

# Extension Tectonics: Rifting and Divergence

## Extension Tectonics: Rifting and Divergence

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

© Ben van der Pluijm  
4/11/2019 13:28

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

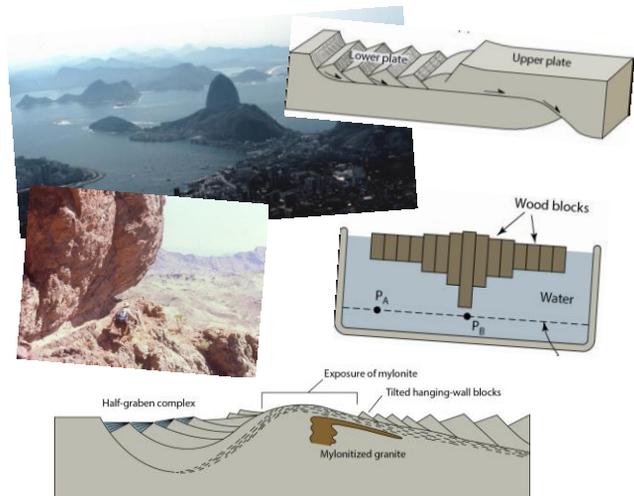
© Ben van der Pluijm

4/26/2019 16:07

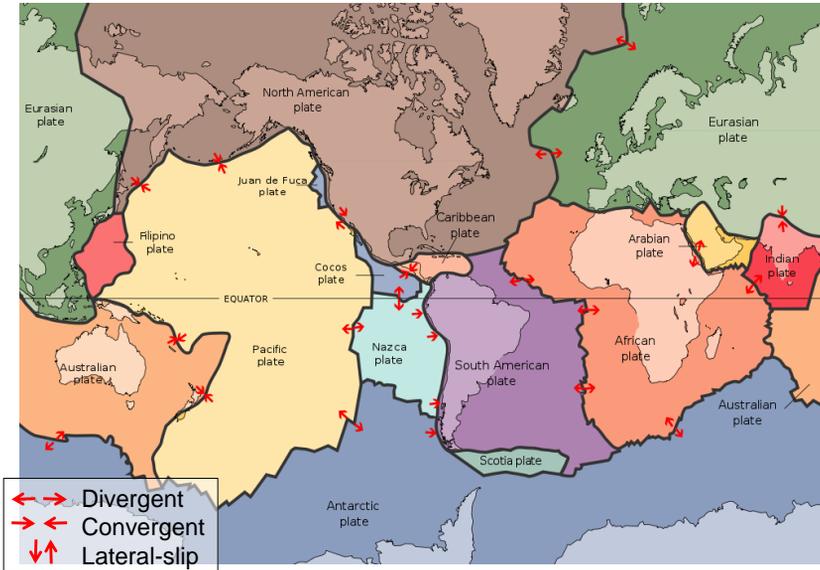
## We Discuss ...

### Extension Tectonics

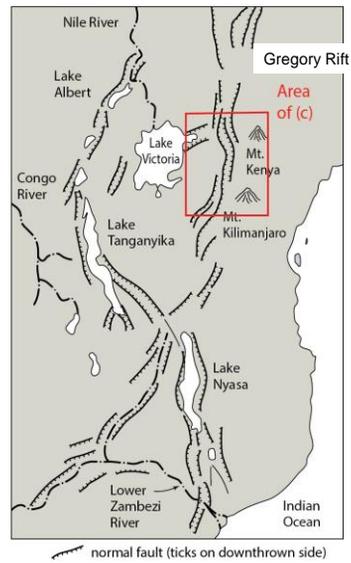
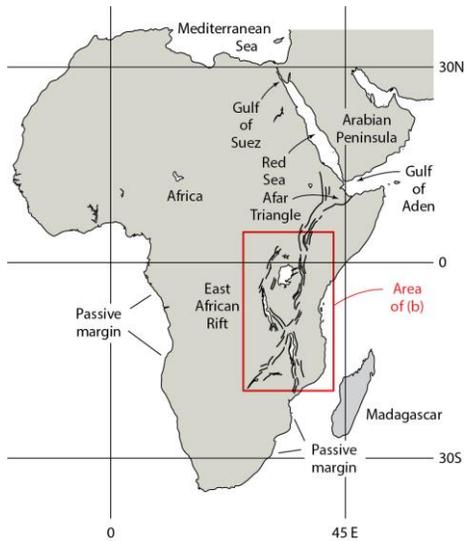
- Today's divergent plate boundaries
  - Ocean Ridges
  - Lithologies
- Failed Rifts
- Structural Styles
  - Pure shear systems
  - Simple shear systems
- Stretching factor
- Metamorphic core complexes
  - (Isostasy)
- Rift evolution
  - Lithologies
  - Passive margins
- Causes of rifting and regional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



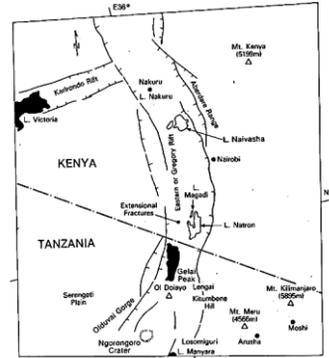
## Today's Plates and Divergent Boundaries



## Continental Rift Systems: East African Rift



# Africa's Gregory Rift

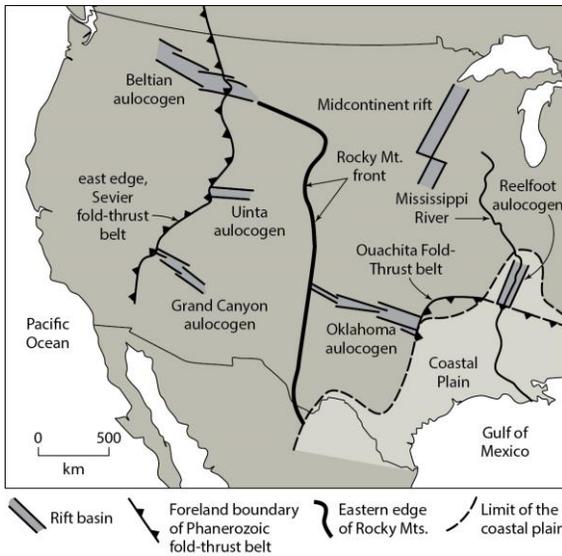


M © Ben van der Pluijm

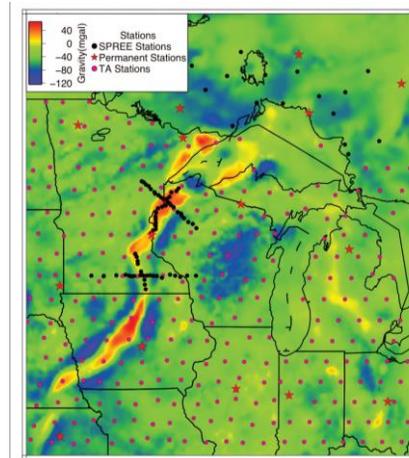
Extension Tectonics

6

# Ancient Continental Rift Systems



Rift basin    
 Foreland boundary of Phanerozoic fold-thrust belt    
 Eastern edge of Rocky Mts.    
 Limit of the coastal plain



Stein et al., 2011

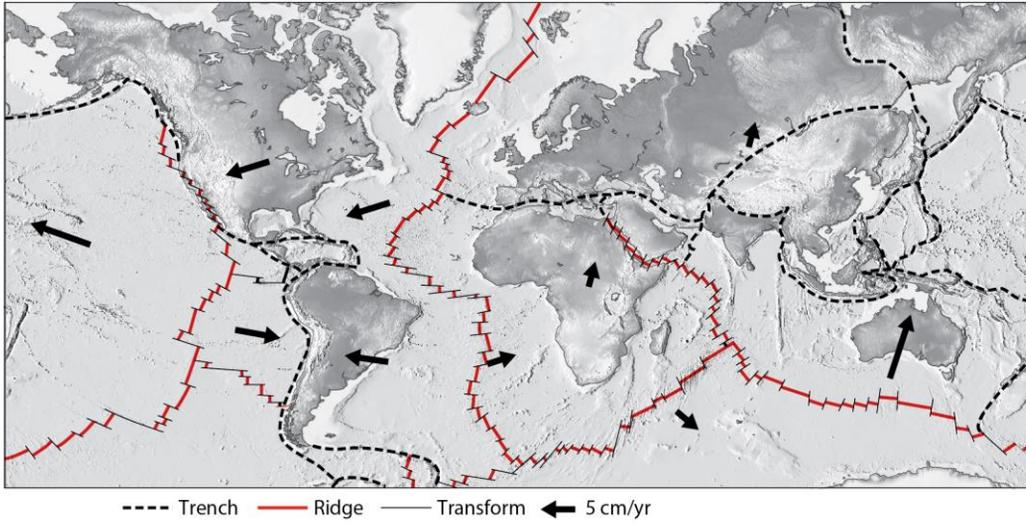
Midcontinent Gravity High

M © Ben van der Pluijm

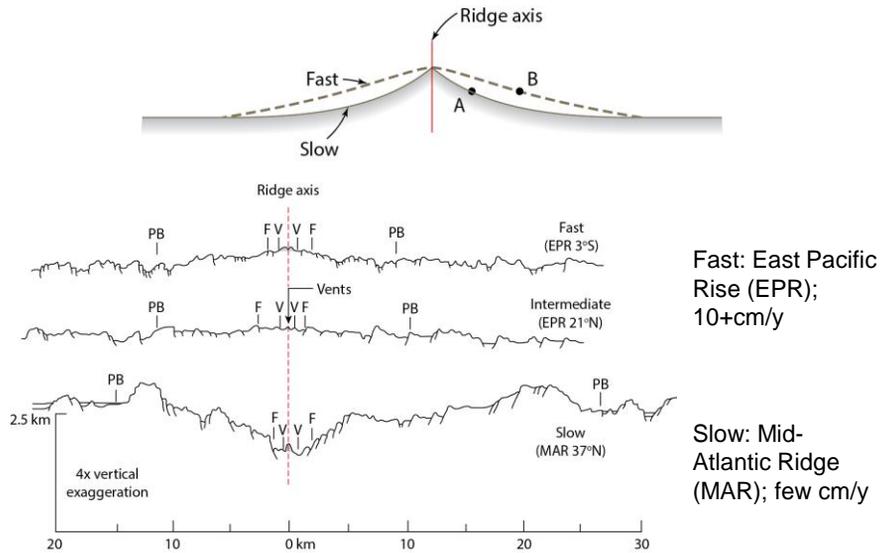
Extension Tectonics

9

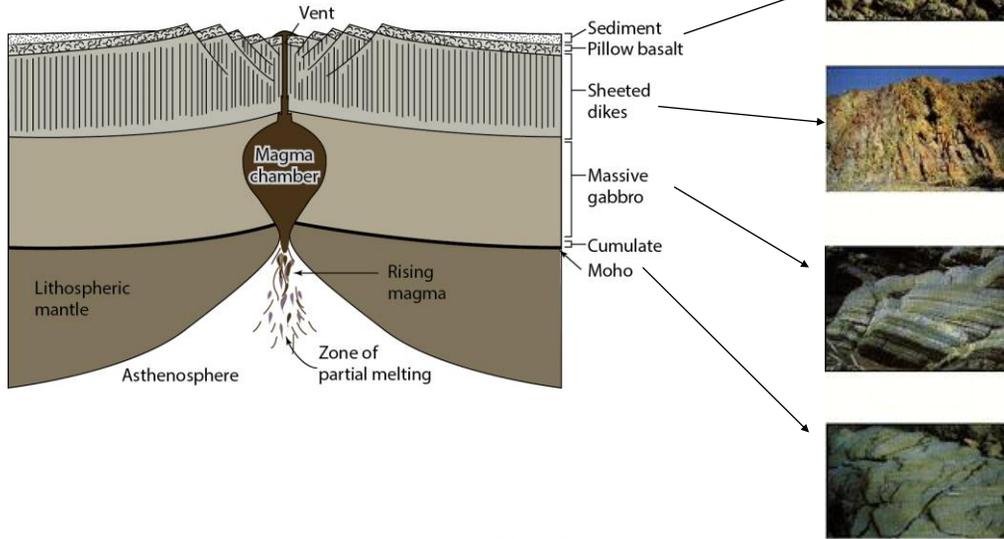
## Rifts and Ocean Ridges



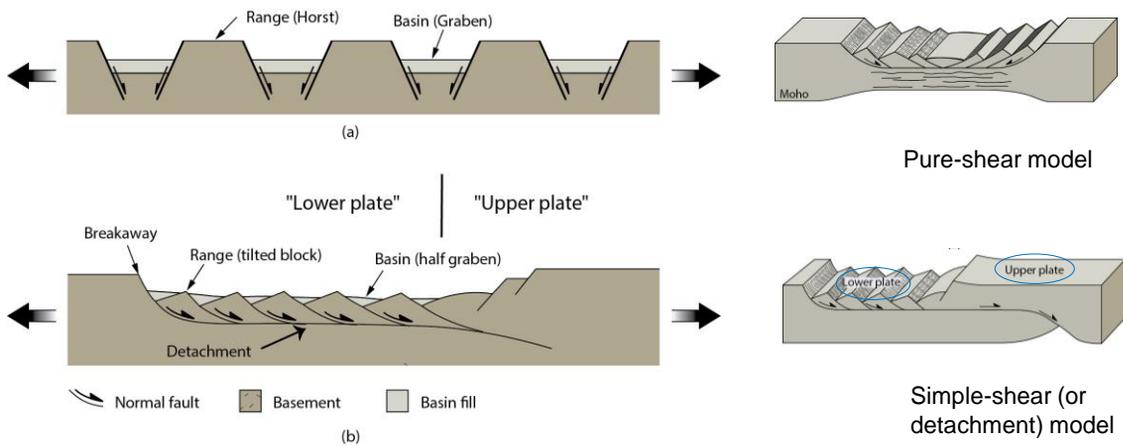
## Morphology of Ocean Ridges and Spreading Rate



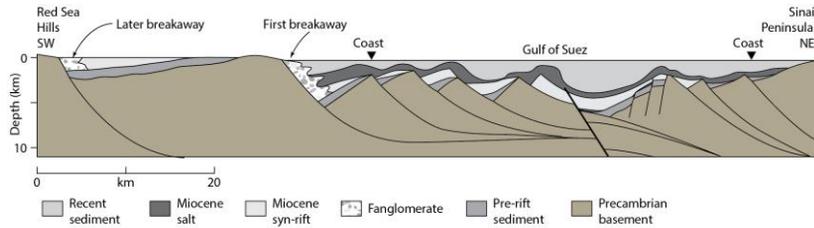
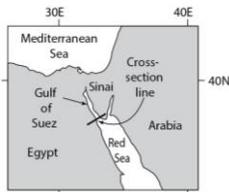
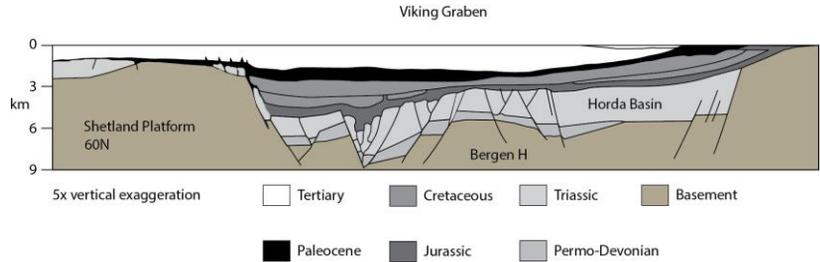
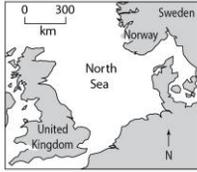
## Extra: Petrology of Ocean Ridges (“ophiolite”)



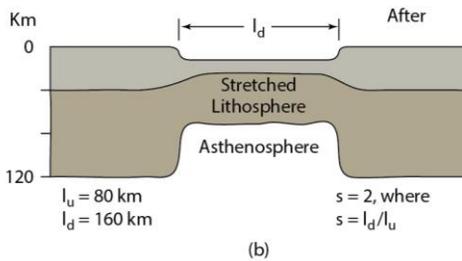
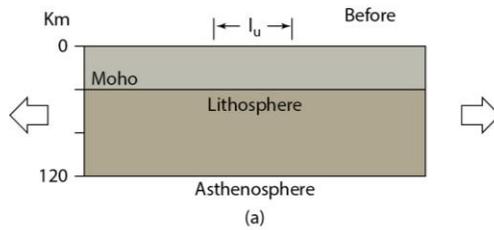
## Structural Styles of Rift Systems



## Examples of Rift Systems



## Extension and Stretching Factor



Stretch and extension:

$$s = l/l_0 = 2$$

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

(recall:  $s = 1 + e$ )

$e$  is typically 1-3

$$(s = 2-4)$$

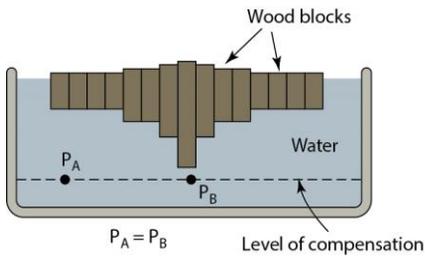
100-400% extension, 50-75% thinning)

## Extension and Isostasy

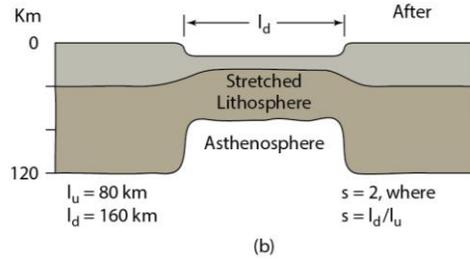
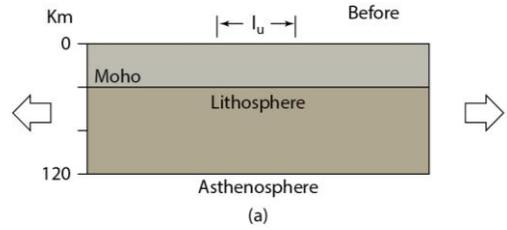
Application of Archimedes' Law of Buoyancy to Earth:

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

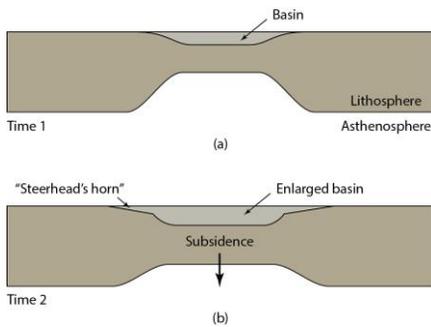
So, surface thinning of "block" (lithosphere) results in subsidence.



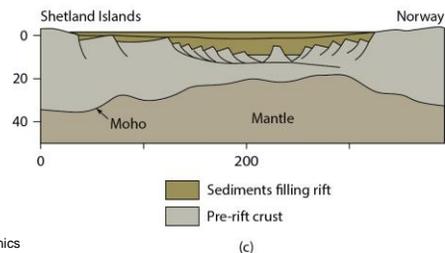
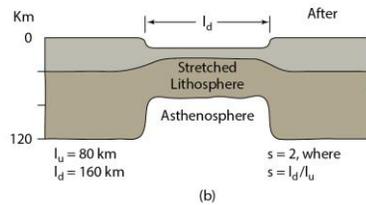
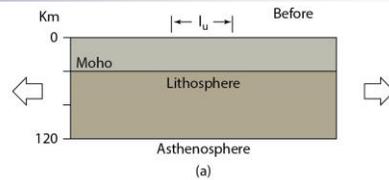
$P_A = P_B$  is called isostatic equilibrium



## Extra: Extension and Sedimentation

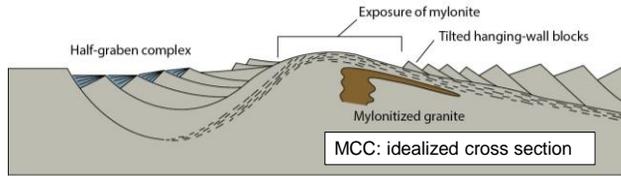
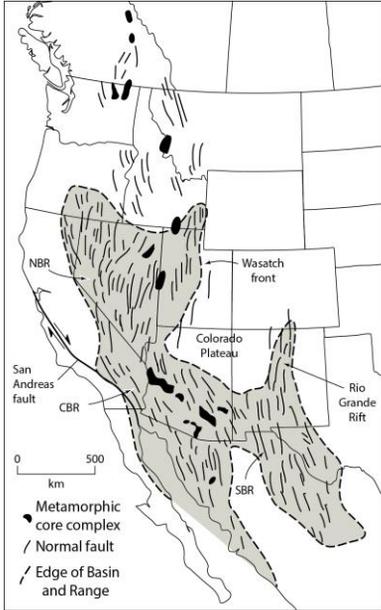


- (a) Thinning and basin formation
- (b) Cooling and further subsidence, forming broad basin fill ("steerhead basin")



Viking Graben (North Sea)

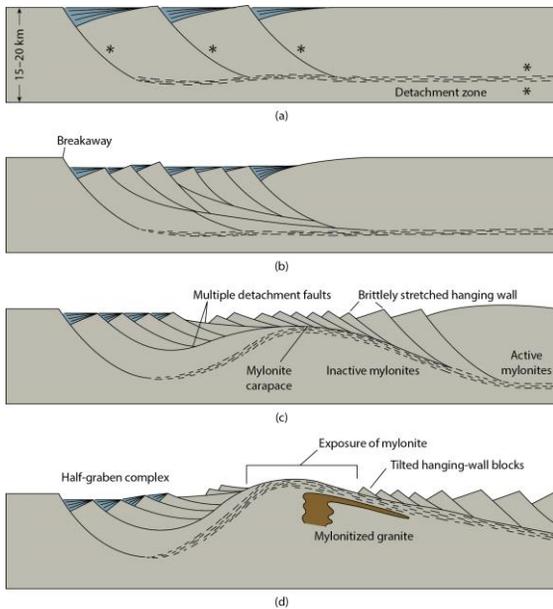
## Continental Extension: Metamorphic Core Complexes (MCCs)



Extension Tectonics

18

## Evolution of Metamorphic Core Complexes



Whipple Mnts, CA

Extension Tectonics

19

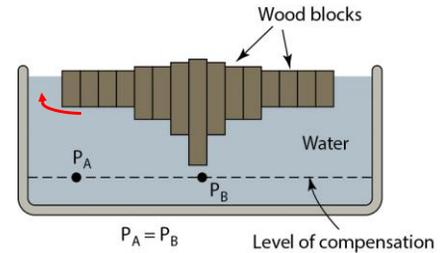
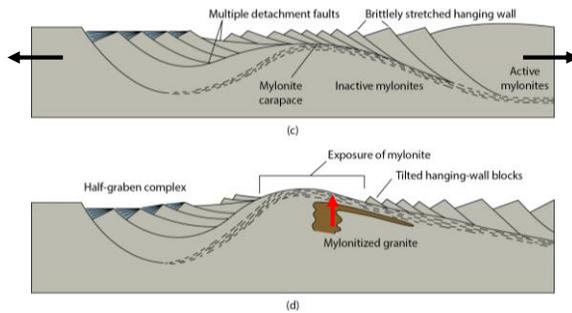
## Extension and Isostasy

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).

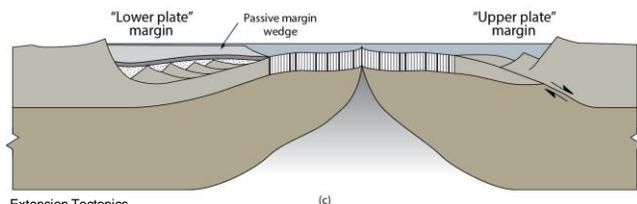
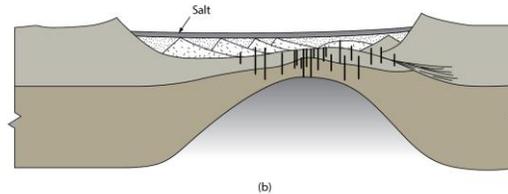
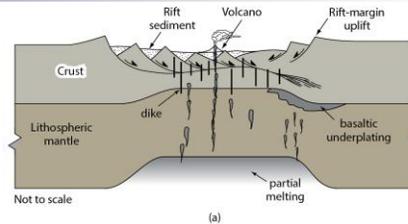
In MCCs, thinning by normal faulting results in exhumation  
of deeper detachment and  
basement rock.



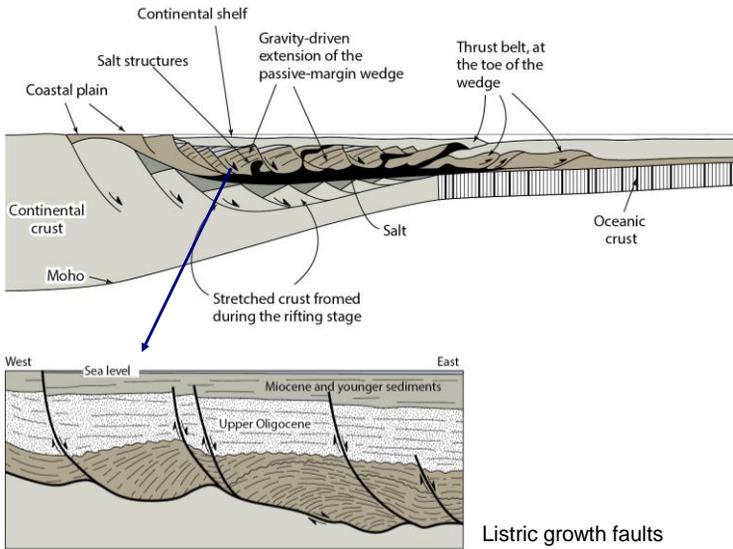
$P_A = P_B$  is called  
isostatic equilibrium

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

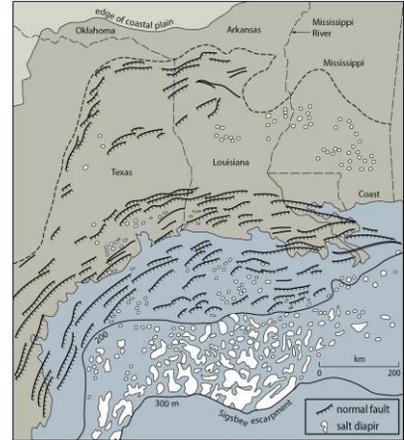
- (a) Rift stage with non-marine basins
- (b) rift–drift transition with evaporate  
deposition
- (c) drift stage, with seafloor  
spreading, passive-margin  
deposition, and marine basin  
deposition.



## Passive Margins (US Gulf Coast)

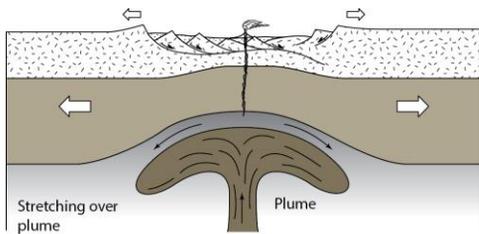


Listric growth faults

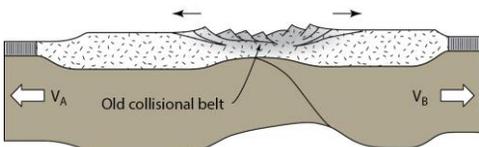


US Gulf Coast region

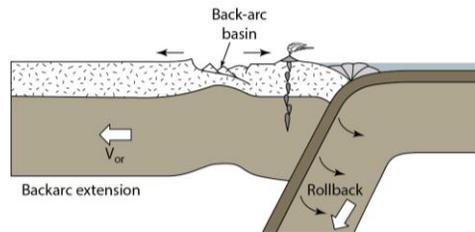
## Causes of Regional Extension and Rifting



1



2



3

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