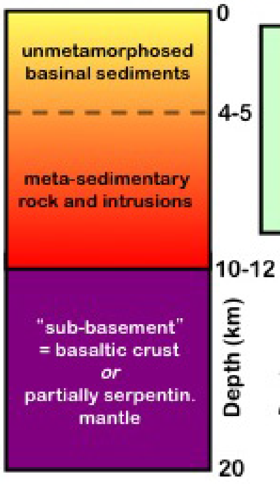
Lithosphere is fully ruptured. Young (post-5.3 Ma) Colorado River sediment and metaseds to depths of 10-12 km



"Novel Crust" (Fuis et al., 1984; Fuis and Mooney, 1991)



… explains seismic refraction data, velocity structure

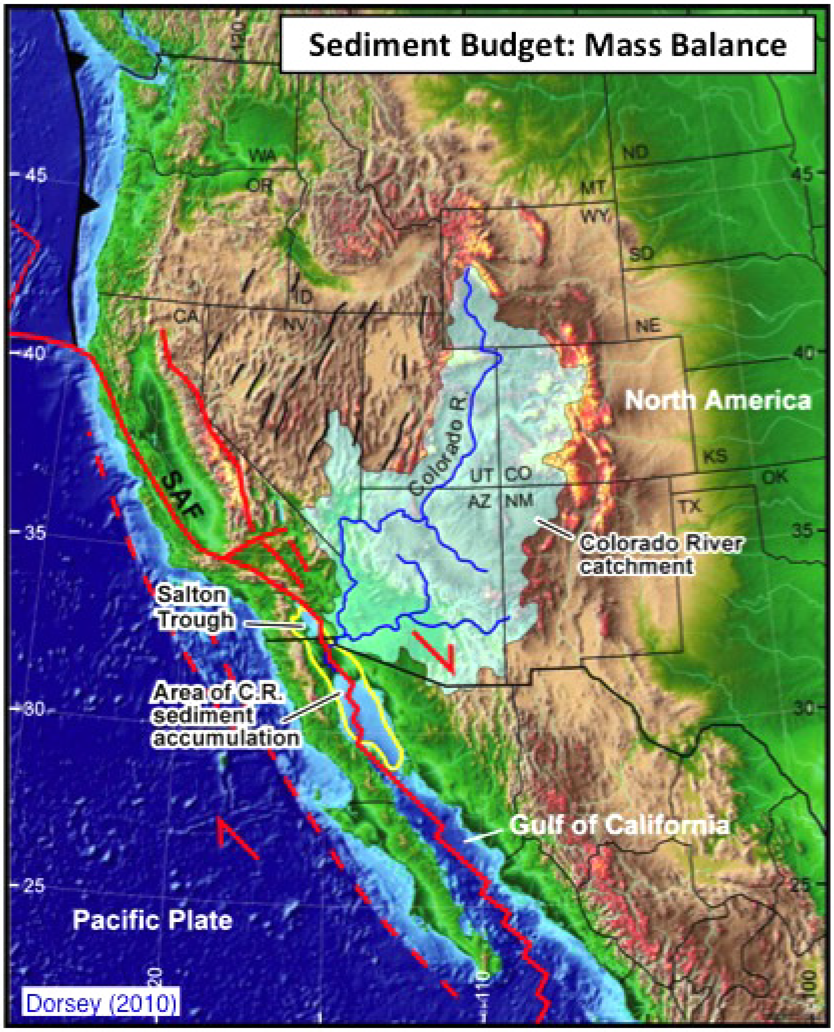


(abrupt increase in Vp)

10-12 km in 5.3 m.y. requires accum. rate of 1.9-2.3 mm/yr … consistent with measured rates
(Van Andel, 1964; Herzig et al., 1988; Schmitt and Hulen, 2008; Dorsey et al., 2011).

Faster velocities (7.5-8.0 km/s) could be basaltic crust (Fuis et al., 1984) or partially serp. mantle (Nicolas, 1985).

Sediment Budget: Mass Balance



Dorsey (2010)

SOURCE: Colorado River

Catchment Area: 630,000 km^2
4th largest in conterminous U.S.;
~10-15 times the area of the sink.

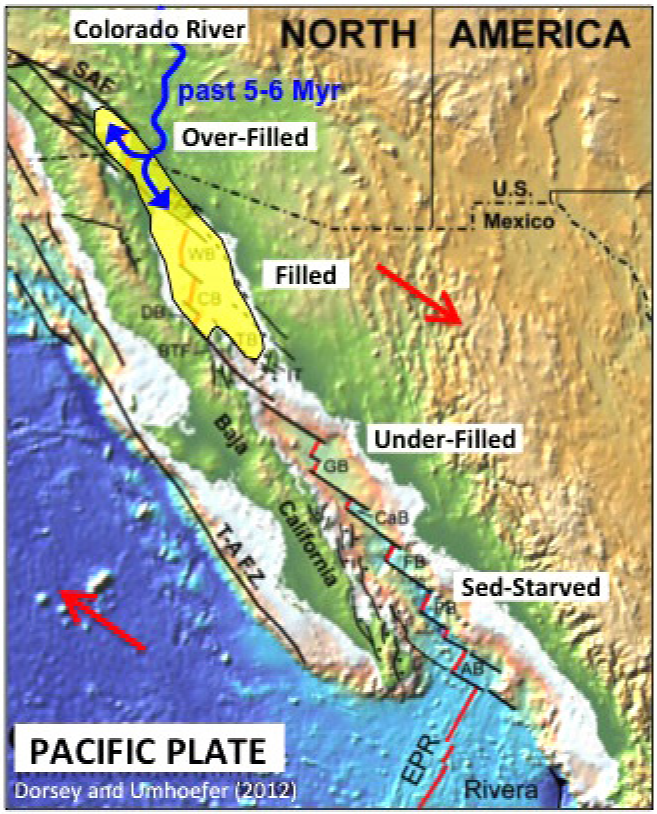
Dissolved Load (TDS):
~ 400 ppm (early 1900's)
~ 800 ppm (modern)

Sediment Discharge:
1.2-1.8 x 10^8 t/yr (pre-dam)
~ 1.0 x 10^5 t/yr (modern)
(Meade and Parker, 1985)

SINK: Basins in Salton Trough and northern Gulf of California

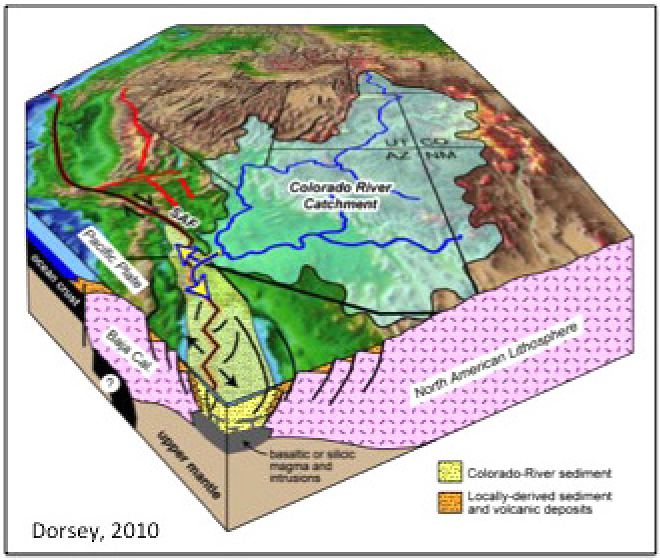
- Opened by oblique divergence along plate boundary since ca. 8 Ma.
- Colorado River sediment arrived in Salton Trough at 5.3 Ma ...
- has dominated basin fill since then.
- Rapid subsidence and sediment accumulation (~1-3 mm/yr)
- High heat flow: greenschist facies metam. (~300°) at 2-4 km depth.

Rapid input of sediment from Colorado River exerts 1st order control on: rift architecture, crustal composition, lithospheric rupture.



Dorsey and Umhoefer (2012)

- Inhibit creation of basaltic crust …
  Prevent formation of new ocean basin
- Favors low-angle detachment faults, *Delays* lithospheric rupture …
- River Sediment → Crustal Recycling



Dorsey, 2010