# Nociones de Geología Estructural

# DEFORMACIÓN DE LA CORTEZA

- **La deformación de la corteza está documentada por movimientos históricos a lo largo de fallas; por terrazas marinas y playas solevantadas (con desarrollo de acantilado costero); por tierras sumergidas ; por cuerpos de roca fracturados, fallados y plegados; etc...**


# Evidencias de deformación en la corteza

- La deformación mas intensa está representada por las **CADENAS DE MONTAÑAS PLEGADAS**, que se desarrollan a lo largo de los contactos convergentes de placas

El tiempo o velocidad de deformación es variable, desde una escala geológica (en millones de años), histórica (en cientos o miles de años), hasta una escala humana (observable)

**LOS MOVIMIENTOS OBSERVABLES, EN PROCESO DE DESARROLLO, pueden ser:**

**MOVIMIENTOS ABRUPTOS** ( ejemplos: Yakutat: 15 m; San Francisco: 7 m; Valdivia: 2 m )

**MOVIMIENTOS LENTOS** (ejemplos: Bakersfield, en California: 2.5 cm x año; Templo de Serapis, en Italia; Mar Báltico, Costa Austral de Chile)

**Las rocas expuestas a esfuerzos de COMPRESIÓN, EXTENSIÓN Y CIZALLE, responden deformándose y generando estructuras**

**Las estructuras resultantes de una deformación cortical son llamadas *estructuras secundarias,* en oposición a las *estructuras primarias o singenéticas,* que son comunes en las rocas sedimentarias**

***La roca se deforma cuando se le aplica un esfuerzo que excede la resistencia del material.***

**La respuesta del material rocoso al esfuerzo, esto es, la deformación de la roca, será en función de la PRESIÓN CONFINANTE, la TEMPERATURA, el TIEMPO DE APLICACIÓN, los FLUIDOS INTRA -POROS y , naturalmente, el TIPO DE ROCA.**

En general, cerca de la superficie, la roca se comporta de manera **FRAGIL** (rígida) y se fractura.. Las estructuras resultantes son: **DIACLASAS y FALLAS**.

A mayor profundidad (del orden de 3 km), la roca se comporta de manera **DÚCTIL** (plástica) y se pliega o fluye plásticamente. La estructura resultante es un **PLIEGUE**

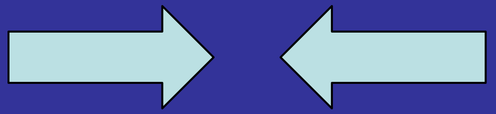
A grandes profundidades se llega al dominio de la **FUSIÓN** (viscoso), dónde se originan pliegues de flujo o aparición de esquistocidad.

# TIPOS DE ESTRUCTURAS
# (y esfuerzos asociados)

FRACTURAS

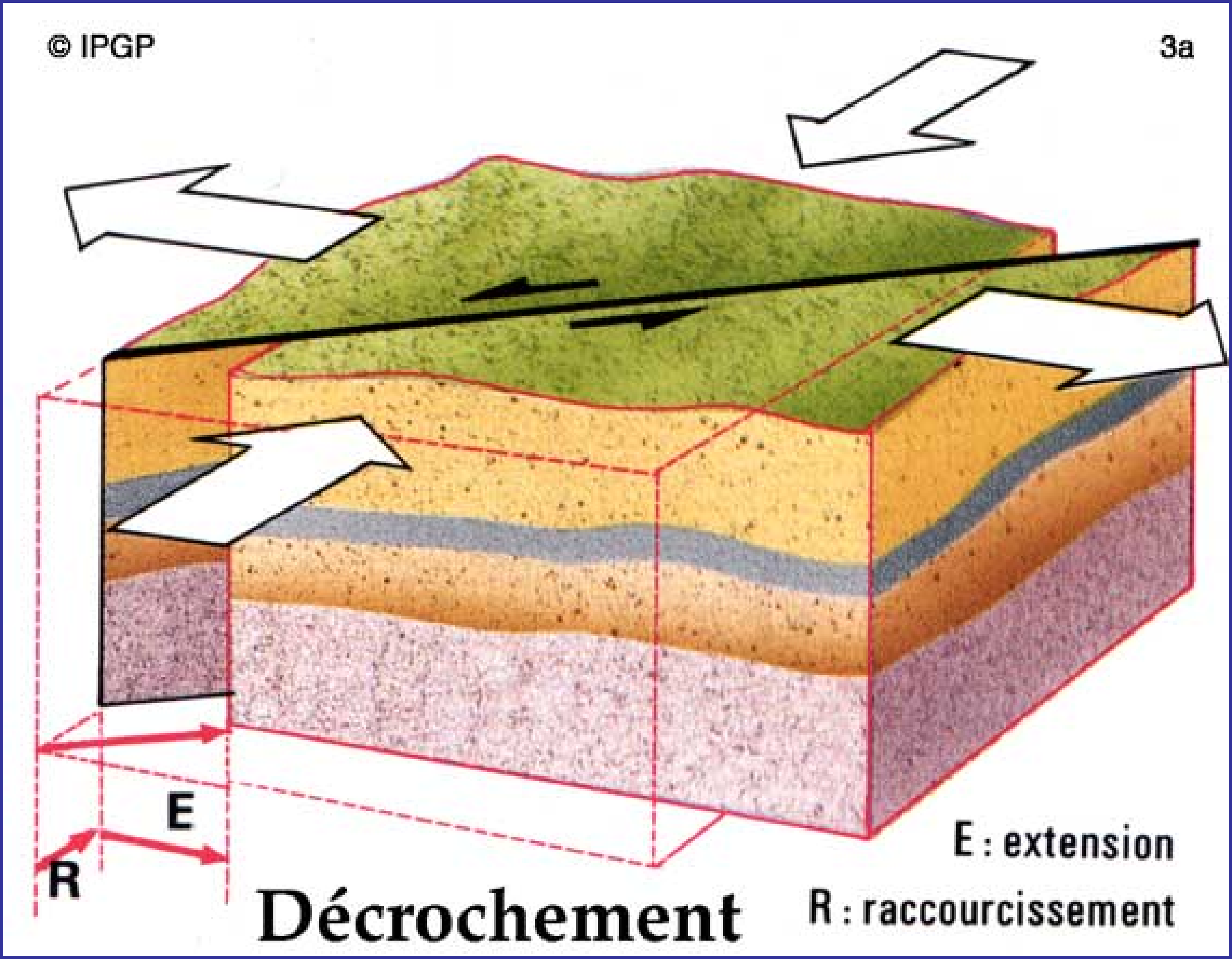
fallas y diaclasas

PLIEGUES



PLIEGUES DE FLUJOS

# Falla de Rumbo



Pliegues y fallas se producen desde dimensiones microscópicos (microestructuras) a macro y megascópicas (megaestructuras de cientos miles de kilómetros de extensión)

- Orientación espacial de un plano (estrato, flanco o limbo del pliegue, diaclasa o falla): **RUMBO y MANTEO**

# Rumbo y Manteo

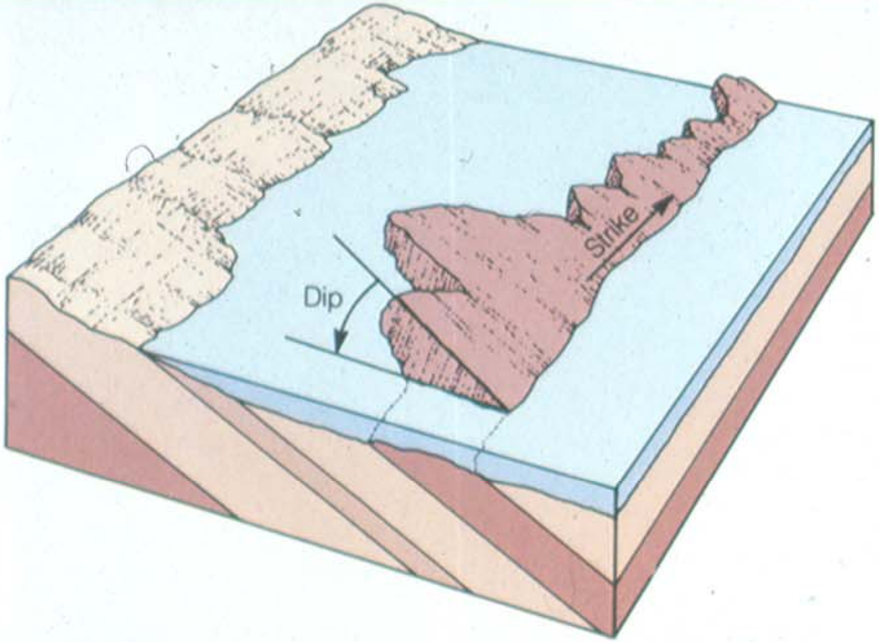
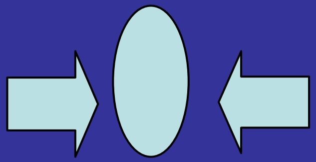



**FIGURE 8.2**
**The concept of dip and strike** can be understood by studying rock layers such as the ones shown in this photograph. The strike of a bed is the compass bearing of a horizontal line drawn on the bedding plane. It can readily be established by reference to the horizontal waterline in this example. The dip is the angle and direction of inclination of the bed, measured at right angles to the strike.

# PLIEGUES

- **PLIEGUE** (esfuerzo compresivo  ): **ANTICLINALES Y SINCLINALES** (simétrico, asimétrico, volcado, recumbente, isoclinal ; **MONOCLINALES; DOMOS Y CUENCAS; PLIEGUES COMPLEJOS**.

- Elementos de un pliegue: **FLANCO o LIMBO, PLANO AXIAL, EJE DE PLIEGUE o CHARNELA**

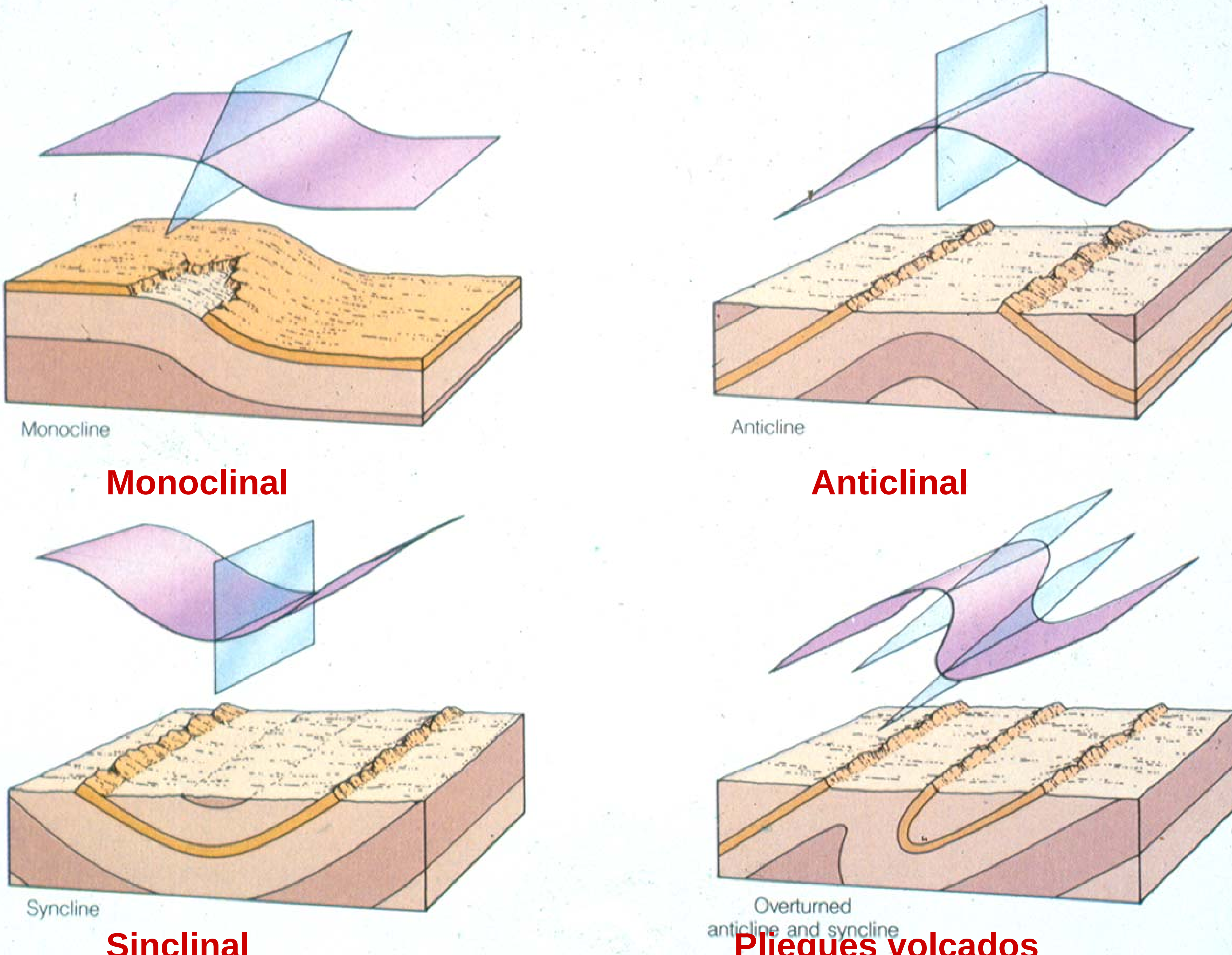



**FIGURE 8.4**
**The nomenclature of folds** is based on the three-dimensional geometry of the structure, although most exposures show only a cross section or map view.

(A) Anticlines and synclines are easily recognized when erosion cuts across the structures and exposes them in a vertical cross section such as these folds in the Calico Hills of southern California.

# Pliegue monoclinal

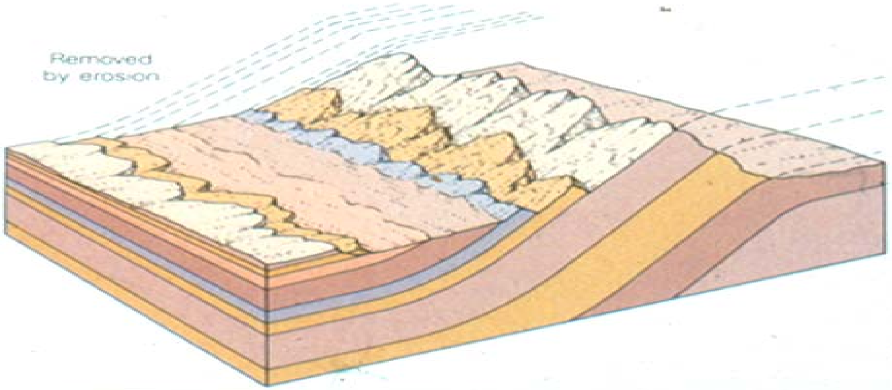
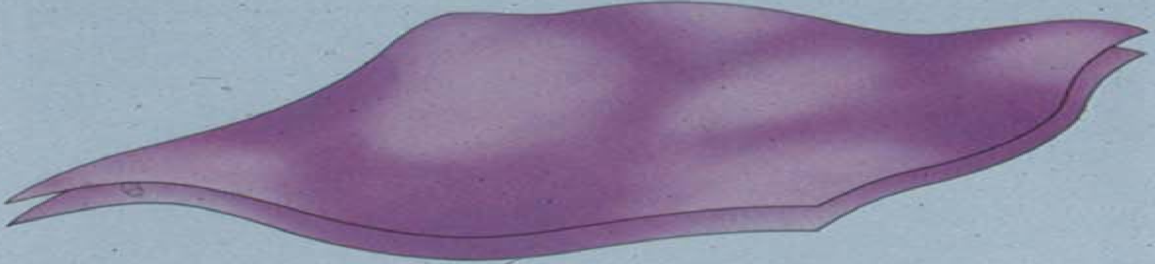
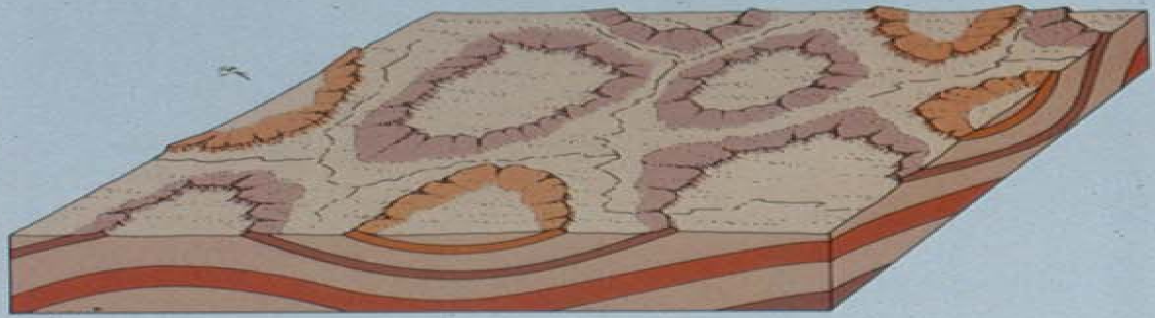



**FIGURE 8.3**
**A sequence of inclined beds** striking south (toward the background) and dipping 40 degrees to the east is shown in this photograph of the San Rafael Swell, in Utah. The diagram shows the configuration of the flexure and the upper beds, which have been removed by erosion.

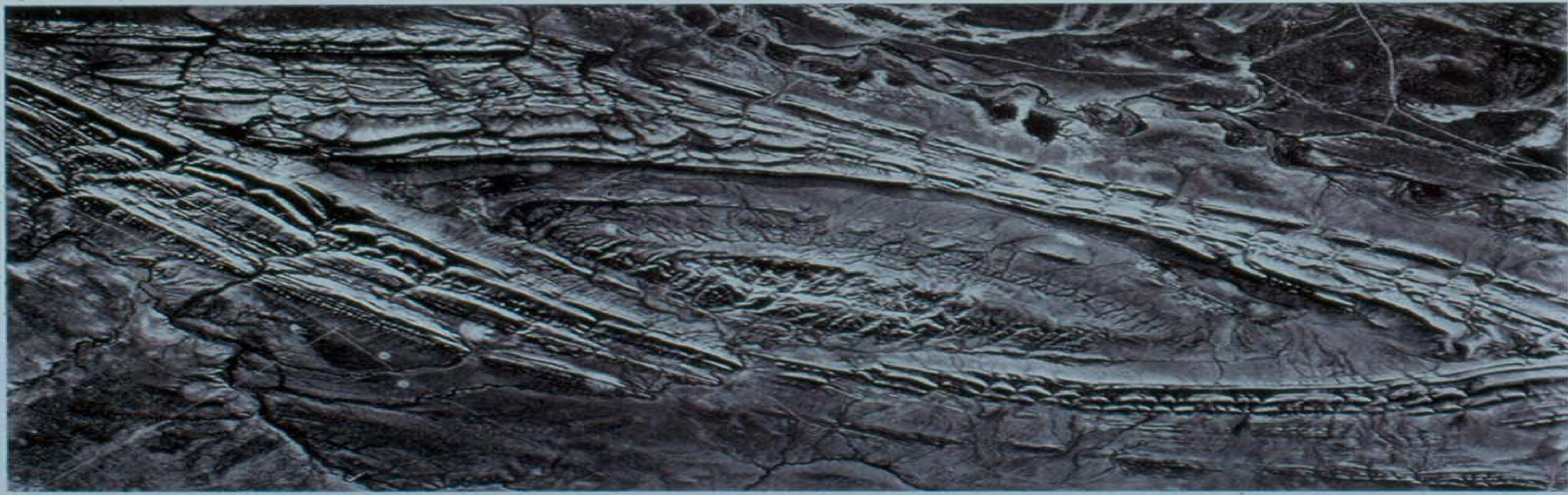
## Domos y cuencas



(A) A single gently folded bed is warped in a configuration of broad domes and basins.

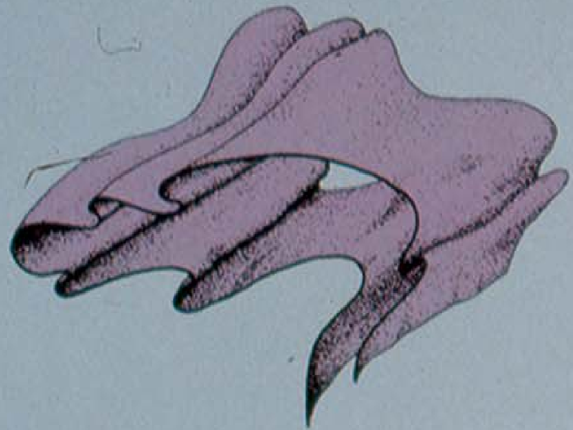


(B) As erosion proceeds, the tops of the domes are eroded first. The outcrop pattern of eroded domes and basins typically is circular or elliptical.

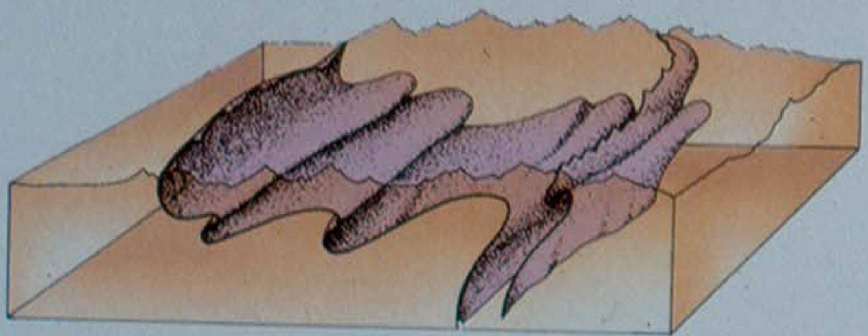


(C) The surface expression of a structural dome in western Wyoming was photographed from an altitude of approximately 6 km. The resistant layers of the structure form ridges, and the nonresistant layers are eroded into elongate valleys. Note that the oldest rocks are at the center of the structure.

**FIGURE 8.6**
**The geometry and topographic expression of domes and basins** involve broad upwarps and downwarps of layered rocks. When eroded, the exposed rock forms circular or elliptical outcrop patterns.



(A) Rocks that have been intensely deformed commonly consist of large overturned folds, with minor folds on the limbs.



(B) The surface outcrop of the same fold, after erosion has removed the upper surface, shows great complexity, so that its details are difficult to recognize.

(C) The topographic expression of complex folds can be a series of linear mountain ridges.

**FIGURE 8.8**
**Complex folds** produce complex outcrop patterns.

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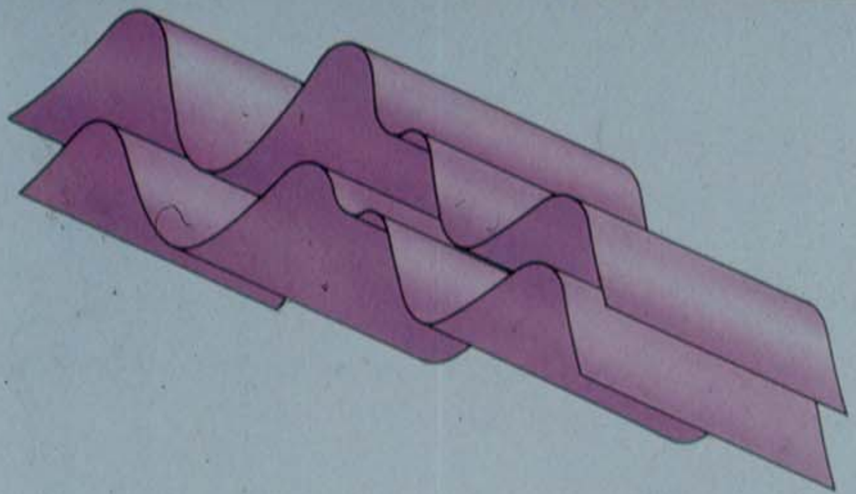
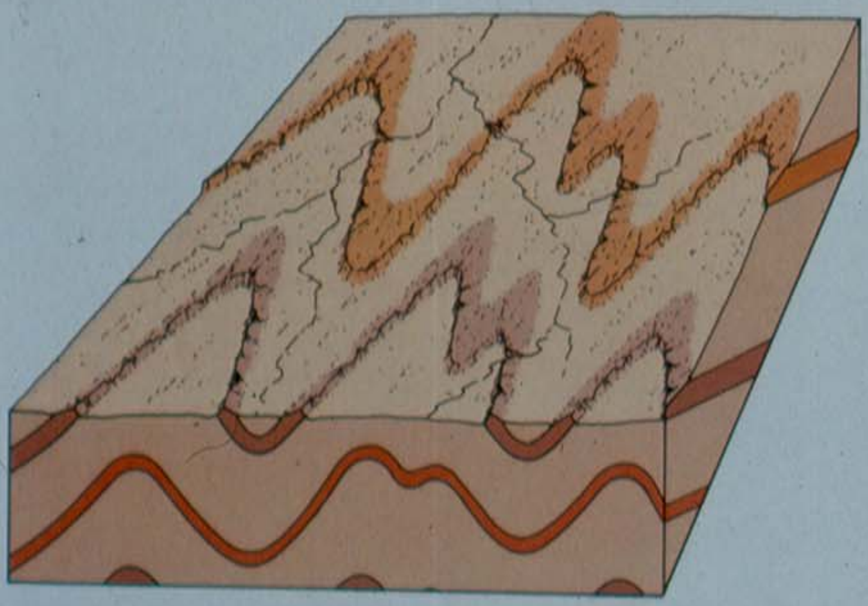
# Pliegues buzantes



(A) The basic form of folded strata is similar to that of a wrinkled rug. In this diagram, the strata are compressed and plunge toward the background.



(B) If the tops of the folded strata are eroded away, a map of the individual layers shows a zigzag pattern at the surface. Rock units that are resistant to erosion form ridges, and nonresistant layers are eroded into linear valleys. In a plunging anticline, like the one shown here, the surface map pattern of the beds forms a V pointing in the direction of plunge.

**FIGURE 8.7**
**A series of plunging folds** forms a zigzag outcrop pattern.

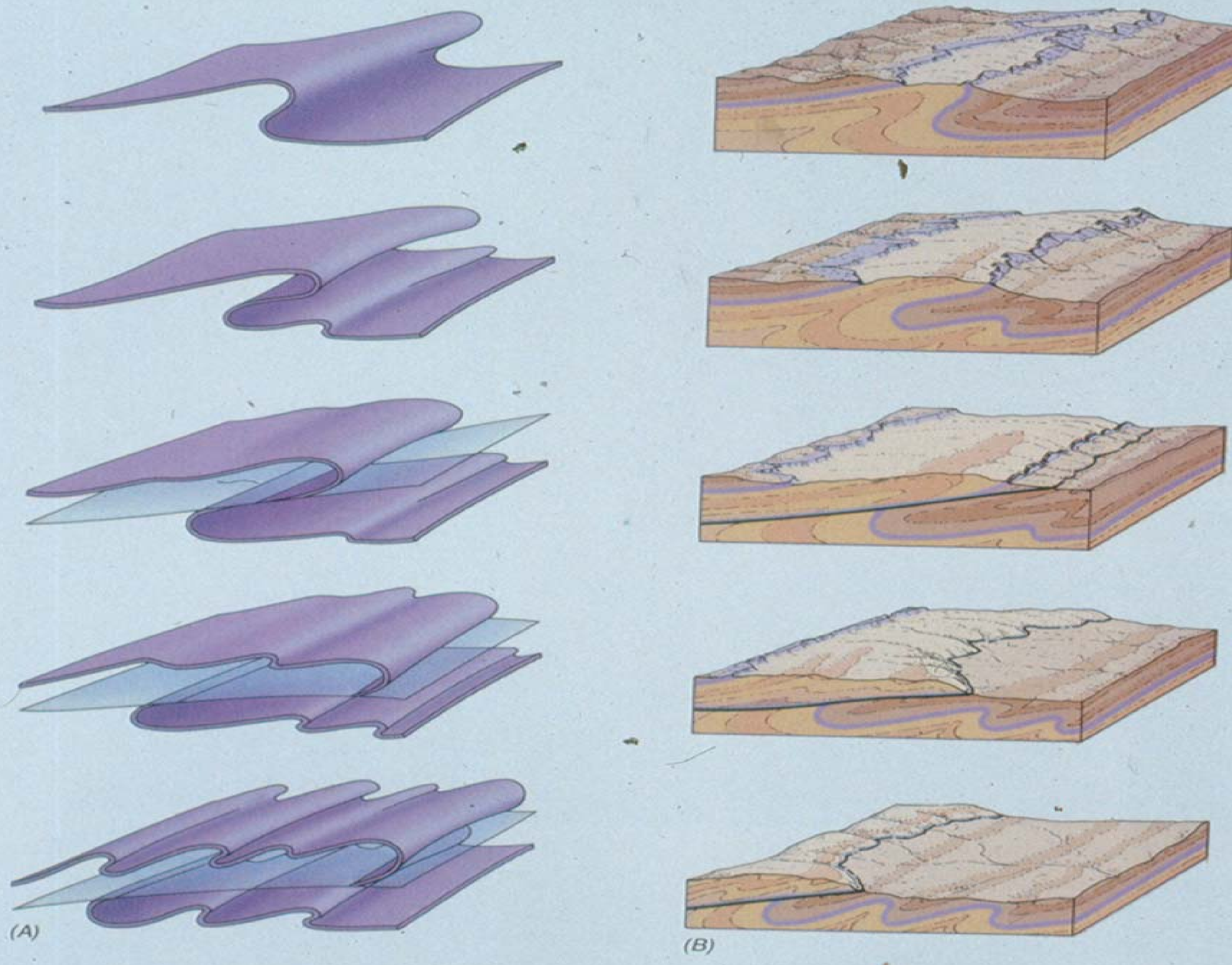



**FIGURE 8.12**
**The evolution of thrust faults from folds** is depicted in this sequence of diagrams. Diagram A shows the fault plane and the progressive development of folds into a thrust fault. Diagram B shows how the structure might be expressed at the surface as a result of contemporaneous erosion.

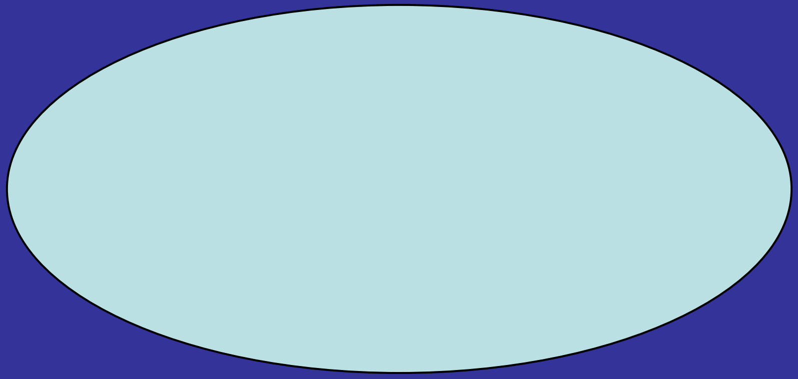
# FRACTURAS

(esfuerzo compresivo, extensivo y de cizalle)

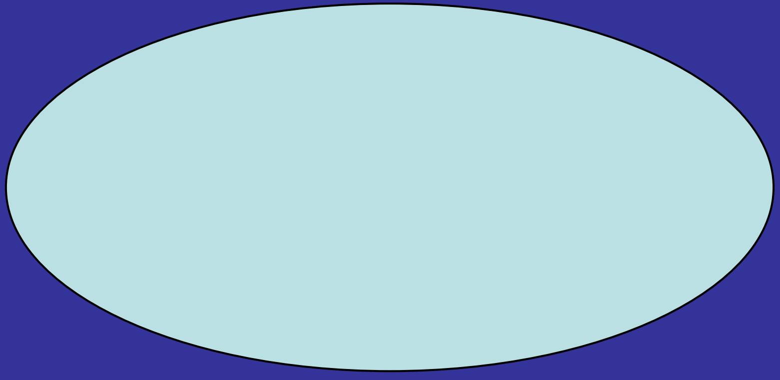
FALLA **:** FALLA NORMAL, FALLA INVERSA O DE EMPUJE, FALLA DE RUMBO O TRANSCURRENTE (SINESTRAL Y DEXTRAL); DIACLASA.

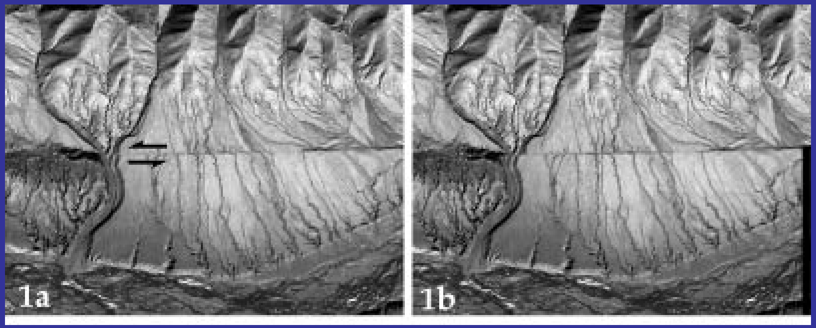
Elementos de una falla: ***plano de falla, traza de falla, desplazamiento de falla, estrías de falla, brecha de falla, escarpe de falla, facetas triangulares.***

## ELIPSOIDE DE ESFUERZO

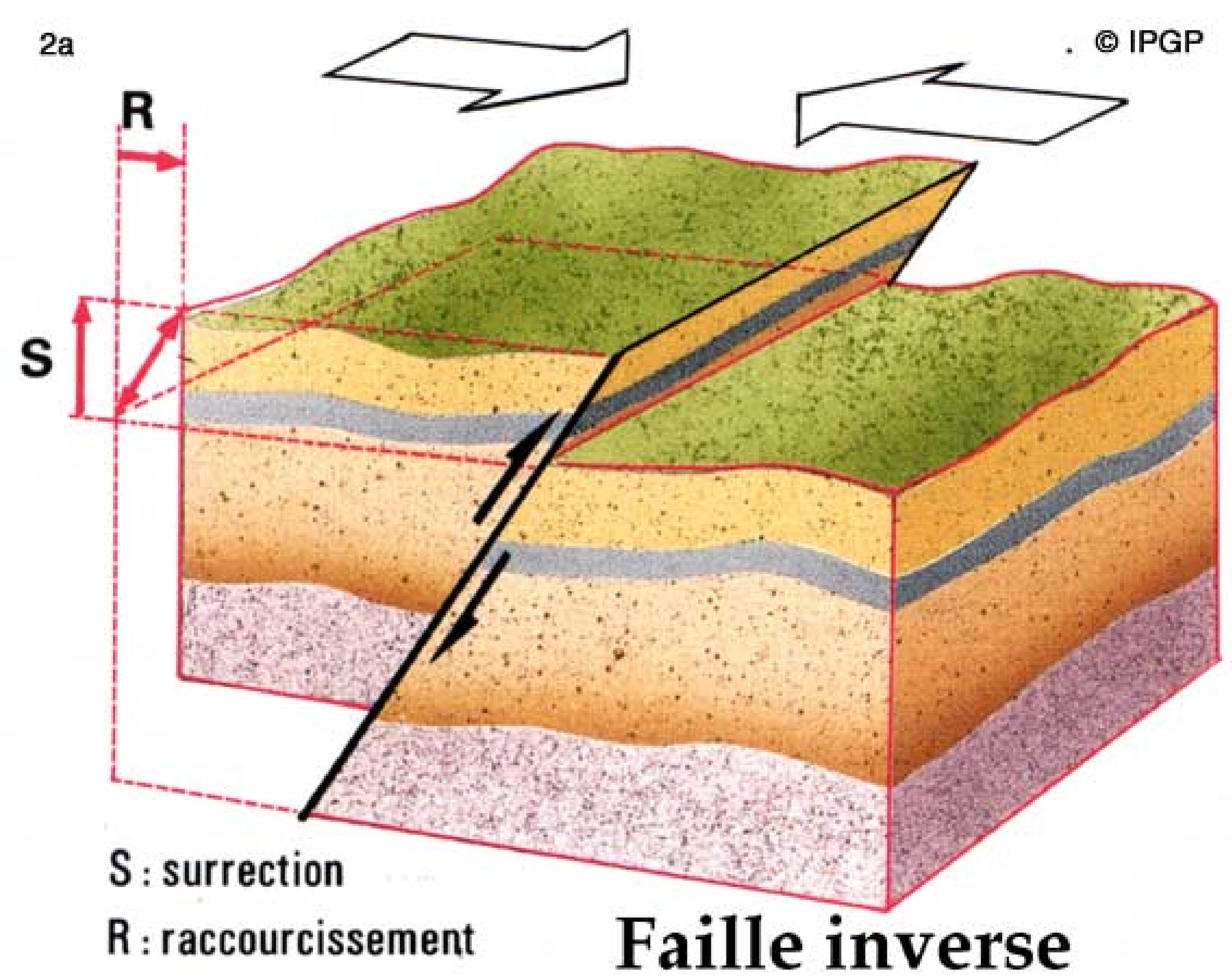


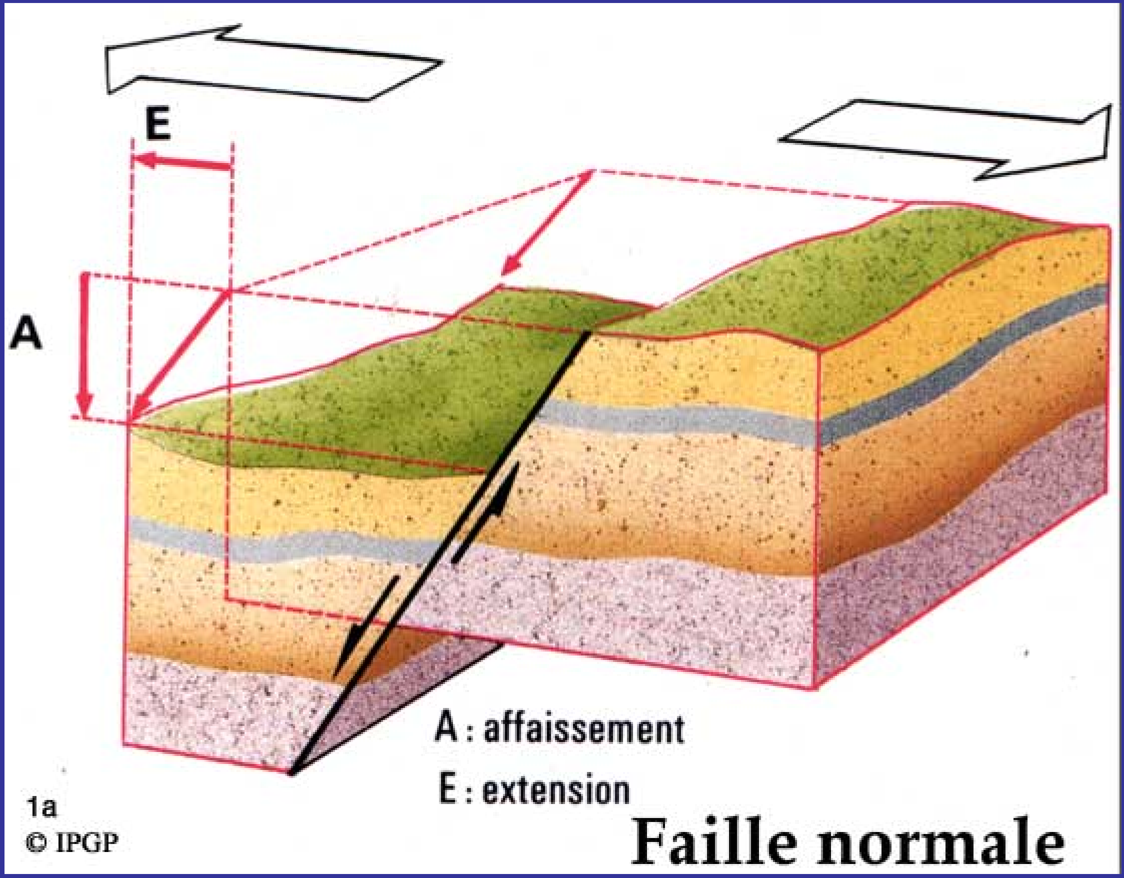
## ELIPSOIDE DE DEFORMACIÓN




1a
1b

# Falla Inversa

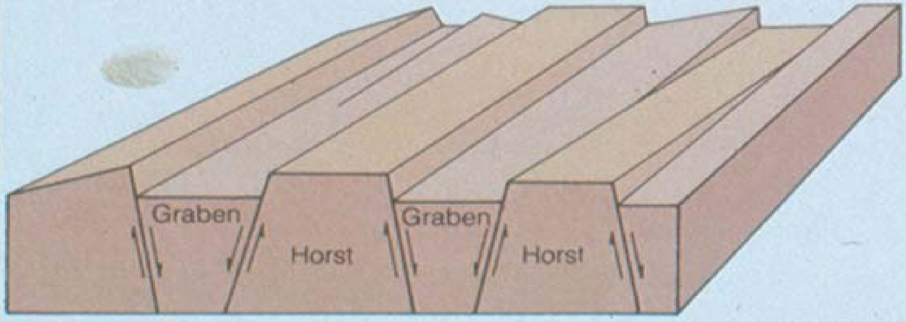



E
A
A : affaissement
E : extension
1a
© IPGP
Faille normale

# Falla Normal

# Escarpe de falla

# Facetas triangulares




# Horst y graben

**FIGURE 8.11**
**Horsts and grabens** in Canyonlands National Park, Utah, are clearly expressed at the surface. Grabens (downdropped blocks) form elongate valleys, which are partly covered with a smooth flat veneer of sediment. Horsts (upraised blocks) form elongate ridges. Relative movement along the major faults is shown in the idealized diagram.

# Falla Normal

## Se producen en condiciones de extensión

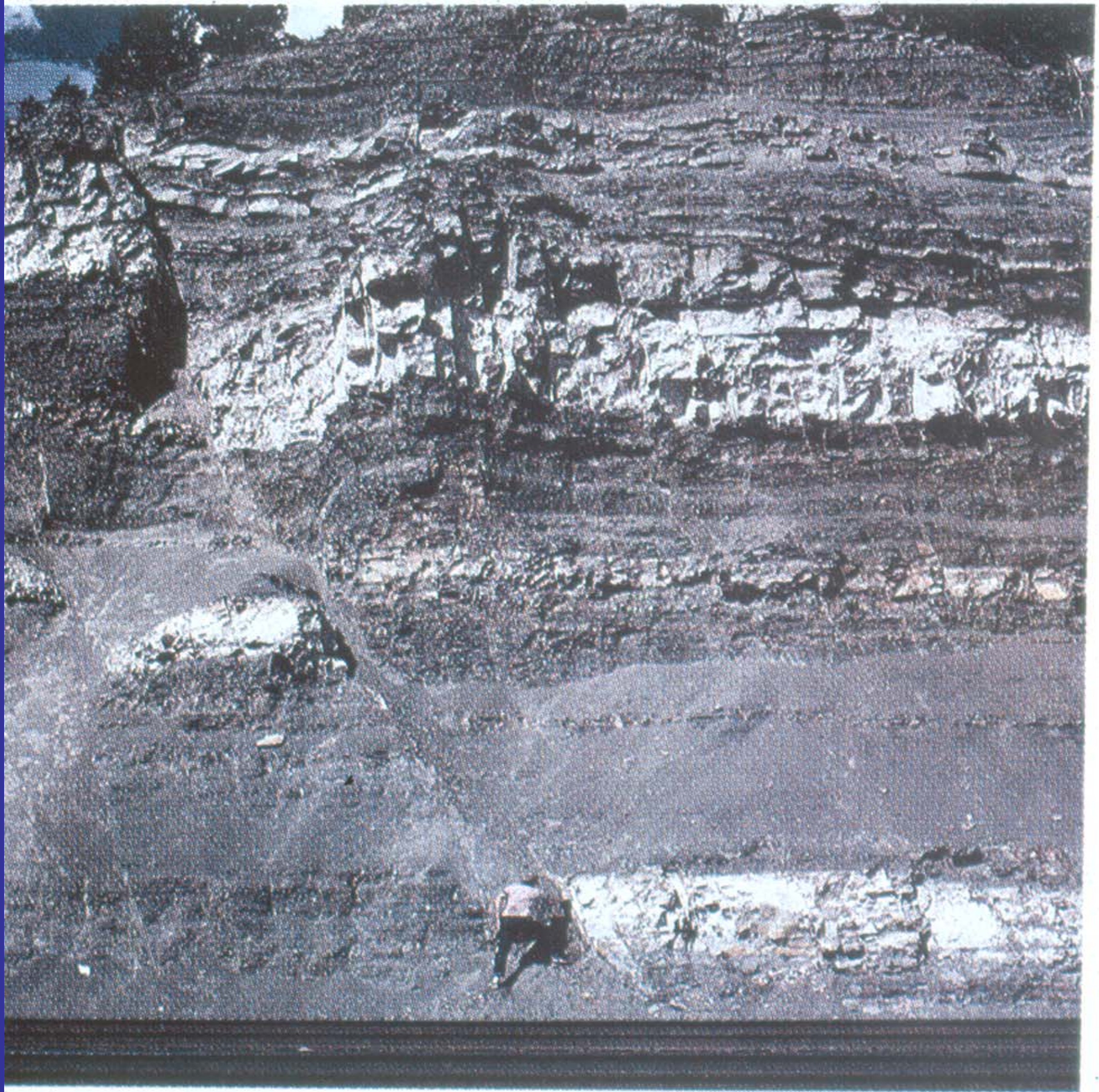
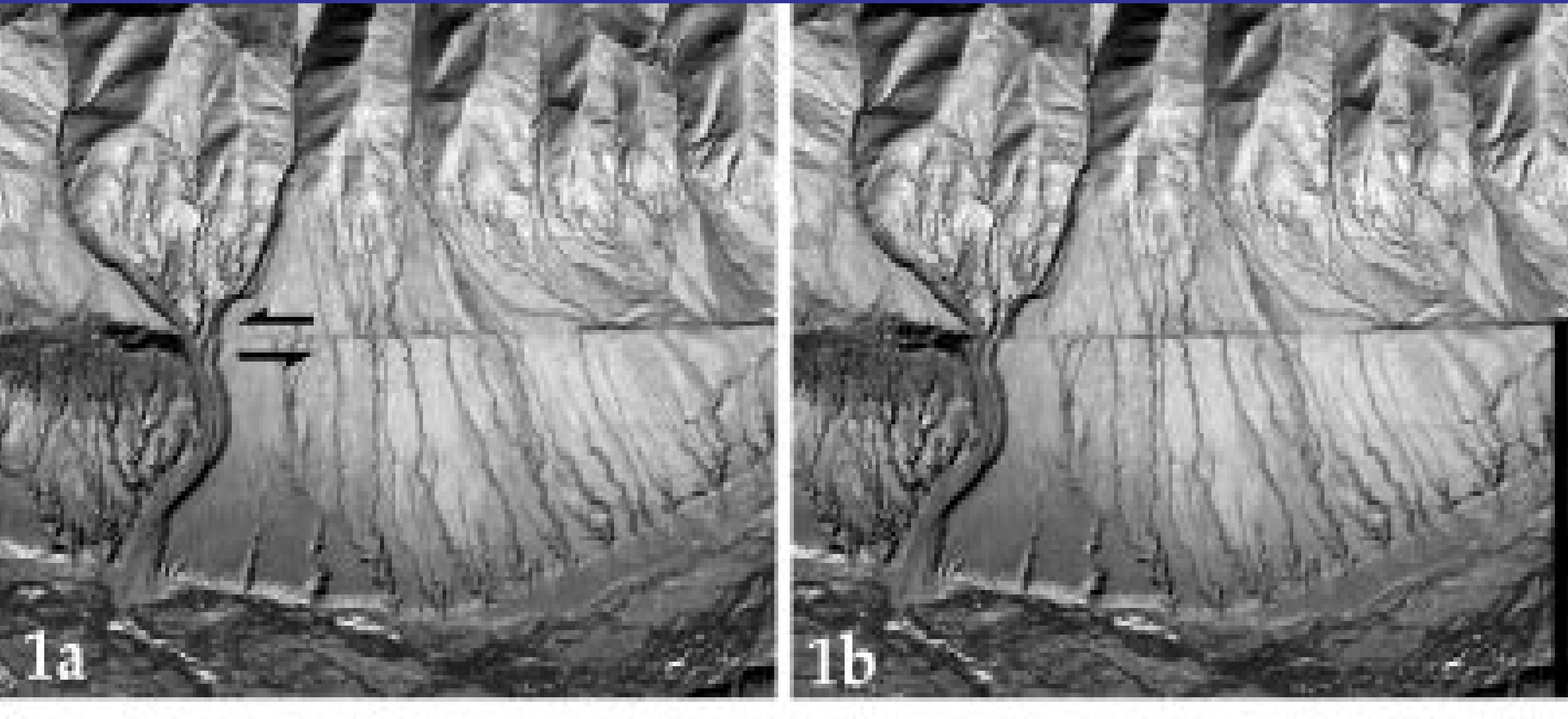
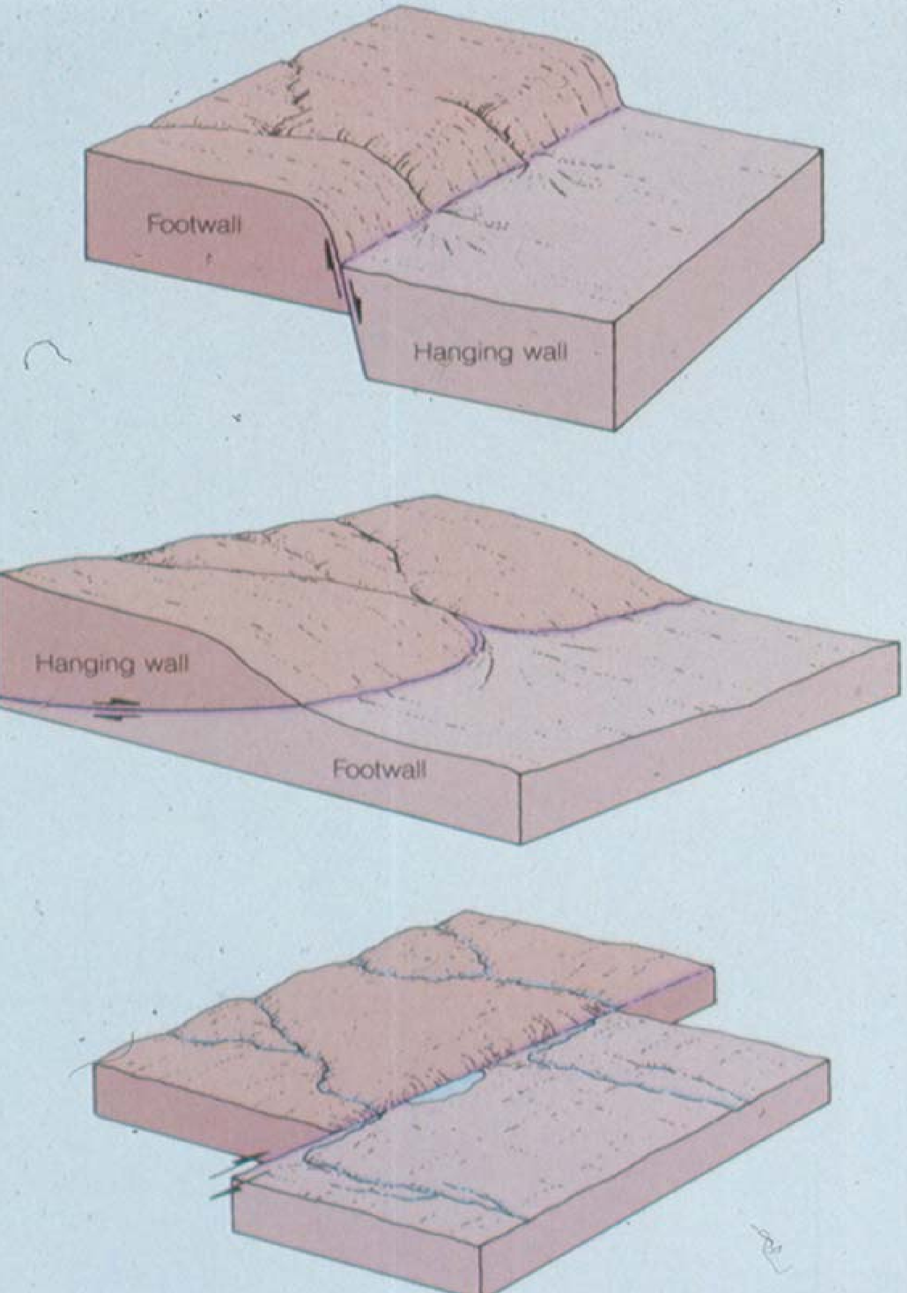


**FIGURE 8.9**
**The displacement of beds in a fault** is often well-expressed on the side of a valley. Here the displacement of the beds can be seen

# Falla de Rumbo




3b
© K. Sieh
CALTECH




## Falla normal

*(A) In normal faults, the hanging wall moves downward in relation to t footwall.*

## Falla inversa o cabalgamiento

*(B) In thrust faults, the hanging wall moves upward in relation to t footwall.*

## Falla de rumbo

*(C) In strike-slip faults, the displacement is horizontal.*

**FIGURE 8.10**
**The three major types of faults** are distinguished by the direction of their relative displacement.

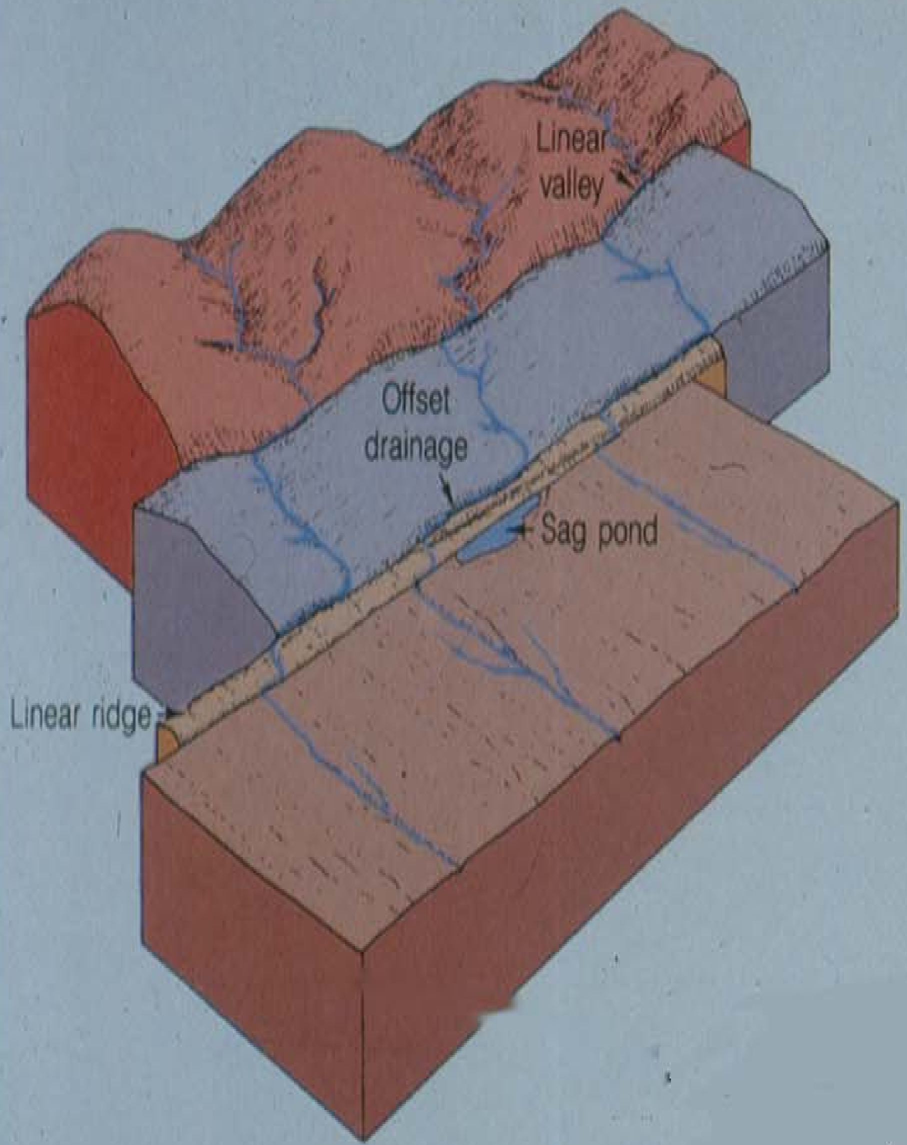



**FIGURE 8.14**

**Strike-slip faults** produce distinctive landforms. Streams are offset by recurrent movement, linear ridges and valleys form, and local sag ponds develop along the fault line.

# Formas asociadas a las fallas de rumbo

(A) In this photograph several generations of dikes cut across the green metamorphic rock. The thick dike is the youngest because it cuts across all the other rock bodies. The green metamorphic rock is older than all of the dikes. Can you determine the relative age of all the dikes?

(B) In this photograph an alluvial fan in Death Valley, California, is cut by several faults expressed as low cliffs close to the mountain front. The fault scarps are obviously younger than the part of the fan they cut, indicating a tectonic event after deposition.

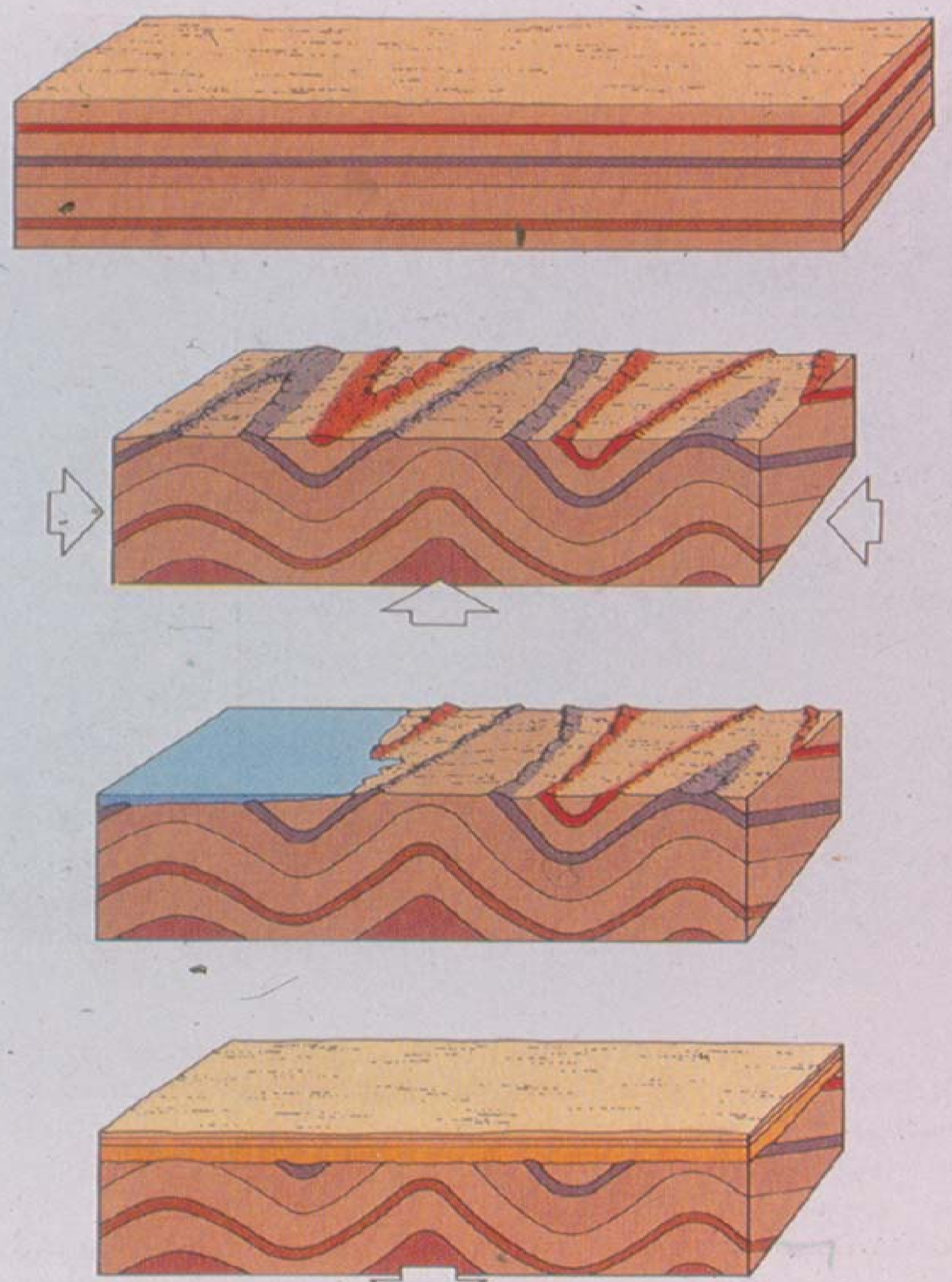
# DISCORDANCIA
# (superficie de tiempo)

- DISCORDANCIA DE EROSIÓN:

- DISCORDANCIA ANGULAR:

**Figure 8.1** **Angular unconformity** at Siccar Point, southeastern Scotland. It was here that the historical significance of an unconformity was first realized by James Hutton in 1788. Note that the older "primary" rocks are nearly vertical and that the younger "secondary" strata were deposited on the eroded surface formed on the older rocks.

**Discordancia angular**



(A) Sedimentation: a sequence of rocks is deposited over time.

(B) Deformation: the sequence of rocks is deformed by mountain-building processes or by broad upwarps in Earth's crust, followed by erosion.

(C) Subsidence and renewed sedimentation.

(D) A new sequence of rocks is deposited on the eroded surface of the older deformed rocks.

**Figure 8.2 The geologic events implied from an angular unconformity** represent a sequence of major events in the geologic