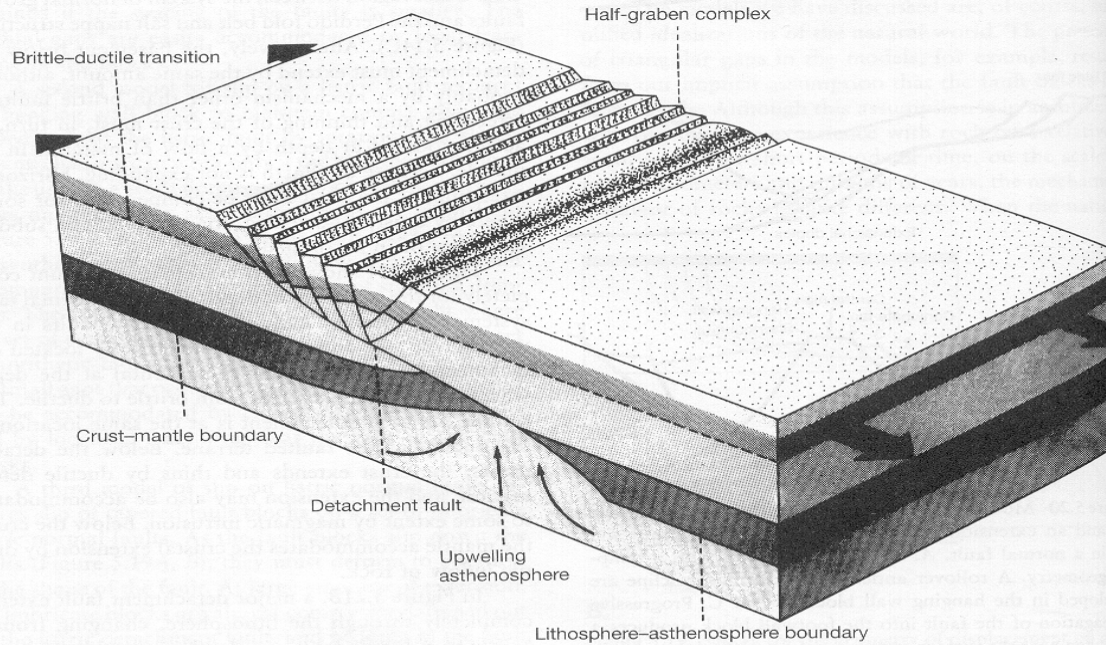
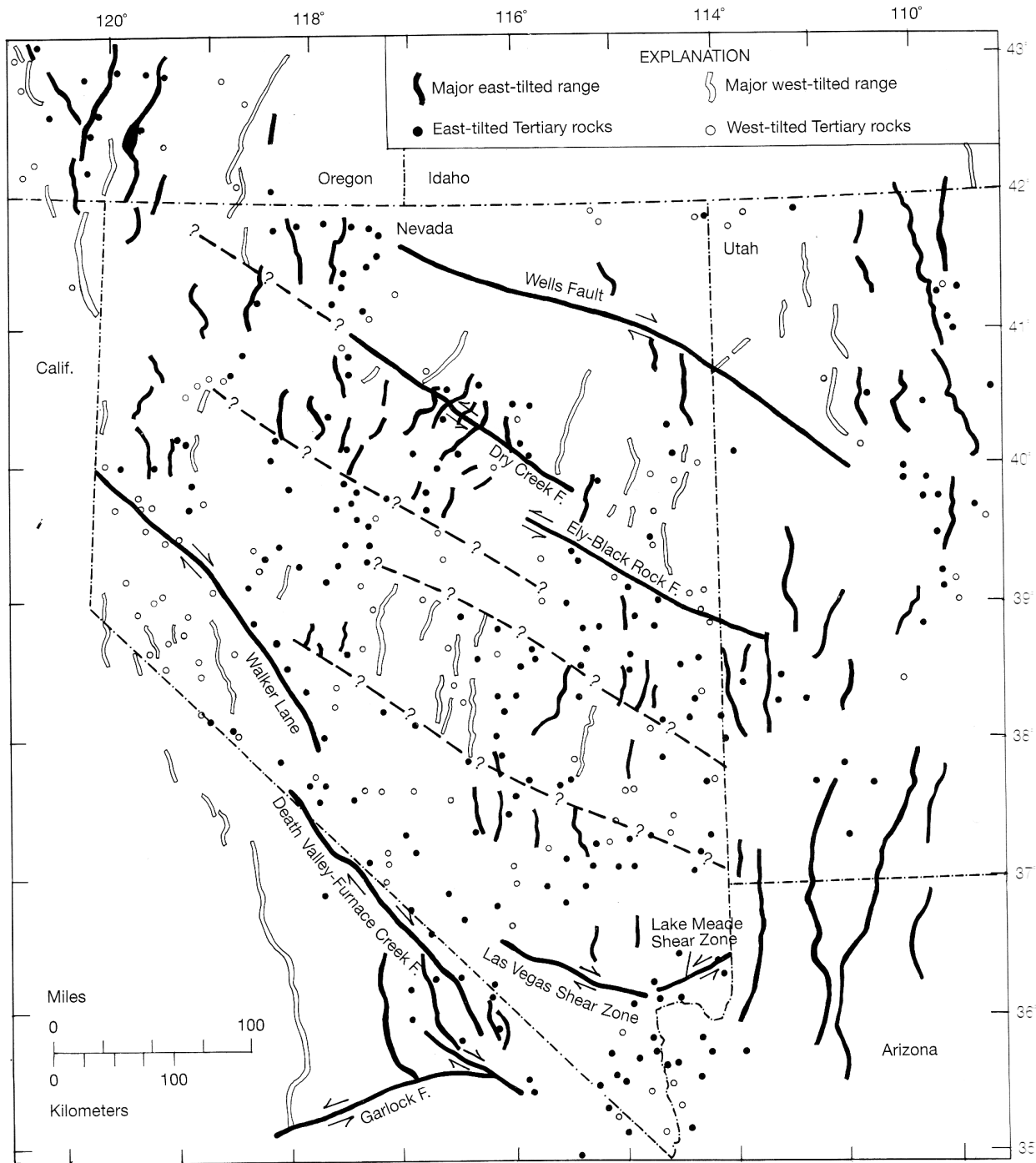


A.

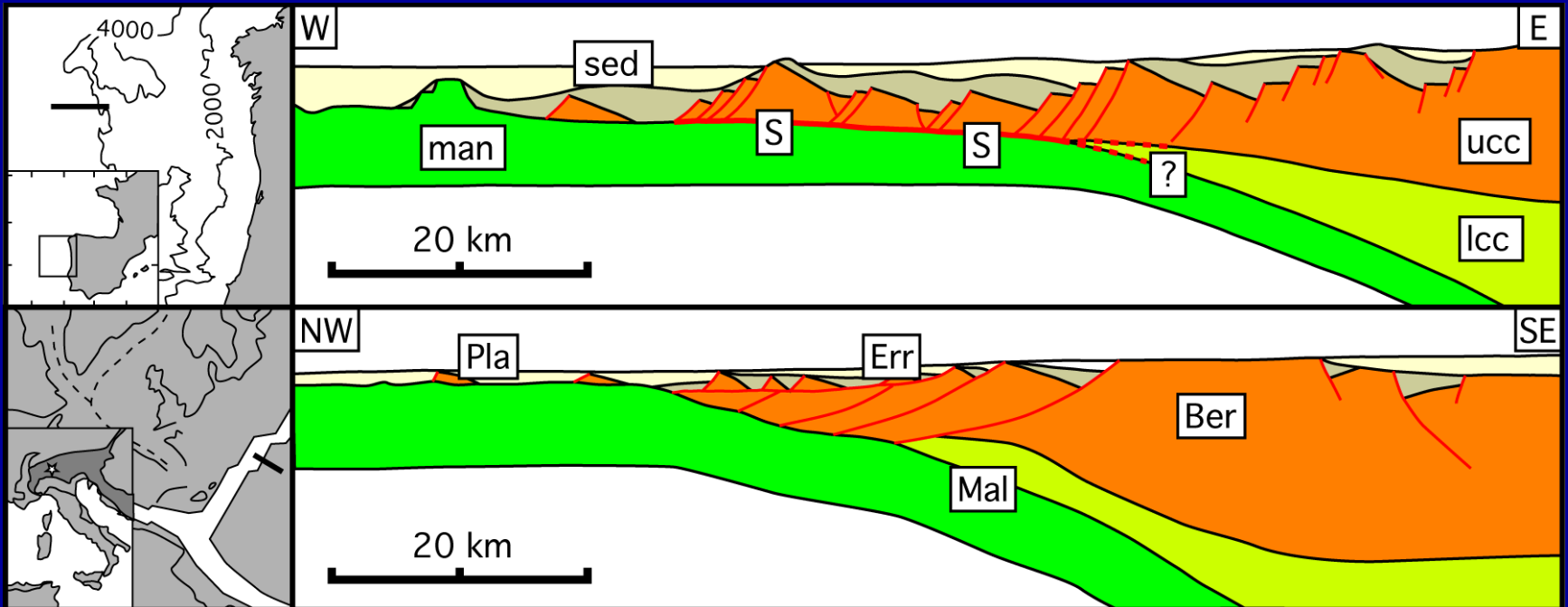


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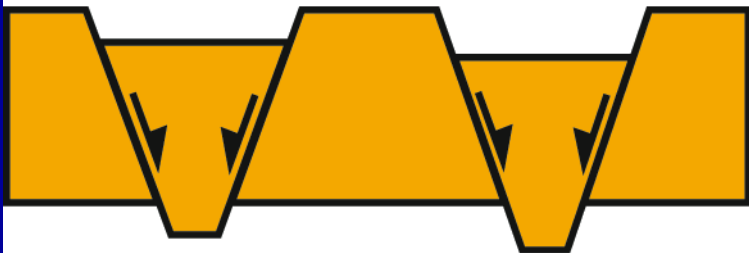
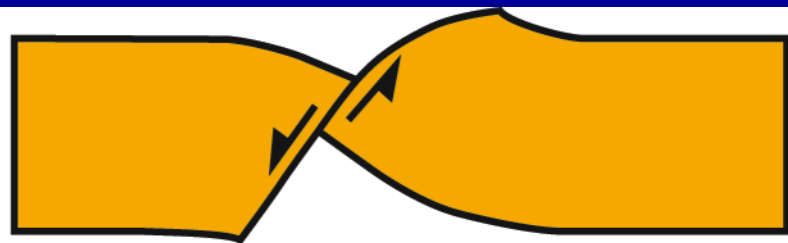


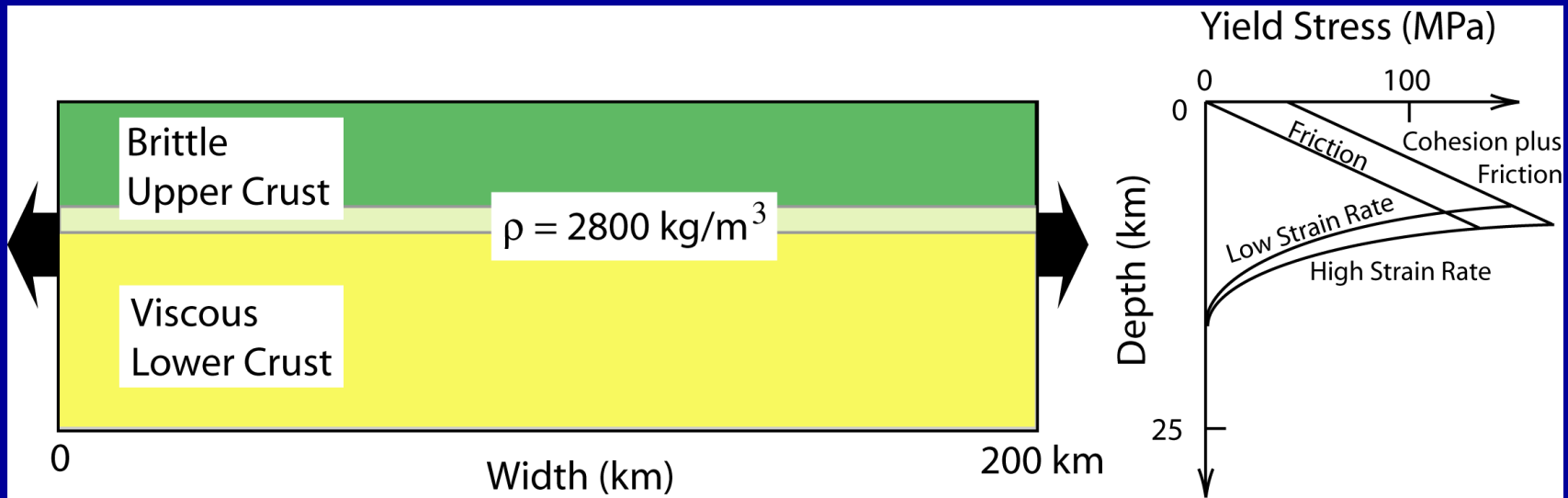
H. Stewart, 1978.

Boillot 1985



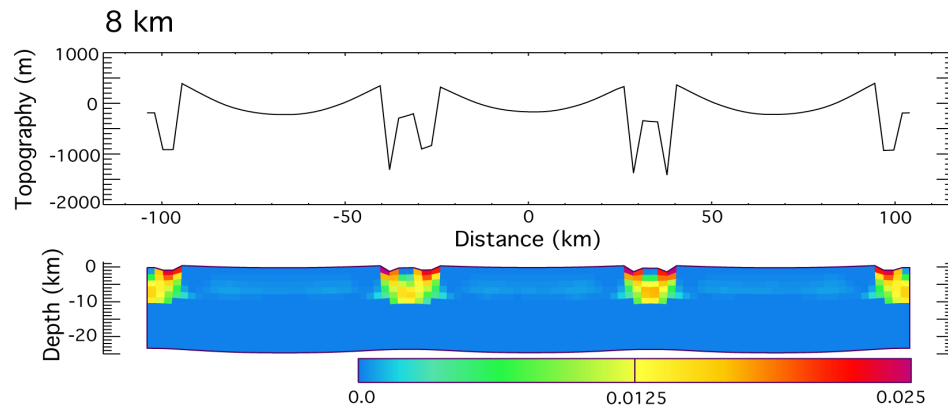
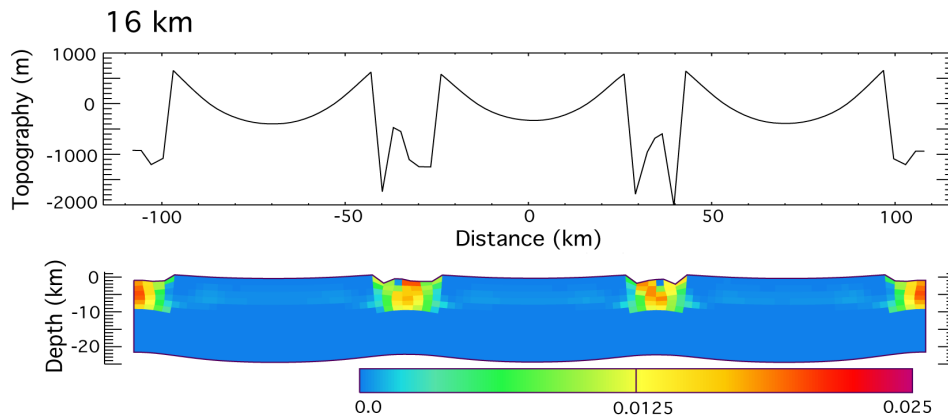
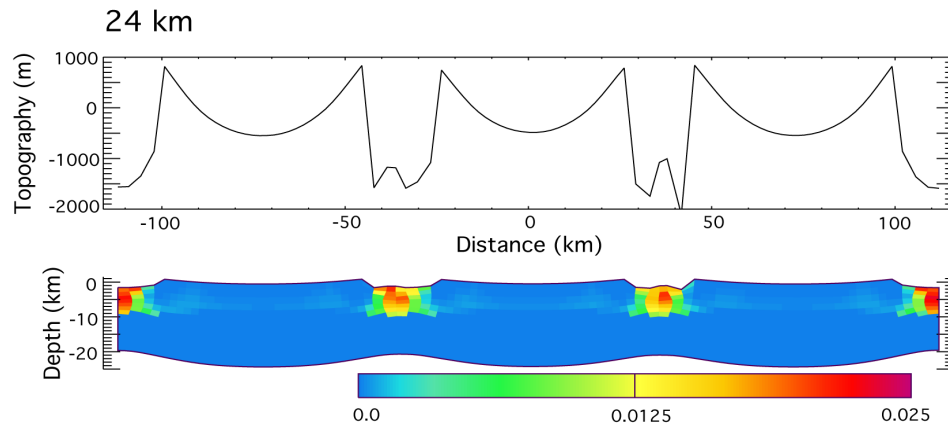
Manatschal & Bernoulli 1999





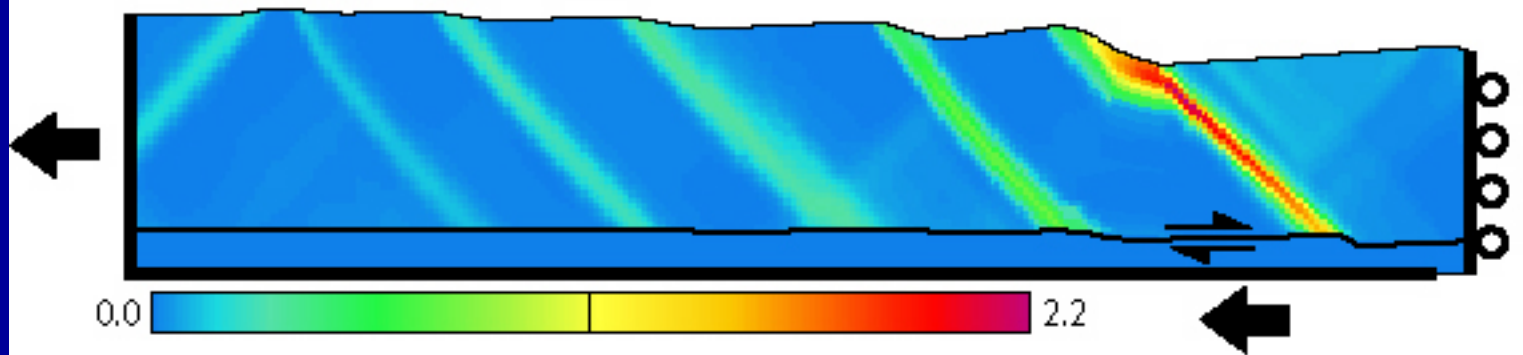
A.

Br 1

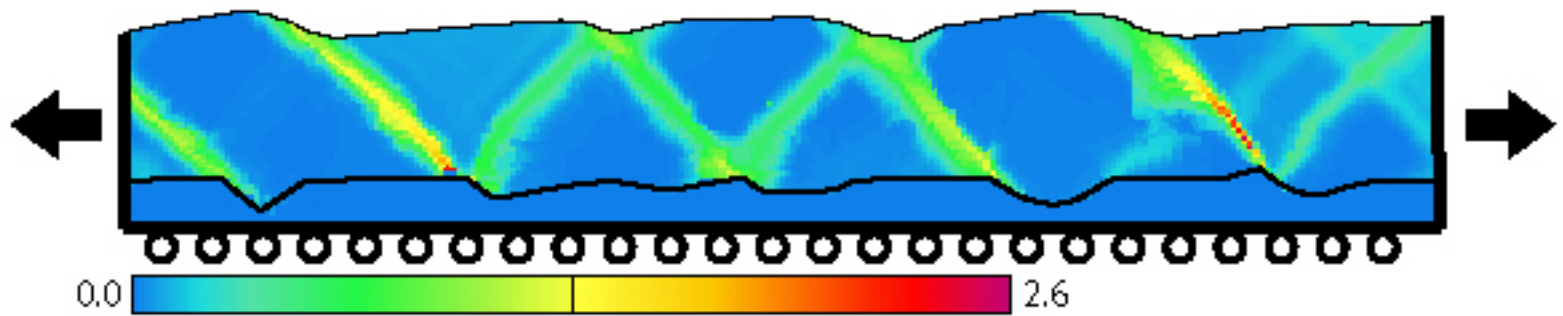




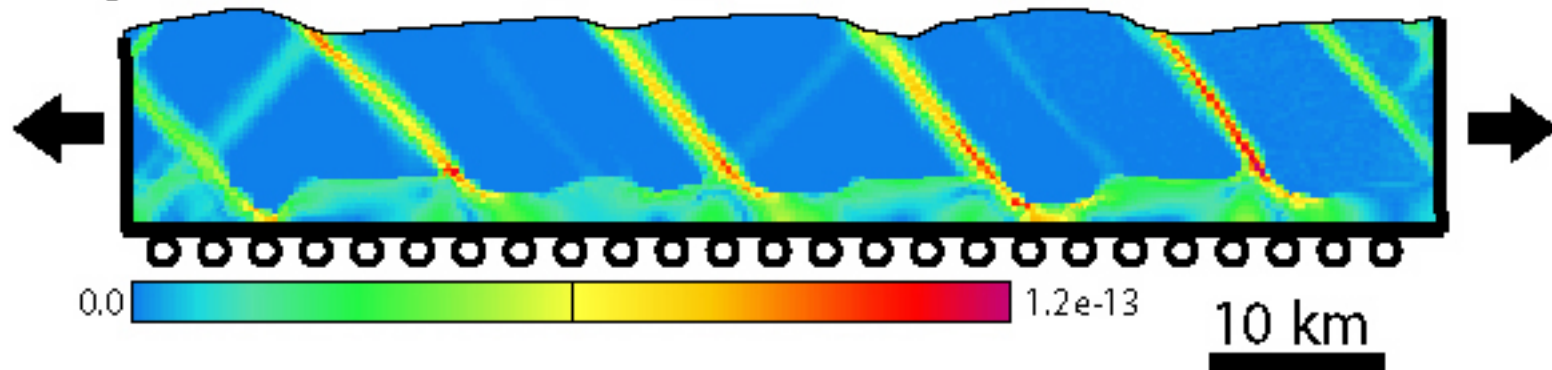
a



b



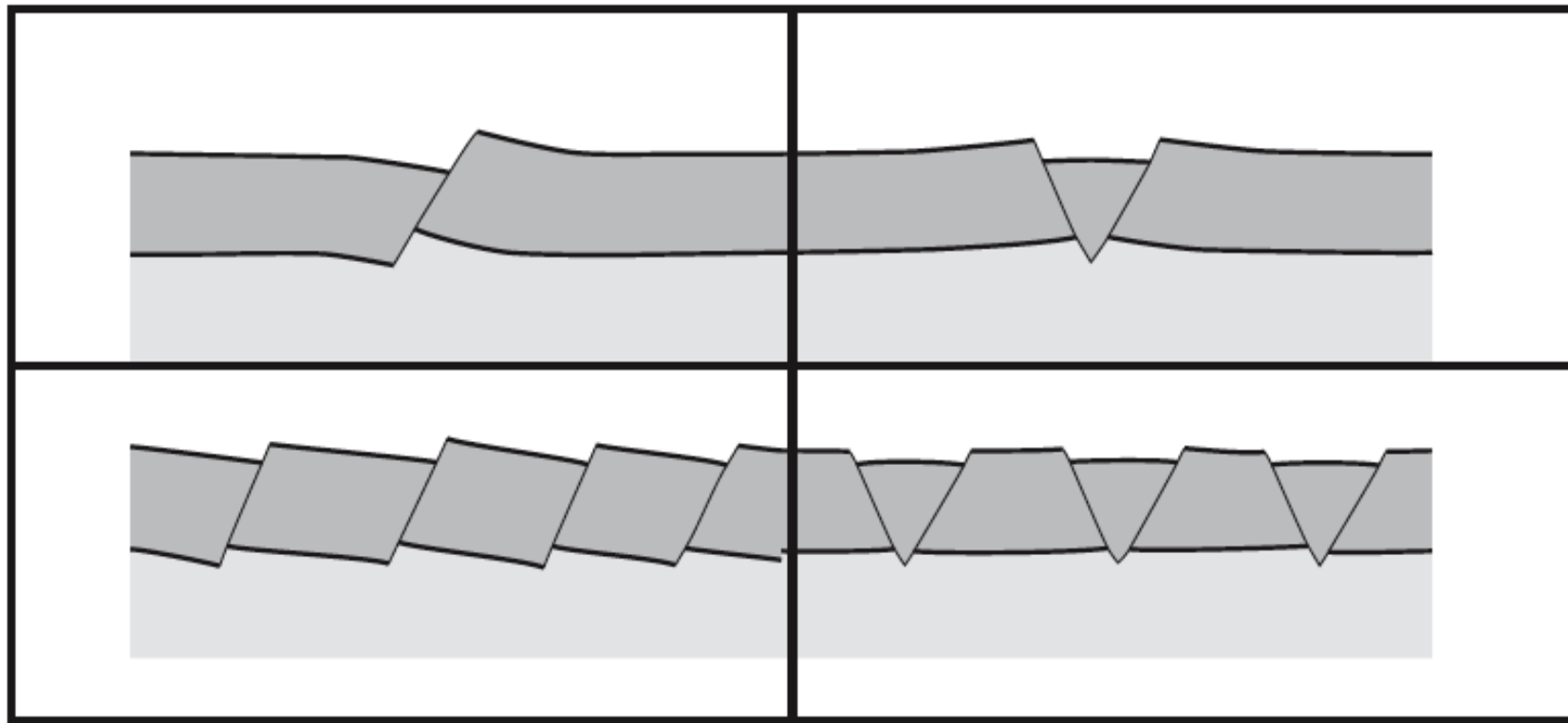
c





Two modes of local necking geometry

decreasing wavelength of necking (boudinage)



# Fault Modeling Challenges

Rheology and the link to fault geometry 2D

3D Models of fault patterns

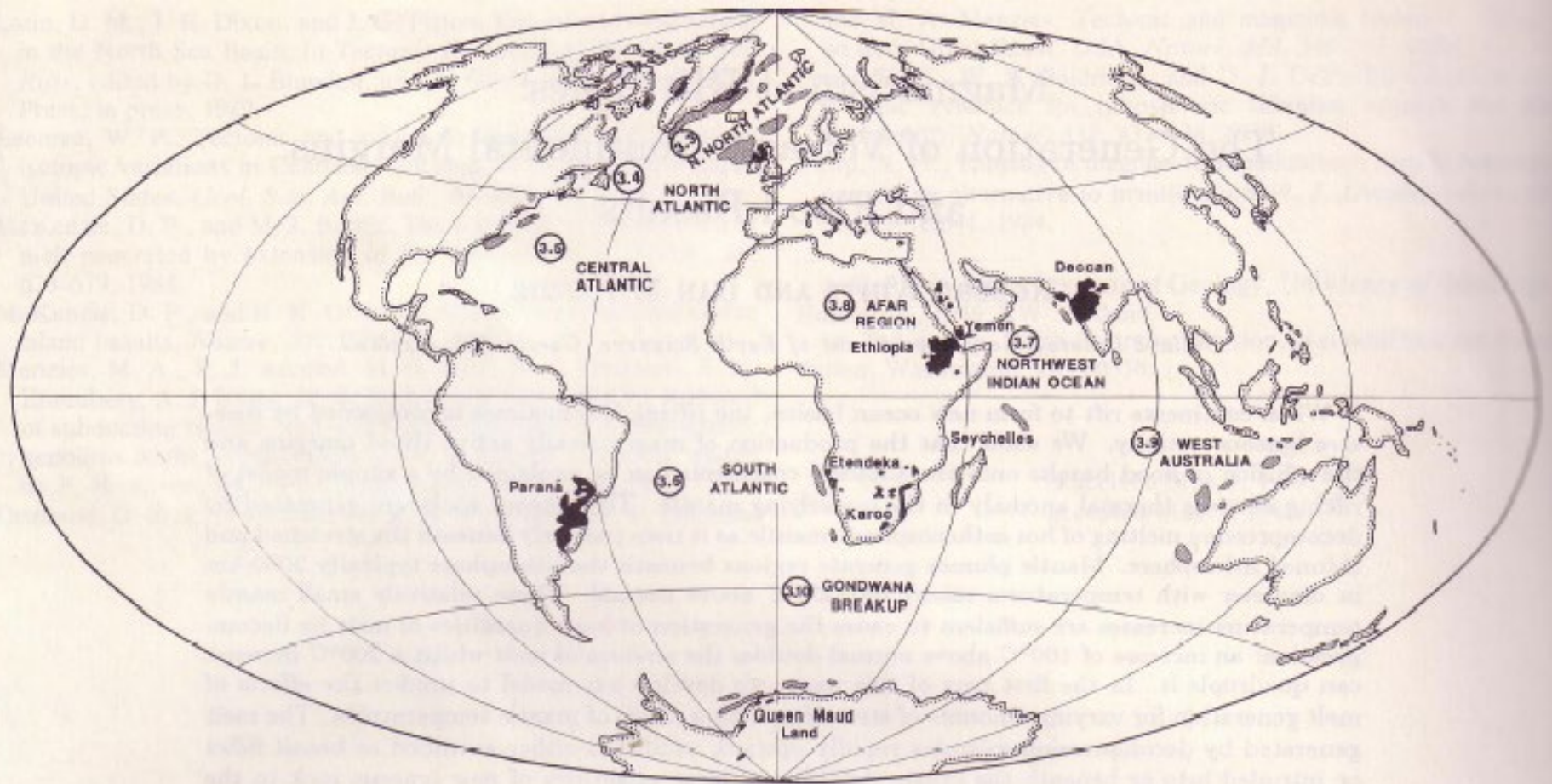
## Biggest Problem For Extensional Models:

- 95% of models are amagmatic

- 95% of plate separation is by dikes

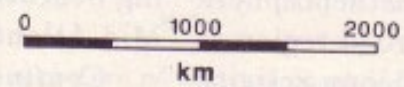
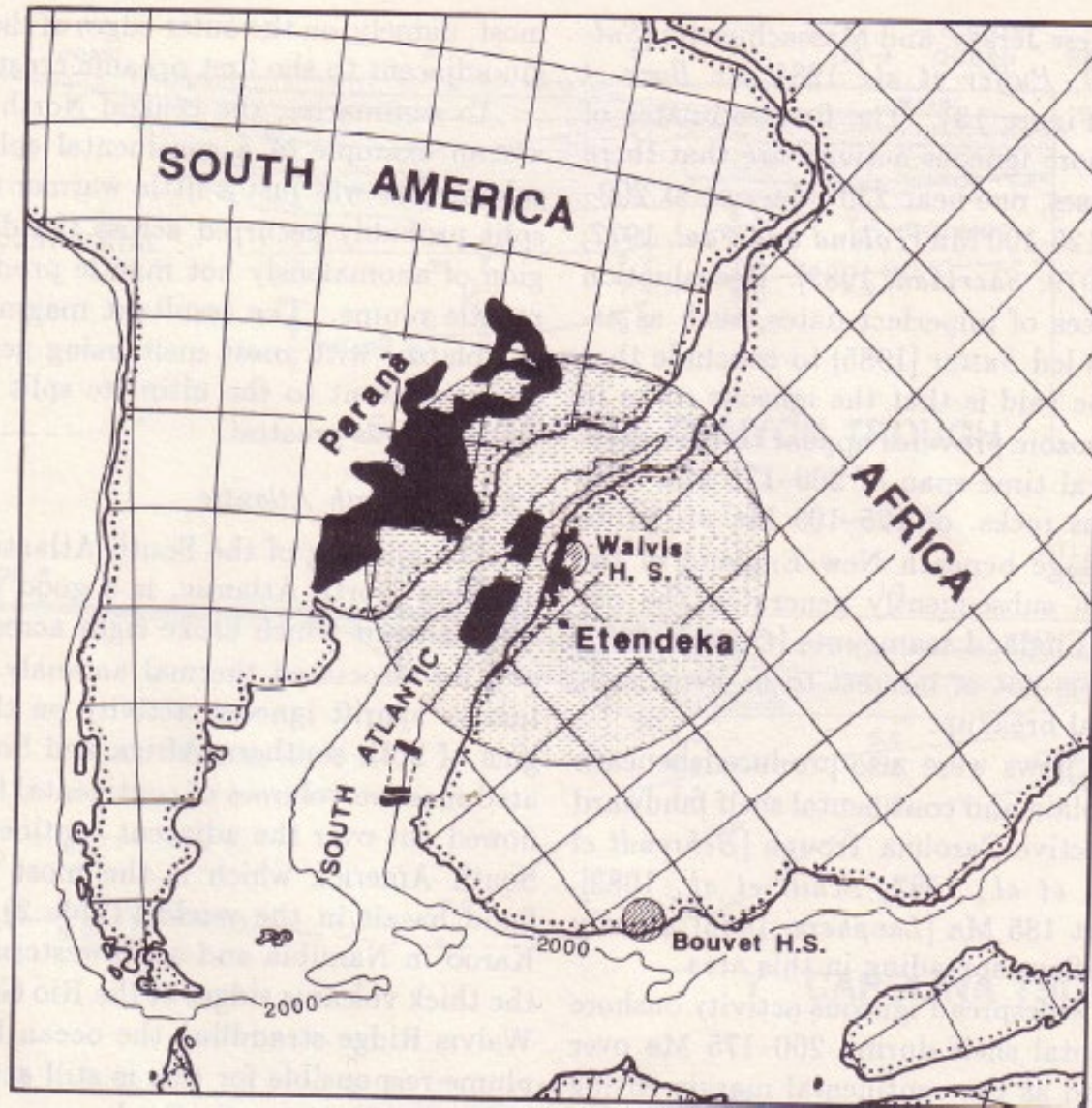
  - both for ridges and rifts



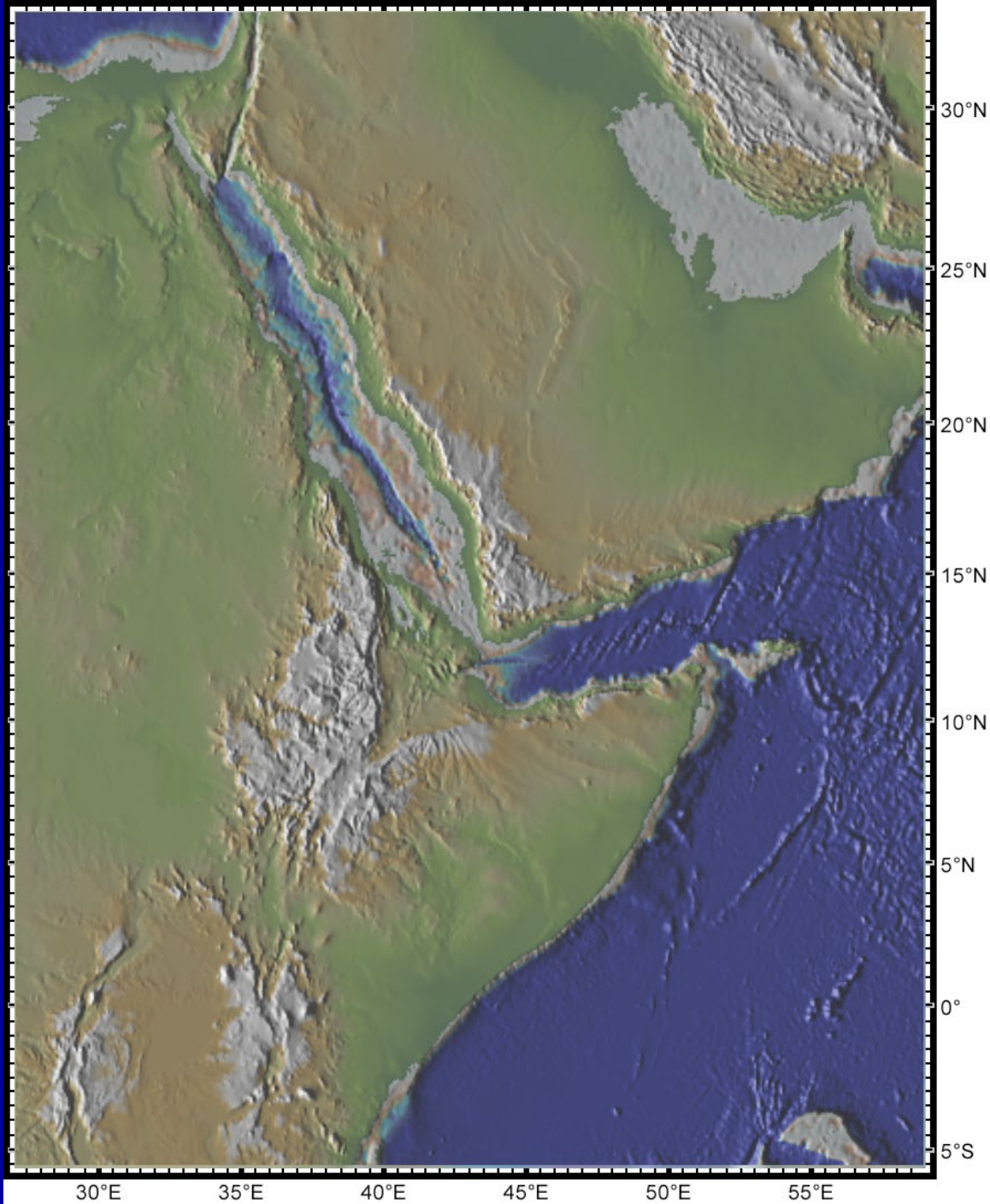


WHITE AND M<sup>c</sup>KENZIE: MAGMATISM AT RIFT ZONES

WHITE AND M<sup>c</sup>KENZIE: MAGMATISM AT RIFT ZONES

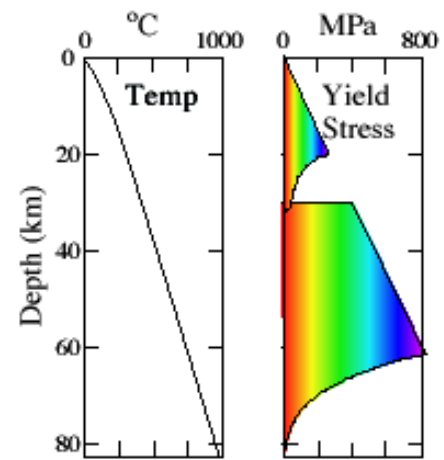
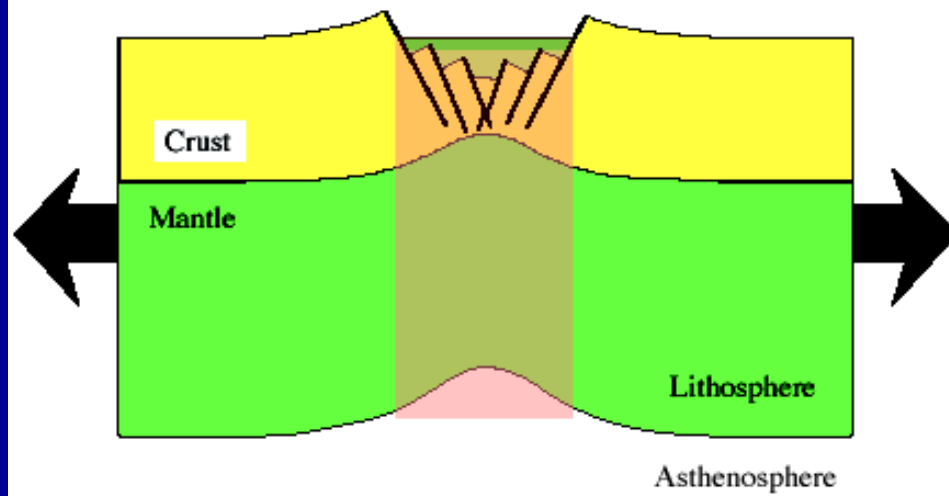




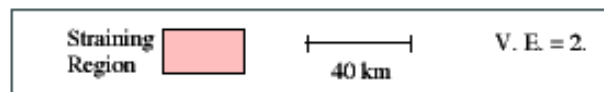
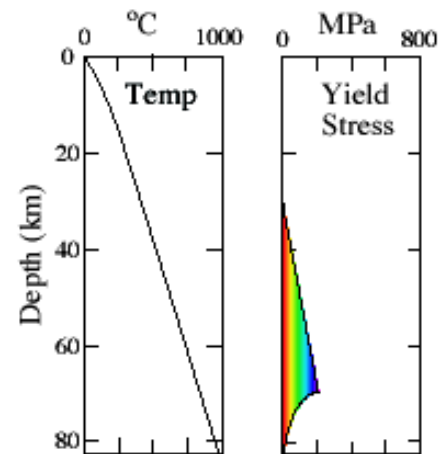
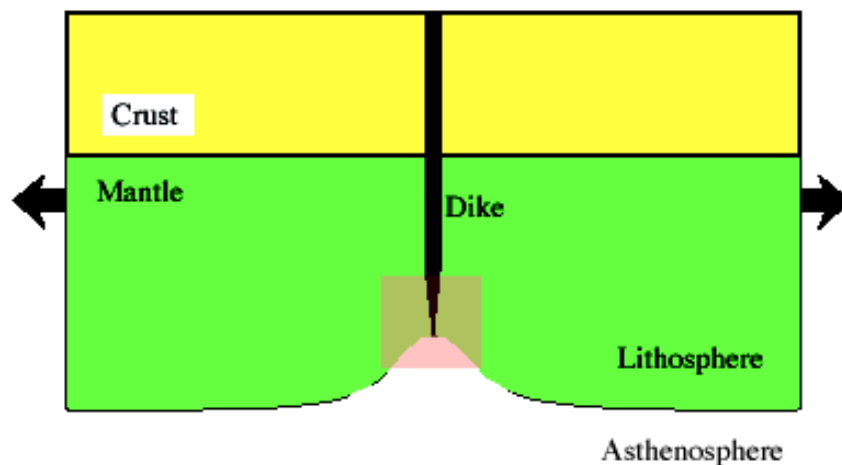




## Tectonic Stretching

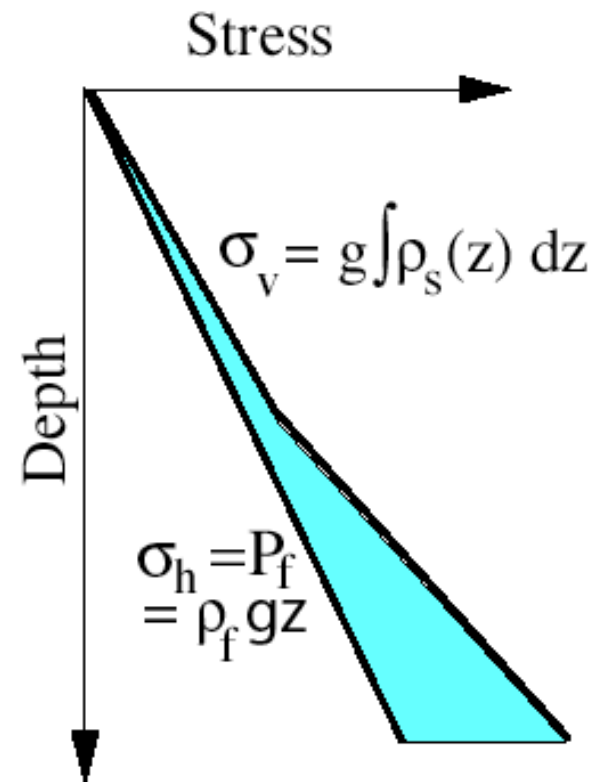
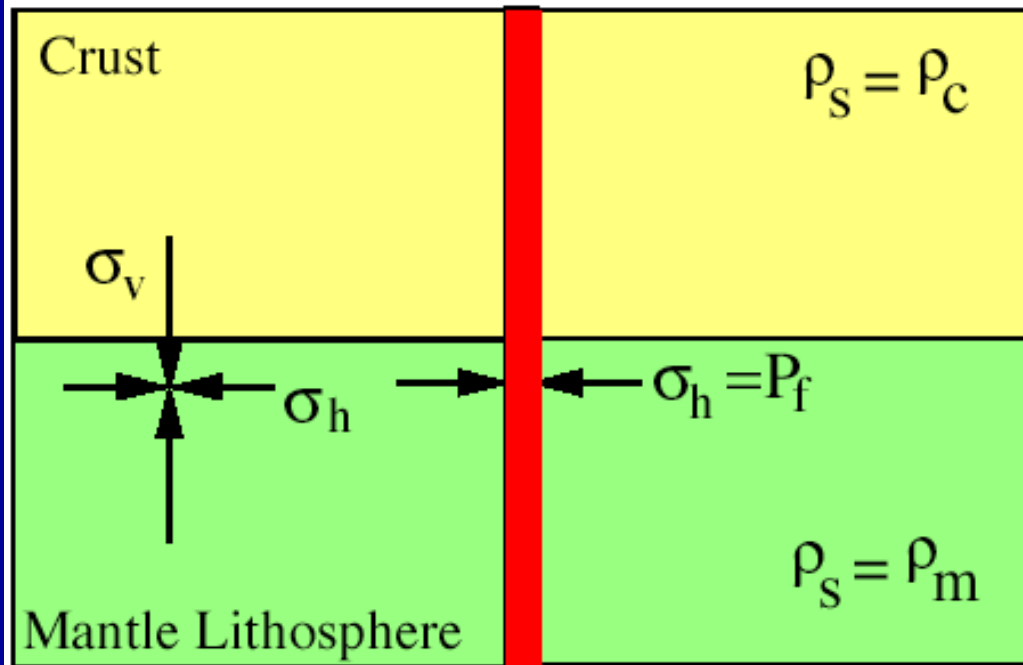


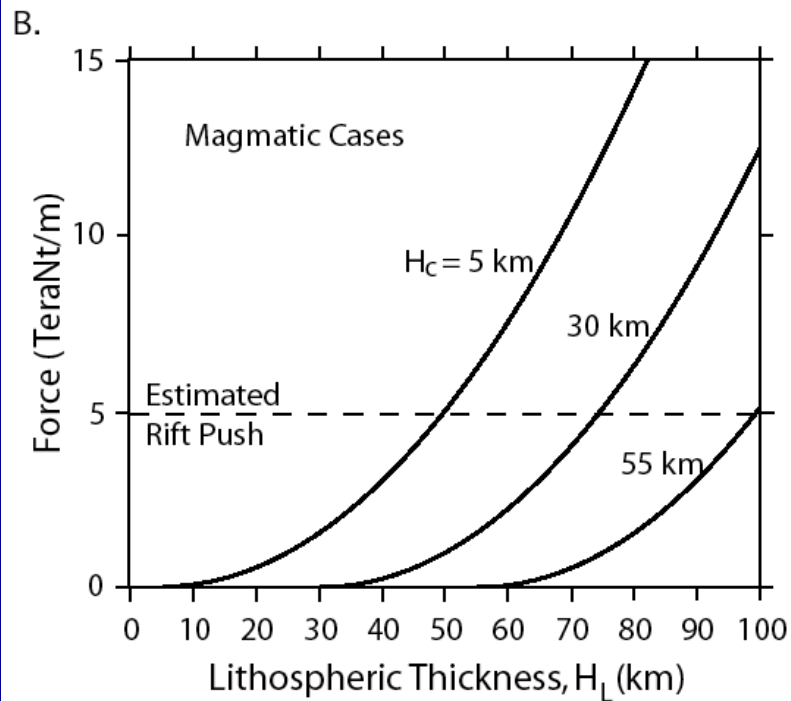
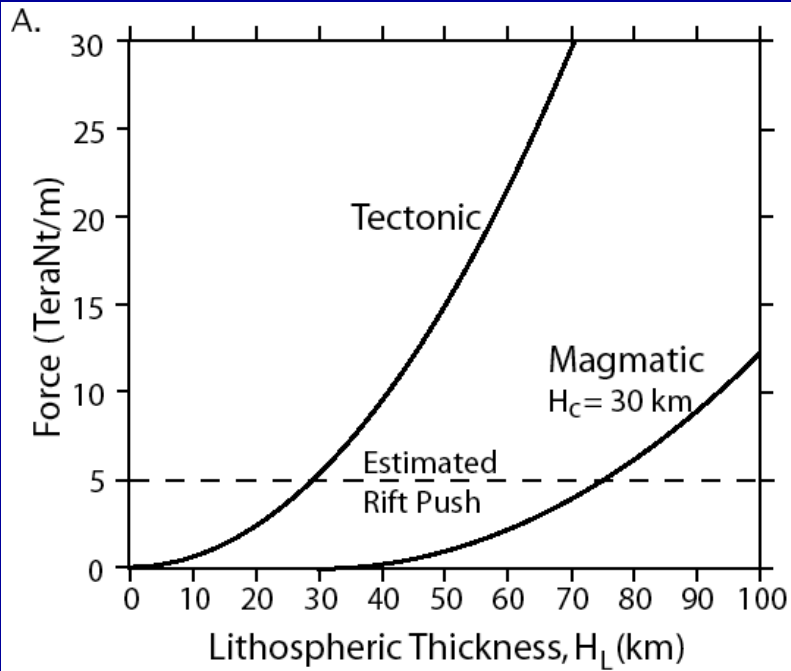
## Magmatic Extension



# Minimum Stress for Opening Dike

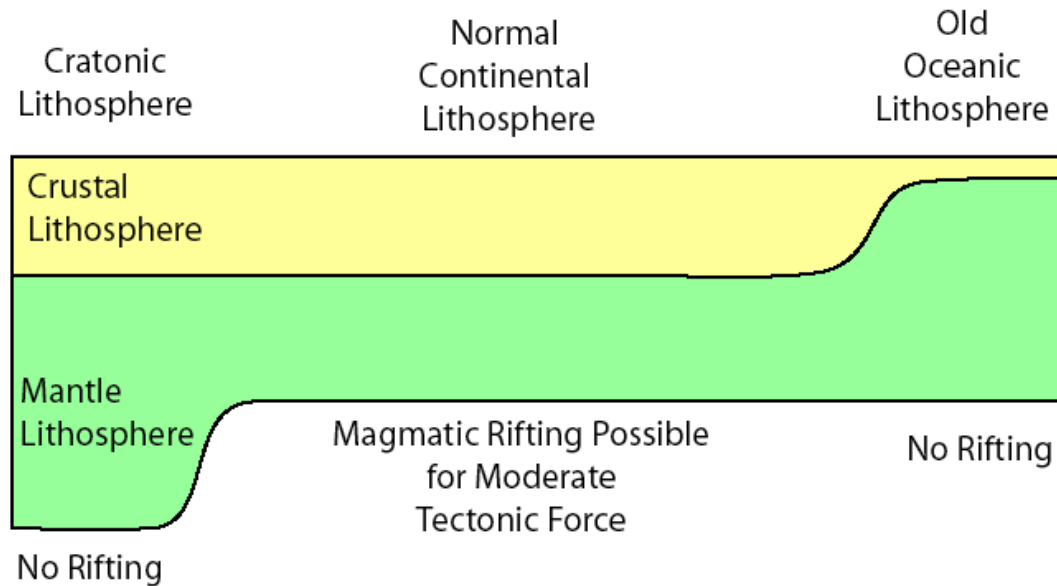
Dike Filled with  
Magma of Density  $\rho_f$



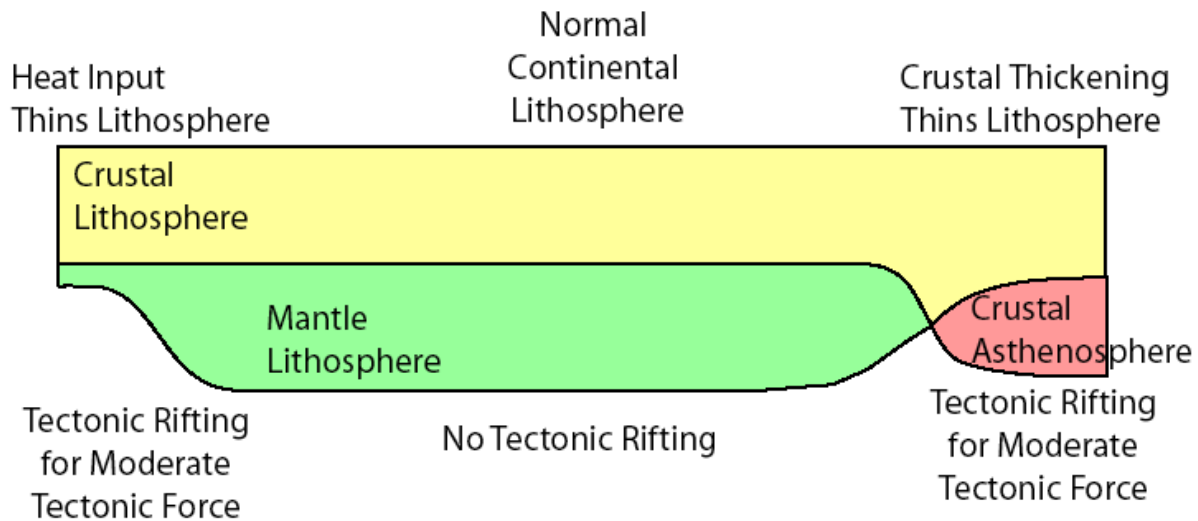


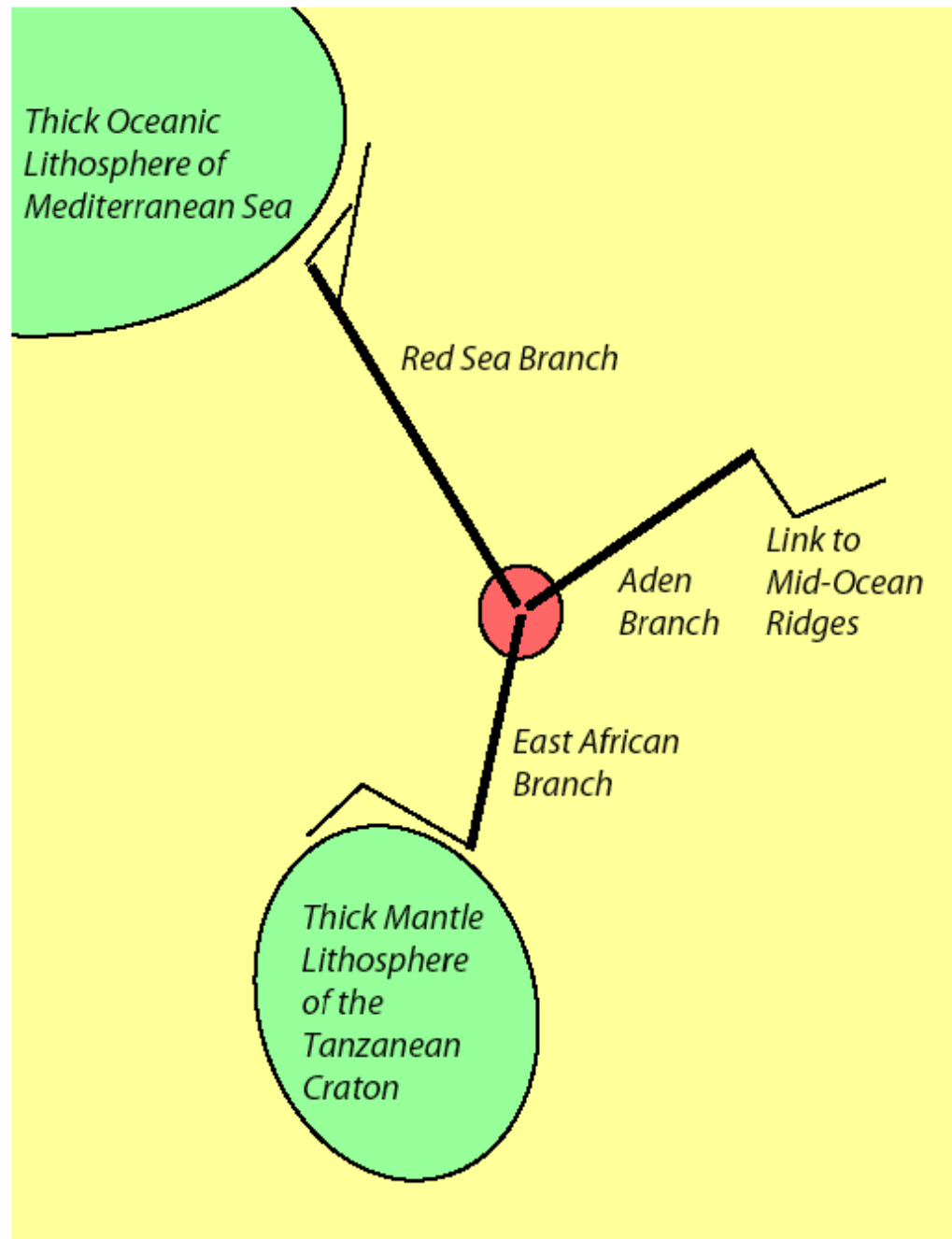


### A. Limits on Magmatic Rifting



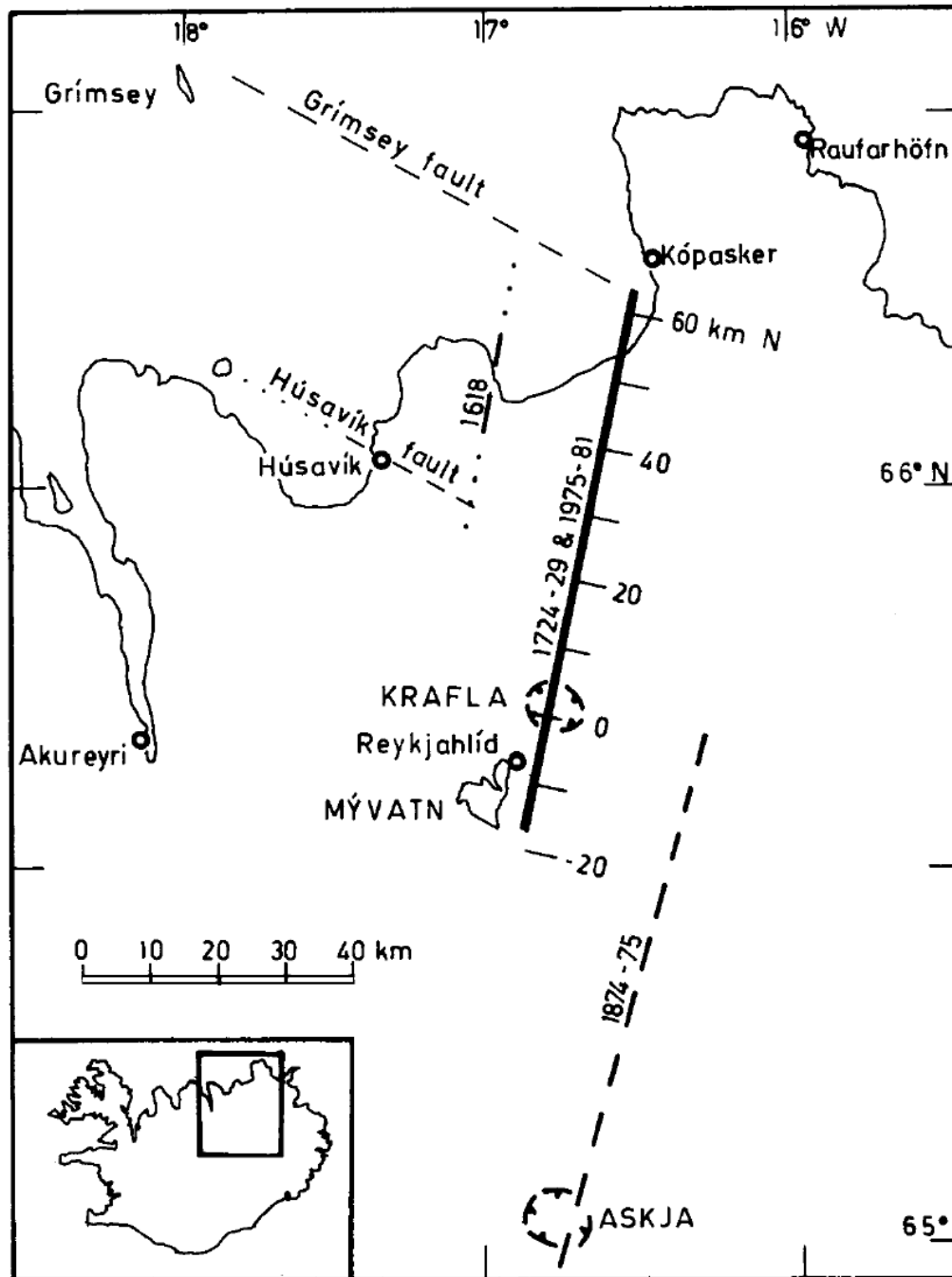
### B. Limits on Tectonic Rifting



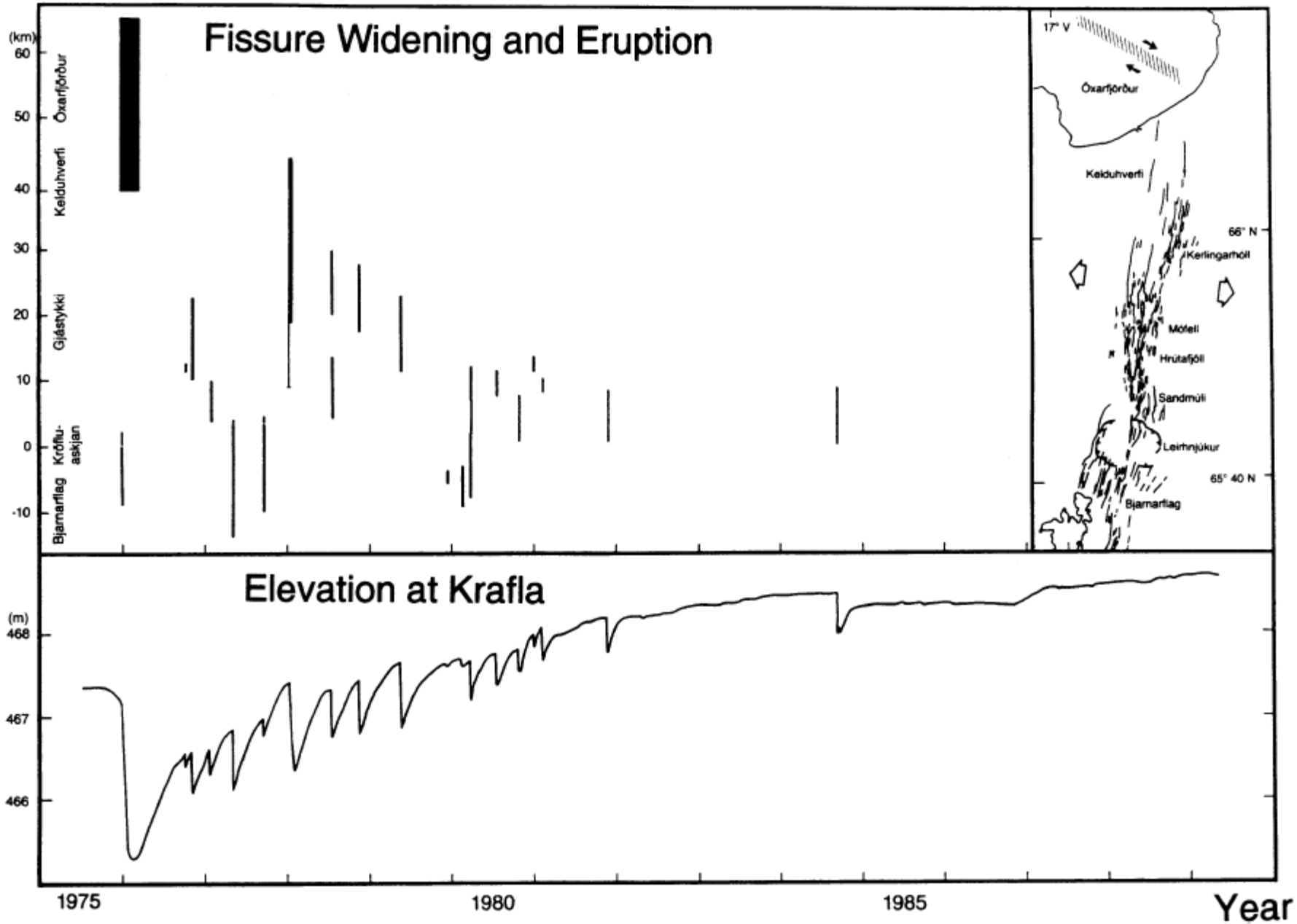


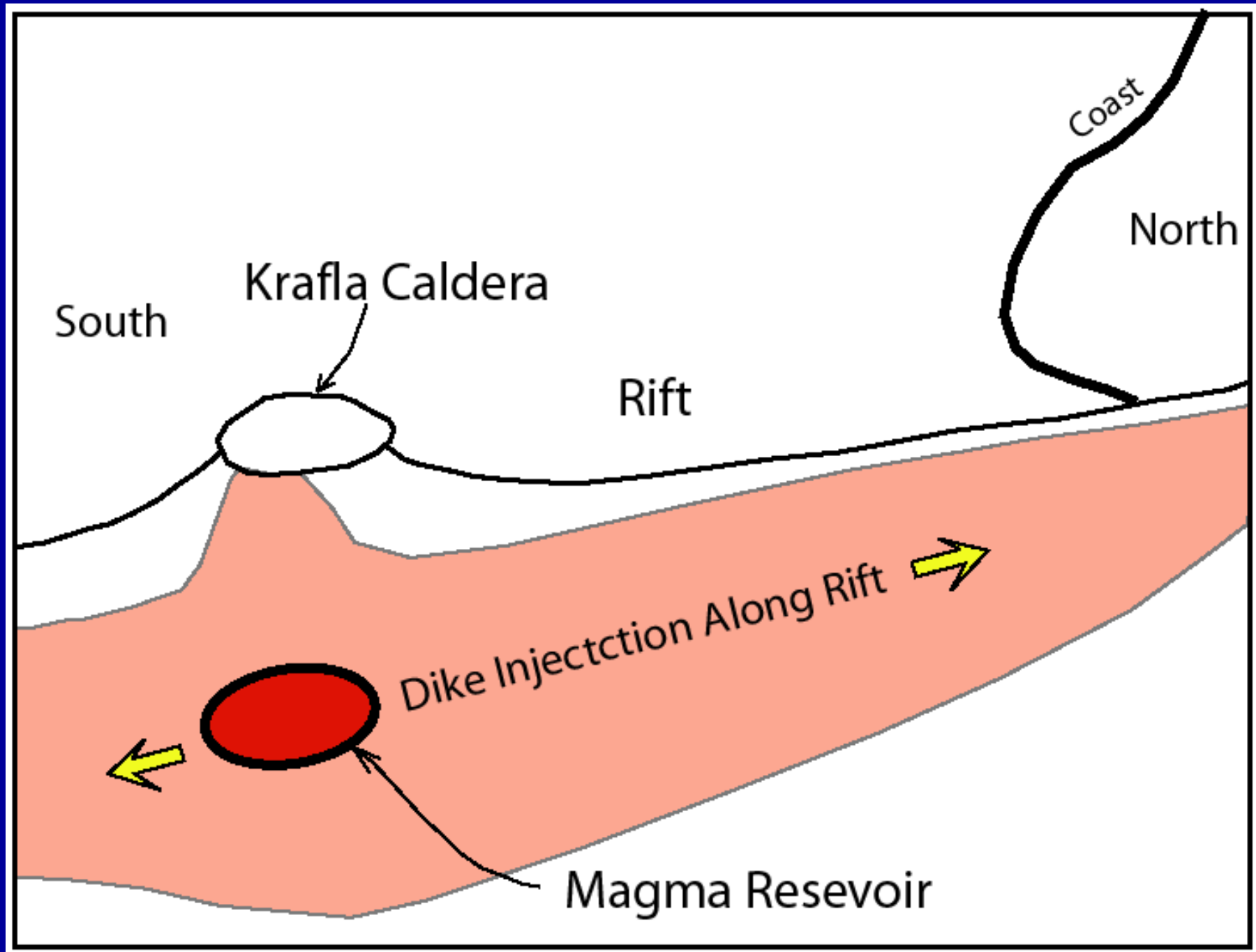


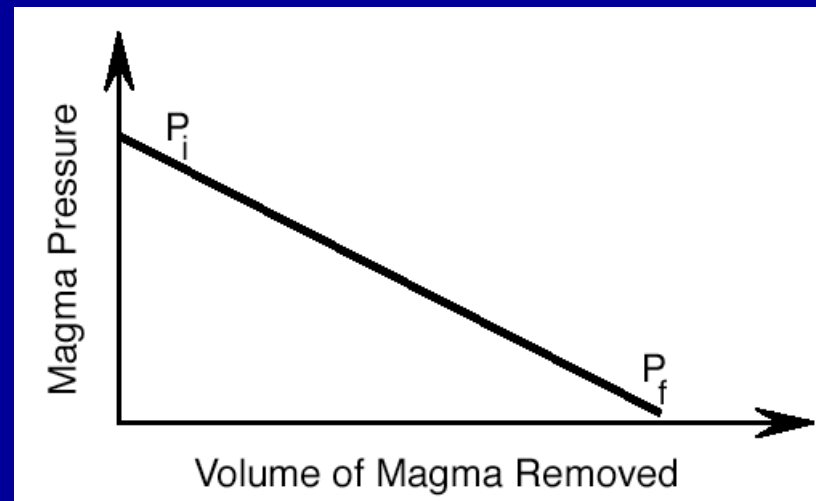
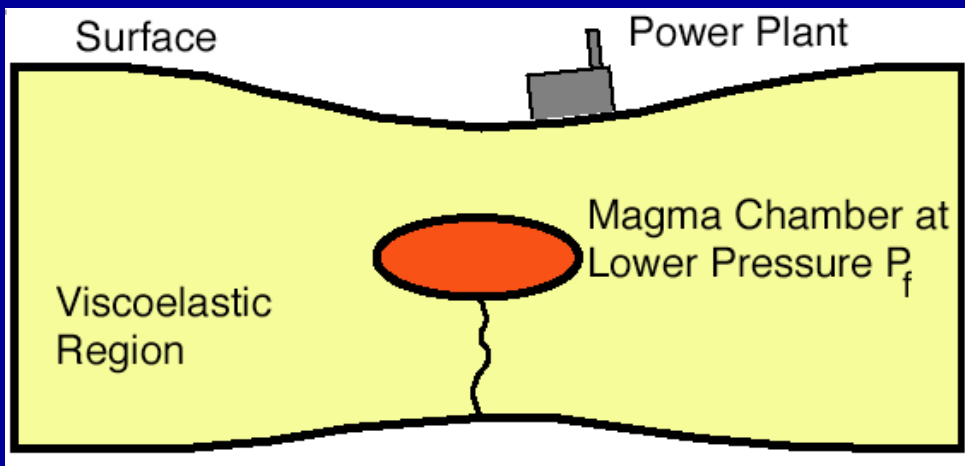
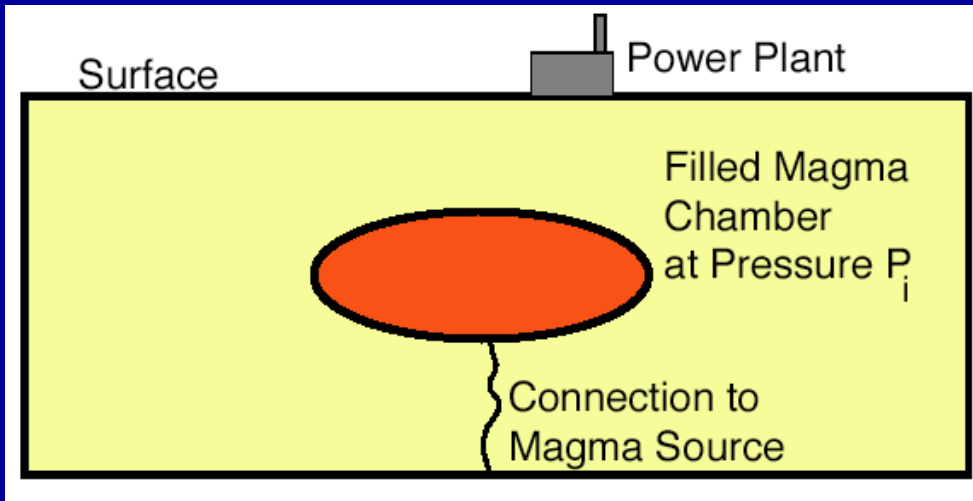
**Thorarinsson September 8, 1977**



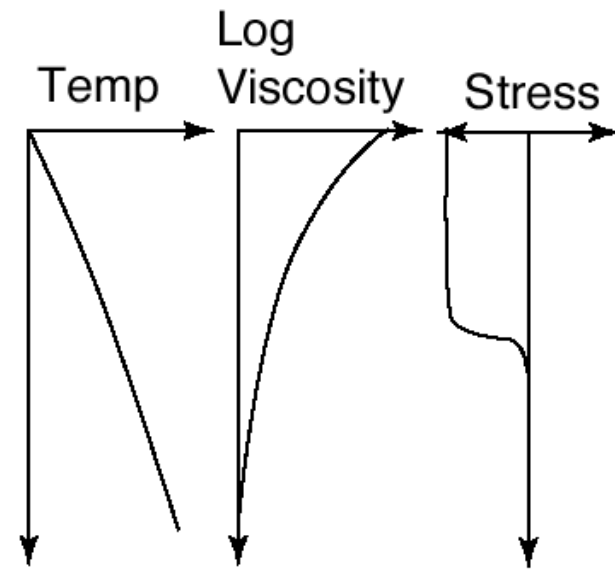
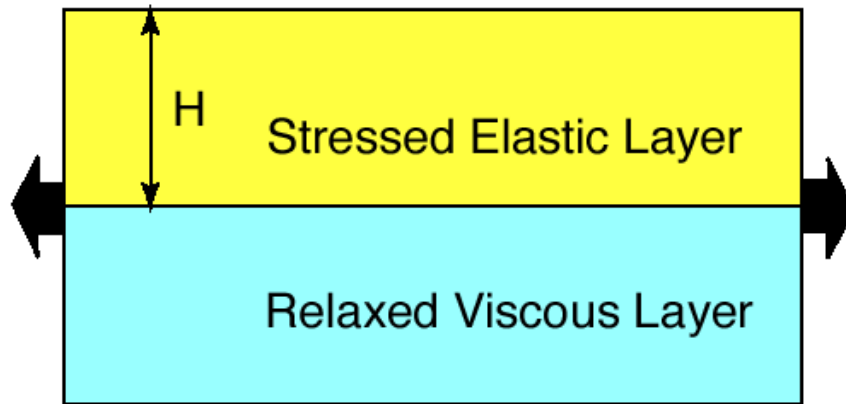




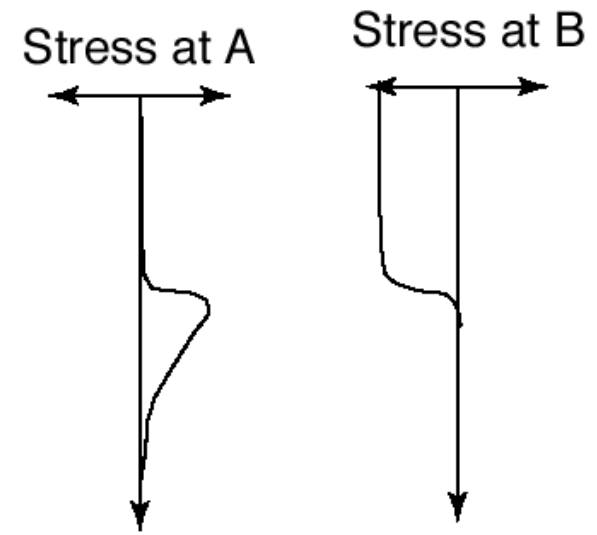
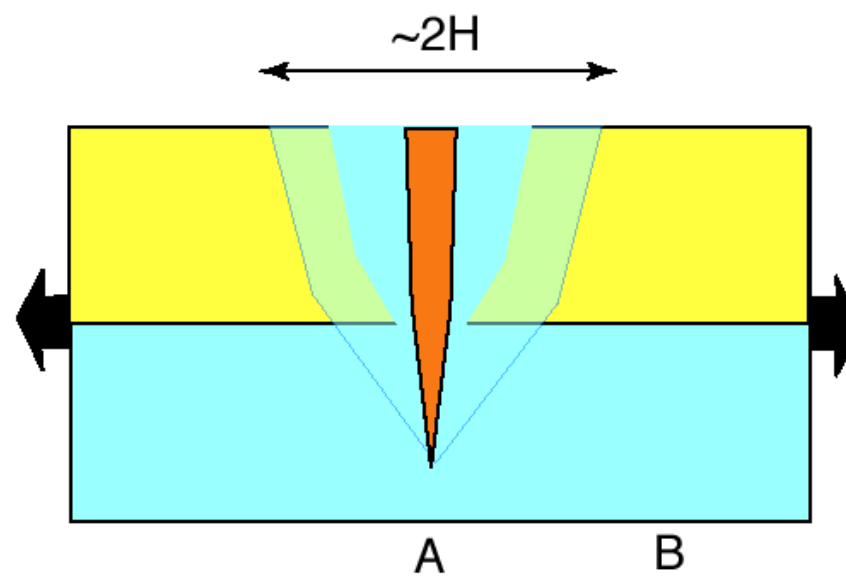




A. After Finite Loading Time  
(10-100's of years)

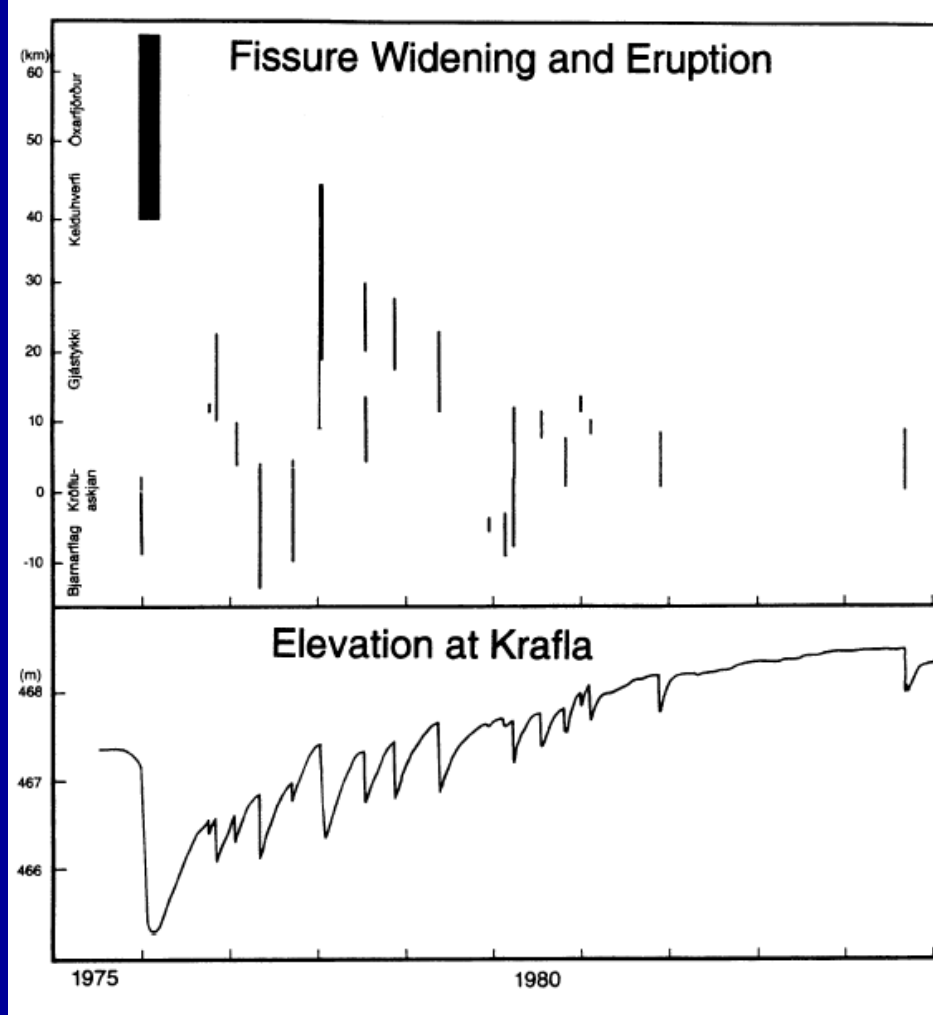
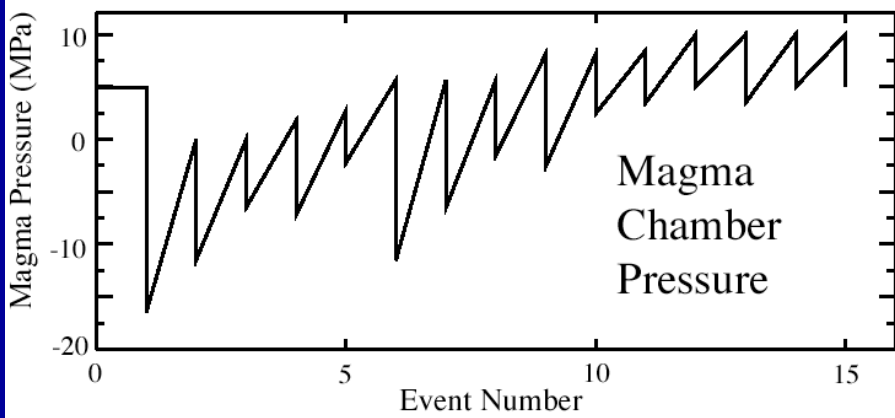
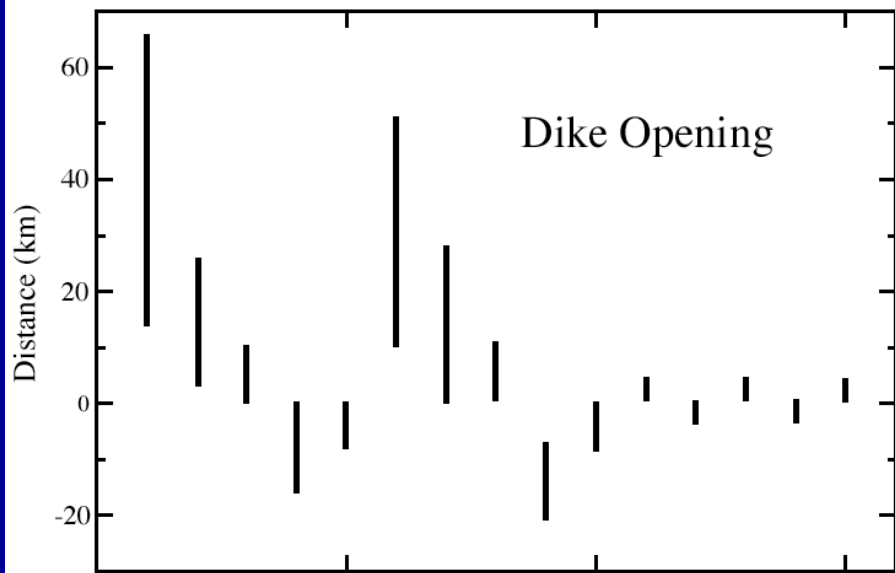


B. After Sudden Dike Intrusion  
(hours-weeks)





$T = 5 \text{ MPa}$ ,  $\Delta P = 10 \text{ MPa}$



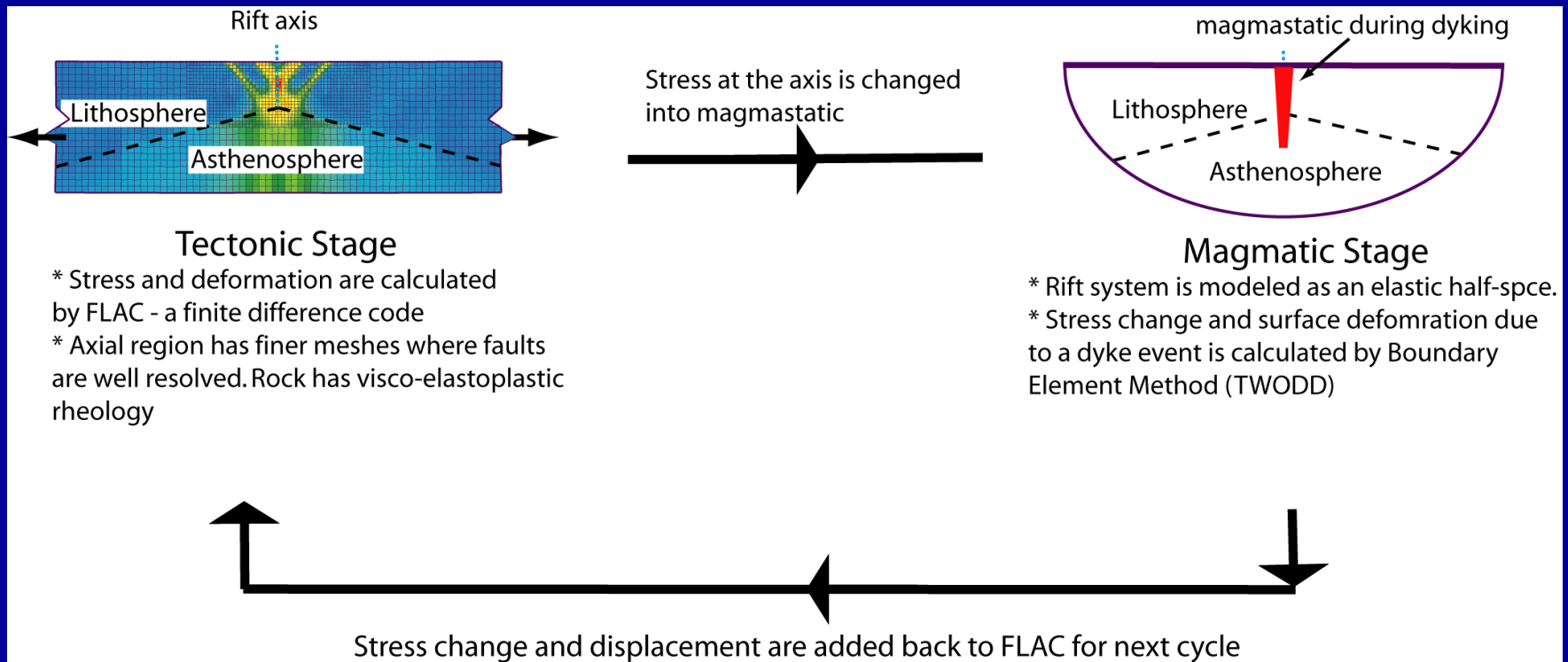
### Small Magma Chamber - Short Dikes



### Large (and shallow) Magma Chamber - Long Dikes

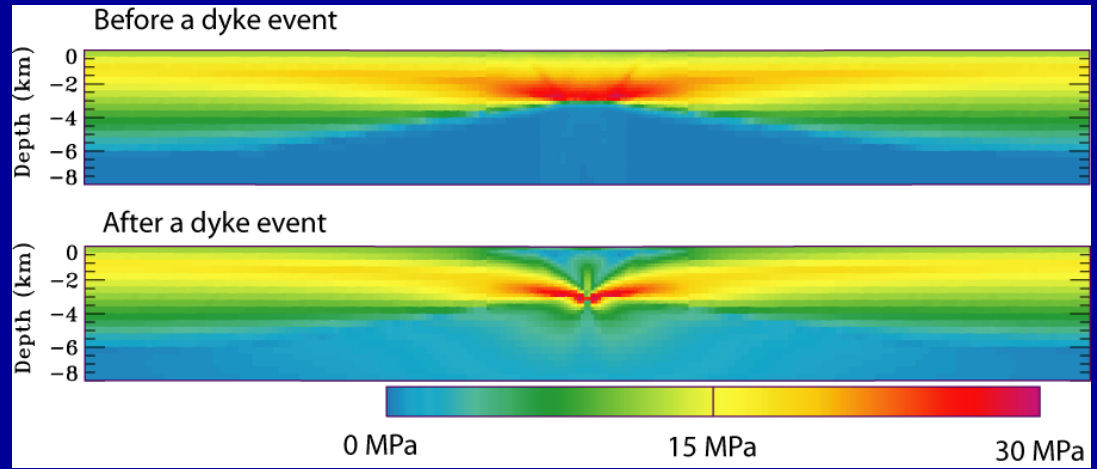


# Coupled modeling of faulting and magmatic processes (an alternative)



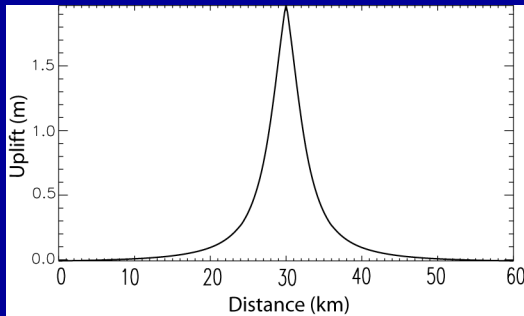
# System response to a single dyke event

Maximum shear stress (Deviatoric stress) Changes due to a dyke event

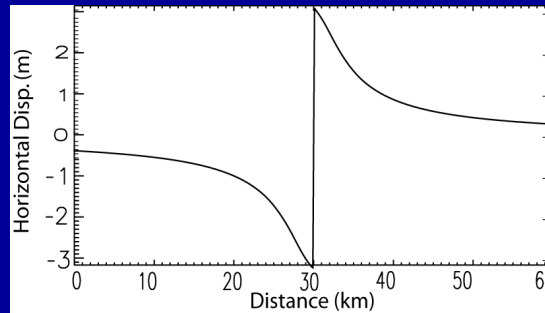


## Surface Deformation

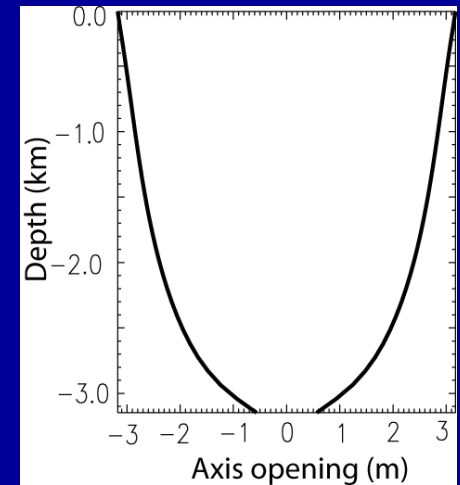
### Uplift



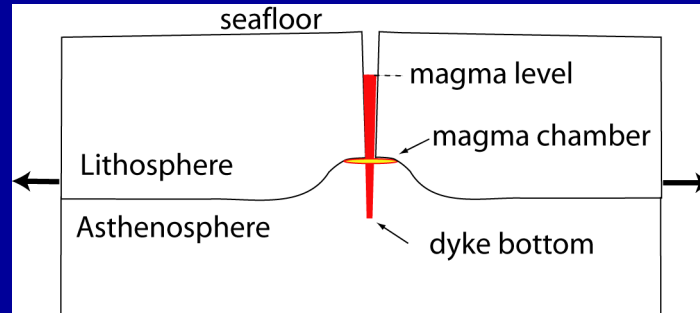
### Horizontal extension



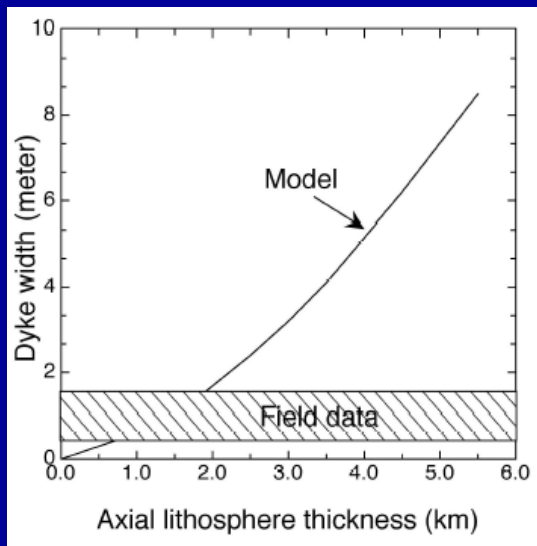
## Opening of the axis



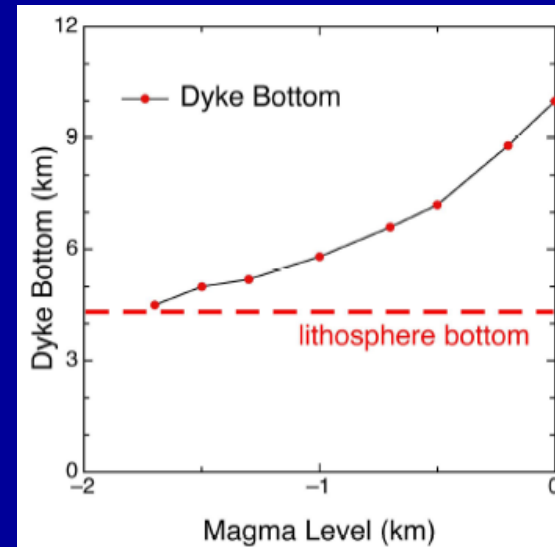
# System response to a single dyke event



## Dyke thickness



## Downward penetration of dyke

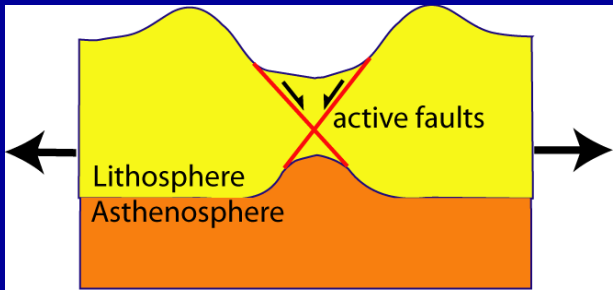




# Big Challenge for Extensional Modeling

- 3D Dike and fault propagation
- Distance of dike propagation
- Effect of dike stress changes on fault patterns
- Thermal effect of diking

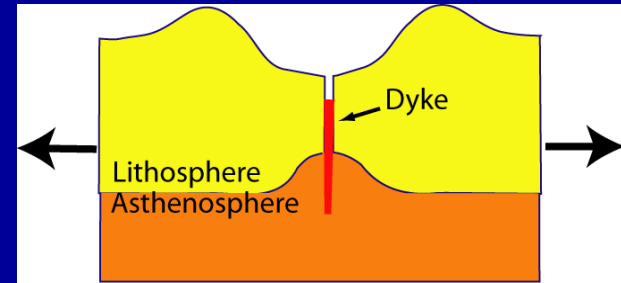
# Coupled modeling of faulting and magmatic processes



## Tectonic Stretching

Normal faults form, modeled by Finite Difference Program FLAC.

A dyke  
breaks out



## Magmatic accretion

Dyke is modeled by Boundary Element Program TWODD. Deformation and stress change are feed back to FLAC

Strain rate imposed on meshes (denser meshes at the axis)

