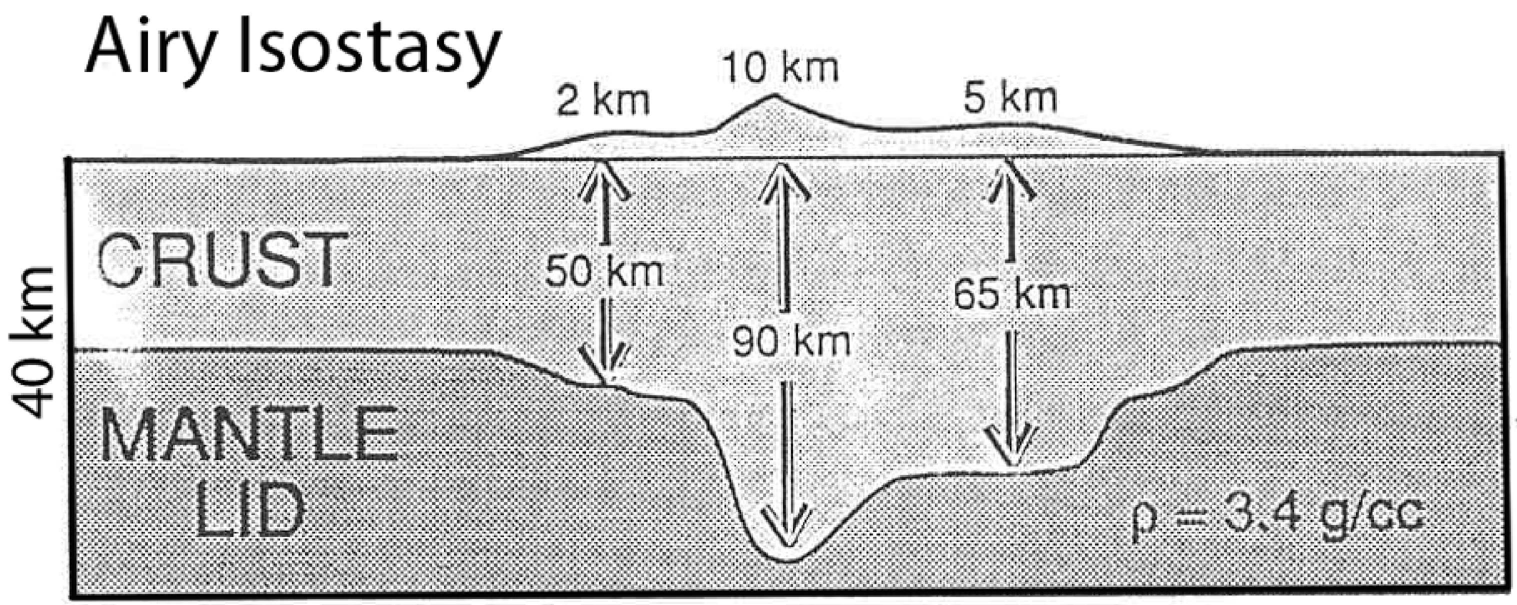
Basin Analysis

Stratigraphy

Basin Analysis

- Basin analysis integrates program sedimentological, stratigraphic, and tectonic principals to develop a full understanding of the rocks that fill sedimentary basins.
- A sedimentary basin is an area in which sediments have accumulated during a time span to significantly greater thickness than in the surrounding areas.
- *What are mechanisms that can generate sufficient subsidence?*

- Isostatic compensation because of sedimentary and volcanic loading.
- This concept of isostasy assumes that local compensation of the crust occurs as if Earth consists of a series of free-floating pistons.



Filling a basin with sediment causes subsidence; removing a load (erosion of the crust) causes uplift.

Mechanisms of basin formations (subsidence)

- Crustal thinning - extensional stretching
- Mantle-lithospheric thickening
- Sedimentary and volcanic loading
- Tectonic loading
- Subcrustal loading – lithospheric flexure during underthrusting of dense lithosphere

Sedimentary Basins

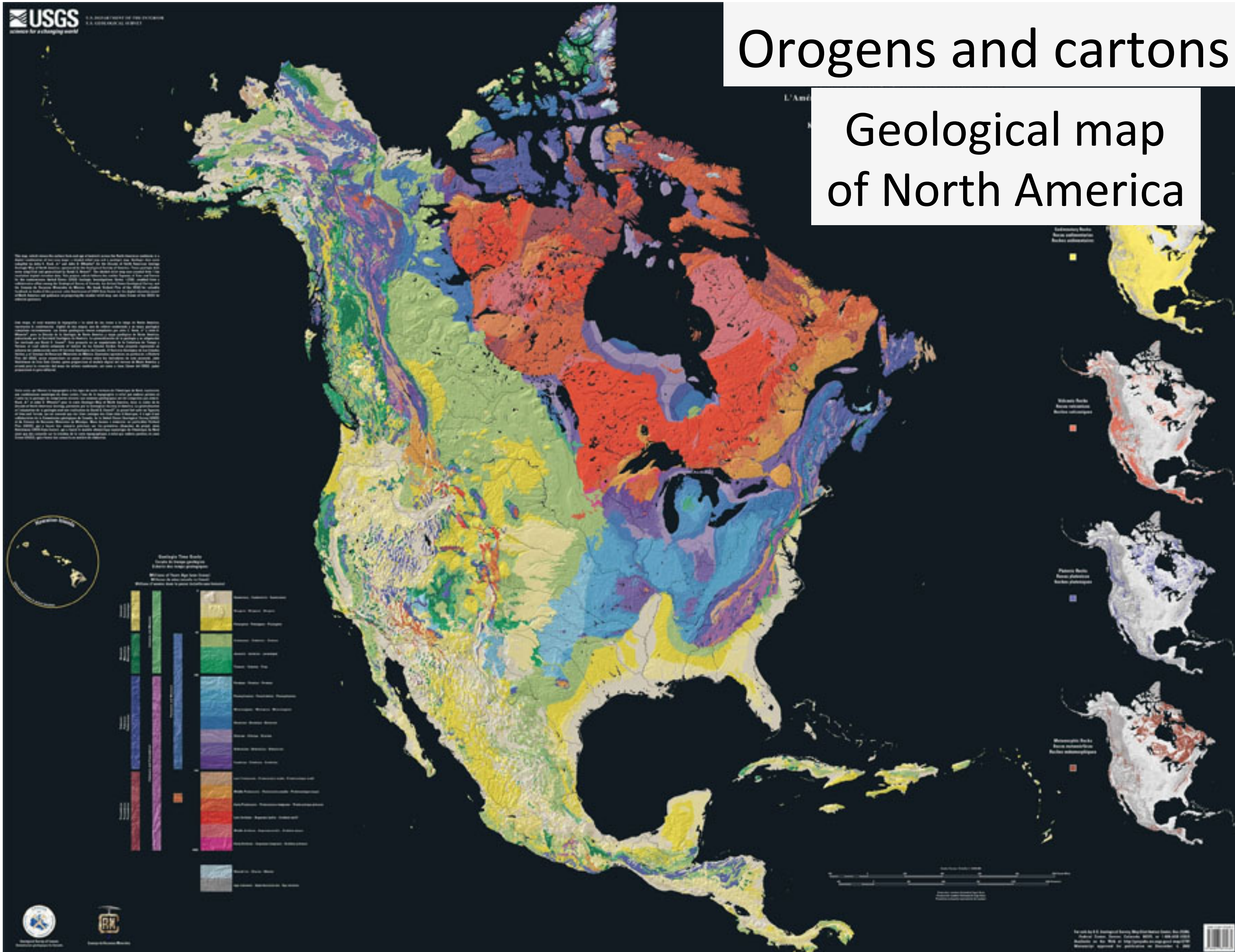
- Basin formation and evolution can be explained by the Theory of Plate Tectonics, and accordingly sedimentary basins can be classified based on this theory, and more specifically according to their location on the three types of plate boundaries:
- Convergent
- Divergent
- Transform

Classification of Sedimentary Basins

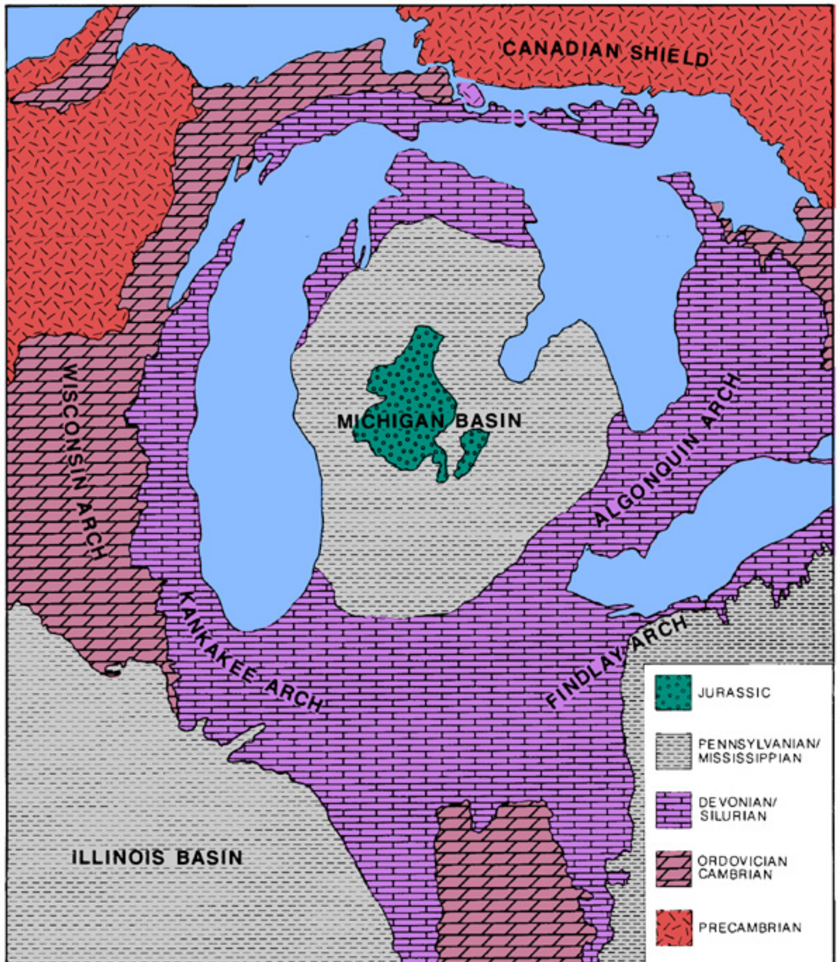
- **A. Basins unrelated to plate boundaries:** Cratonic and epicratonic basins
- Cratons are rather stable, continental blocks that have a basement of Precambrian rocks. They make up the cores of present-day continents in both North and South Americas, Australia, Russia and Africa, where there are several cratons separated by more mobile belts. Within them *intracratonic basins* may develop because of very slow subsidence.
- *Mechanism=Stretching and thinning of the continental lithosphere followed by cooling and thermal contraction.*

Orogens and cartons

Geological map of North America



- Intracratonic basins: Stable cratons covered with thin and laterally extensive sedimentary strata.



The Michigan Basin.

- The present outcrop pattern is essentially that at the end of the Paleozoic

Cratonic and epicratonic basins

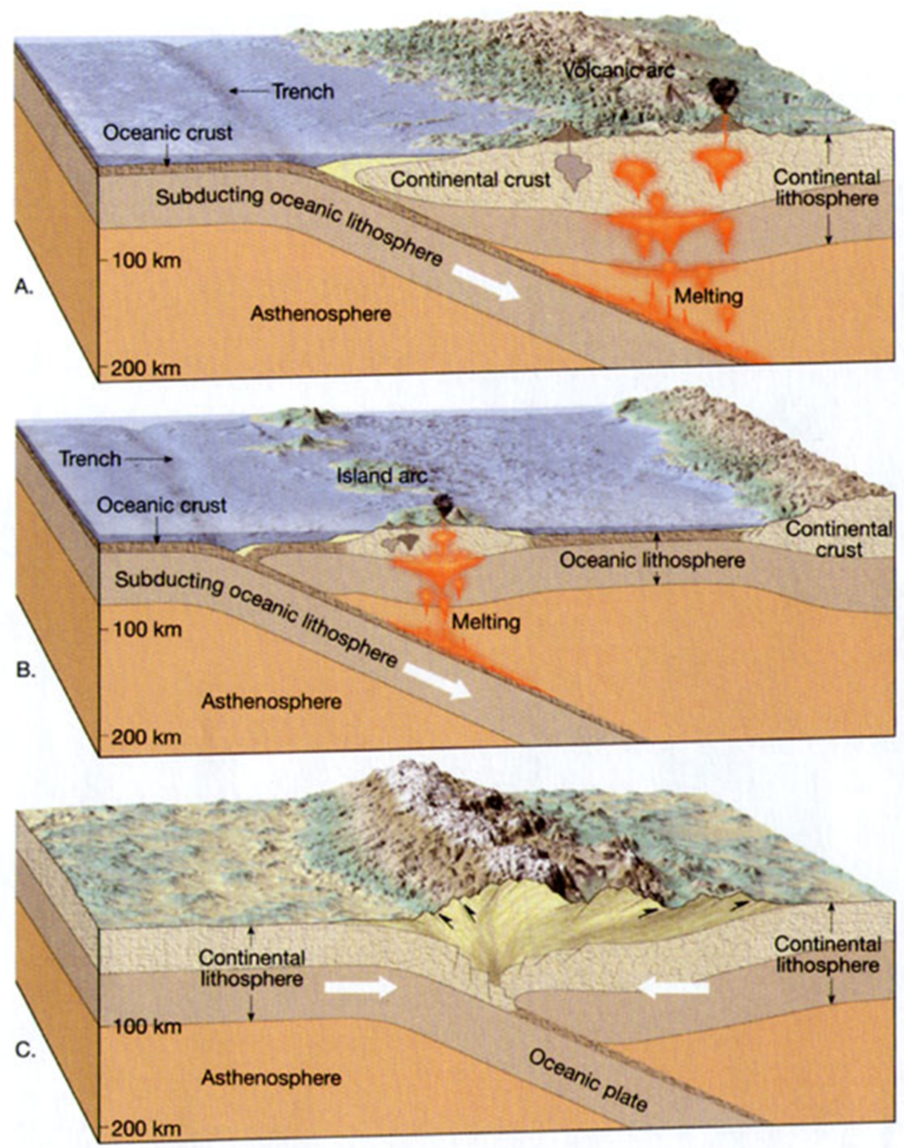
- Cratonic basins can be divided as intracratonic and epicratonic basins
- Intracratonic basins lie within the continental crust. Epicratonic basins lie on continental crust, but are partially open to an ocean basin.
- These two types often occur adjacent to one another with little fundamental difference in genesis or sediment fill!
- Both intracratonic and epicratonic basins include either siliciclastic- (shale-sandstone) or carbonate-dominated successions.

Classification of Sedimentary Basins

B. Basins related to convergent plate boundaries:

- a) Back-arc basins (e.g., Black Sea)
- b) Intra-arc basins
- c) Fore-arc basins (e.g., Trakya basin)
- d) Trenches (e.g., many trenches in the Pacific Ocean)
- e) Foreland basins

Subduction zone plate boundaries



Active continental margins

Island arcs

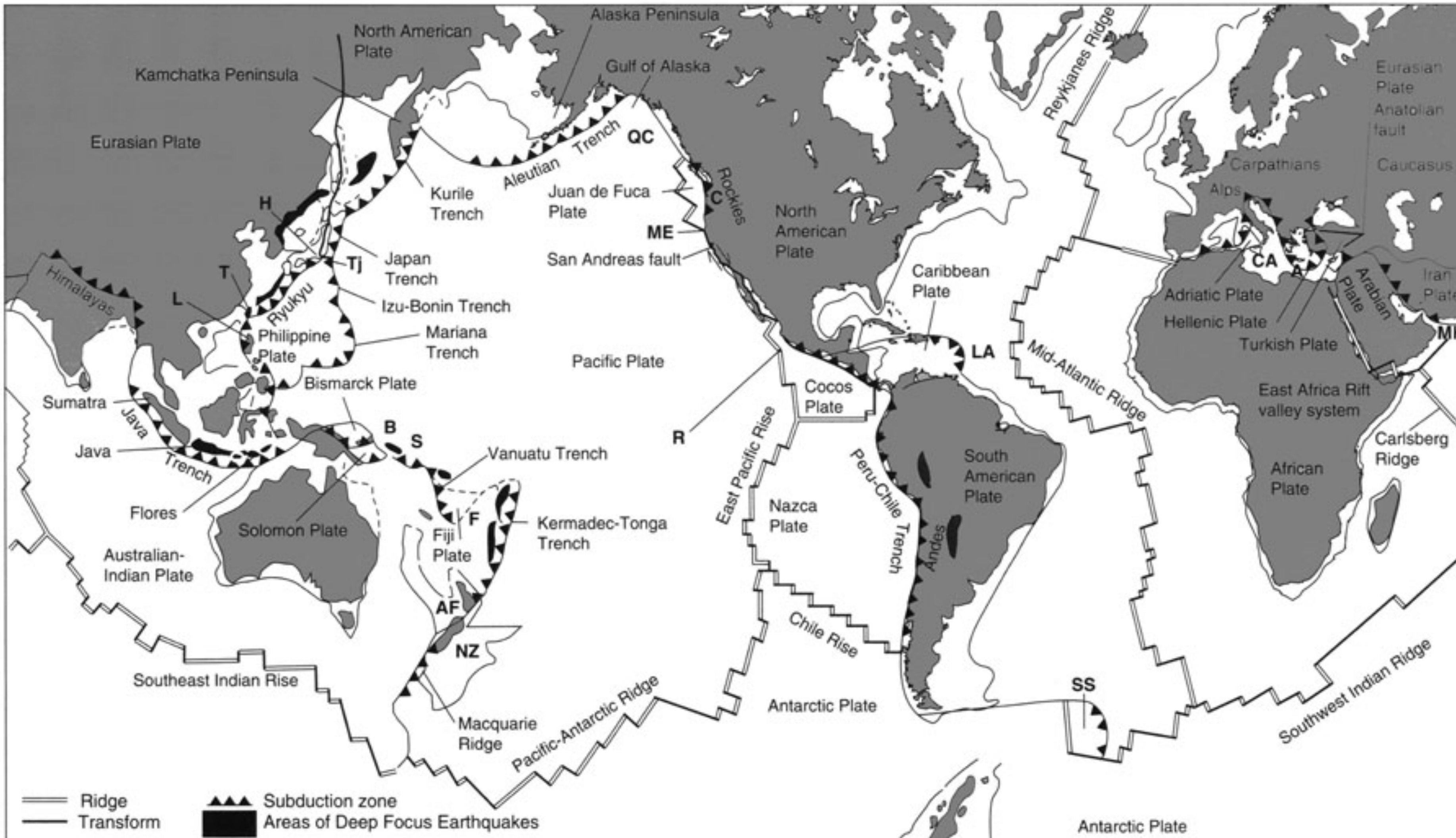
Subduction

Continental collision

Collision

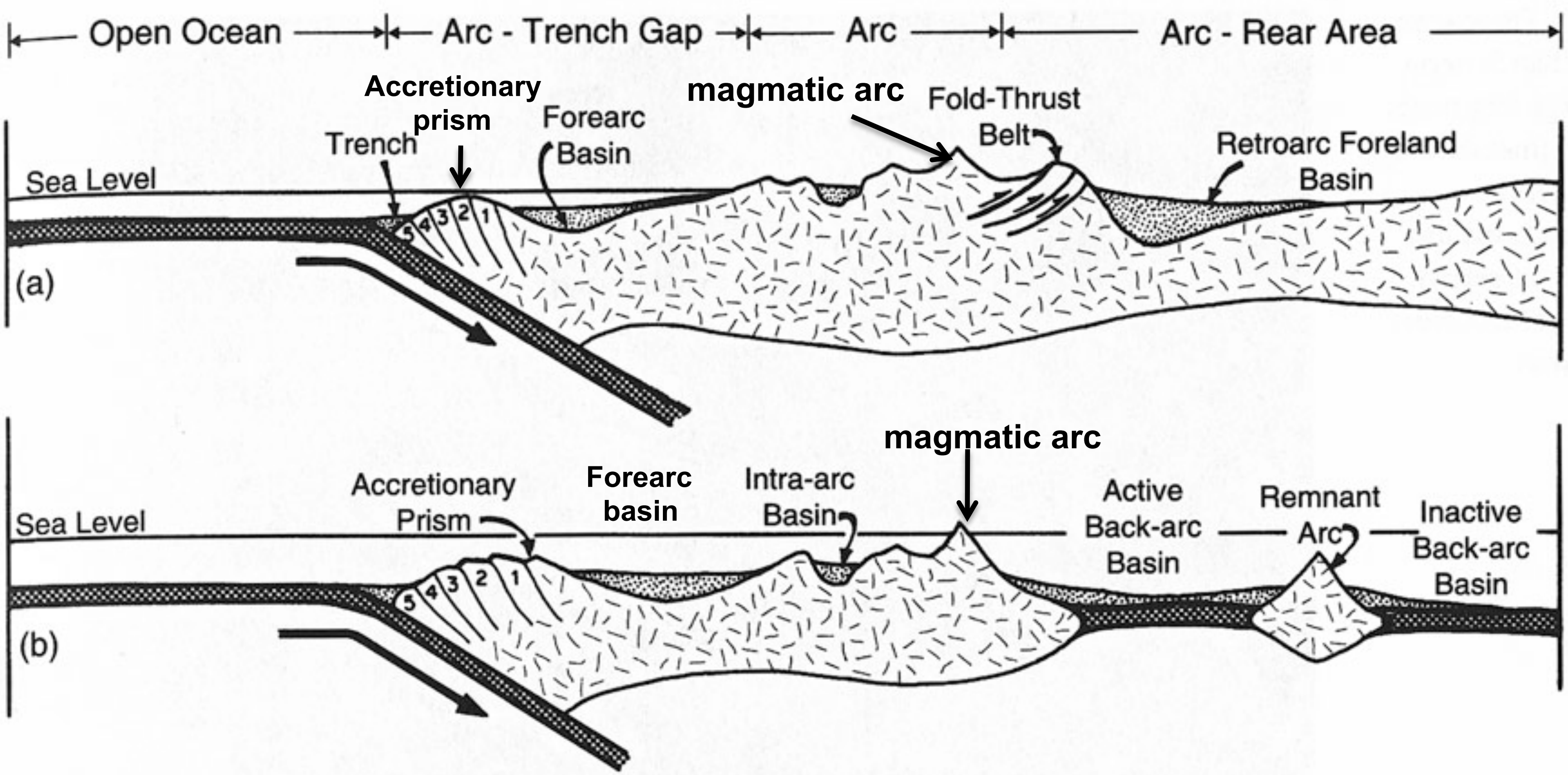
Convergent plate boundaries

Convergent plate boundaries

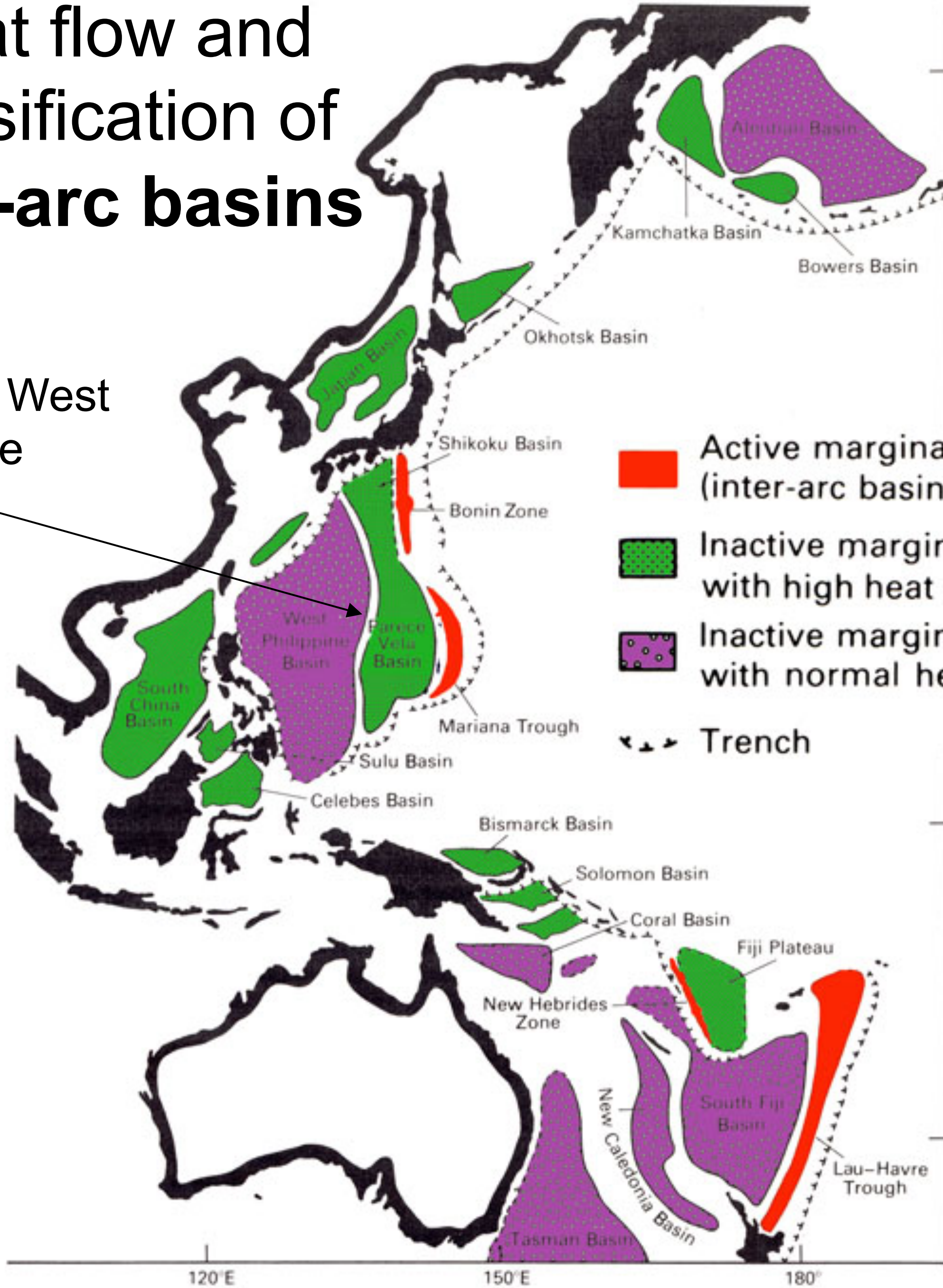


The cumulative length of convergent plate margins is ≈55,000 km

Island arcs and active continental margin



Heat flow and classification of **back-arc basins**



Trapped Aleutian Basin

Trapped West Philippine Basin

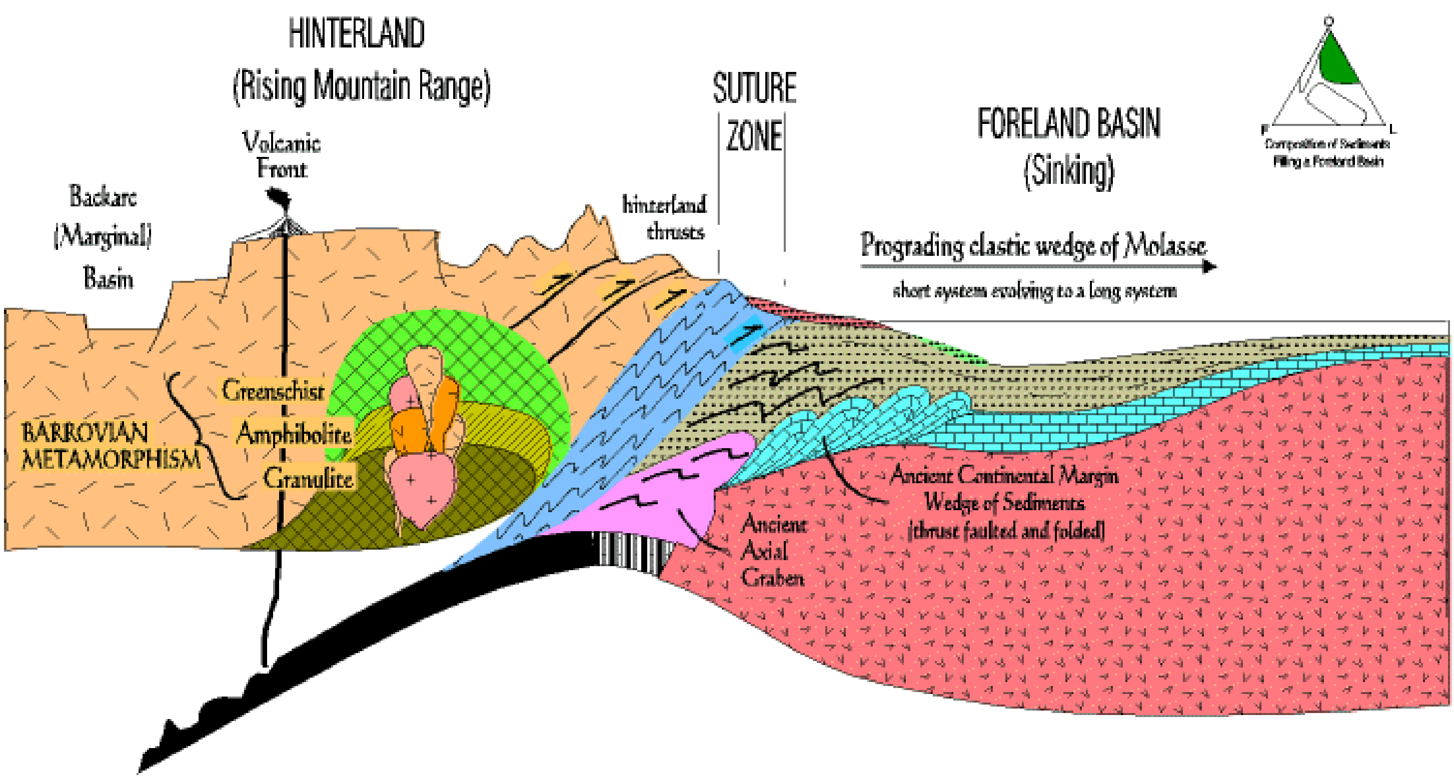
Active and inactive marginal seas are true backarc basins

Trapped basins are formed when subduction zone suddenly jumps in a new position

Convergent plate boundaries, Collisions

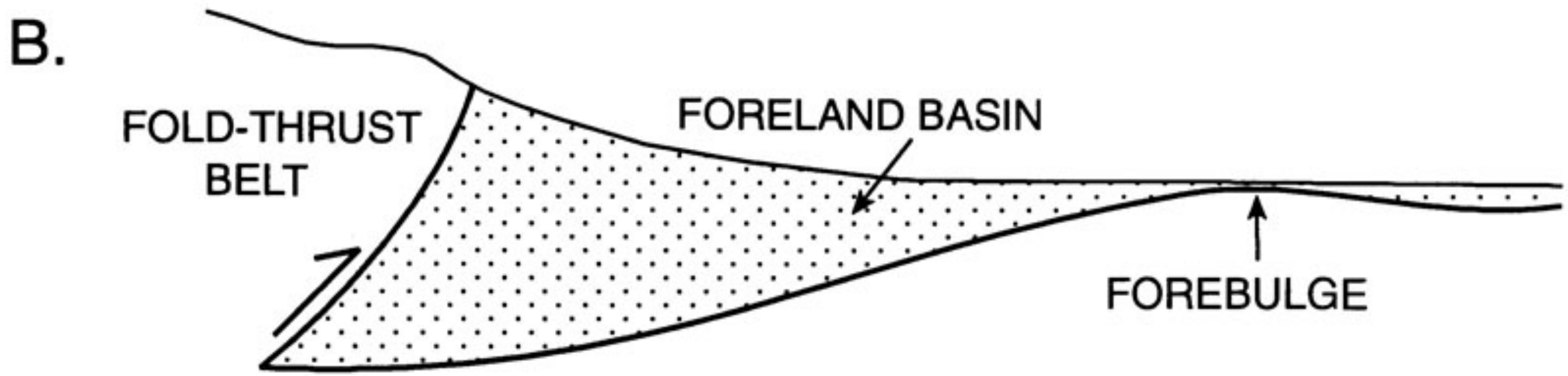
- Thickening of continental crust
- Foreland basins filled with molasse deposits
- Fold-and-thrust belts

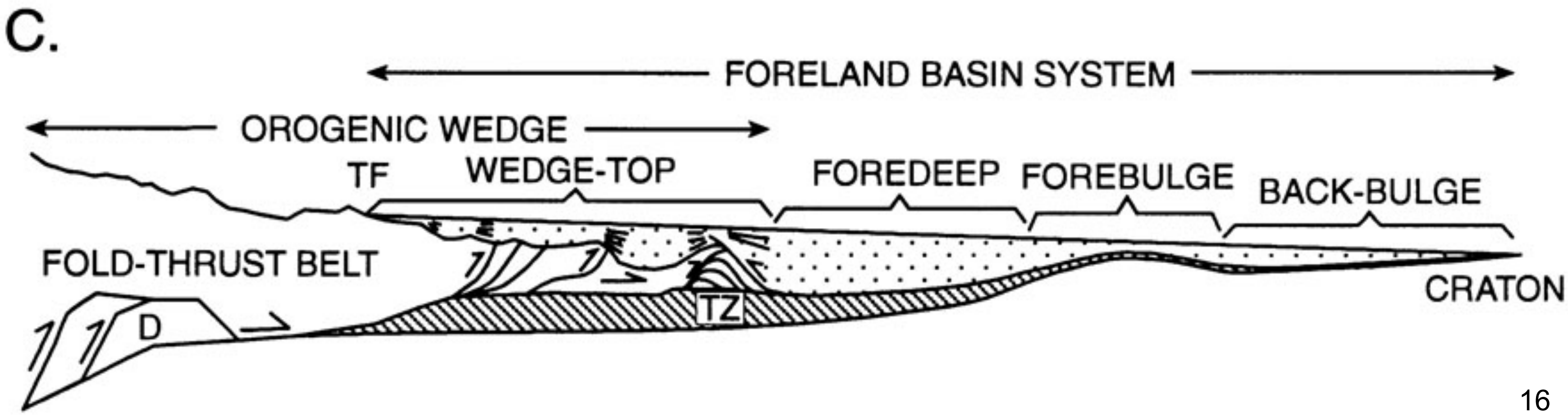
DETAILED FEATURES OF A CONTINENT-CONTINENT COLLISION OROGENY



Foreland basin

P. G. DeCelles and K. A. Giles



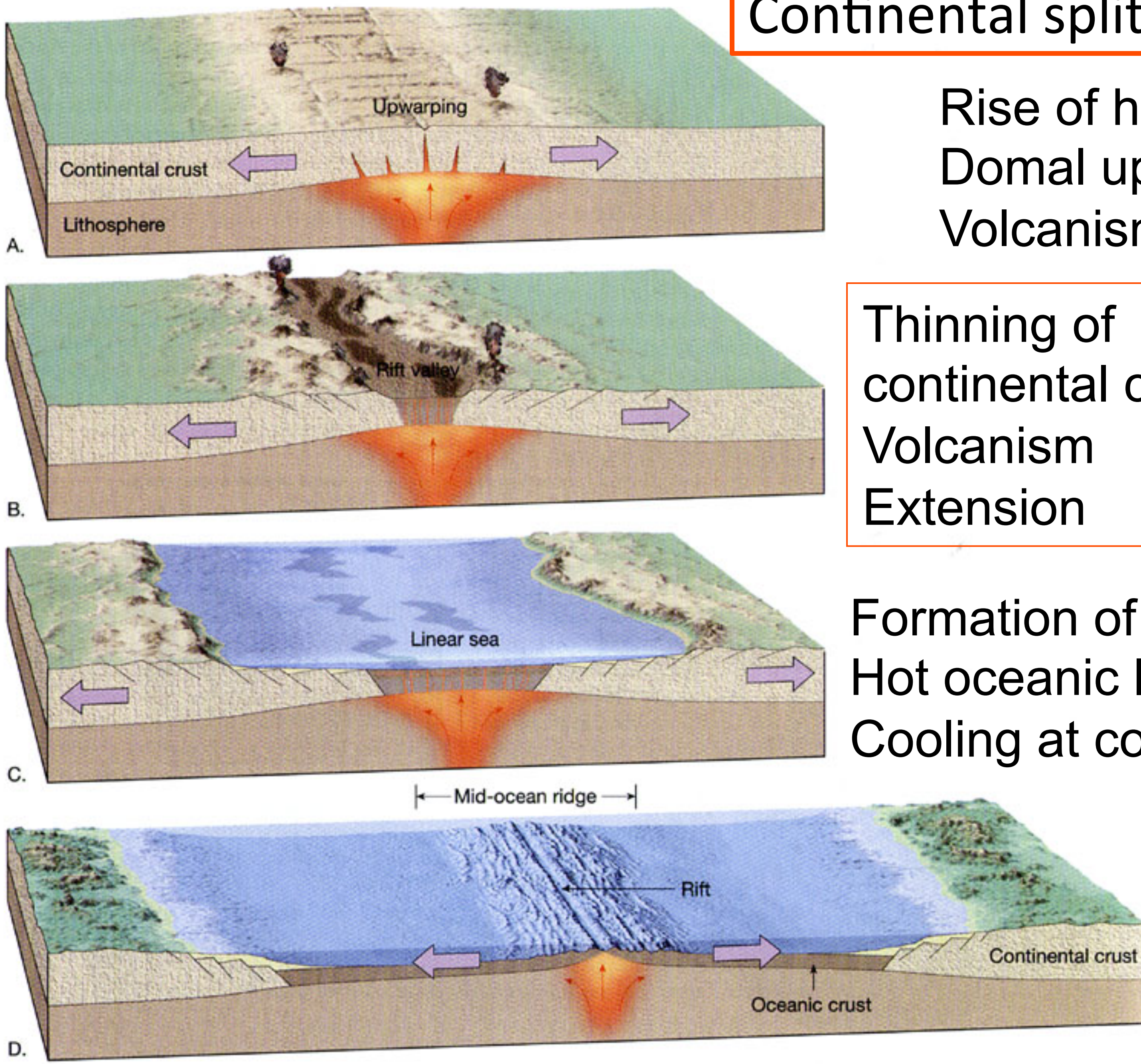


Classification of Sedimentary Basins
Divergent plate boundaries

- Continental rifts
- Failed-rift basins (aulacogens)
- Passive continental margins *(e.g. SE Turkey)*

These types of sedimentary basins are the most important types for stratigraphers and petroleum geologists

Continental splitting

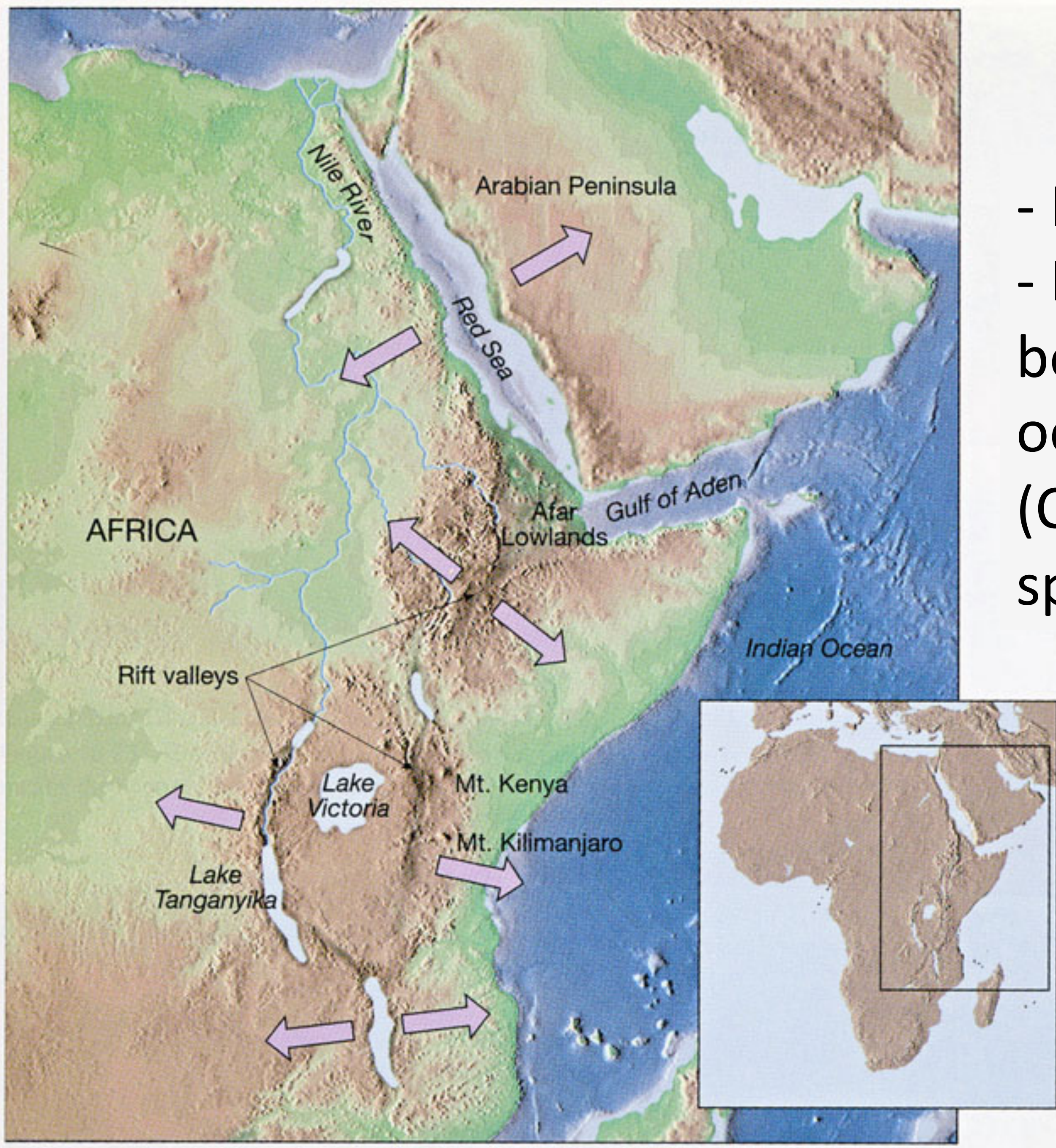


Rise of hot material
Domal uplift
Volcanism

Thinning of continental crust
Volcanism
Extension

Formation of oceanic crust
Hot oceanic lithosphere
Cooling at cont. margin

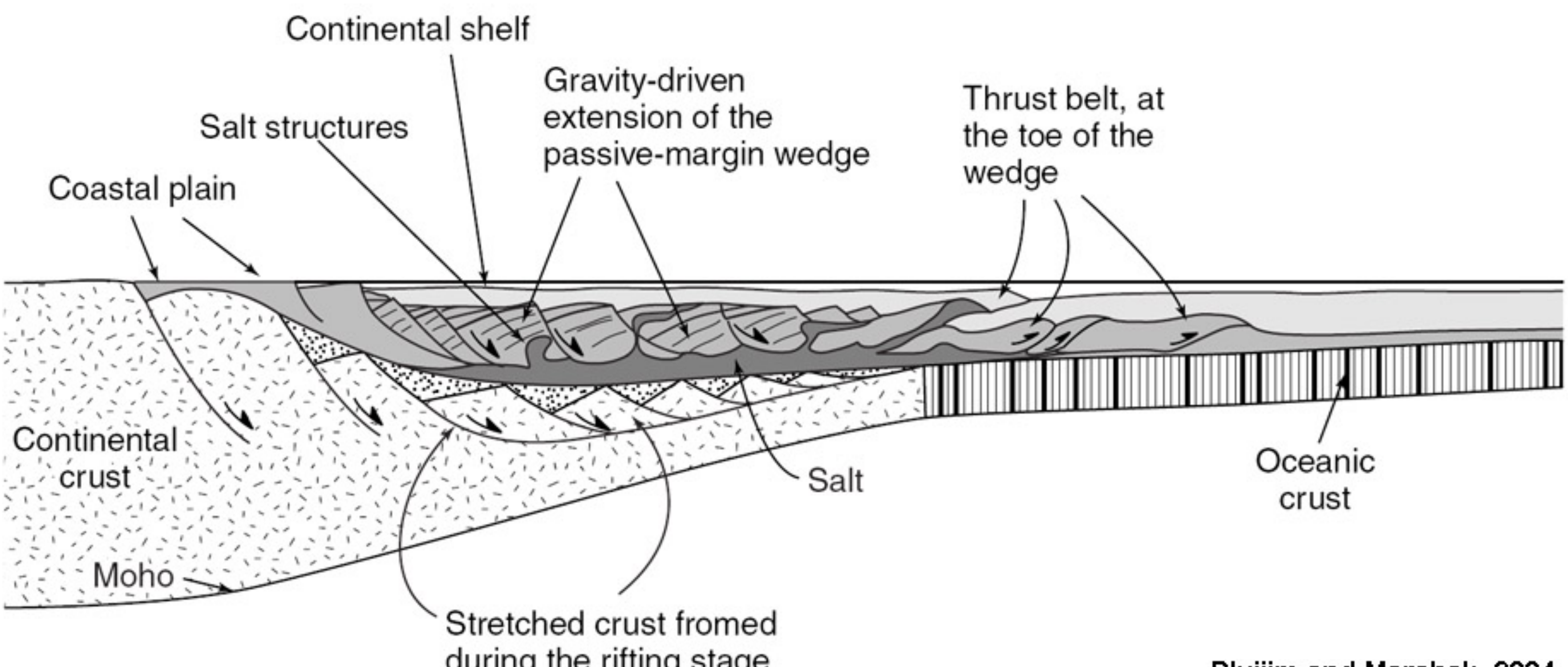
Subsidence at the margins



- Rifts in Africa
- Red Sea rift – beginning of the oceanic stage (Continental splitting)

Passive continental margins

Thinning of continental crust during splitting of a continent
Listric faults
Graben facies
Thermal subsidence of margin because of young oceanic lithosphere cooling
Shallow sea to deep-water facies changes



Pluijim and Marshak, 2004

Wilson Cycle

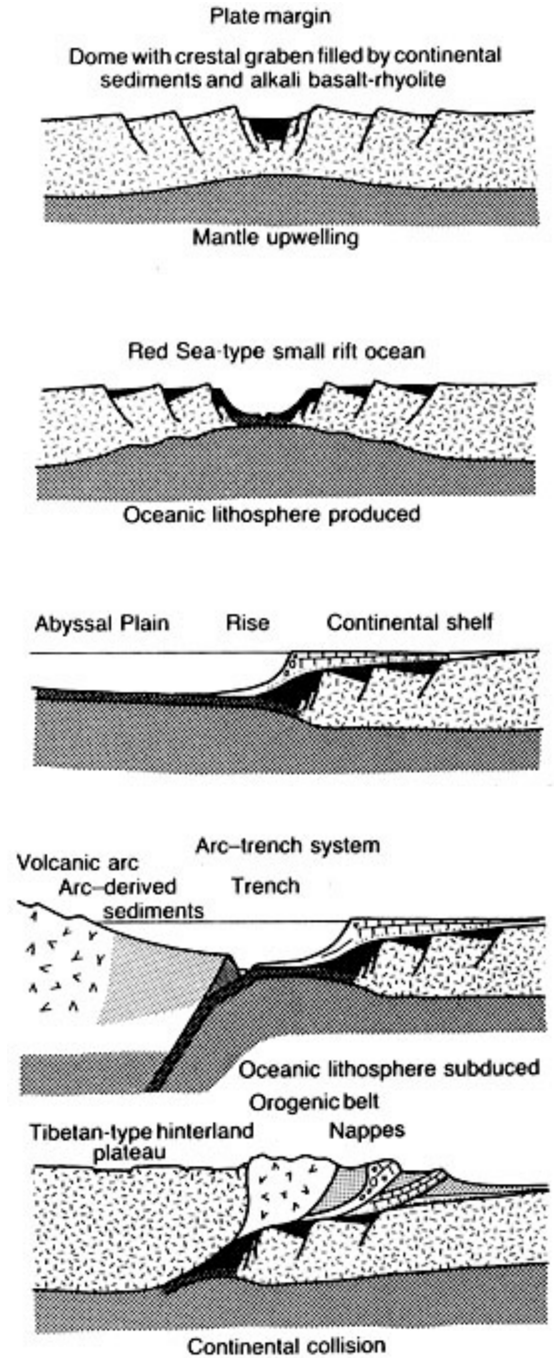
Continental rift

Continental splitting

Oceanic stage

Closure of the ocean

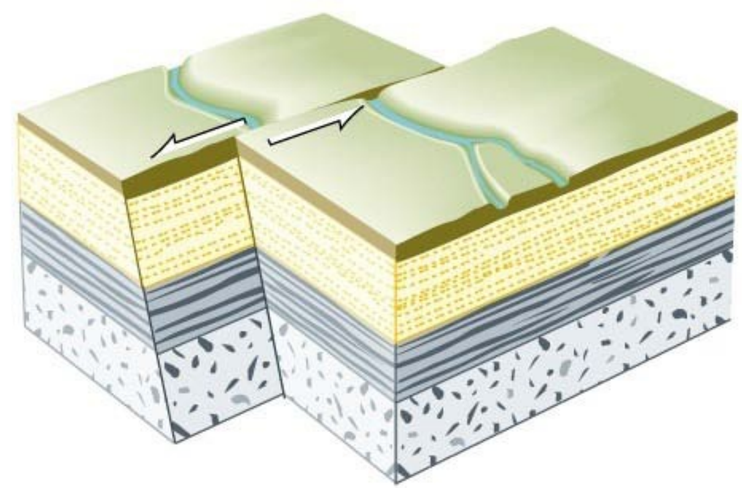
Collision of the split continents



Classification of Sedimentary Basins

D. Transform Plate Margins

- Along strike-slip faults there are transtensional and transpressional zones.
- Strike-slip basins (extensional basins)
- Fault
- Pull-apart basins
- Examples: Marmara Sea and many other basins on the North Anatolian

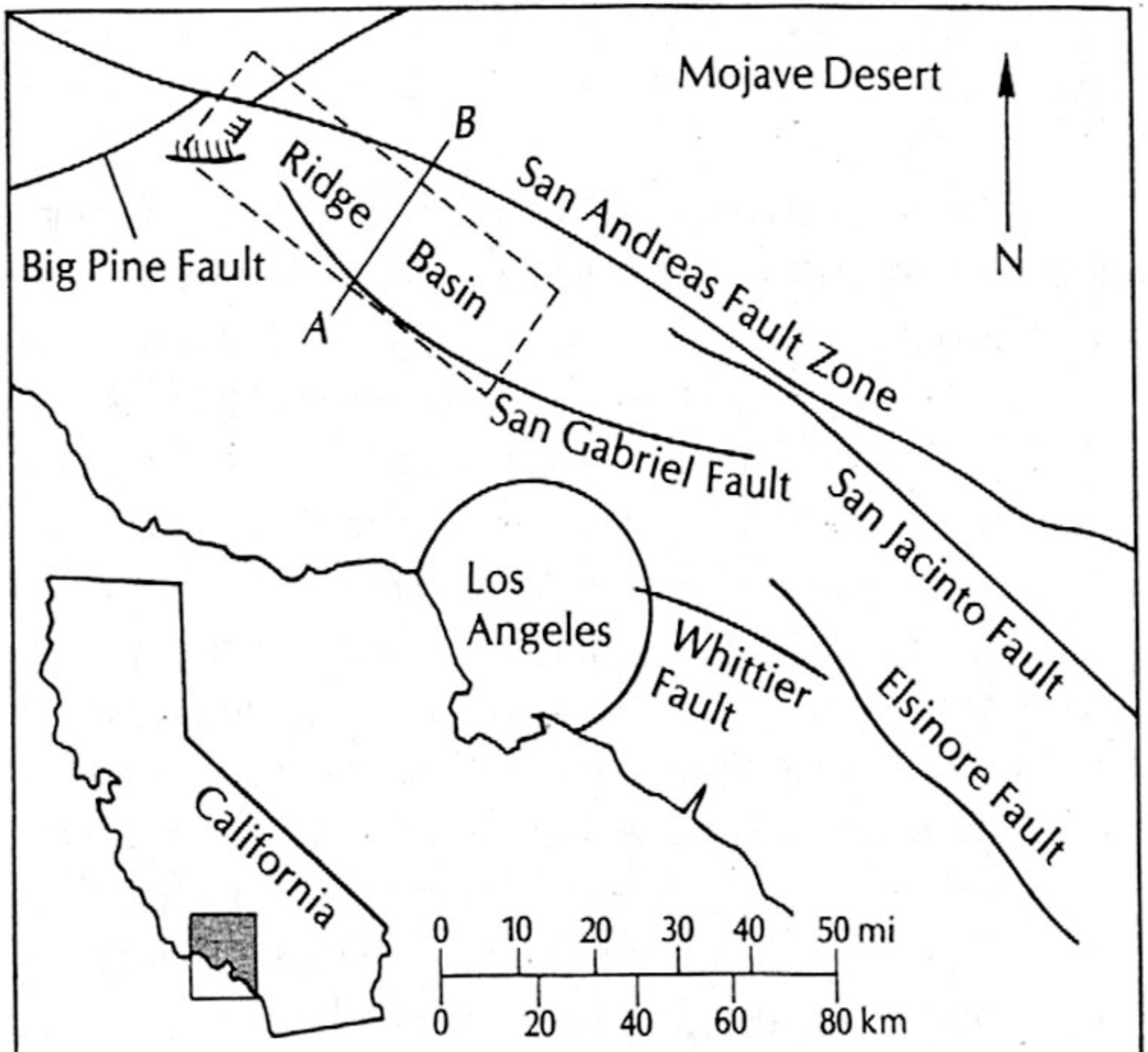


(c) STRIKE-SLIP FAULT
(left-lateral)

Transform fault basin

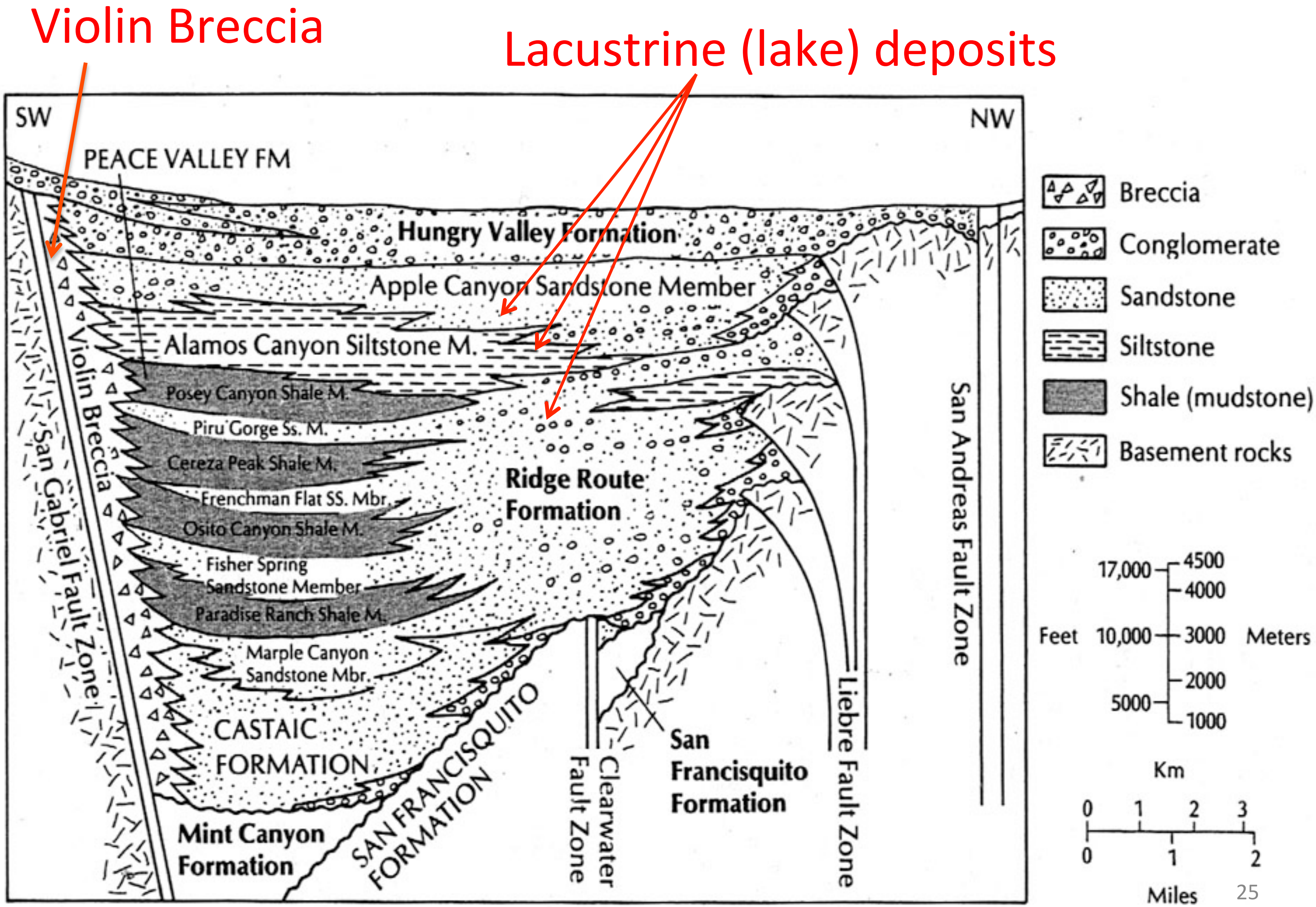
Dextral
San Andreas
transform fault

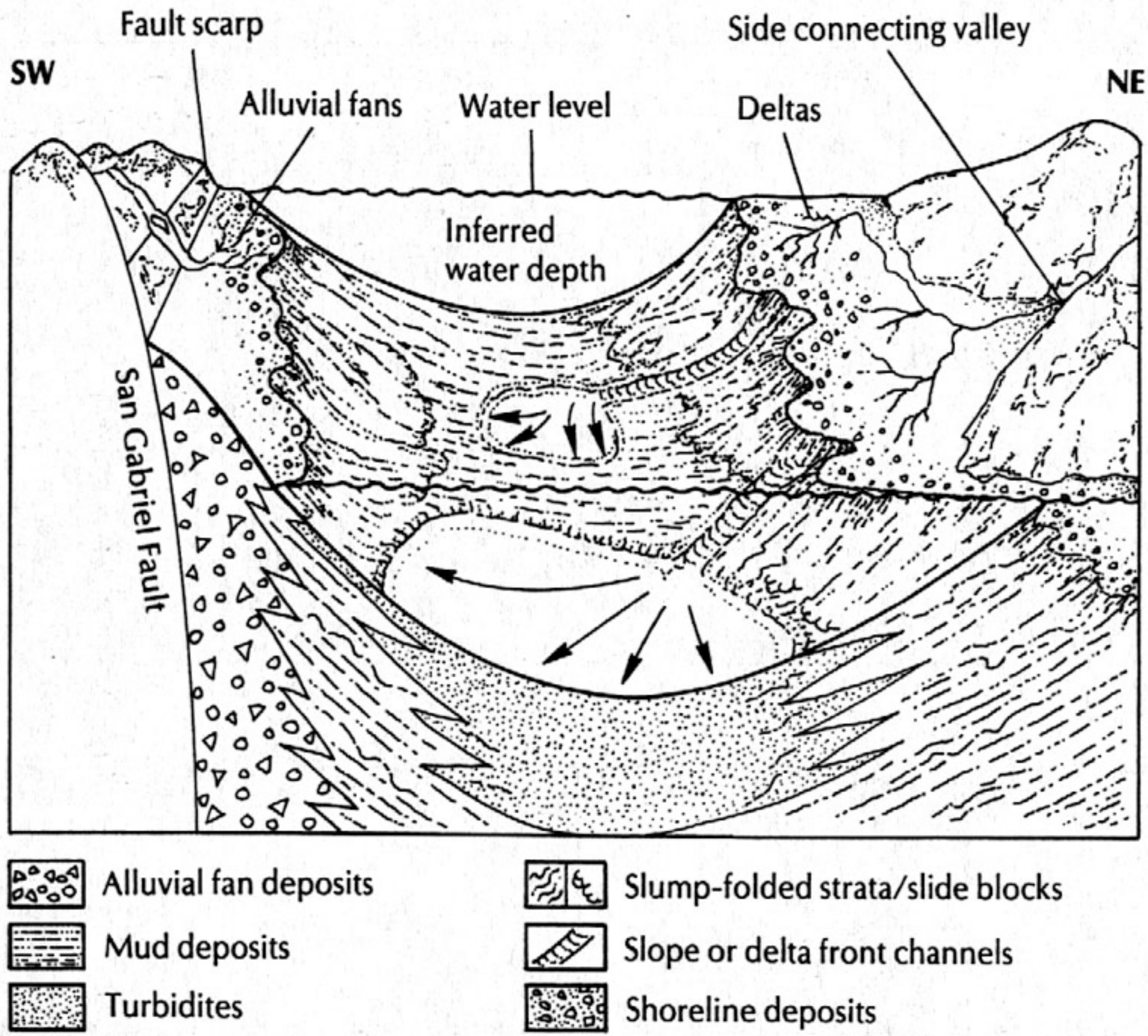
Ridge Basin, California



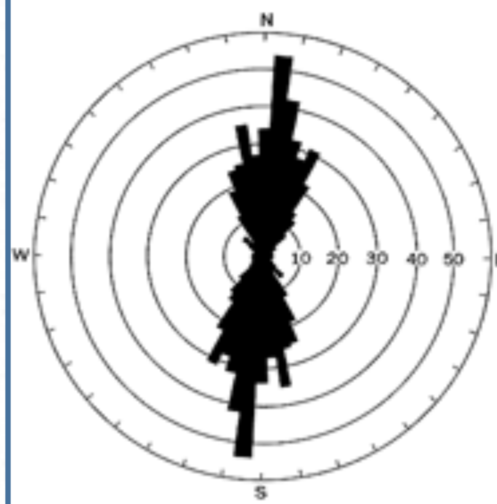
- Miocene-Pliocene sedimentary fill;
- The northern boundary is San Andreas Fault;
- The San Gabriel Fault is in the south
- Deposition is controlled by dextral motions along the San Andreas Fault

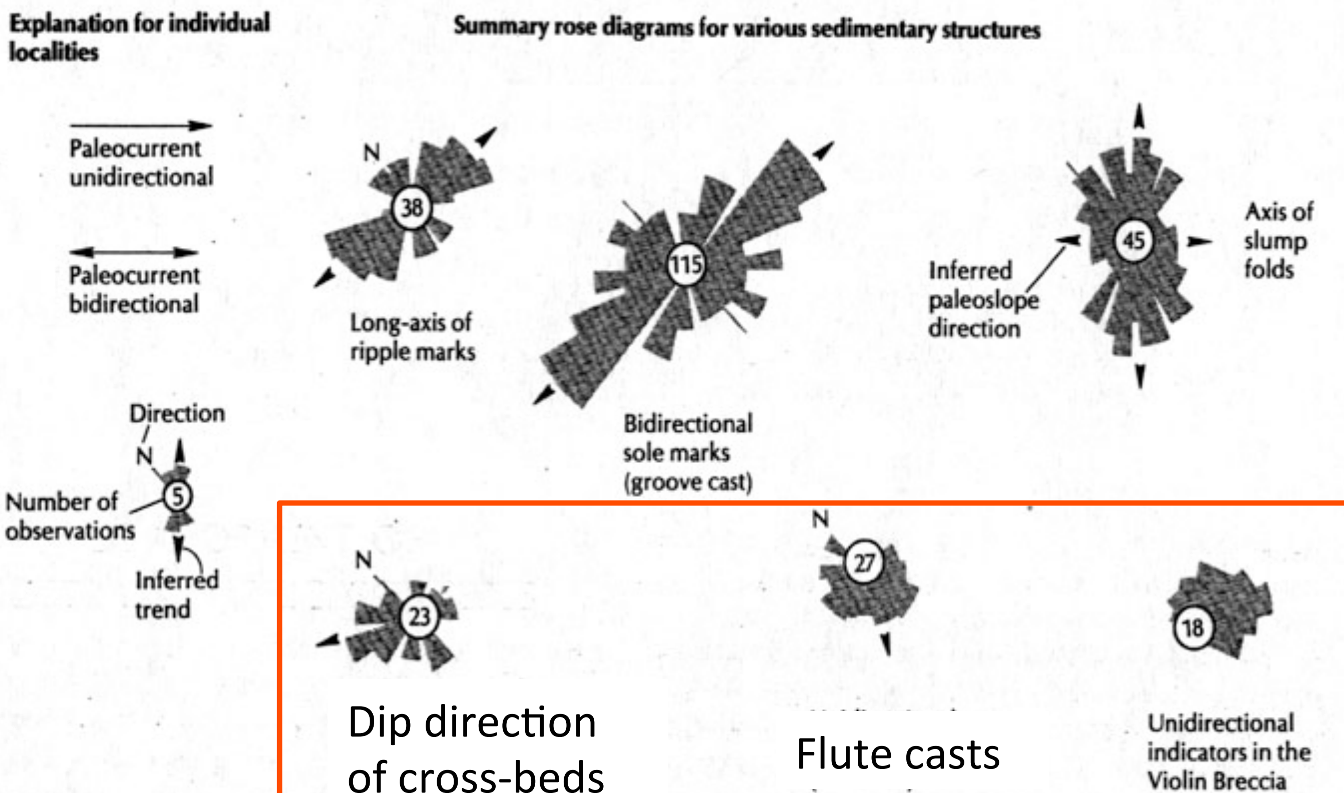
The Ridge Basin cross section



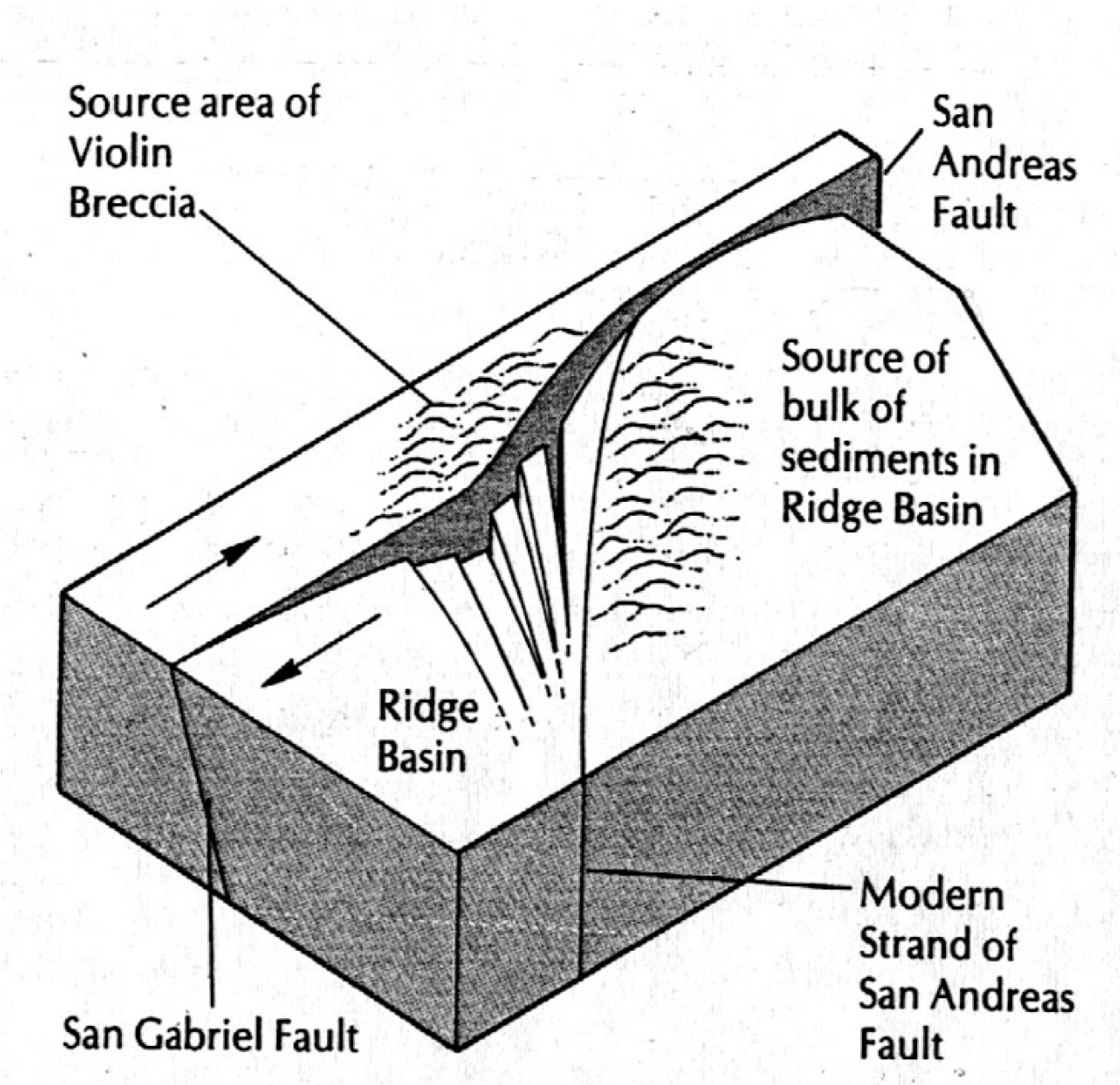

Fault scarp
Side connecting valley
SW
NE
Alluvial fans
Water level
Deltas
Inferred
water depth
San Gabriel Fault
Alluvial fan deposits
Mud deposits
Turbidites
Slump-folded strata/slide blocks
Slope or delta front channels
Shoreline deposits

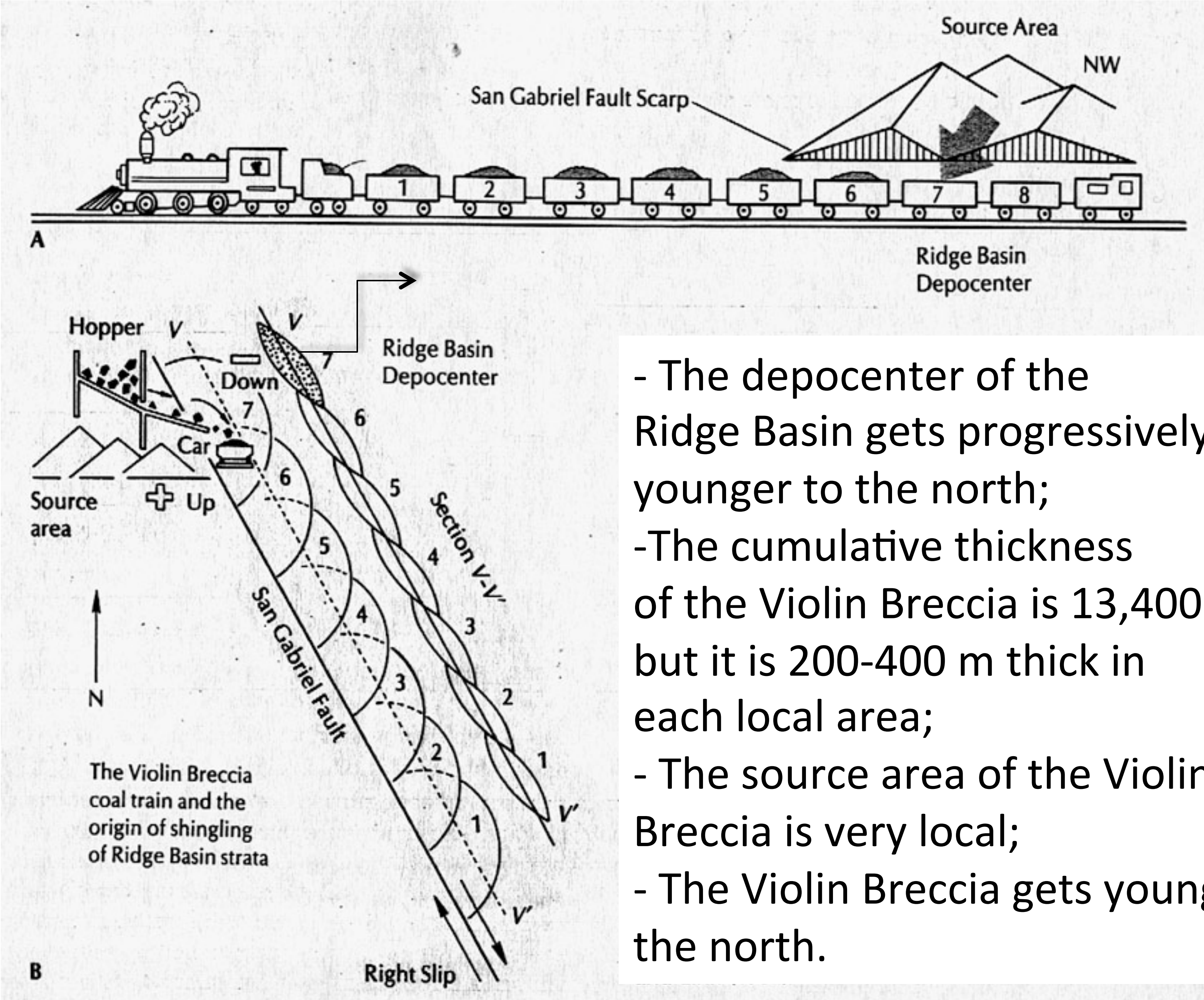
Rose diagram





Interpretation?


Source area of
Violin
Breccia
San
Andreas
Fault
Source of
bulk of
sediments in
Ridge Basin
Ridge
Basin
Modern
Strand of
San Andreas
Fault
San Gabriel Fault



- The depocenter of the Ridge Basin gets progressively younger to the north;
- The cumulative thickness of the Violin Breccia is 13,400 m but it is 200-400 m thick in each local area;
- The source area of the Violin Breccia is very local;
- The Violin Breccia gets younger to the north.

The North Anatolian Fault and sedimentary basins

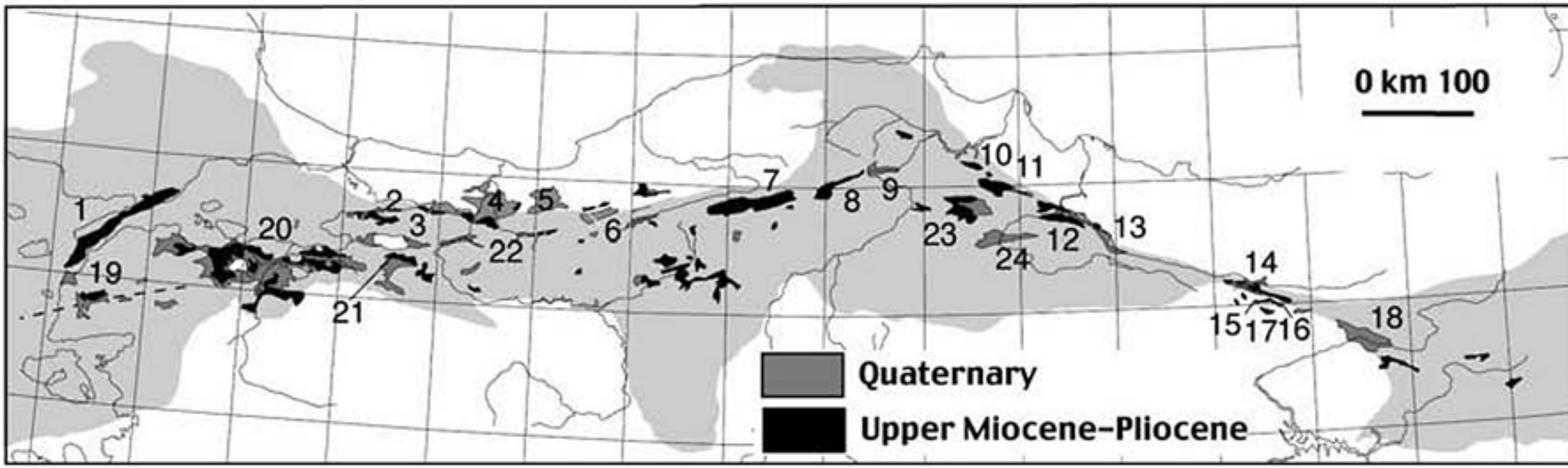


Figure 7 Basins defining the North Anatolian Keirogen (NAK). Numbers refer to those in the text and in Figures 8*A* and 8*B*(*a*). For the stratigraphy of the basins, see Figures 8*A* and 8*B*(*a*). For geological histories, see the text.

Şengör et al. 2005

Some of these basins may evolve as the Ridge Basin in California. It can be an interesting topic of your personal research.

The North Anatolian Fault and sedimentary basins