

Extension Tectonics: Rifting and Divergence

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Rifting and Divergence

Earth Structure (2019)
(Processes in Structural Geology & Tectonics)

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4/11/2019 15:28

Earth Structure (2019)
(Processes in Structural Geology & Tectonics)

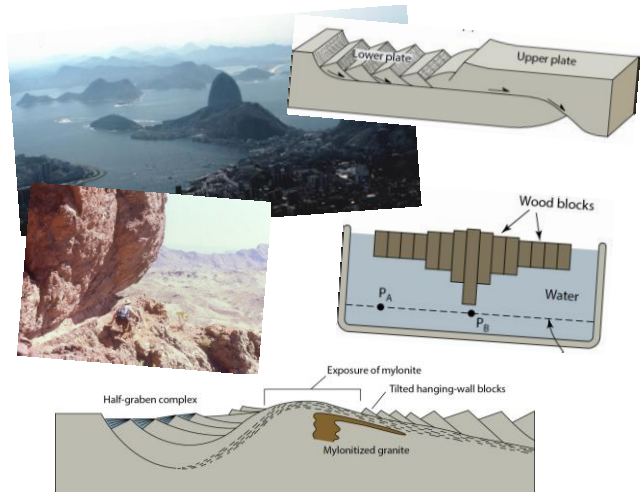
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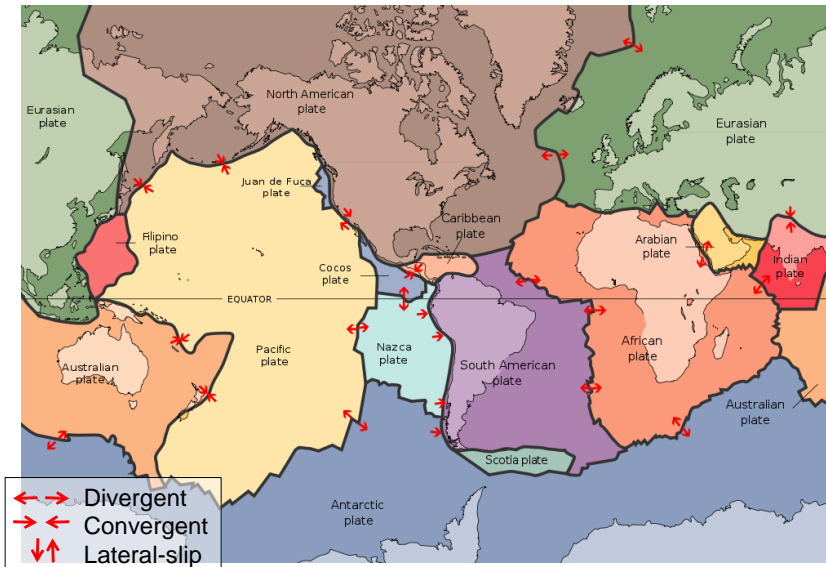
We Discuss ...

Extension Tectonics

- Today's divergent plate boundaries
 - Ocean Ridges
 - Lithologies
- Failed Rifts
- Structural Styles
 - Pure shear systems
 - Simple shear systems
- Stretching factor
- Metamorphic core complexes
 - (Isostasy)
- Rift evolution
 - Lithologies
 - Passive margins
- Causes of rifting and regional extension



Today's Plates and Divergent Boundaries

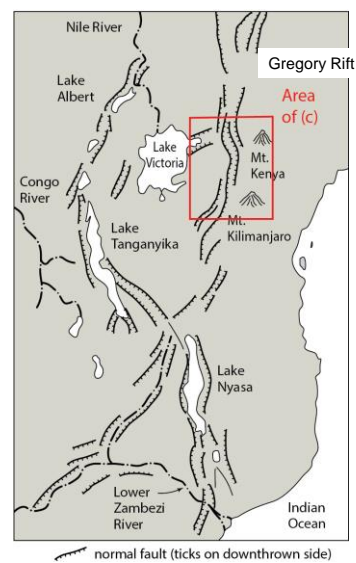
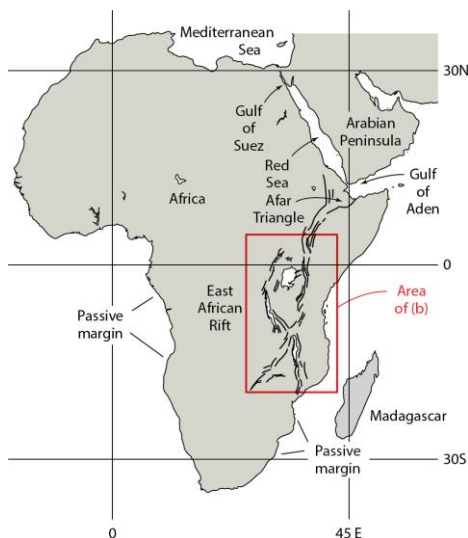


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Continental Rift Systems: East African Rift


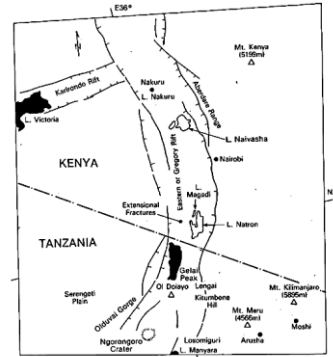


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Africa's Gregory Rift

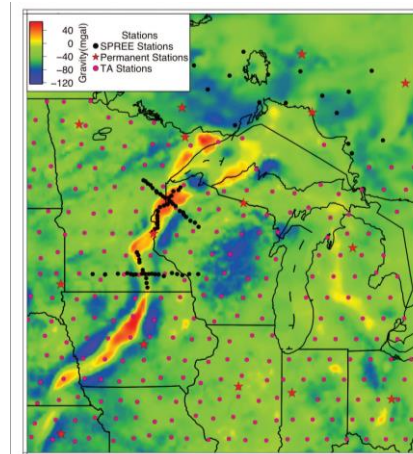
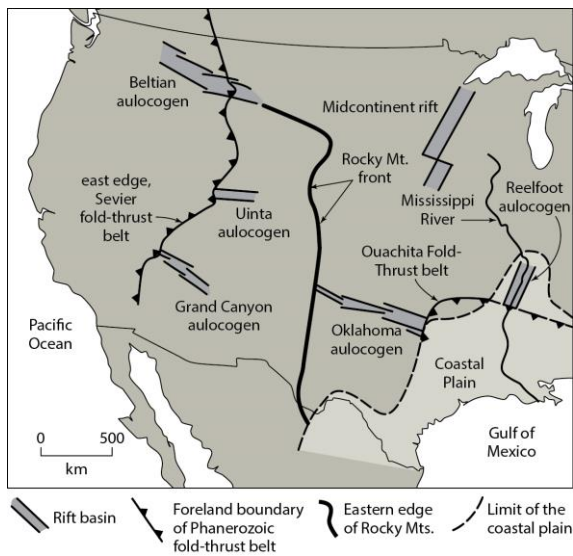


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Ancient Continental Rift Systems



Stein et al., 2011

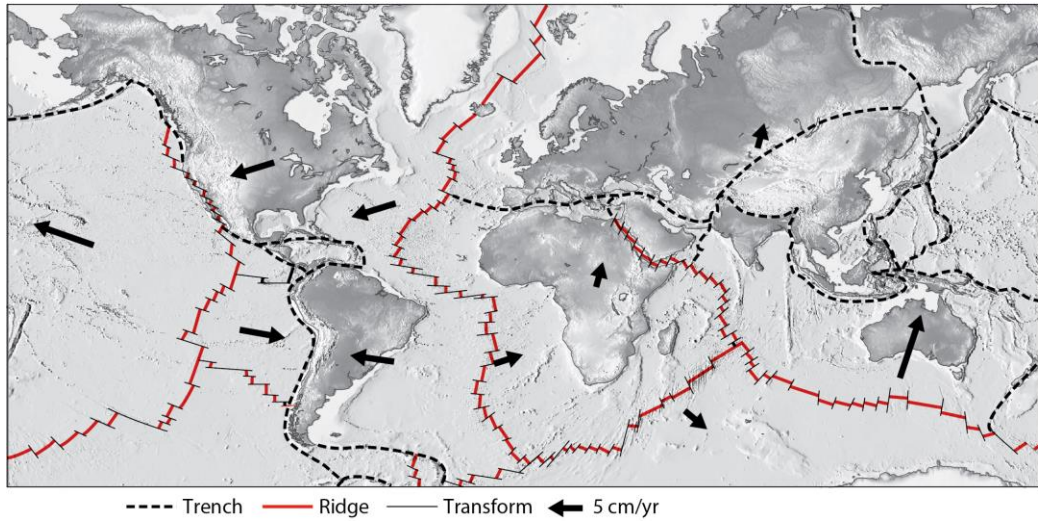
Midcontinent
Gravity High

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Rifts and Ocean Ridges

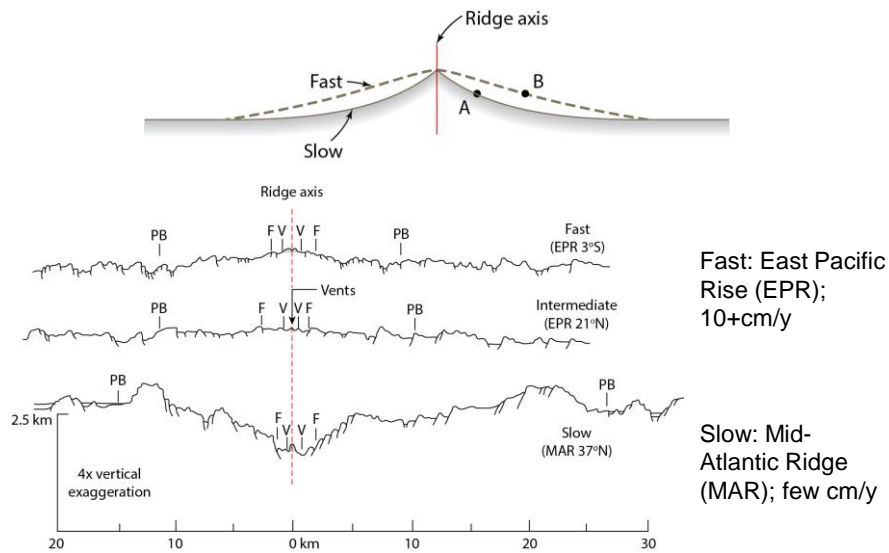


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Morphology of Ocean Ridges and Spreading Rate

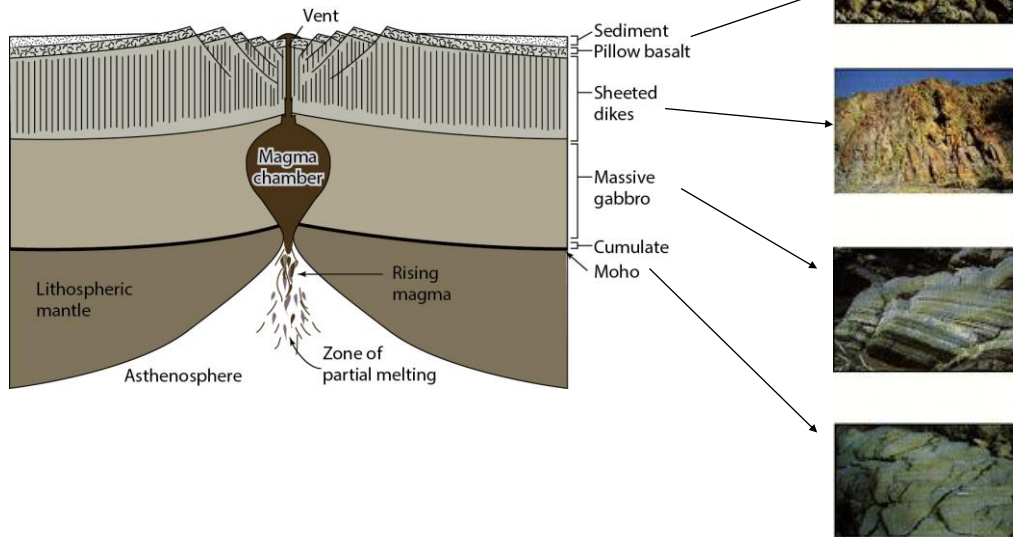


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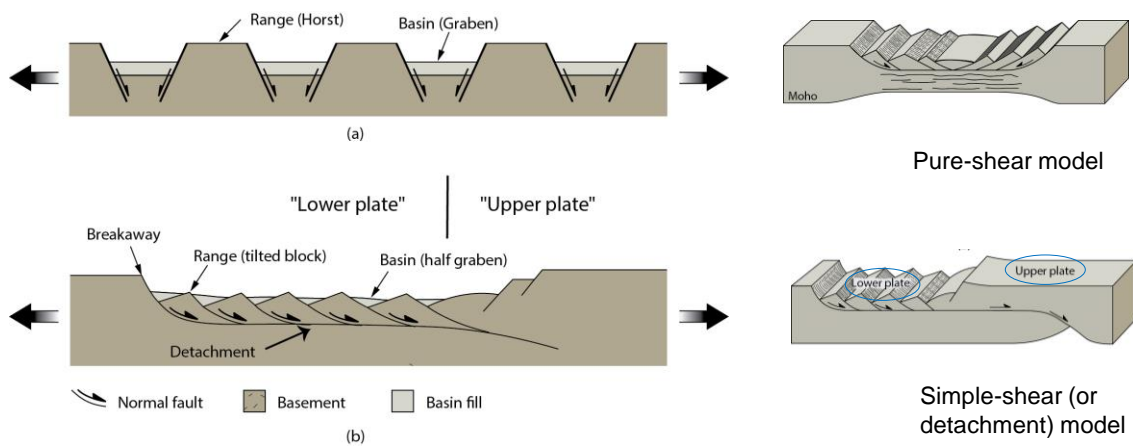
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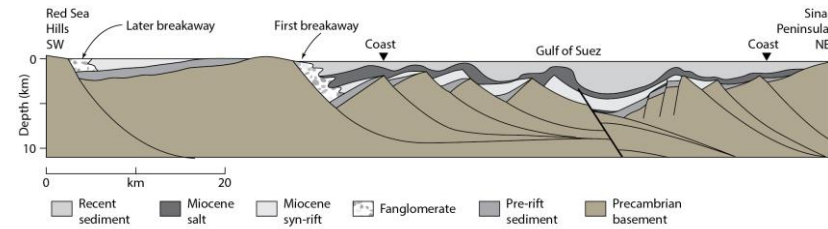
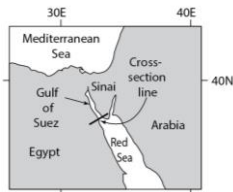
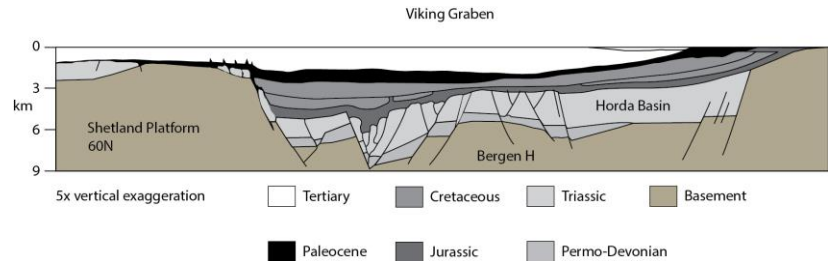
Extra: Petrology of Ocean Ridges ("ophiolite")



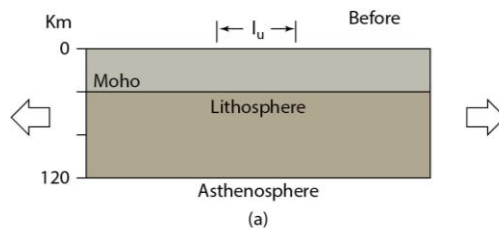
Structural Styles of Rift Systems



Examples of Rift Systems



Extension and Stretching Factor

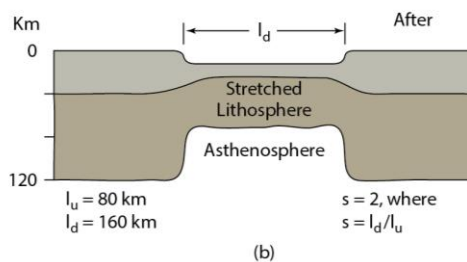


Stretch and extension:

$$s = l/l_0 = 2$$

$e = (l - l_0)/l_0 = 1$ (=100% extension, so 50% thinning)

(recall: $s = 1 + e$)



e is typically 1-3

($s = 2-4$)

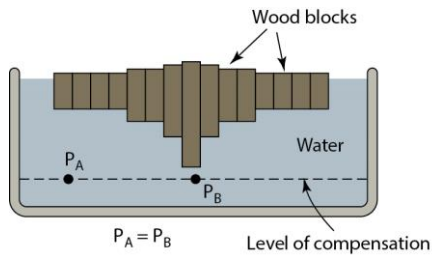
100-400% extension, 50-75% thinning)

Extension and Isostasy

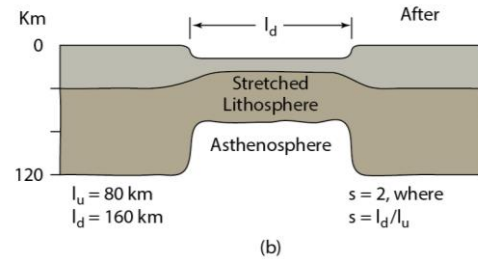
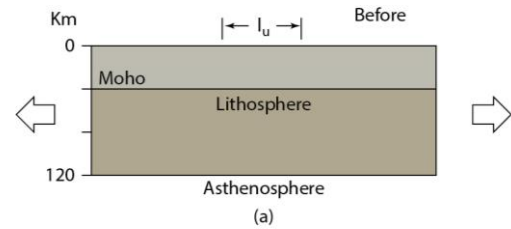
Application of Archimedes' Law of Buoyancy to Earth:

"the mass of water displaced by a block is equal to the mass of the block"

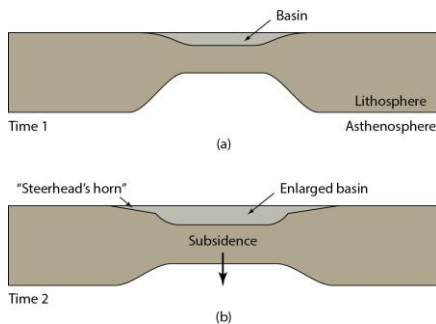
So, surface thinning of "block" (lithosphere) results in subsidence.



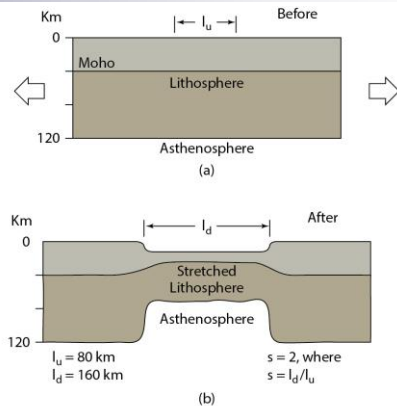
$P_A = P_B$ is called
isostatic equilibrium



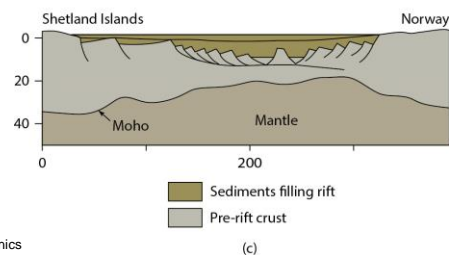
Extra: Extension and Sedimentation



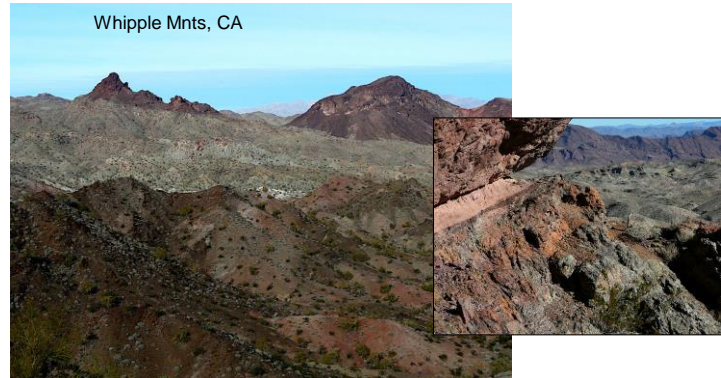
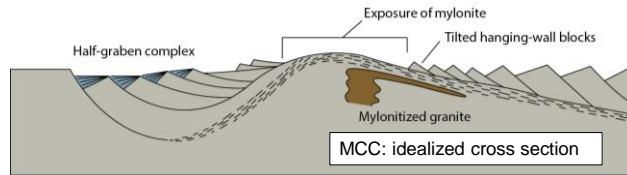
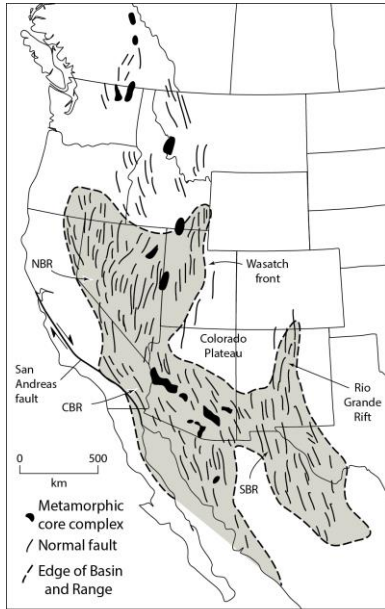
- (a) Thinning and basin formation
- (b) Cooling and further subsidence, forming broad basin fill ("steerhead basin")



Viking Graben
(North Sea)



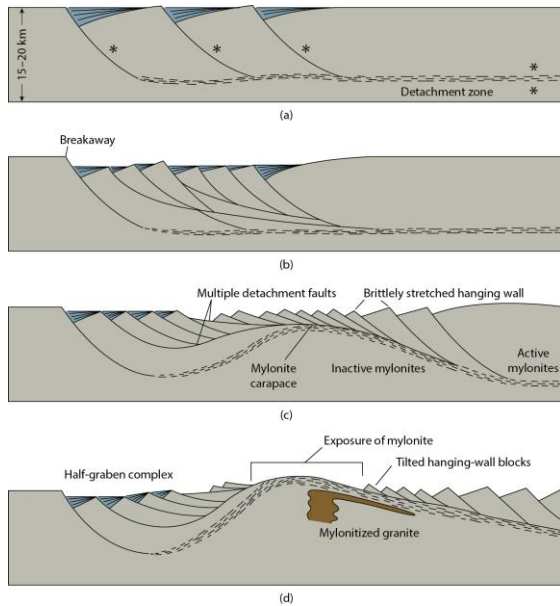
Continental Extension: Metamorphic Core Complexes (MCCs)



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Evolution of Metamorphic Core Complexes



Whipple Mnts, CA

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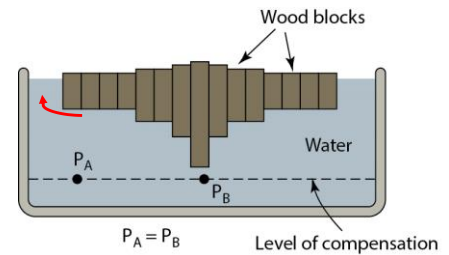
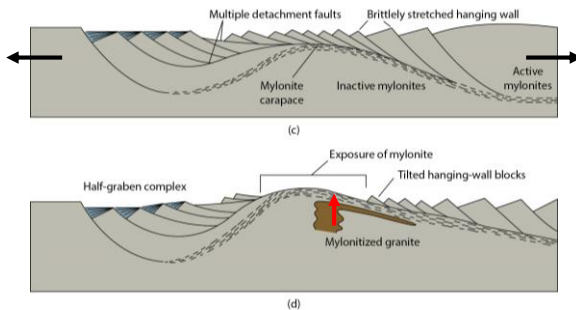
Extension and Isostasy

Application of Archimedes' Law of Buoyancy to Earth:

"the mass of water displaced by a block
is equal to the mass of the block"

So, surface thinning of "block" (upper crust) results in
upward flow of "water" (lower crust).

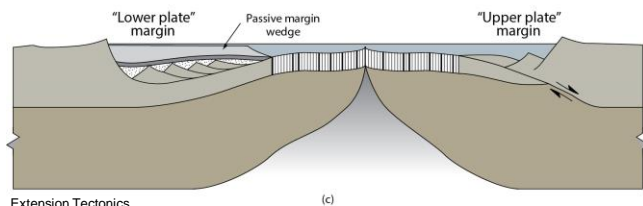
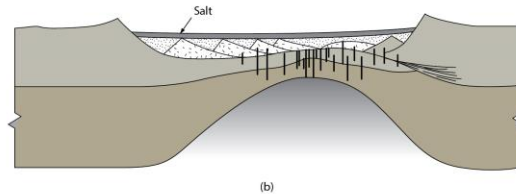
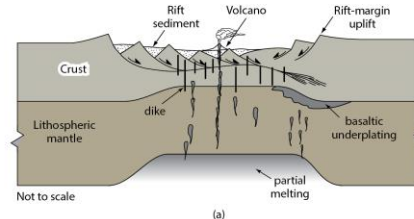
In MCCs, thinning by normal faulting results in exhumation
of deeper detachment and
basement rock.



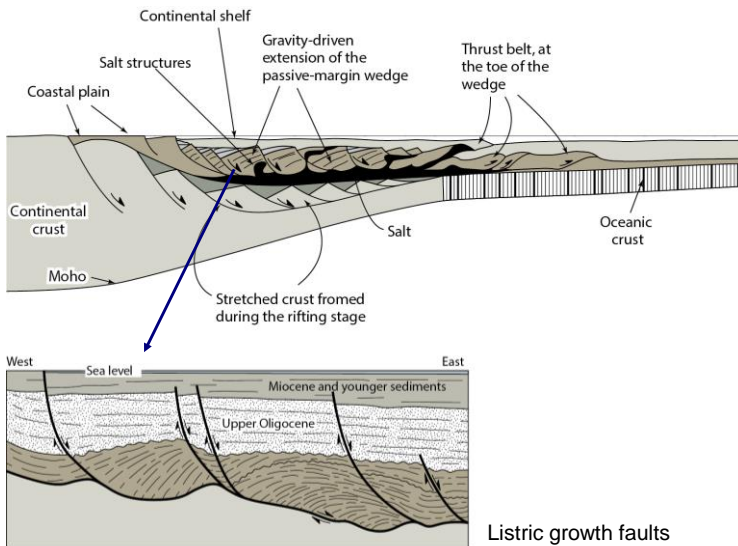
$P_A = P_B$ is called
isostatic equilibrium

Rift Evolution (Rift-to-Drift) and Lithologic Assemblages

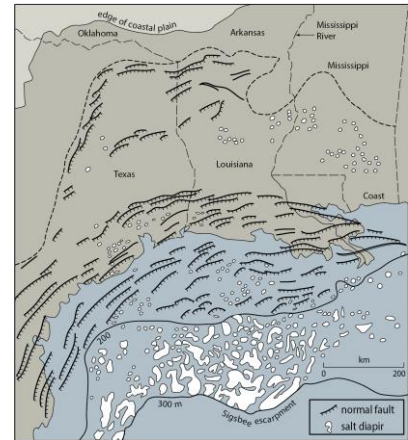
- (a) Rift stage with non-marine basins
- (b) rift–drift transition with evaporate deposition
- (c) drift stage, with seafloor spreading, passive-margin deposition, and marine basin deposition.



Passive Margins (US Gulf Coast)



Listric growth faults



US Gulf Coast region

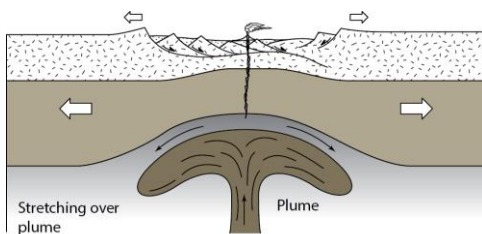


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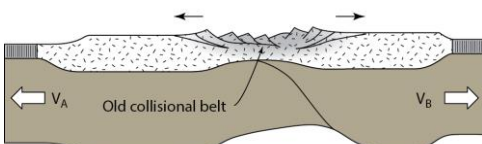
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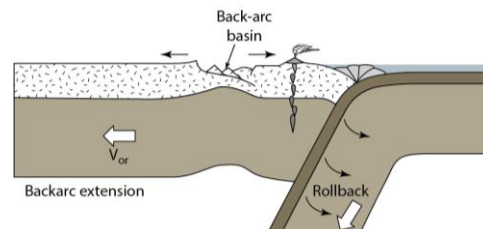
Causes of Regional Extension and Rifting



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1. Rifting above thermal plume.
2. As plates move apart, continent is stretched and pulled apart.
3. Backarc extension associated with subduction and slab roll-back.



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