Strike-Slip Basins

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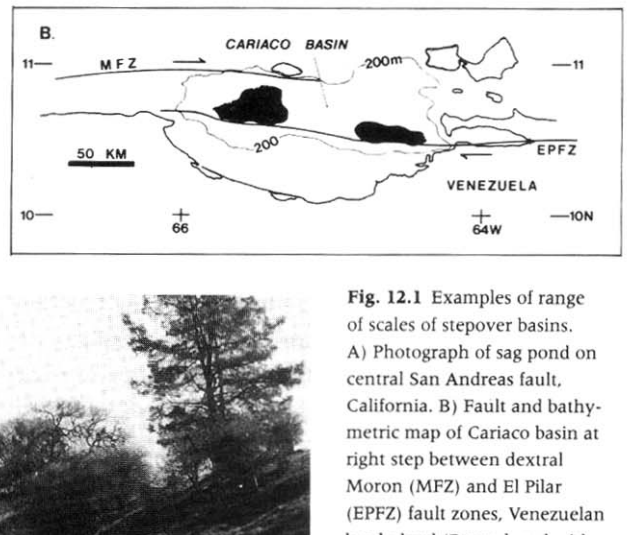
Introduction

Various types of basins, previously grouped together by many workers as "pull-apart basins" (Burchfiel and Stewart, 1966), commonly form along major strike-slip faults. We refer to these basins herein as *strike-slip basins,* following Mann et al. (1983), because "pull-apart basins" are only one of a range of basin types that may develop as a result of strike-slip faulting.

Strike-slip basins range in size from small sag ponds to rhombochasms as wide as 50 km (Fig. 12.1). Basin length-to-width ratios are typically 4:1, with a range from 1 to 10:1 (Aydin and Nur, 1982). The surface dimensions of a strike-slip basin may be measured either structurally by bounding faults or flexures, or physiographically by the extent of the area of subsidence. The basin margins, however, are commonly deformed by younger folds and faults, or have been displaced from the basin depocenter by continued strike slip. Bounding faults may dip in varying directions and be of various types. As a result, definition of basin size and shape may be a difficult task because bounding faults may dip either more steeply or more gently with depth, and may merge at depth into a single master fault; some basin margins may sag rather than be faulted. Some strike-slip basins



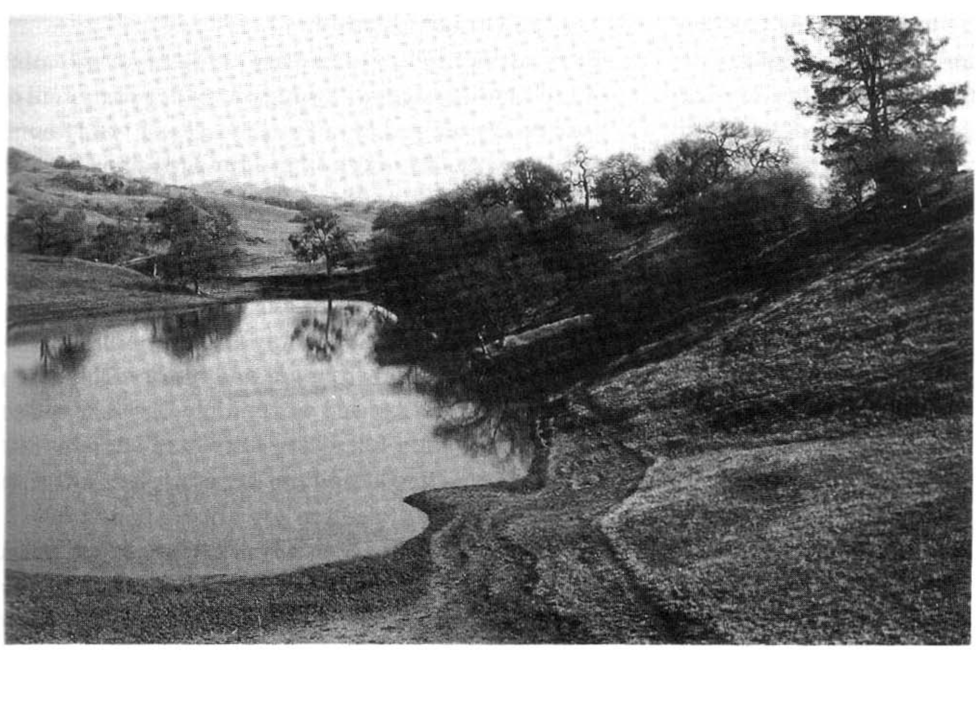


Fig. 12.1 Examples of range of scales of stepover basins. A) Photograph of sag pond on central San Andreas fault, California. B) Fault and bathymetric map of Cariaco basin at right step between dextral Moron (MFZ) and El Pilar (EPFZ) fault zones, Venezuelan borderland (Reproduced with permission from Mann, et al., 1983).

Table 12.1 Classification of strike-slip faults by Sylvester (1988), based partly on Woodcock's (1986) relation of strike-slip faults to plate-tectonic setting (see Fig. 12.2)

INTERPLATE (deep-seated)	INTRAPLATE (thin-skinned)
TRANSFORM faults (delimit plates, cut lithosphere, fully accommodate motion between plates)	TRANSCURRENT faults (confined to the crust)
Ridge Transform faults* • Displace segments of oceanic crust having similar spreading vectors • Present examples: Owen, Romanche, and Charlie Gibbs fracture zones	Indent-linked strike-slip faults* • Separate continent-continent blocks which move with respect to one another because of plate convergence • Present examples: North Anatolian fault (Turkey); Karakorum, Altyn Tagh, and Kunlun fault (Tibet)
Boundary transform faults* • Join unlike plates which move parallel to the boundary between the plates • Present examples: San Andreas fault (California), Chaman fault (Pakistan), and Alpine fault (New Zealand)	Tear faults • Accommodate differential displacement within a given allochthon, or between the allochthon and adjacent structural units (Biddle and Christie-Blick, 1985) • Present examples: northwest- and northeast-striking faults in Asiak fold-thrust belt (Canada)
Trench-linked strike-slip faults* • Accommodate horizontal component of oblique subduction; cut and may localize arc intrusions and volcanic rocks; located about 100 km inboard of trench • Present examples: Semanko fault (Burma), Atacama fault (Chile), and Median Tectonic Line (Japan)	Transfer faults • Transfer horizontal slip from one segment of a major strike-slip fault to its overstepping or en-echelon neighbor • Present examples: Lower Hope Valley and Upper Hurunui Valley faults between the Hope and Kakapo faults (New Zealand), and Southern and Northern Diagonal faults (eastern Sinai)
	Intracontinental transform faults • Separate allochthons of different tectonic styles • Present example: Garlock fault (California)

*See Woodcock (1986, p. 20) for additional examples, both ancient and modern, and for their geometric and kinematic characteristics.

from the other. Sharply defined clefts may form at the mesoscopic scale along releasing fault bends. At larger and longer scales, the sliding block may sag into the extended zone. More commonly, parts of both blocks sag toward the fault to form an elongate zone of subsidence along the fault bend, referred to as a lens-shaped basin (Crowell, 1974b) or a "lazy pull apart" (Mann et al., 1983). How the walls of a fault-bend basin converge at depth and merge with the master fault is largely unknown. Fault-bend basins may also form near restraining bends, where one of the fault blocks extends differentially as it slides around the bend, out of the zone of restraint.

Fault-bend basins are strongly asymmetric, have prominent coarse-grained aprons along their principal displacement zones, are commonly lens-shaped in map view, and generally develop in transtensional settings, subsequently undergoing inversion in transpressional settings. These basins may resemble other rift basins (see Chapter 3), especially in two-dimensional seismic-reflection profiles.

Stepover basins (Fig. 12.3B) form between the ends of two parallel to sub-parallel strike-slip faults that are not connected (Aydin and Nur, 1985; Schubert, 1986; Sarewitz and Lewis, 1991). Because the zone between two fault segments in en-echelon arrangement is termed a "stepover," basins that form as a result of extension between the two faults are referred to as "stepover basins." The bounding faults may merge at depth into a single master fault. At basement level, the extended domain between the two en-echelon faults generally forms a mesh-like arrangement of normal and strike-slip faults that are steep at depth. Stepover basins typically

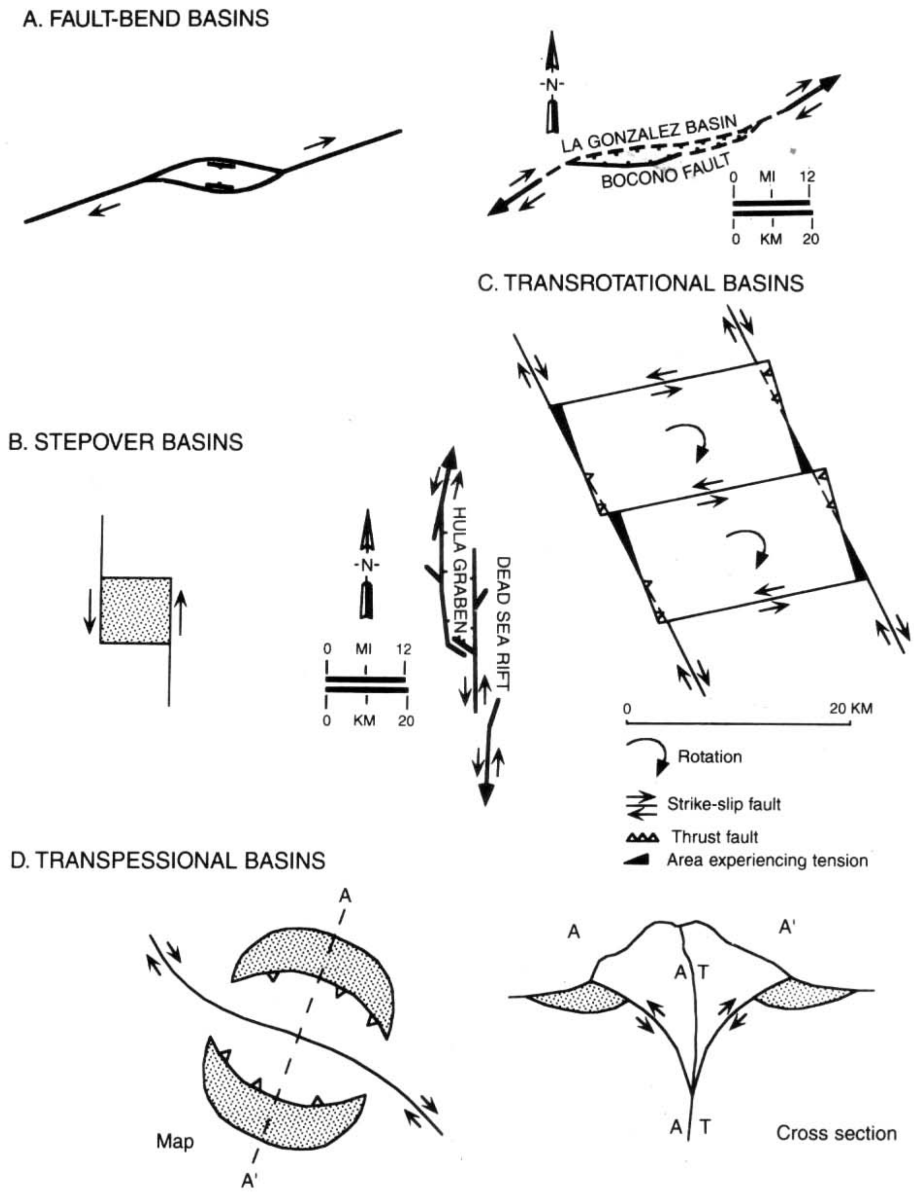


Fig. 12.3 Diagrammatic maps of six strike-slip basin types: A) fault-bend basin (left) with map of La Gonzalez basin, Venezuela (right); B) stepover basin (left) with map of part of Dead Sea rift (right); C) transrotational basins (black areas); D) transpressional basins (dot pattern) in map view (left) and cross section (right); E) polygenetic basins (dot pattern) in regional extension (left) and in regional shortening (right); and F) polyhistory basins initiated as rift basin.

form between left-stepping faults in left slip and between right-stepping faults in right slip (Fig. 12.3B).

Stepover basins may be more symmetric than fault-bend basins, with coarse-grained aprons shed basinward from all faulted margins. Depocenters may not lie preferentially adjacent to one of the marginal faults. Transverse structures may be common, segmenting the basin into separate subbasins. Continued transtension may extend and rupture the crust, producing magmatic activity, high heat flow, and in extreme cases, generation of new crust that may be younger than the overlying sedimentary succession. The floors of other stepover basins may consist of gently dipping faults at the basement-cover interface or deeper in the basement.

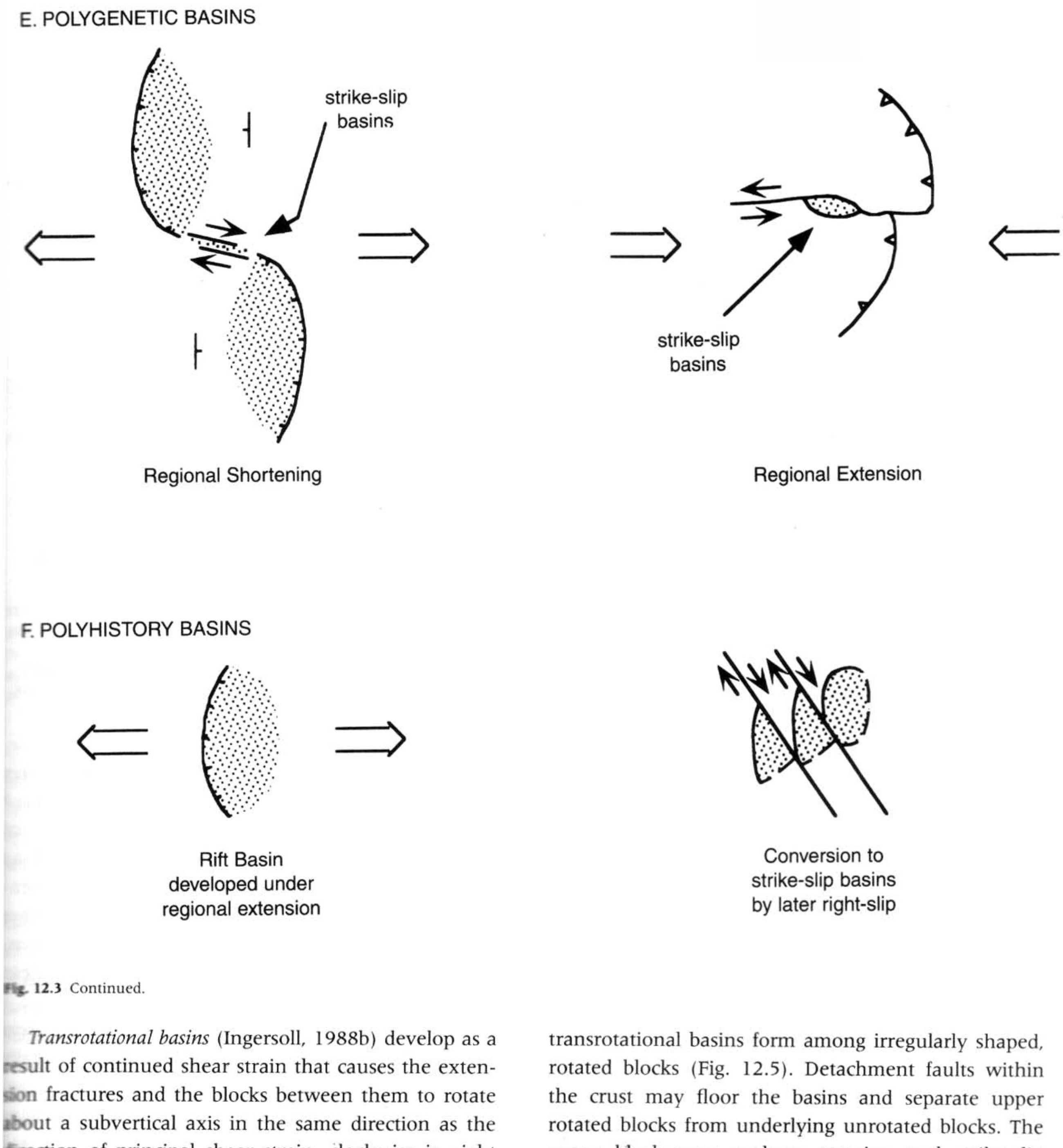


Fig. 12.3 Continued.

Transrotational basins (Ingersoll, 1988b) develop as a result of continued shear strain that causes the extension fractures and the blocks between them to rotate about a subvertical axis in the same direction as the direction of principal shear strain, clockwise in right simple shear and counterclockwise in left simple shear (Fig. 12.3C). The rate and magnitude of rotation depend on the rate of shear strain. Triangular gaps or transrotational basins form among irregularly shaped, rotated blocks (Fig. 12.5). Detachment faults within the crust may floor the basins and separate upper rotated blocks from underlying unrotated blocks. The upper block may undergo rotation and strike-slip deformation during and following deposition. Major amounts of slip along basin-bounding faults are not necessary.

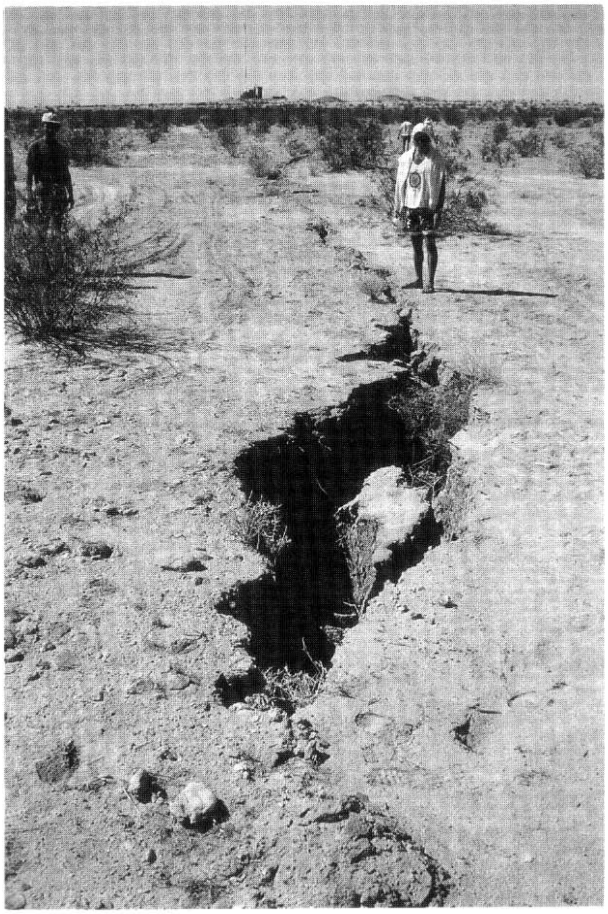


Fig. 12.4 Small fault-bend basin from Superstition Hills earthquake zone. Fault strikes away from viewer, from bottom of photograph to tower on horizon. Axis of basin is about 25° to fault strike. Net right-lateral strike-slip at this site was 1.5 m (photograph by A. G. Sylvester).

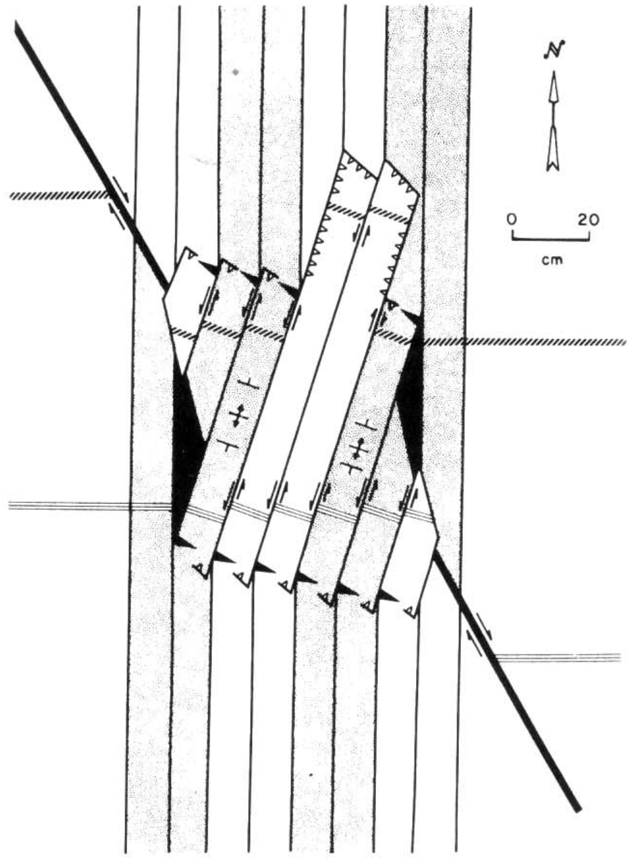


Fig. 12.5 Idealized diagram of gaps or basins (black areas) among rotated blocks in a right-simple-shear couple (Reproduced with permission from Terres and Sylvester, 1981). Hachures are on overthrust parts of blocks.

Transpressional basins (Fig. 12.3D) are generally long and narrow structural depressions, parallel to regional faults and folds, and are commonly bounded by underlying thrust faults and flanking strike-slip, or reverse faults. These basins may be dominated by axial transport of sediments parallel to structural depressions that develop in several ways, generally in response to flexural subsidence. They form next to uplifted and overthrust fault blocks that dip back into the principal displacement zone or other strike-slip faults (Fig. 12.6), typically adjacent to positive "flower" or "palm tree" structures in zones of transpression along strike-slip faults. Subsidence results from flexural loading of the marginal crust, forming mini-foreland basins adjacent to the uplifted blocks. Piggyback basins, forebulges, and related structures may develop in the transpressive regions. Paired transpressional basins may form on opposite sides of transpressive uplifts. With continued strike-slip along the principal displacement zone, patterns of sedimentation and subsidence can be very complex. Other transpressive basins may develop in response to synclinal downfolding or paired reverse faulting within transpressive regions.

Polygenetic basins (Fig. 12.3E) as defined herein develop in local regimes of strike slip in generally convergent or divergent tectonic settings. In rift settings, transfer faults or accommodation zones may link border faults of normal displacement and bound small strike-slip basins. In convergent settings, strike-slip faults and strike-slip basins may be confined to

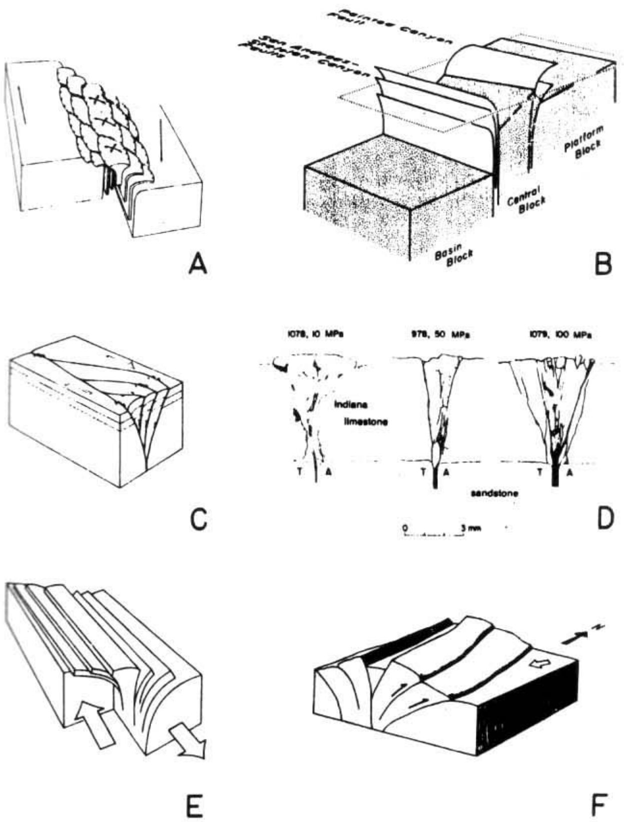


Fig. 12.6 Conceptual diagrams of flower or palm-tree structures in right simple shear (from Sylvester, 1988): A) from Lowell (1972, p. 3099); B) from Sylvester and Smith (1976); C) from Woodcock and Fisher (1986); D) from Bartlett et al. (1981); E) adapted with modifications from Ramsay and Huber (1987, p. 529); and F) with axial graben from Steel et al. (1985).

the upper plate of allochthonous thrust sheets, yielding a type of piggyback basin. Polygenetic strike-slip basins are also common in accommodation zones, where they may be confined to upper structural plates or hanging walls.

Polyhistory basins (Fig. 12.3F) are those in which episodes of pure extensional rifting or pure compressional thrusting alternate with episodes of strike slip, generating complex and commonly multicyclic basins. They can be of almost any size and shape, and they generally record pulses of subsidence caused by varying mechanisms. Many "successor basins" in complex orogenic belts are of this type; they may be long-lasting, with multiple histories of uplift and subsidence related to shifting tectonic settings. Polyhistory strike-slip basins may also have the characteristics of many of the other types of strike-slip basins, but they tend to be even more complicated because of their varying tectonic framework.