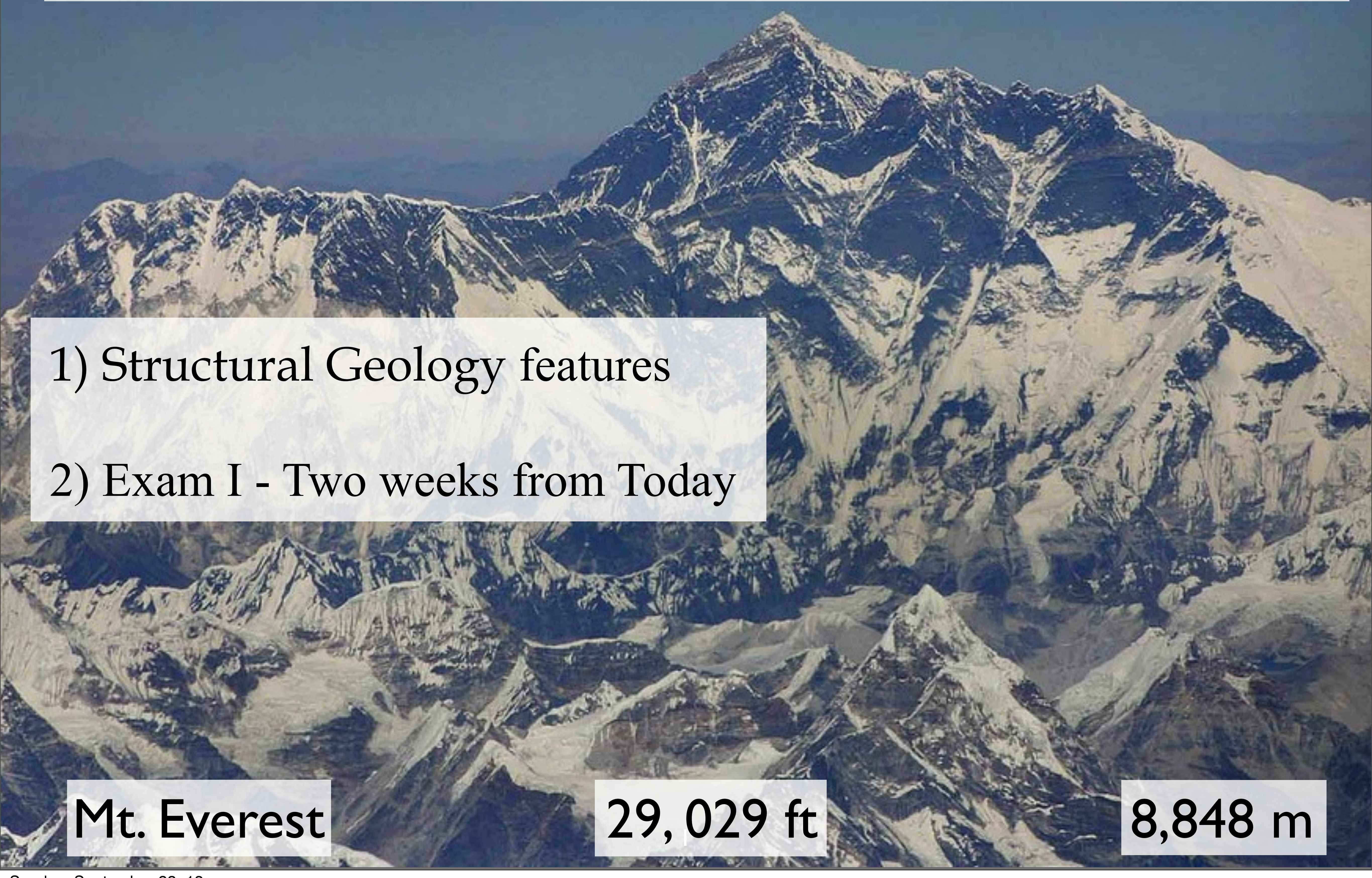
Structural Geology and Deformation

Chapter 9

1) Structural Geology features

2) Exam I - Two weeks from Today



1) Ophiolite, ~100 Ma translate a subduction zone.

2) The rocks in the bay area are a mixture of the earth from all over. Making land filling over time.

2) The rocks around the bay area have different compositions, but serpentine tells us that SF used to be underwater.

4) Mostly marine sediments, basalt and serpentinite rocks, it tells us that the Bay Area used to be underwater.

5) Lots of serpentinite tells us that land was once under water.

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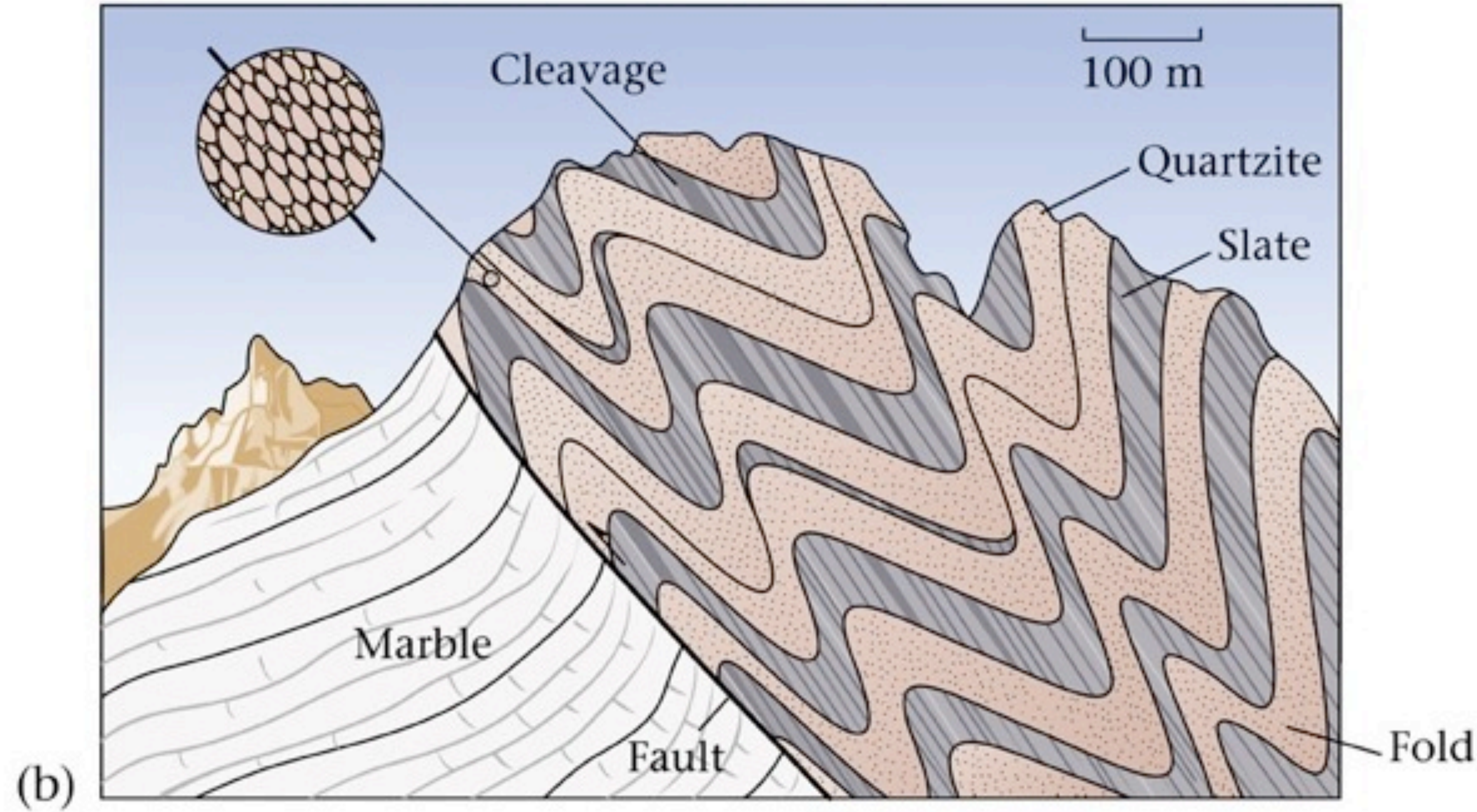
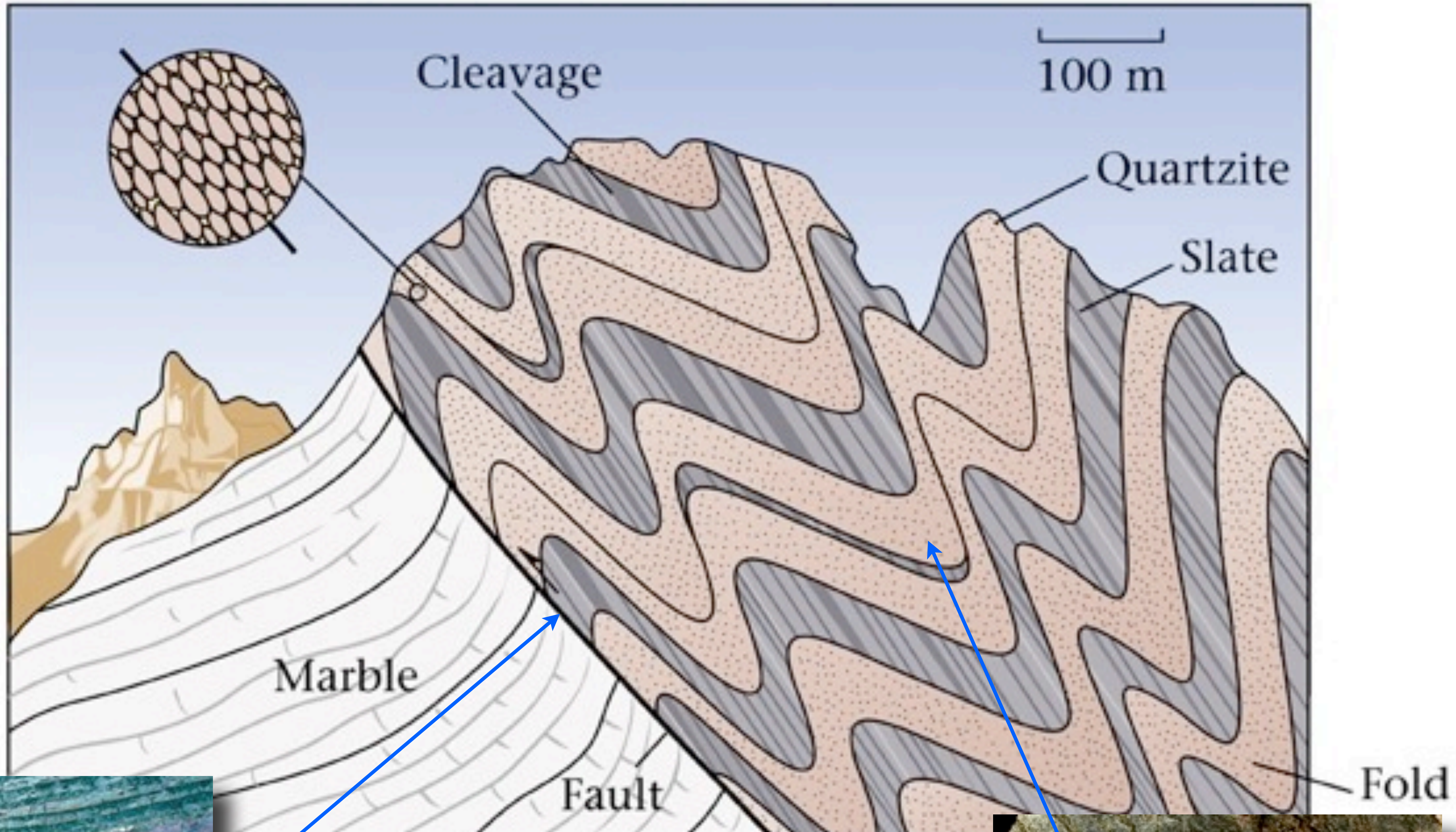
5) Lots of serpentinite tells us that land was once under water.

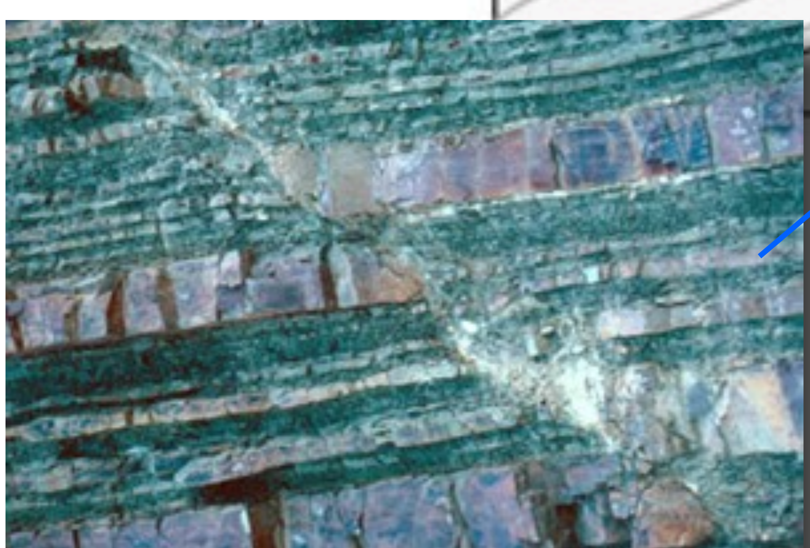
Rocks in the Bay Area are composed of basalt, ocean sediment, and serpentinite, which are typical of an Oceanic lithosphere (Ophiolite). In order for these rocks to now be a part of the North American continent they must have been scraped off the sea floor in an accretionary wedge, which tells us that the western north america was a subduction zone in the past.

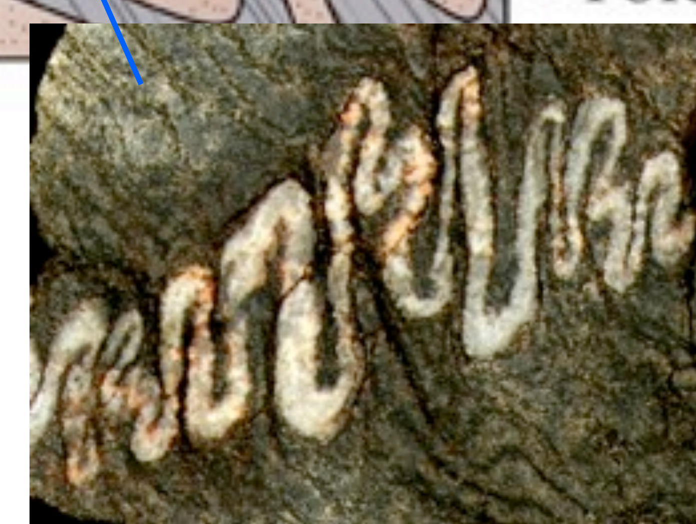
Brittle and Ductile Deformation



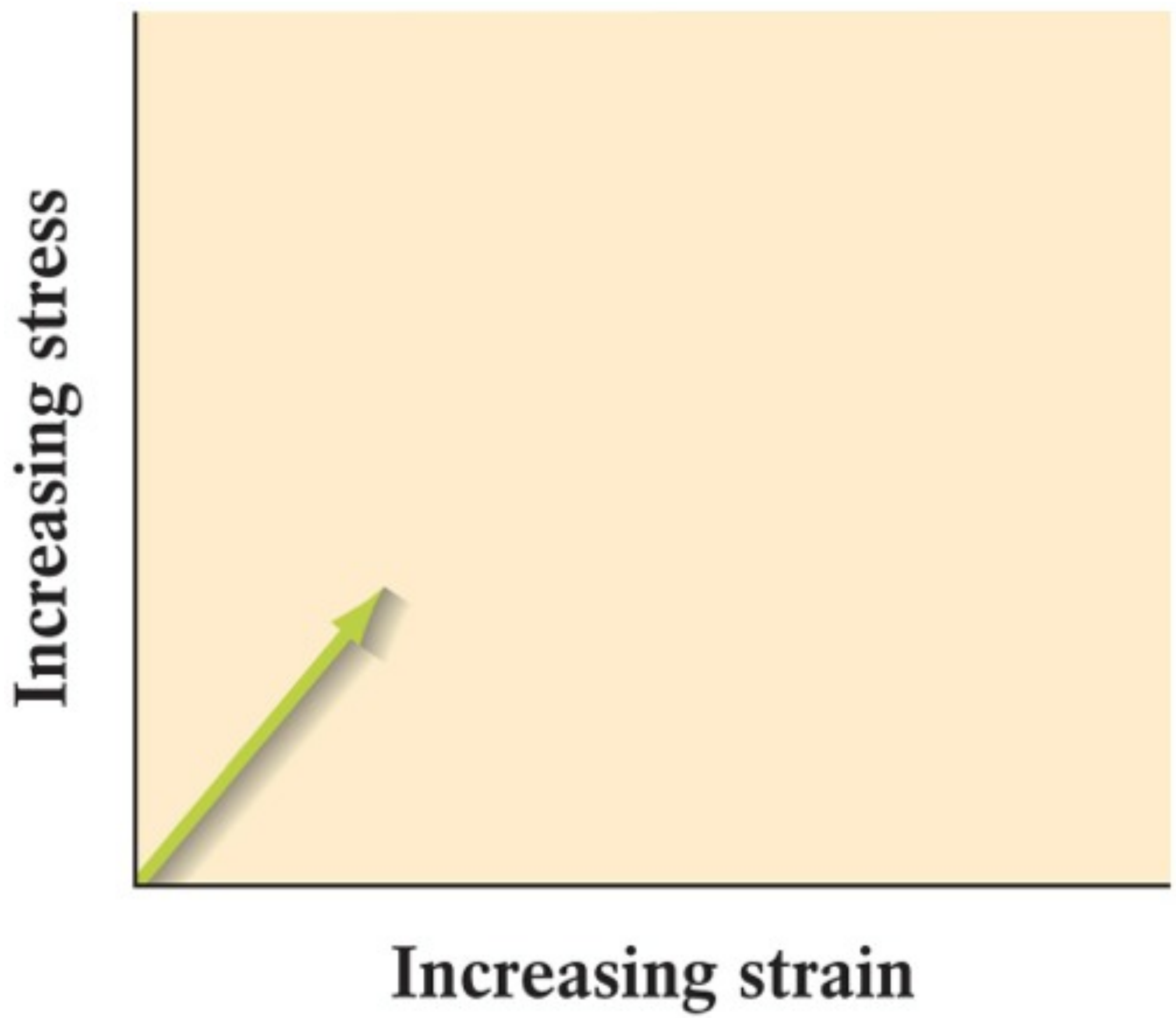
Brittle and Ductile Deformation







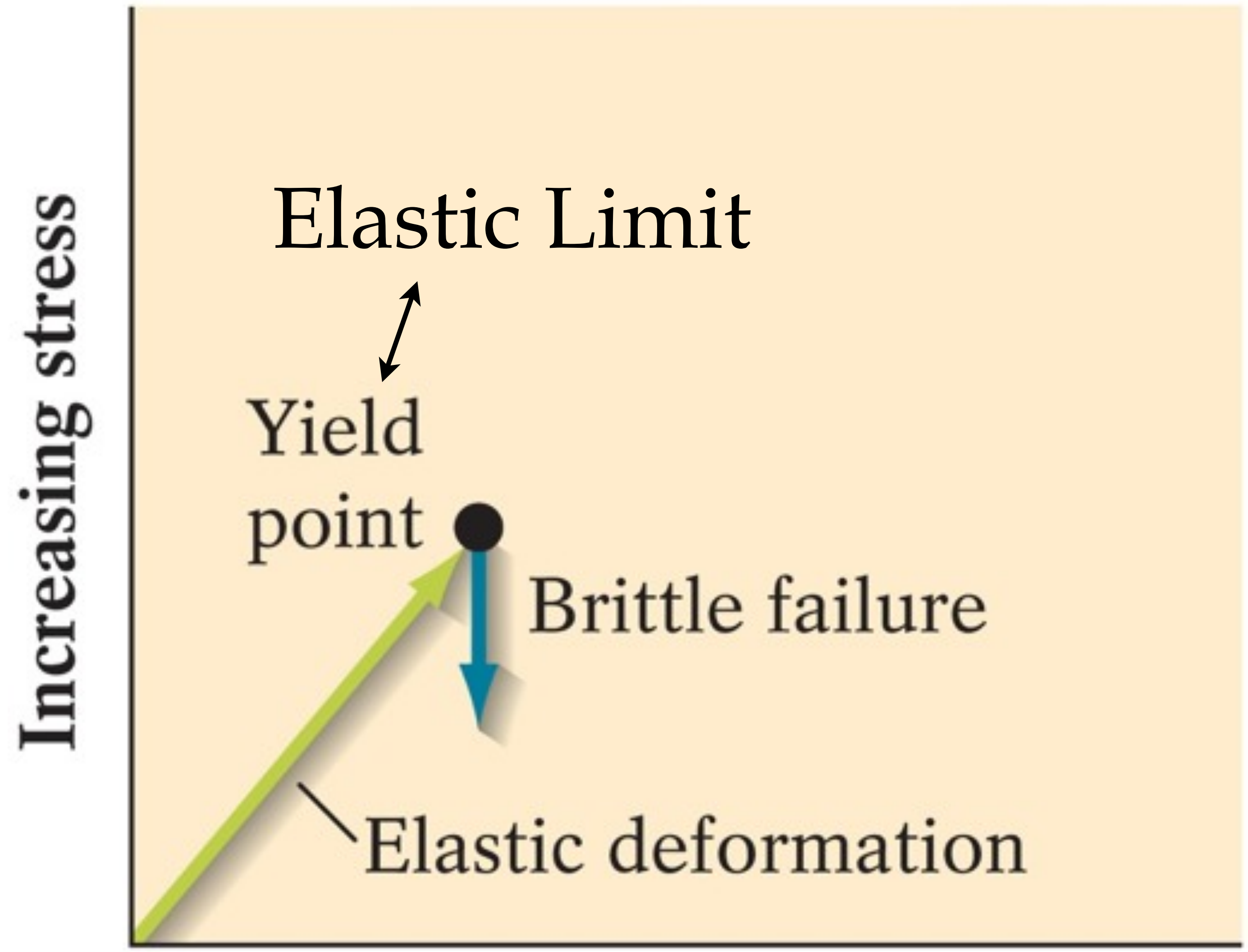
Elastic Strain (recoverable deformation)



(a) Elastic deformation

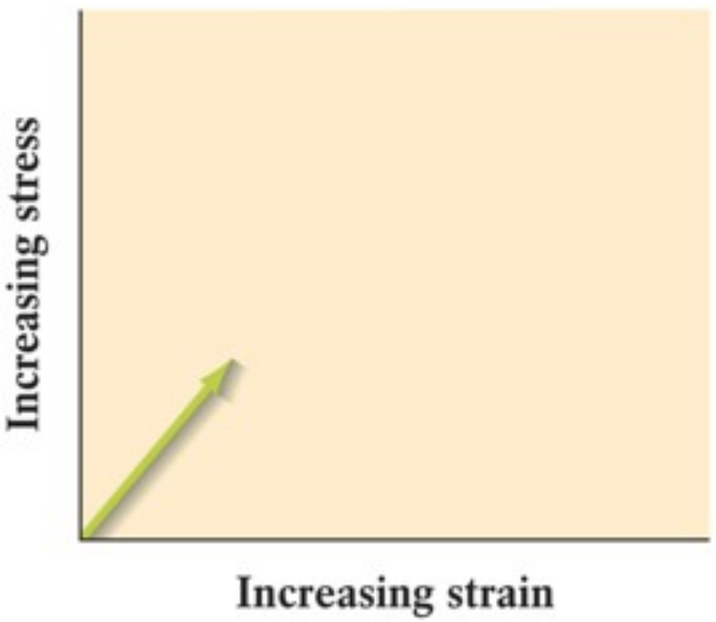
Brittle Strain (non-recoverable)

(a) Elastic deformation

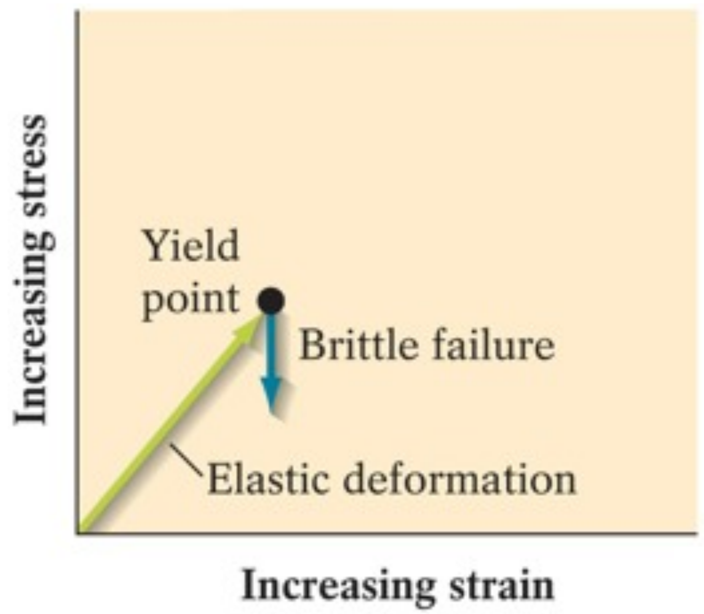


(b) Brittle failure

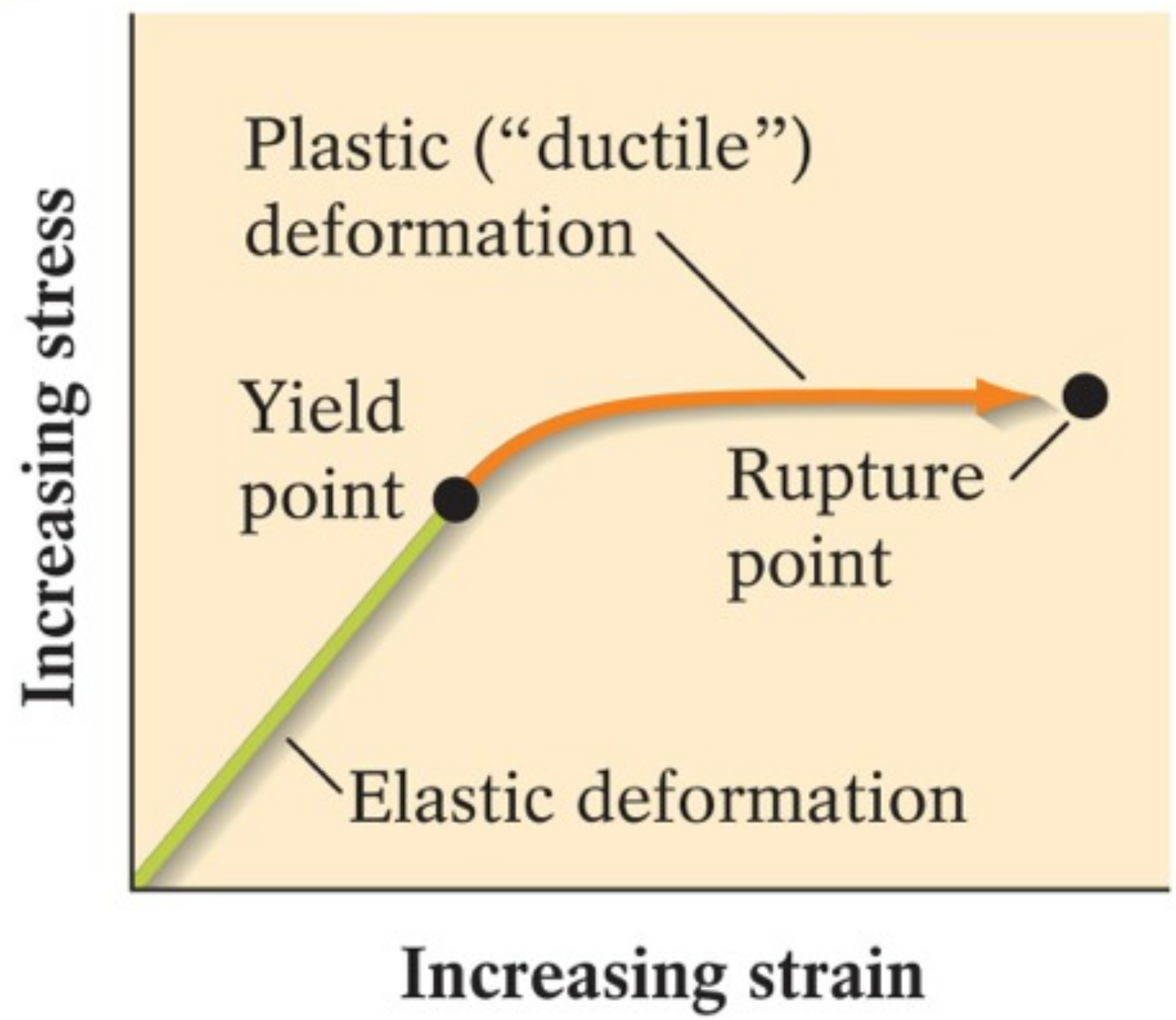
Ductile/plastic strain (non-recoverable)



(a) Elastic deformation

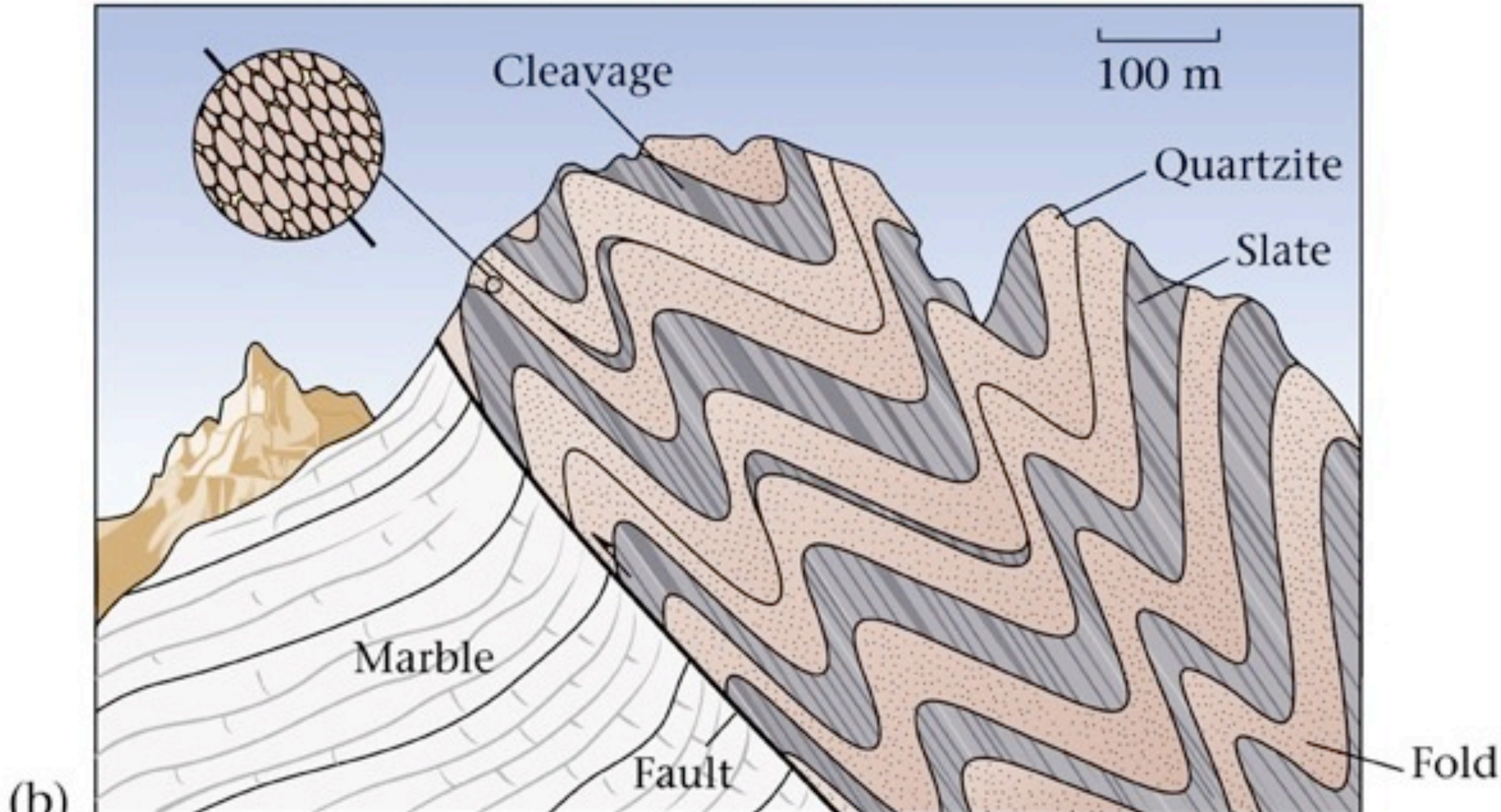


(b) Brittle failure



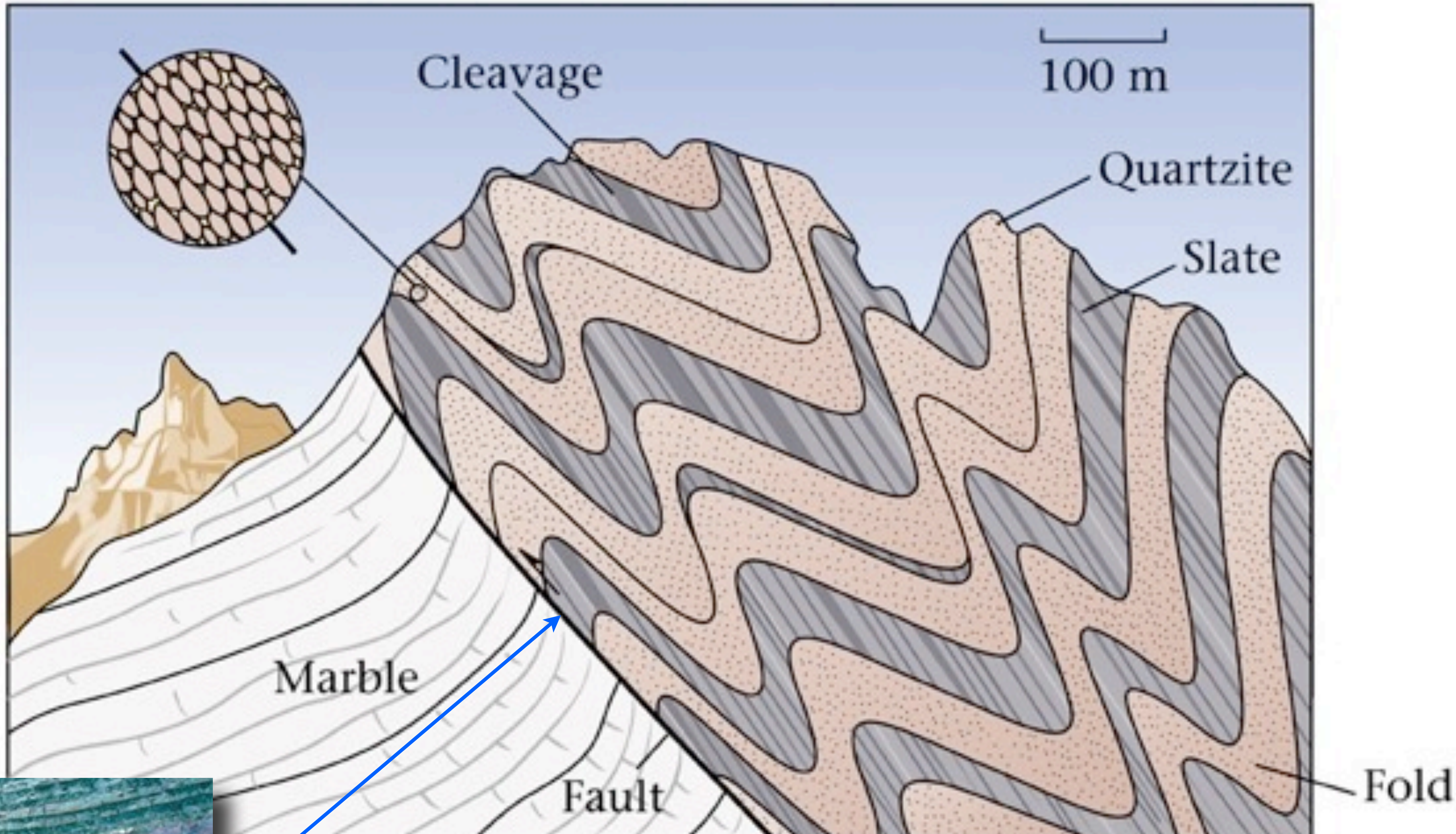
(c) Plastic deformation

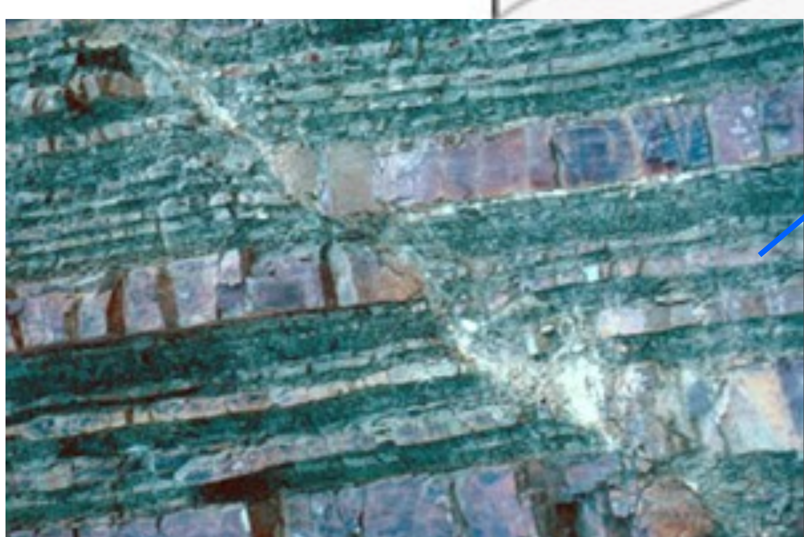
Brittle and Ductile Deformation



Faulting

Brittle and Ductile Deformation





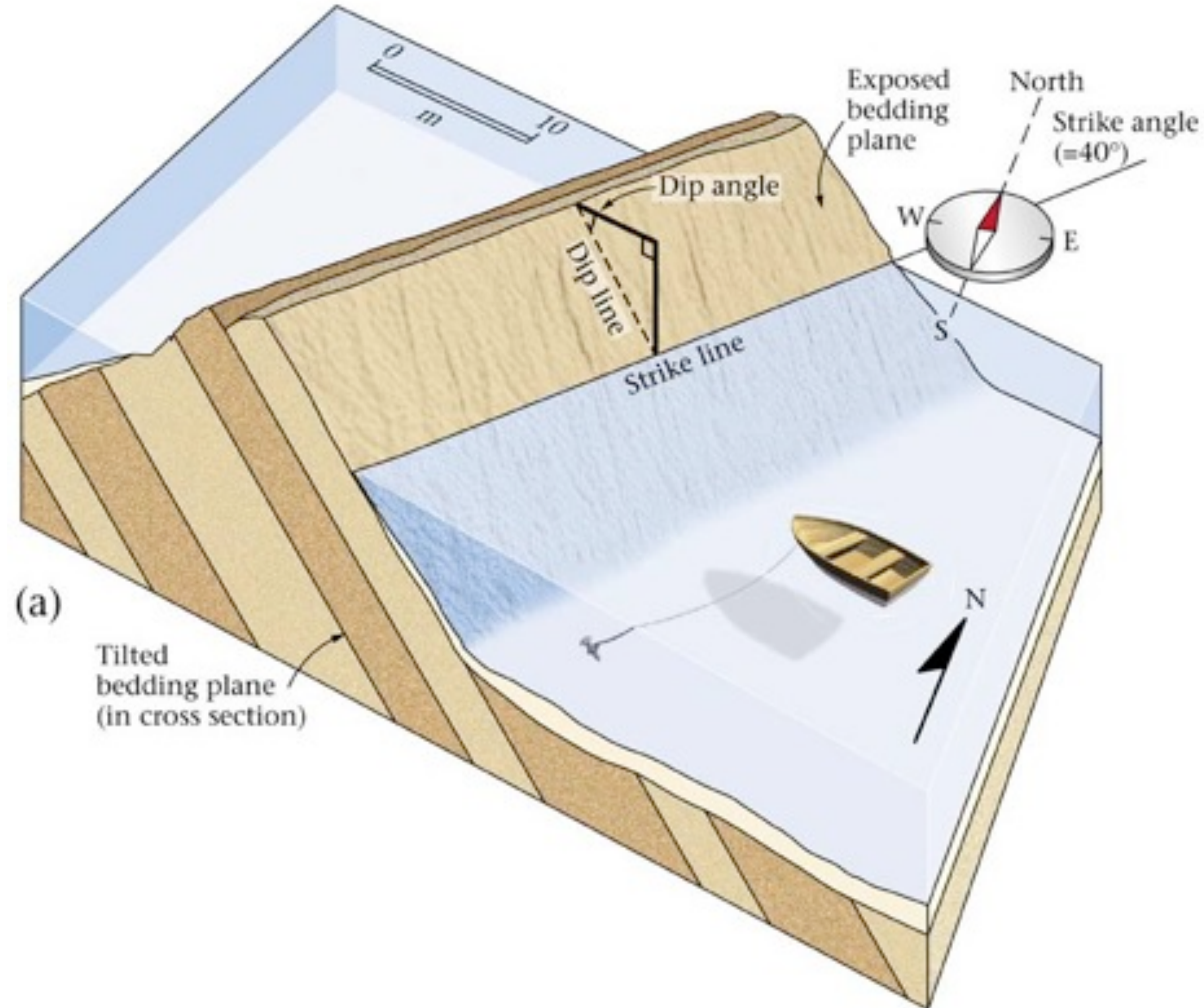
Faulting

Bedding and Fault plane Attitudes Strike and Dip

Strike- an imaginary line that is formed by the intersection of a tilted geologic surface (rock layer or a fault) and an imaginary horizontal surface. The strike like defines the 2D map orientation of the feature

Dip- the angle formed between an imaginary horizontal surface and a tilted geologic surface. The direction of Dip is always 90 degrees off of the orientation of strike.

Bedding and Fault plane Attitudes Strike and Dip



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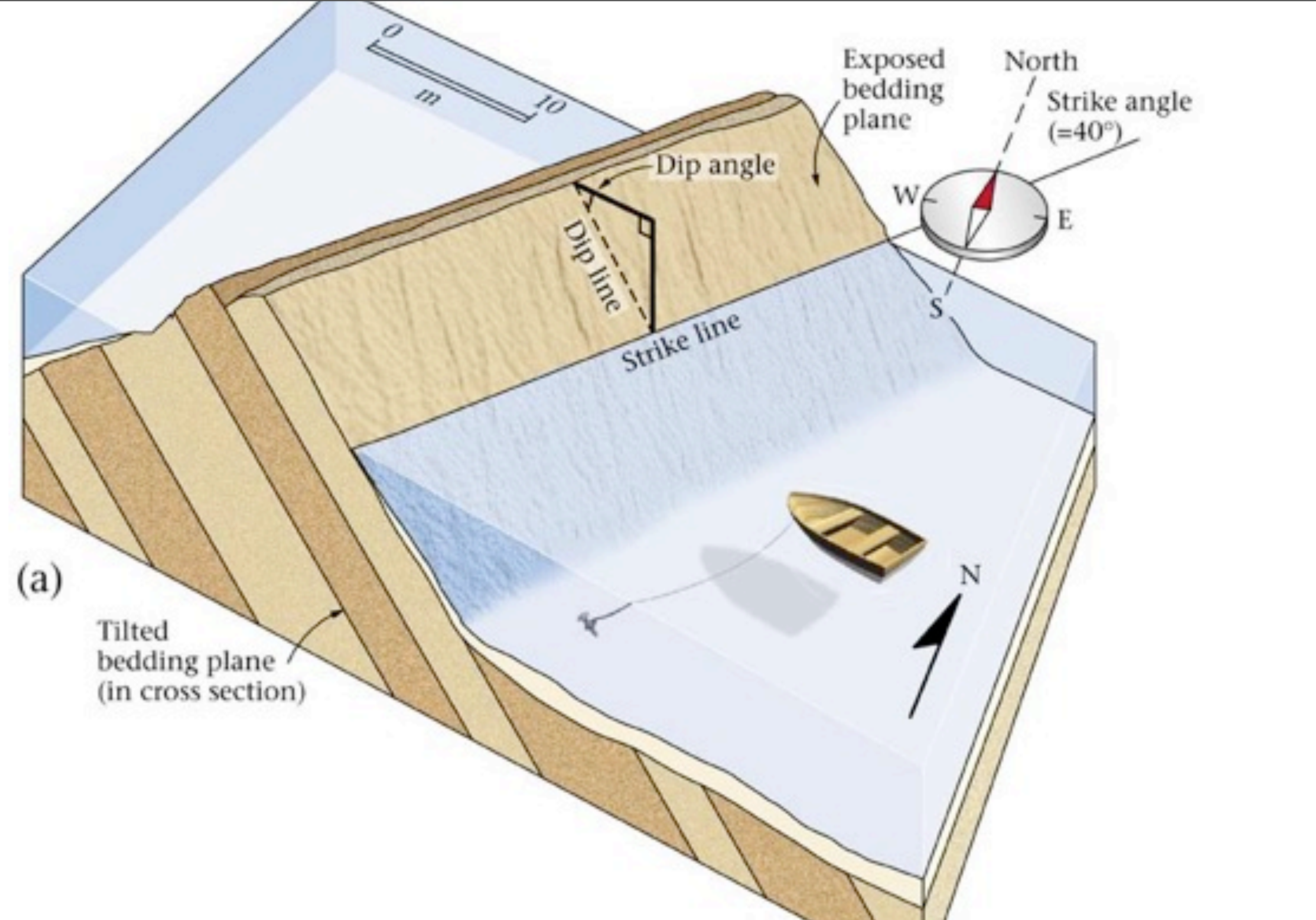
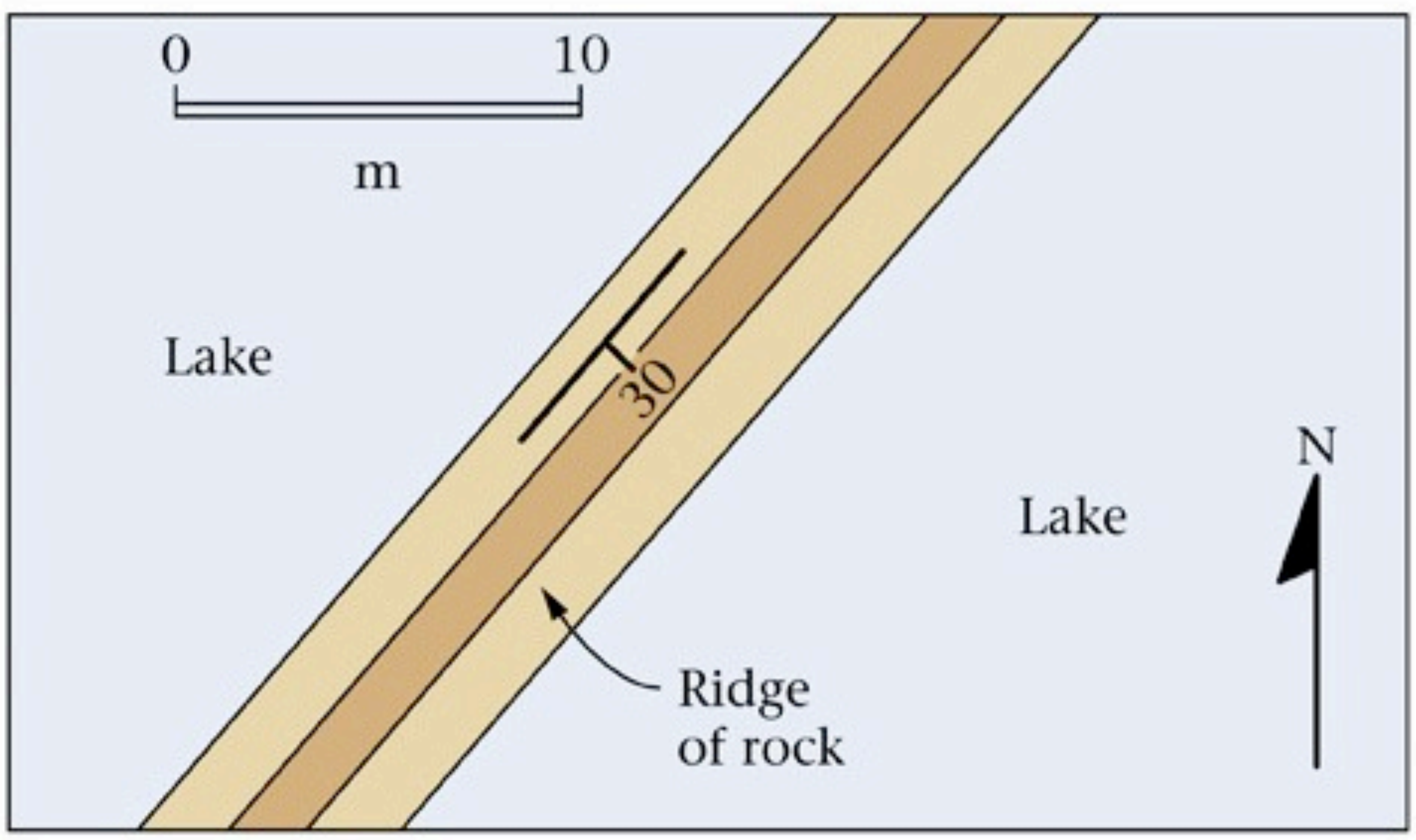
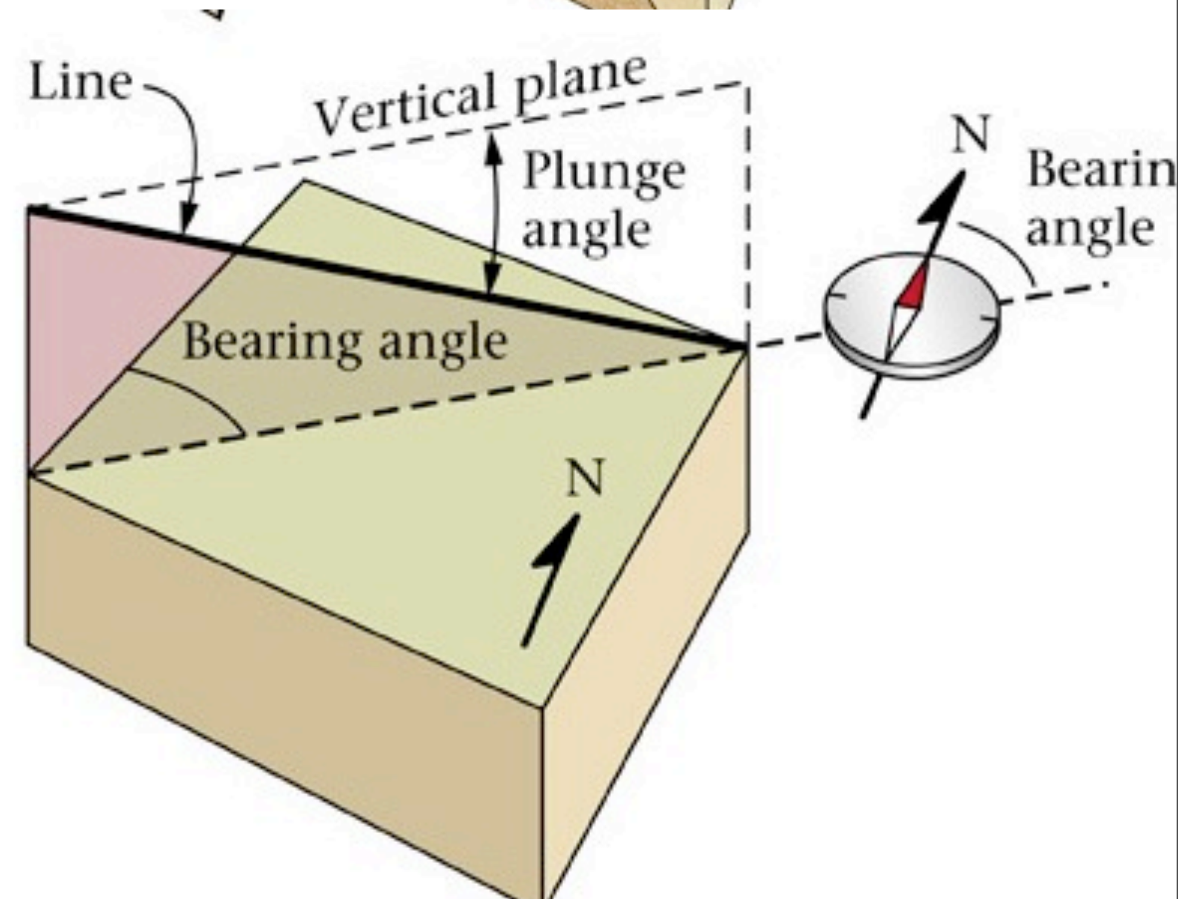


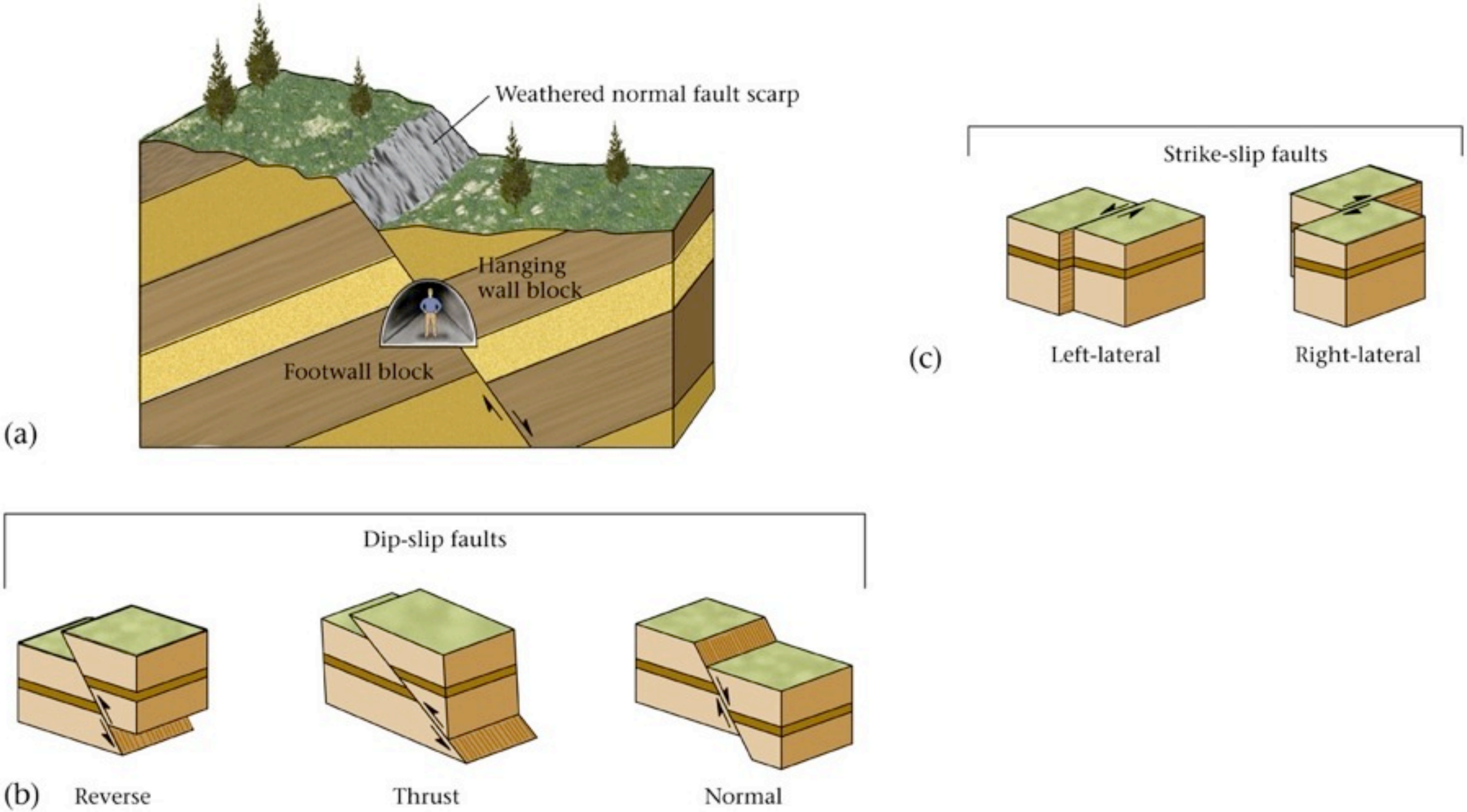


(b)



(c)

Fault Details

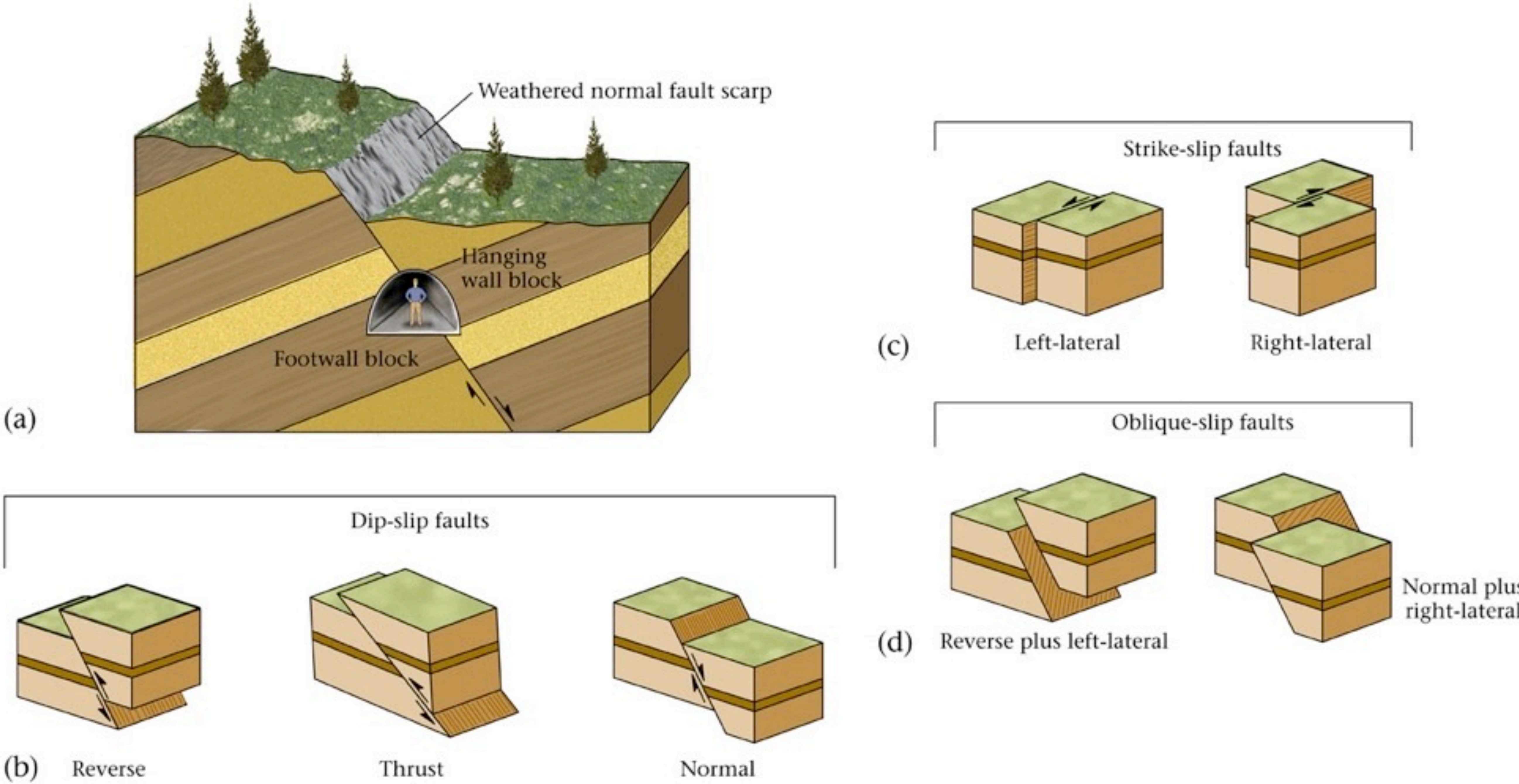


Normal - Hangingwall goes <u>down</u> relative to the Footwall

Reverse - Hangingwall goes <u>up</u> relative to the Footwall

Strike-slip - <u>No</u> Hangingwall or Footwall (Right or Left-lateral)

Fault Details



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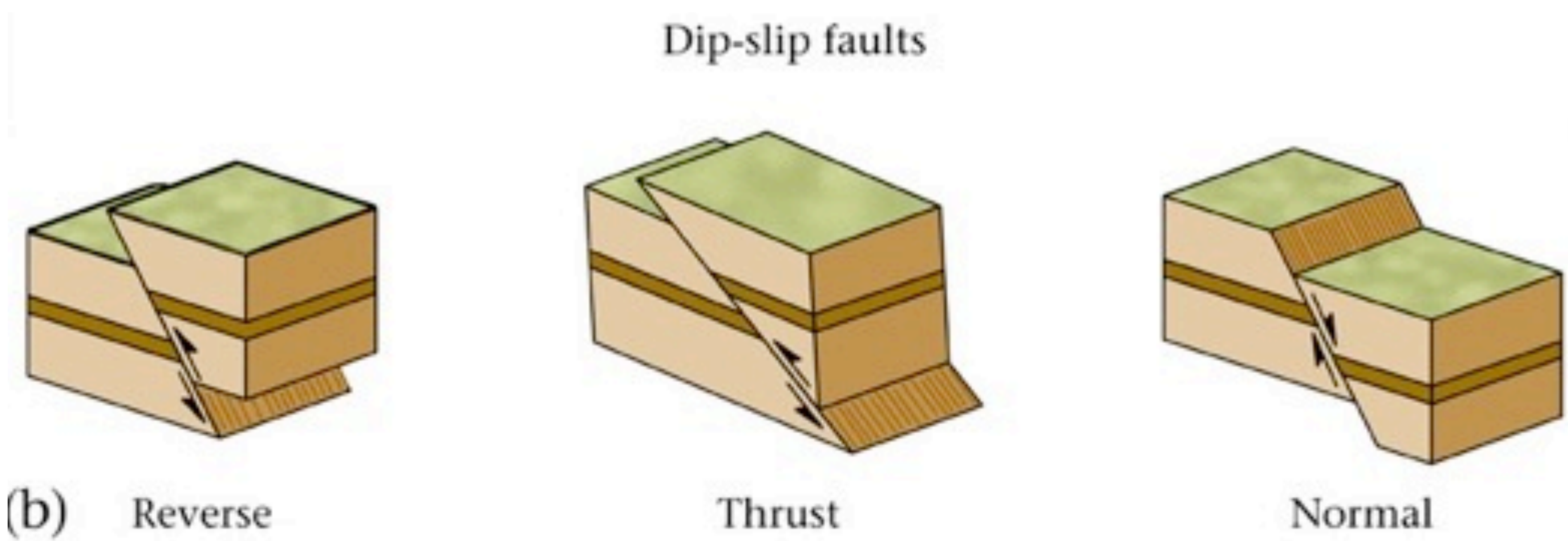
3 types of plate boundaries = 3 types of Stress = 3 types of <u>Brittle Strain</u>

Normal (Dip-slip)- Tension, extension

Reverse (Dip-slip)- Compression

Strike-slip- Translation

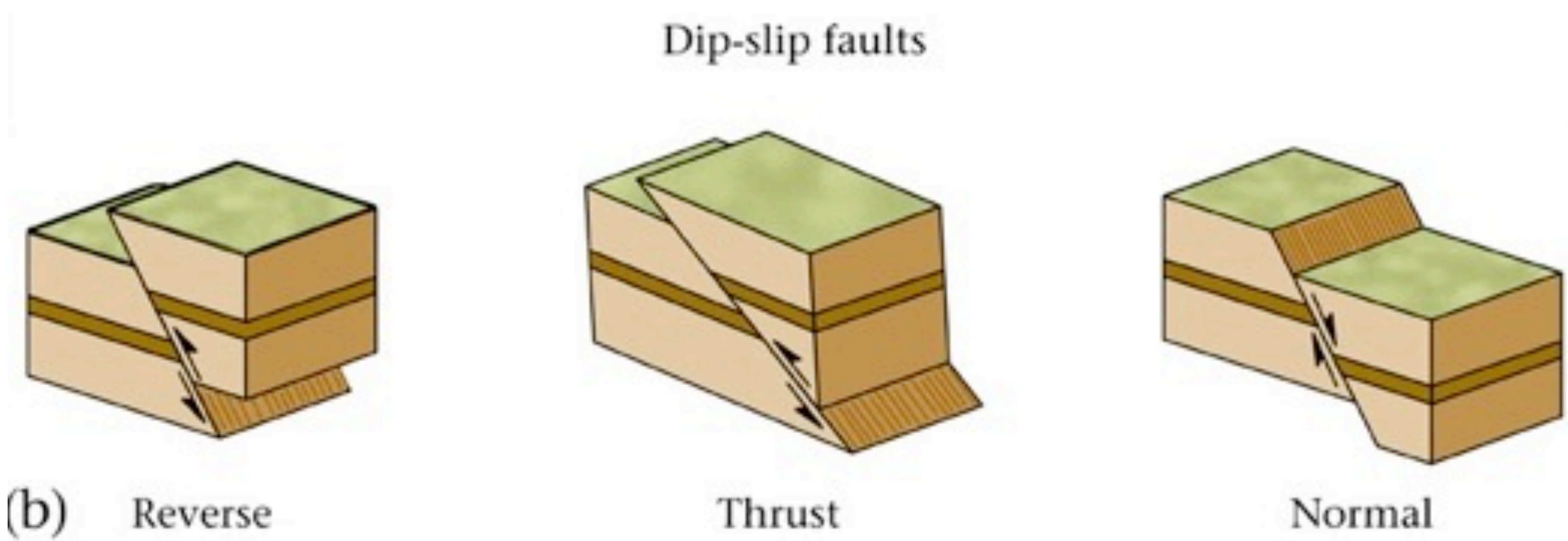


3 types of plate boundaries = 3 types of Stress = 3 types of Brittle Strain

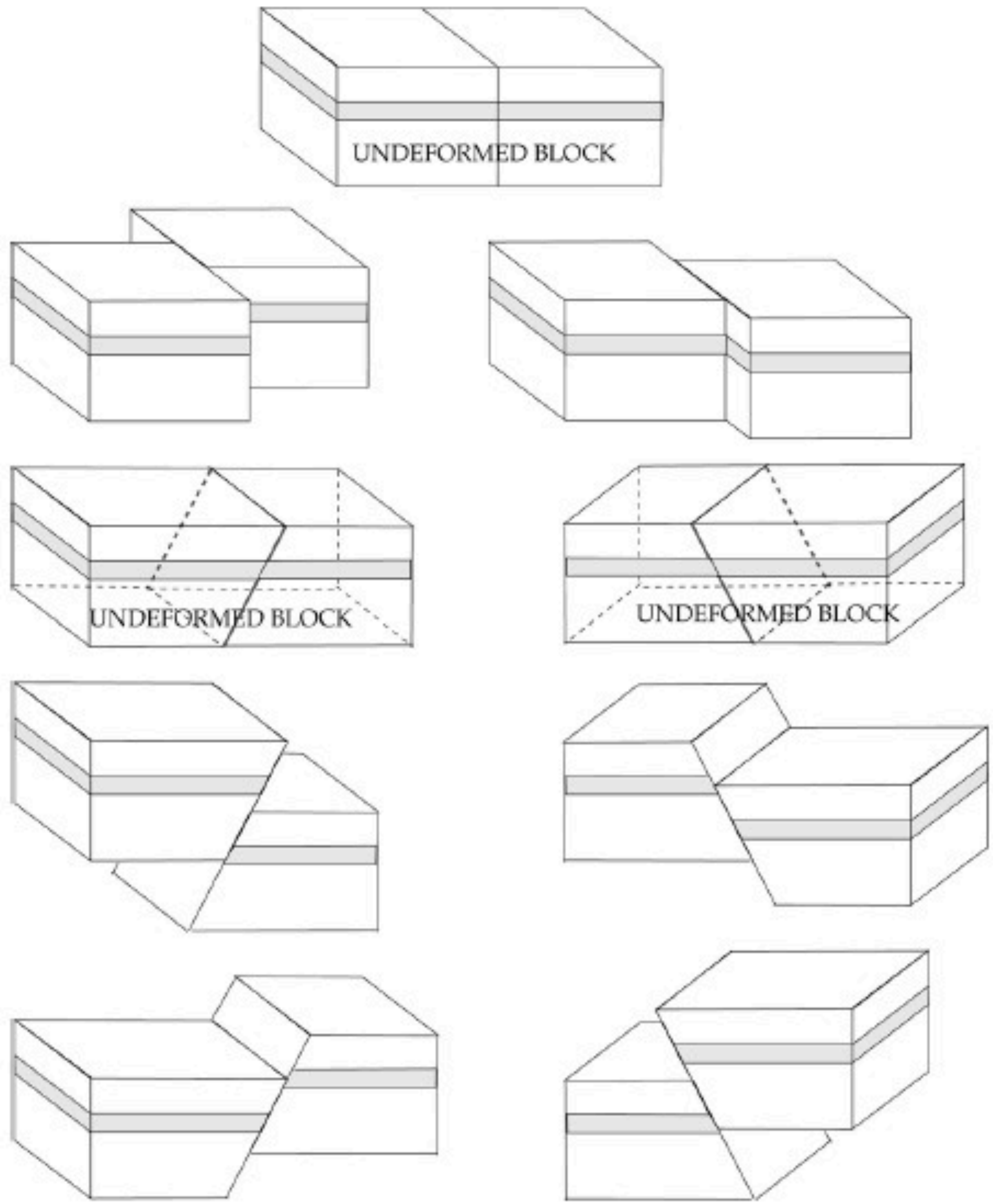
Normal (Dip-slip)- Tension, extension — Divergent

Reverse (Dip-slip)- Compression — Convergent

Strike-slip- Translation — Transform



In class Group Exercise



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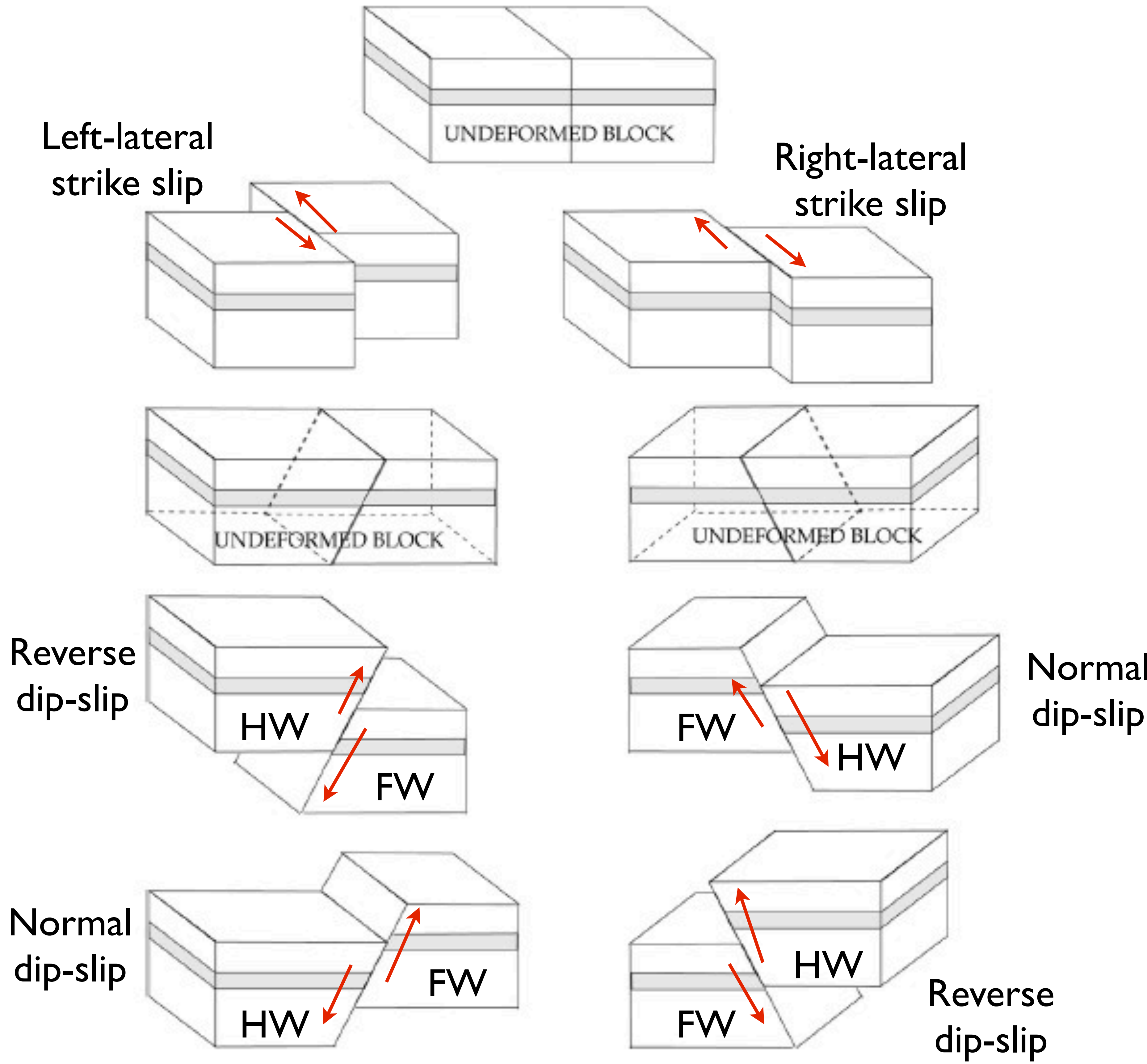


Bedding and Fault plane Attitudes
Strike and Dip

Bedding and Fault plane Attitudes
Strike and Dip

Strike N65E
Dip 60 NW

Bedding and Fault plane Attitudes
Strike and Dip

Normal (Dip-slip)- Extension
Reverse (Dip-slip)- Compression
Strike-slip- Translation

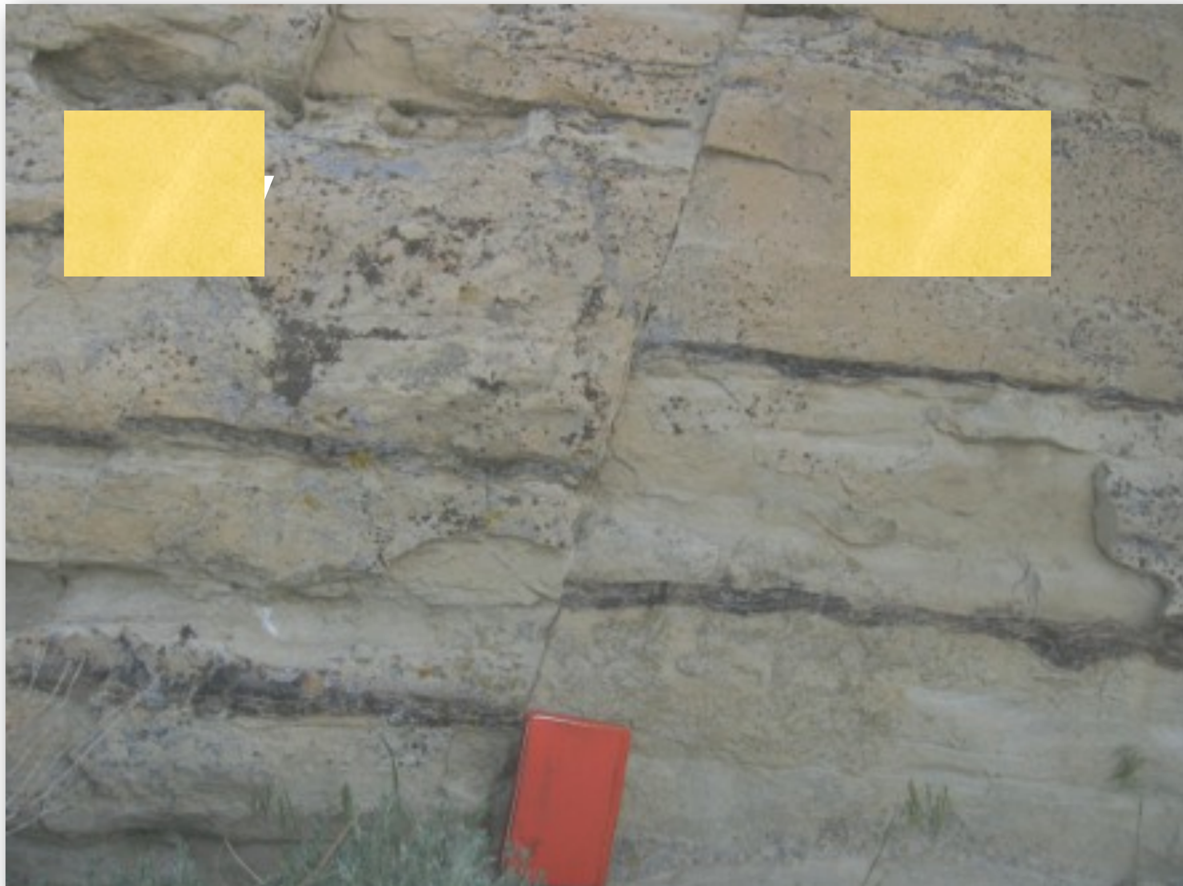
Is the climber standing on the hangingwall or footwall?

Bedding and Fault plane Attitudes
Strike and Dip

Normal (Dip-slip)- Extension
Reverse (Dip-slip)- Compression
Strike-slip- Translation

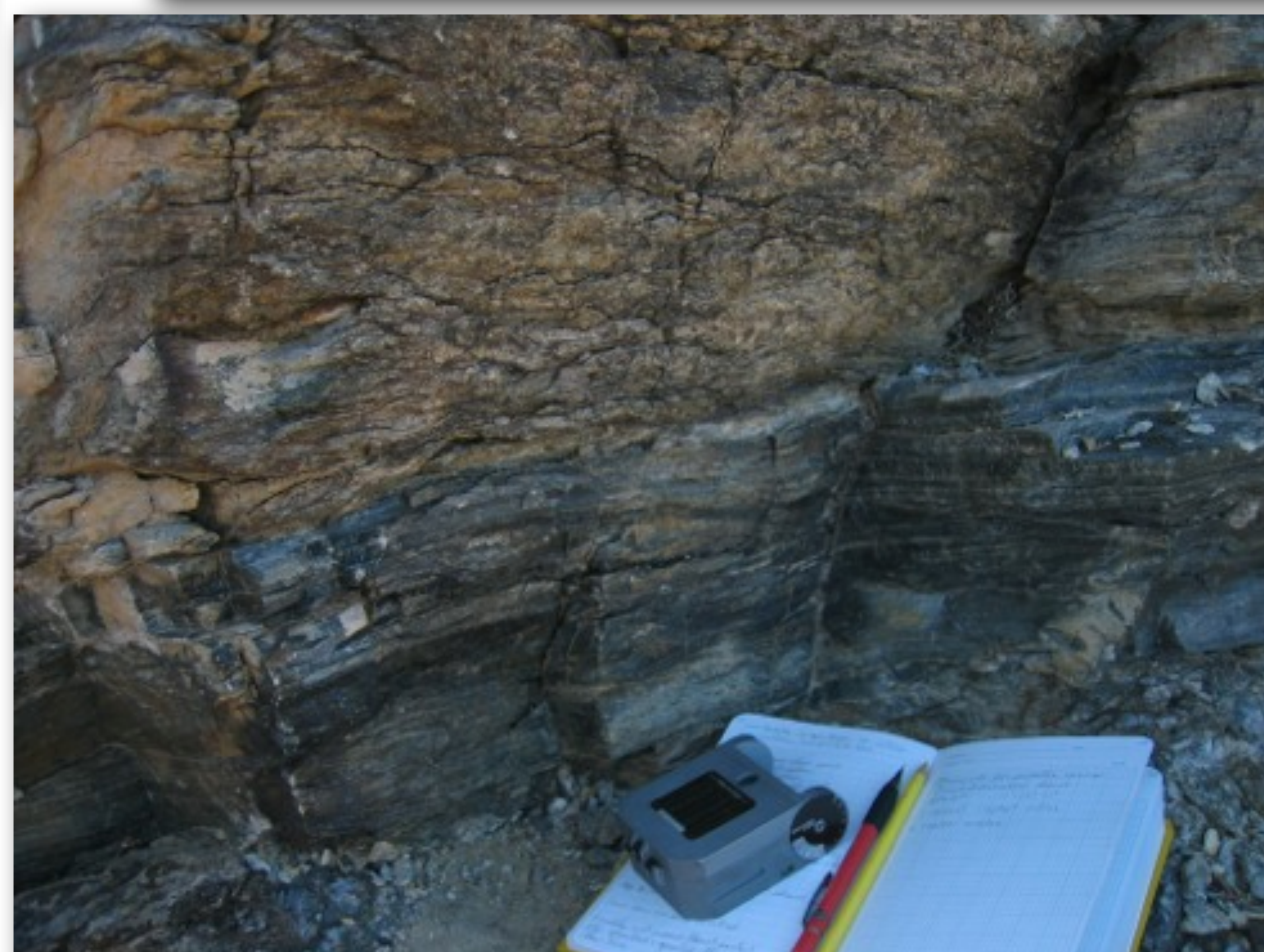
Is the climber standing on the hangingwall or footwall?
Can you tell what the what is the relative fault motion was?

Faults at all scales



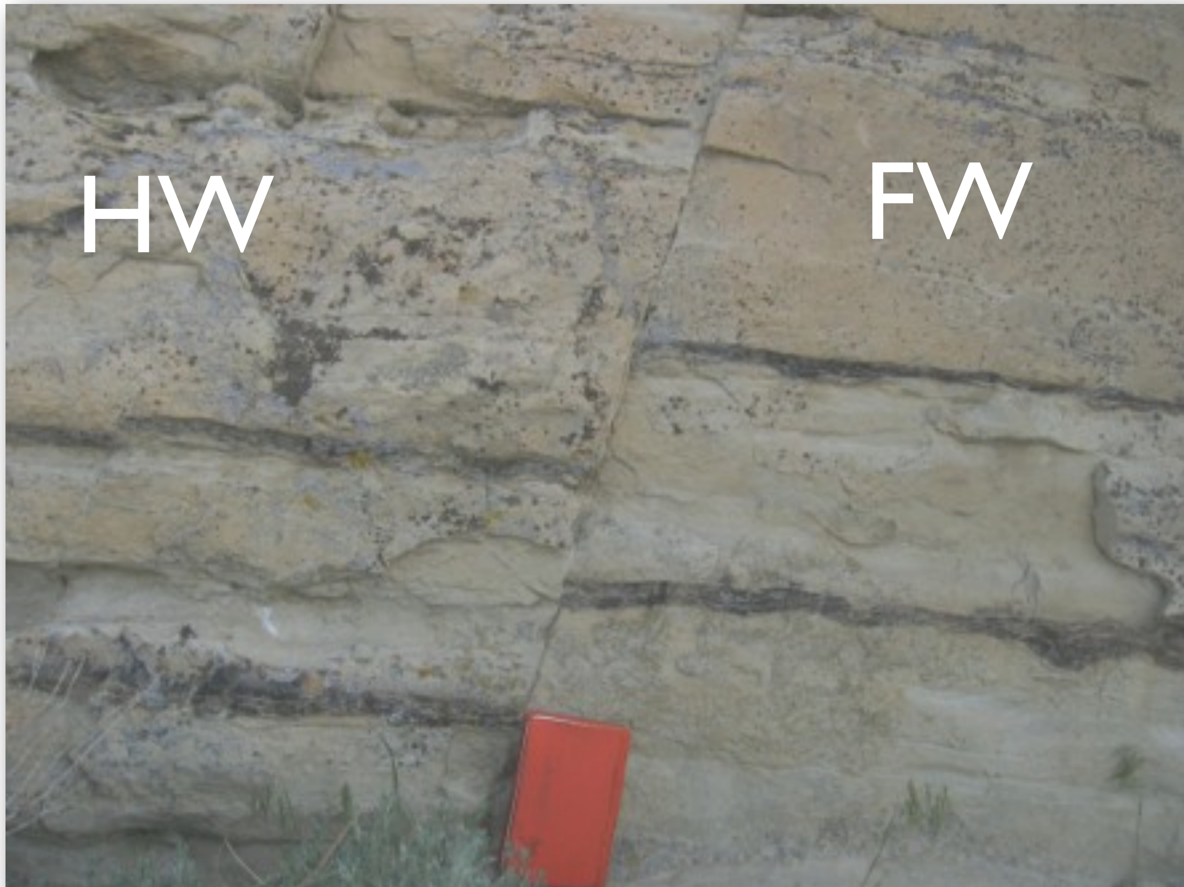
,WY (20 cm slip)

Normal Fault, CA (100's m slip)

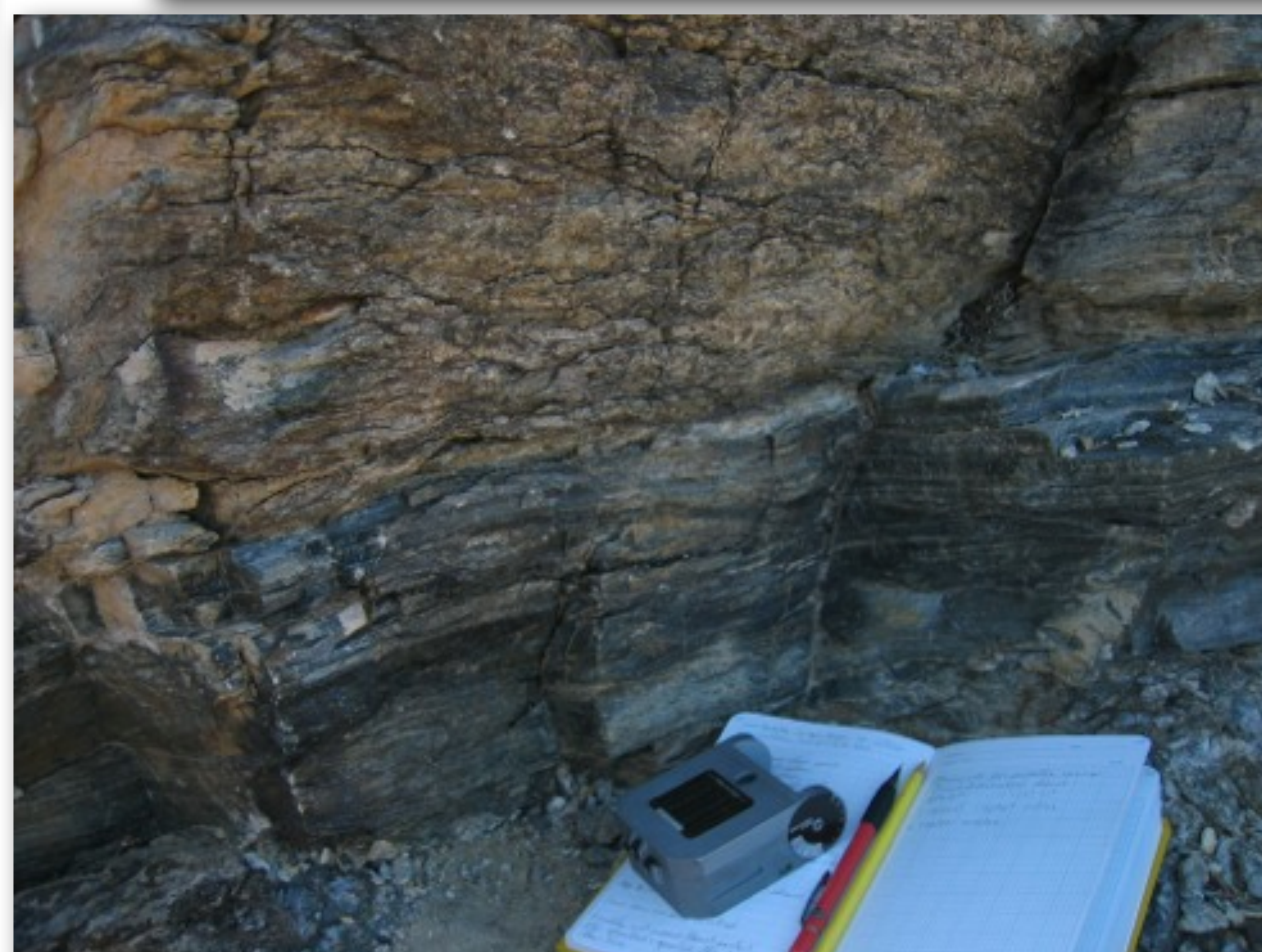


Reverse Fault, CA (100's km slip)

Faults at all scales

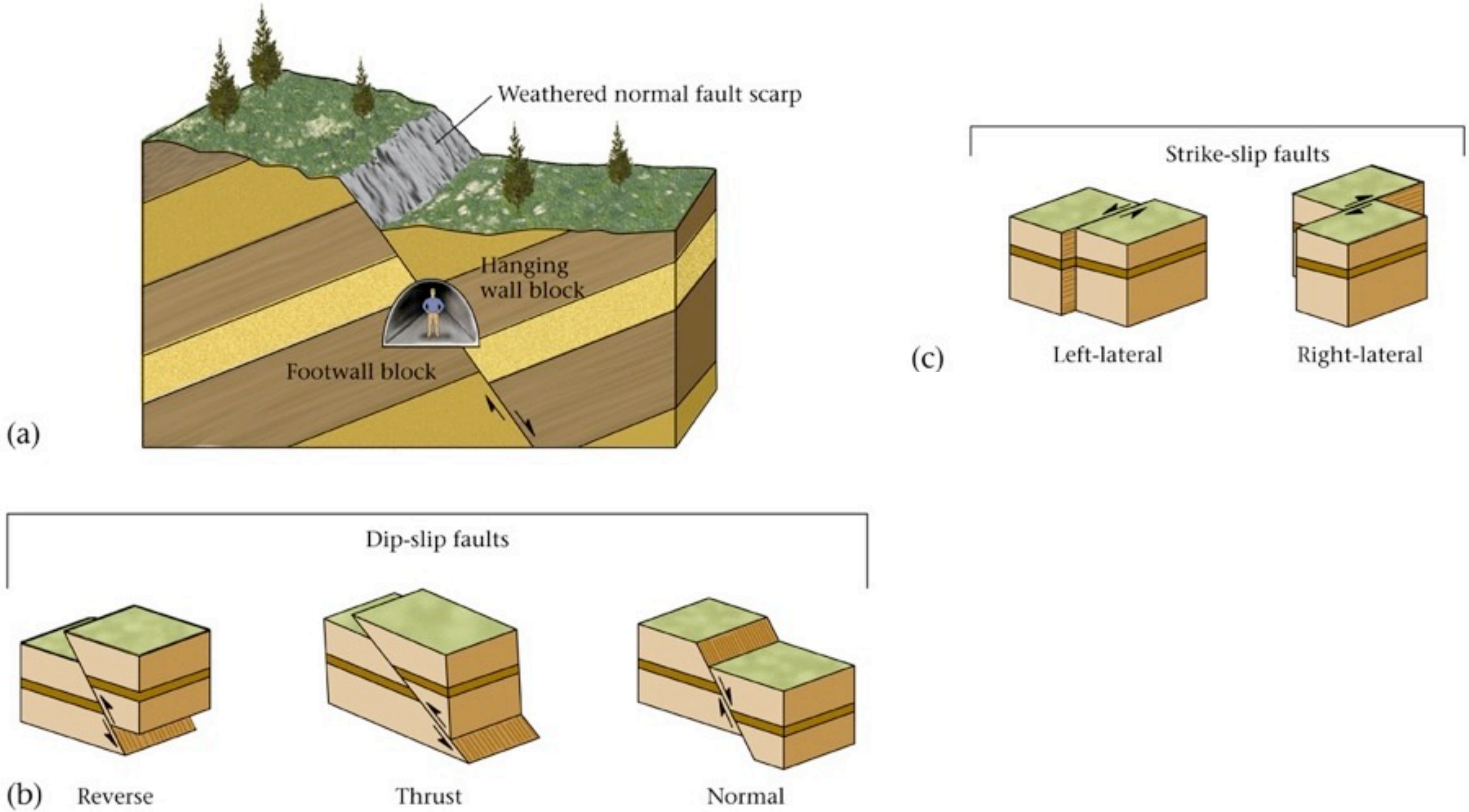


Normal Fault, WY (20 cm slip)



Reverse Fault, CA (100's km slip)

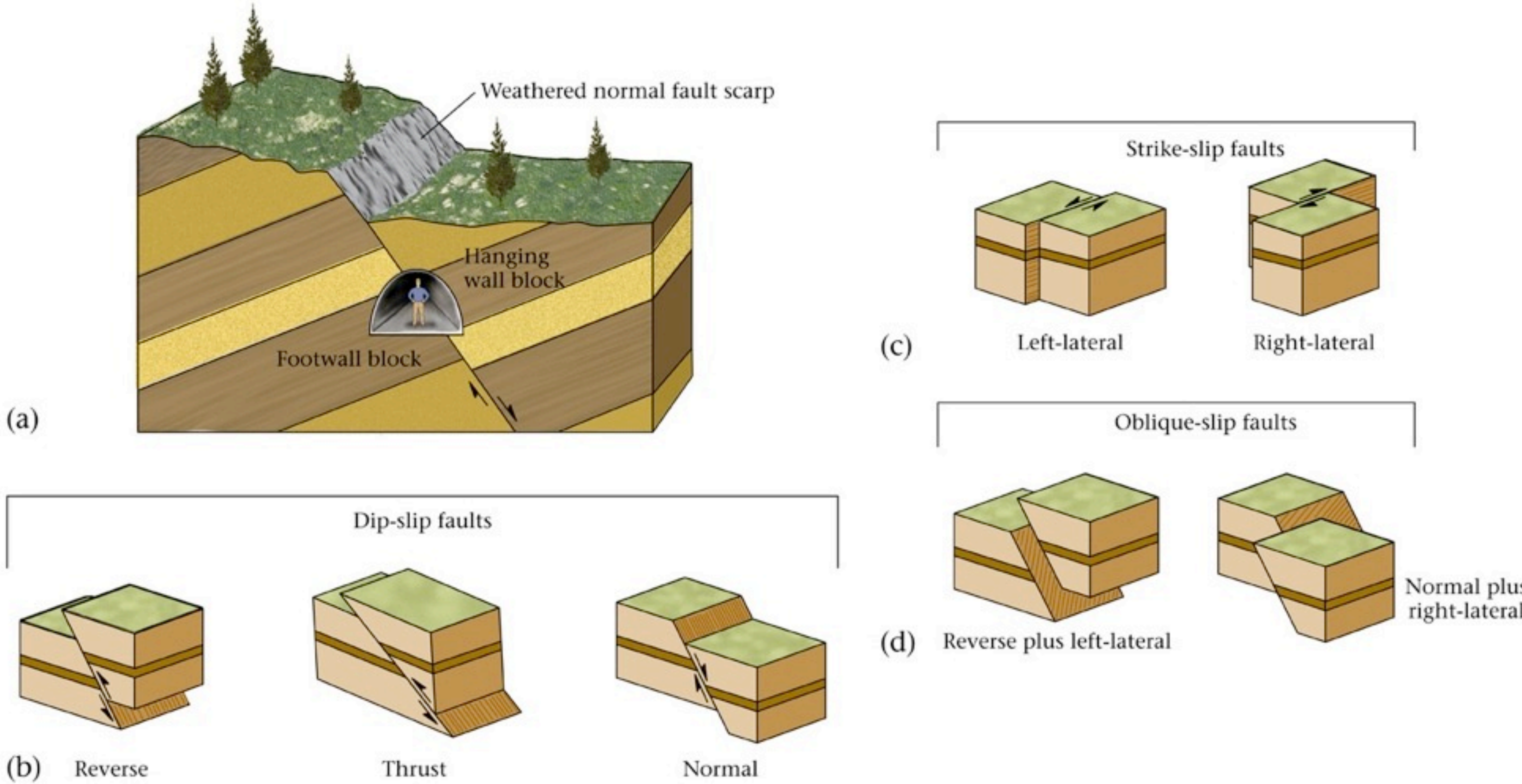
Fault Details



Normal faults- Place younger rocks on older rocks (omits Rx)

Reverse faults-Place older rocks on younger rocks (duplicates Rx)

Fault Details



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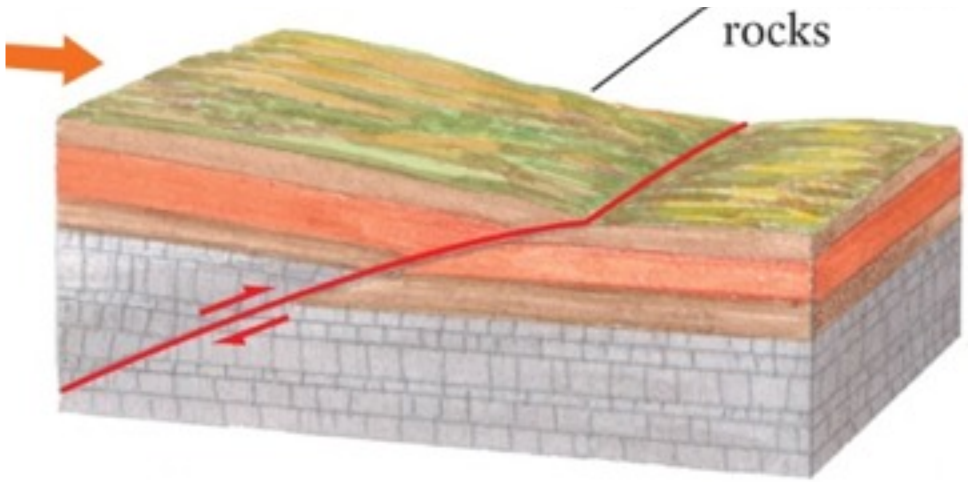
Compressional Mountain Building



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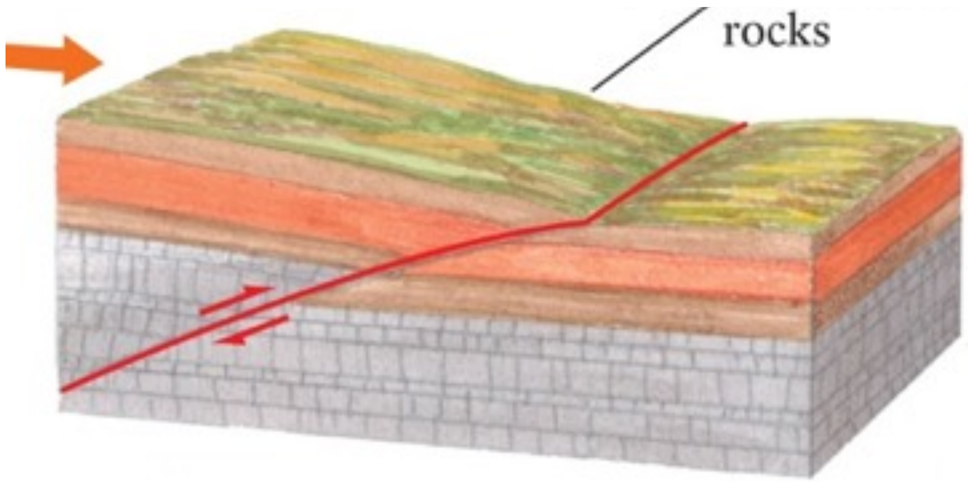

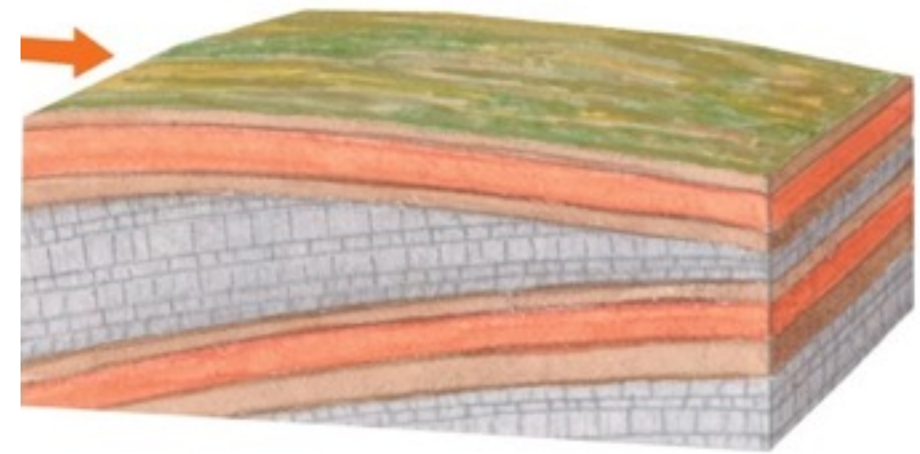

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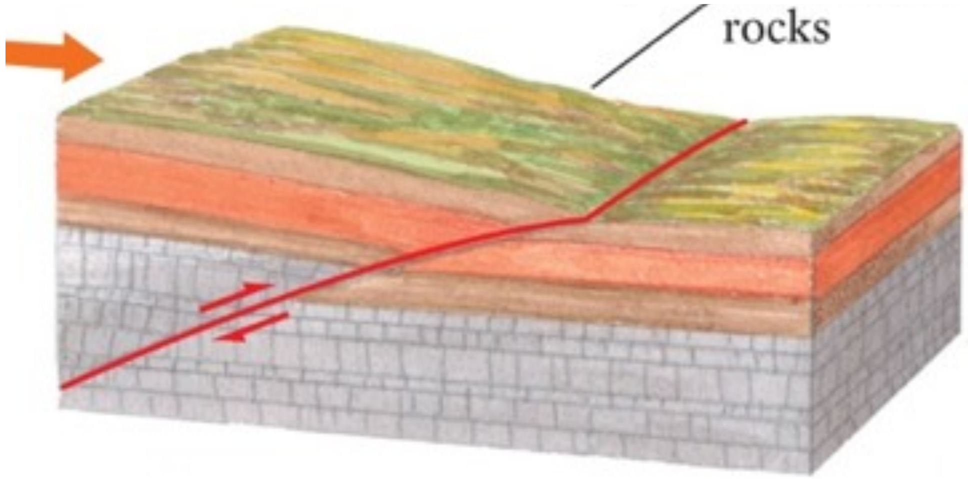
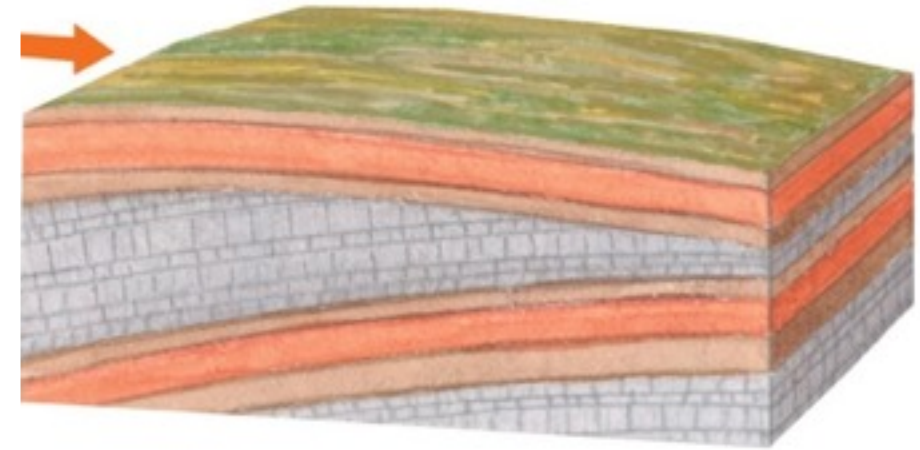
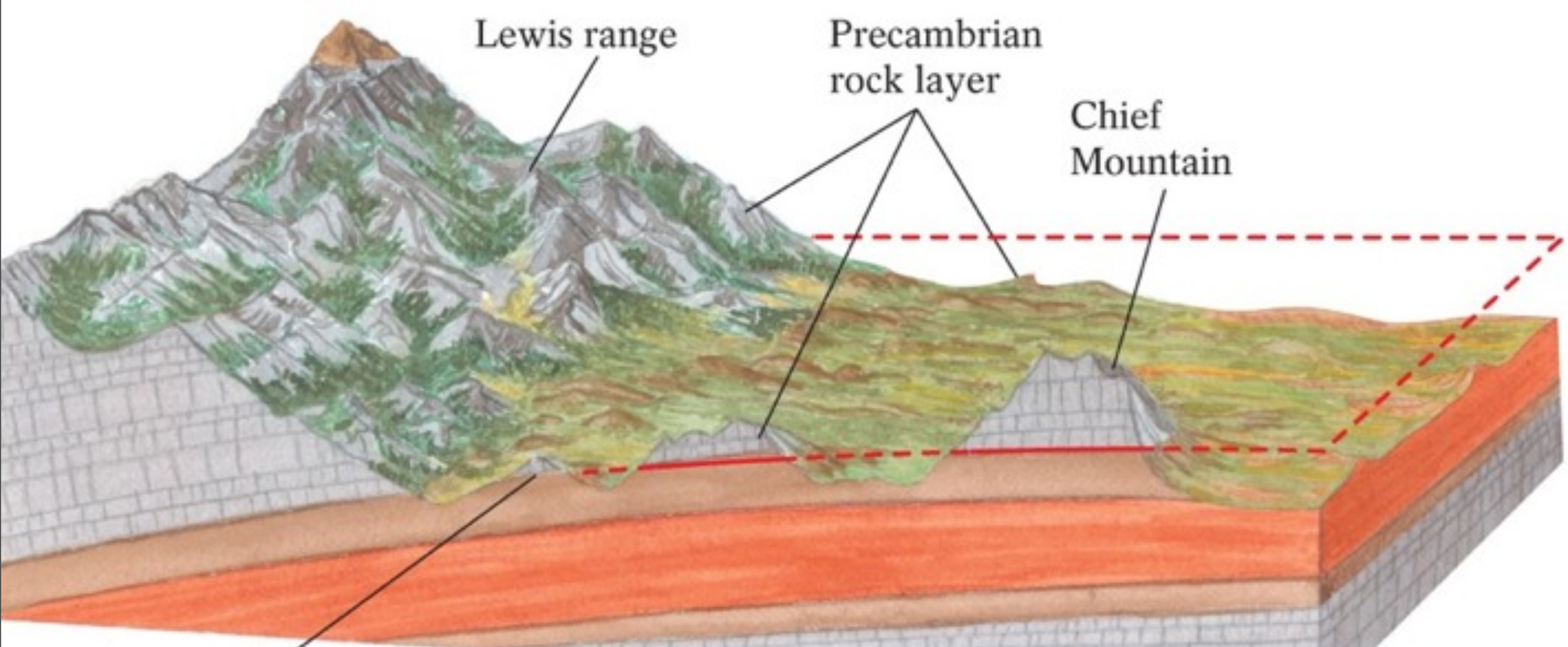
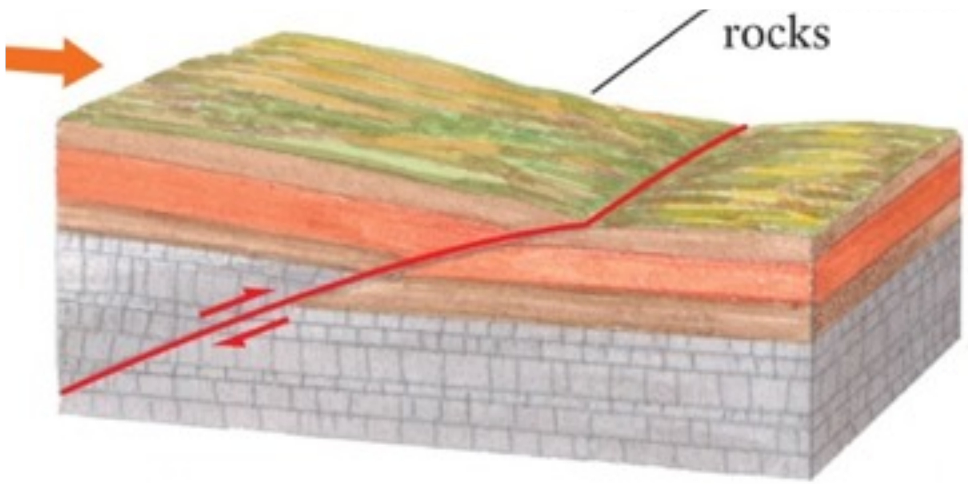


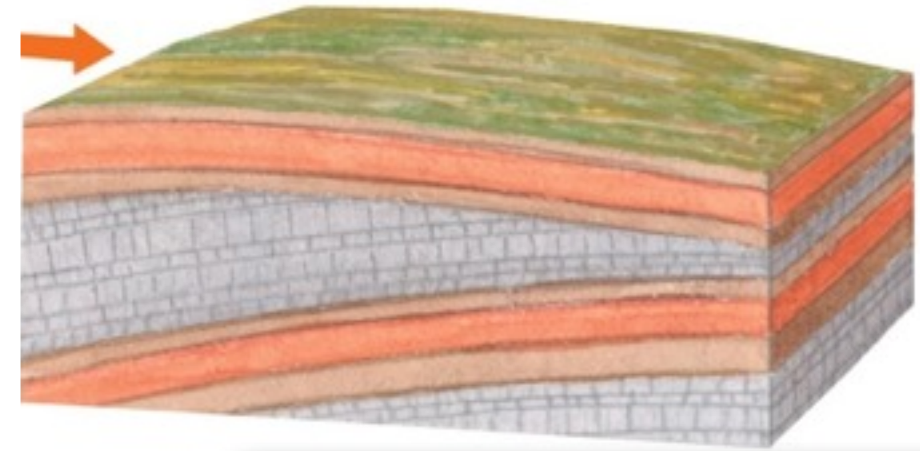


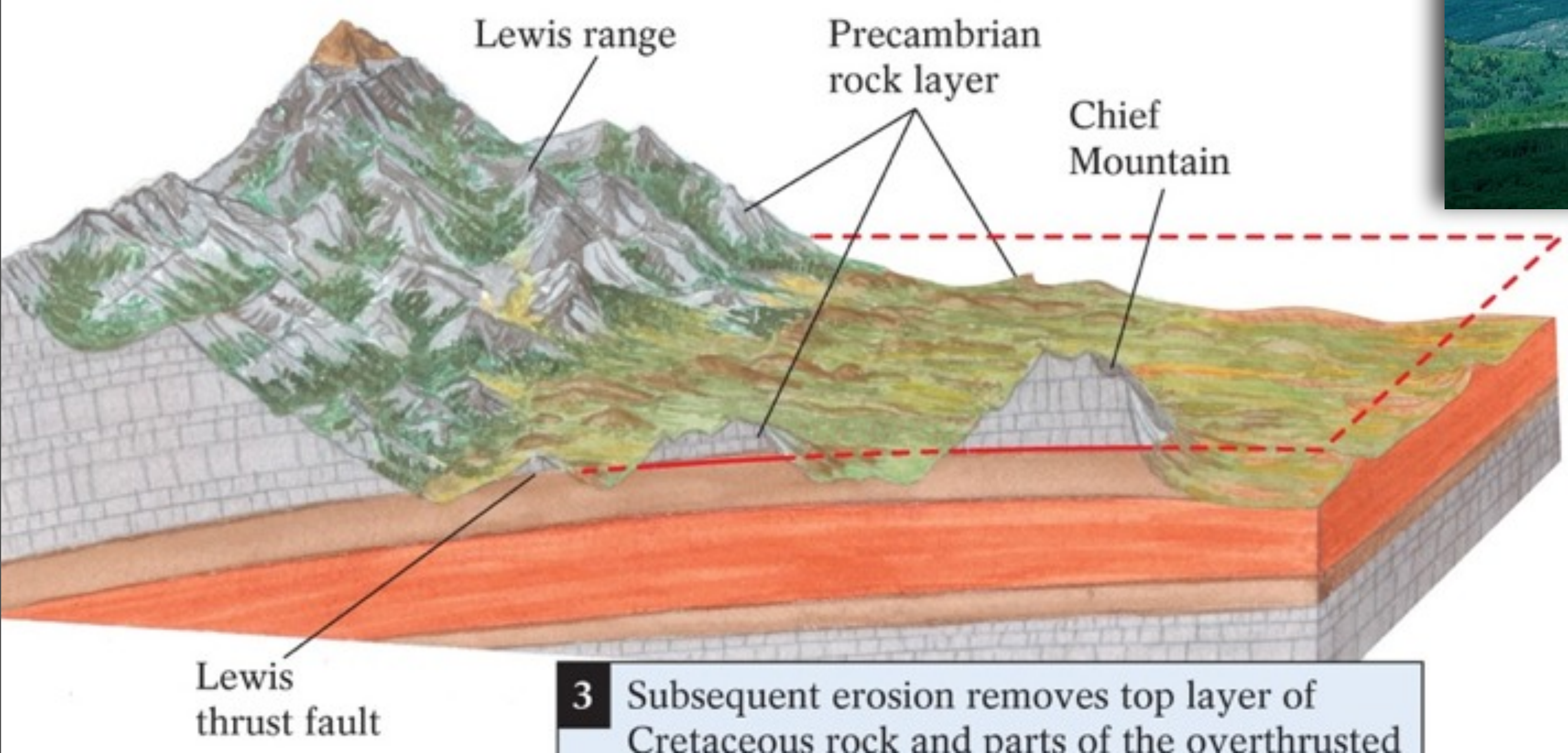


3 Subsequent erosion removes top layer of
Cretaceous rock and parts of the overthrusted

Compressional Mountain Building







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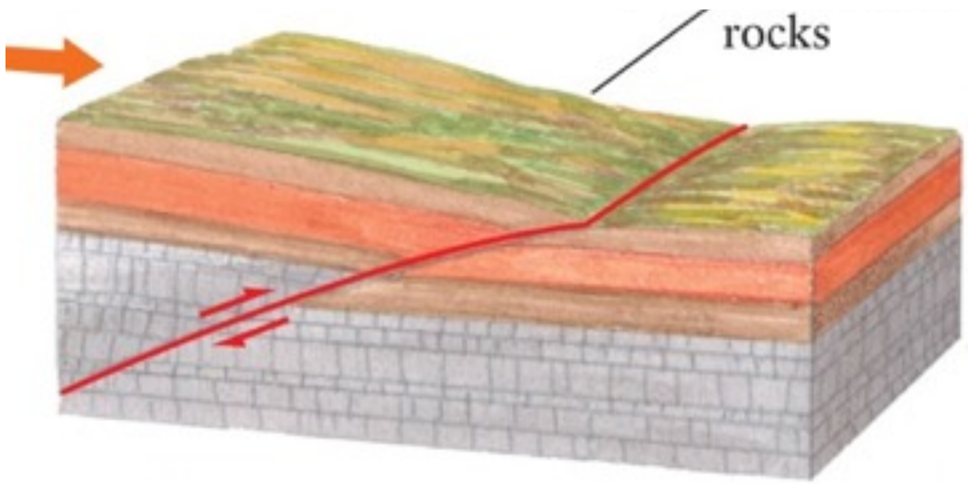
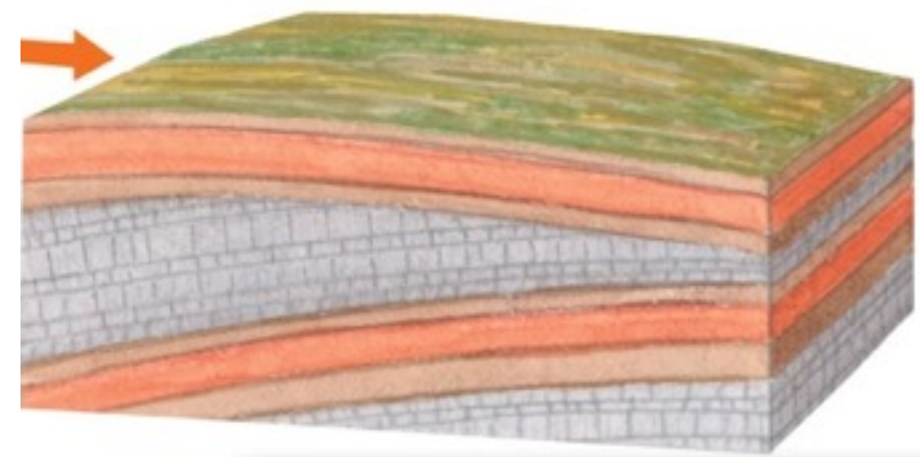
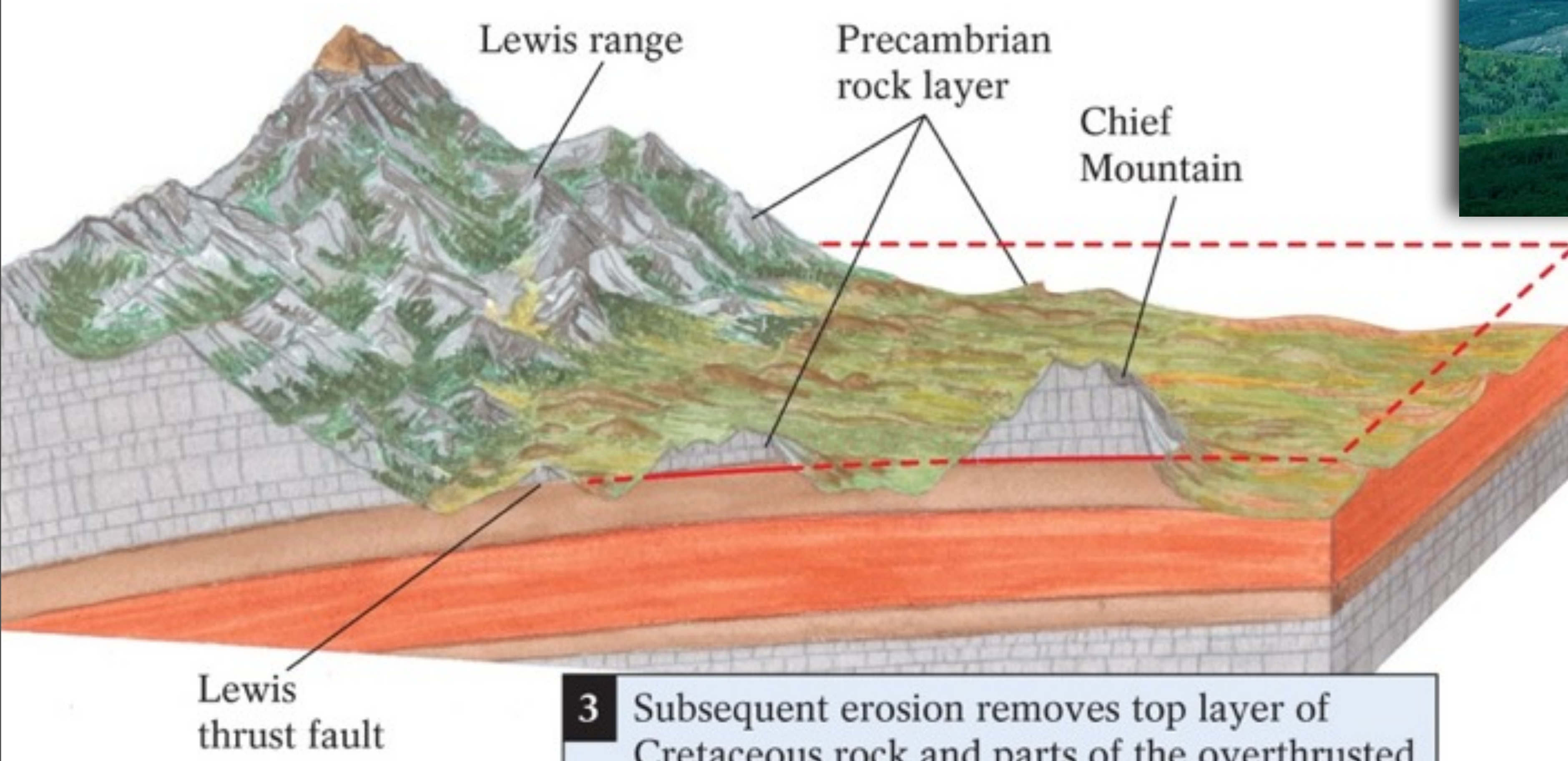


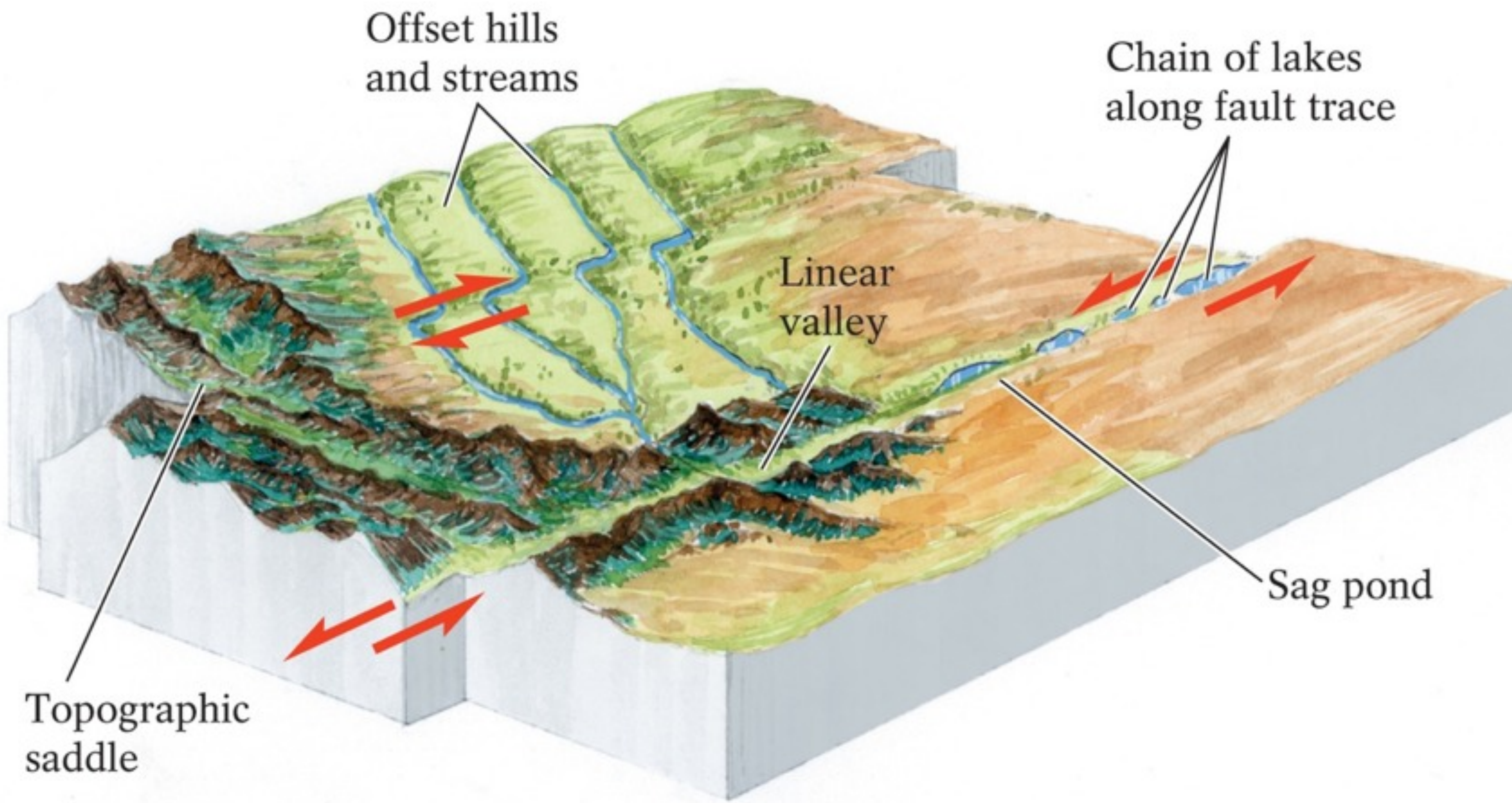


Is older or younger on top?

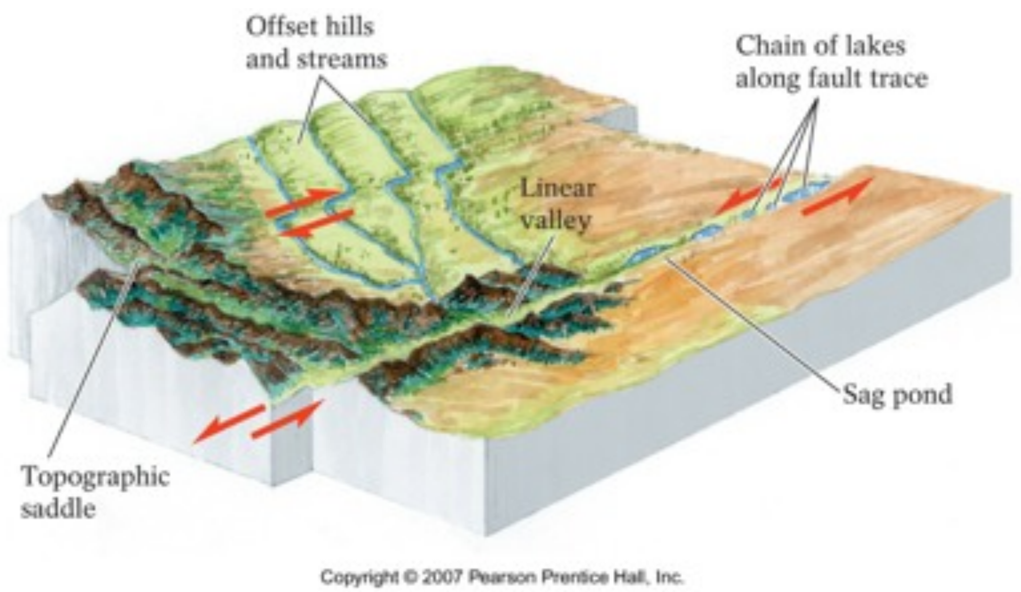


Keystone Thrust

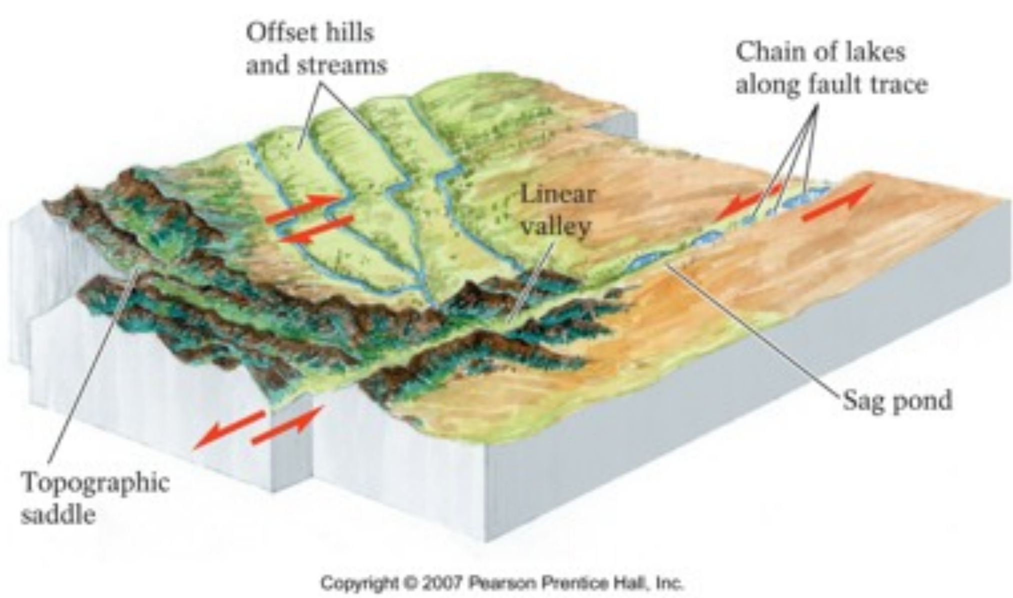
Right-lateral vs. Left-lateral strike slip fault



Strike slip fault features

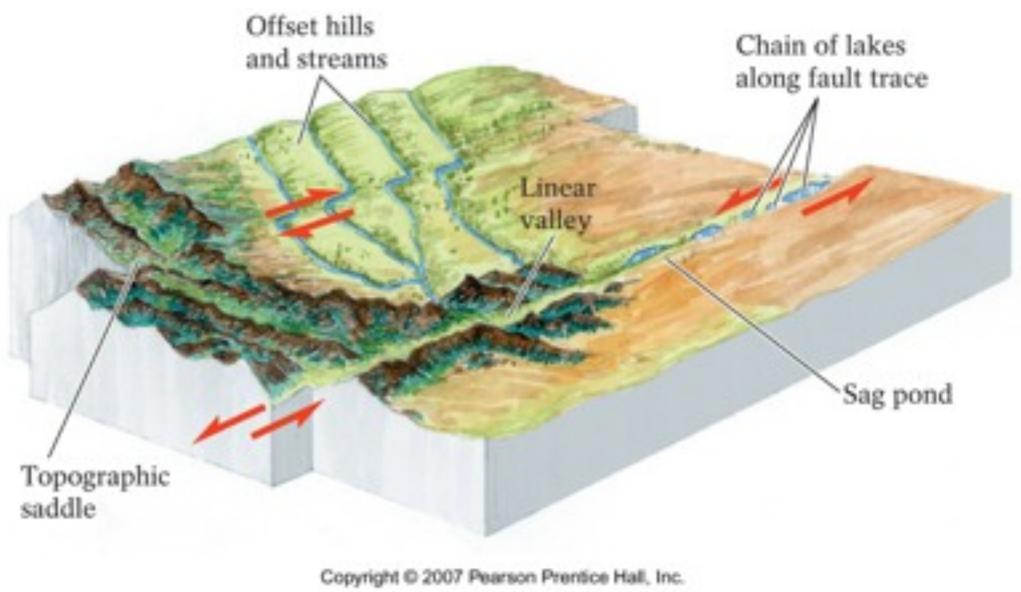


Strike slip fault features



right-lateral strike-slip

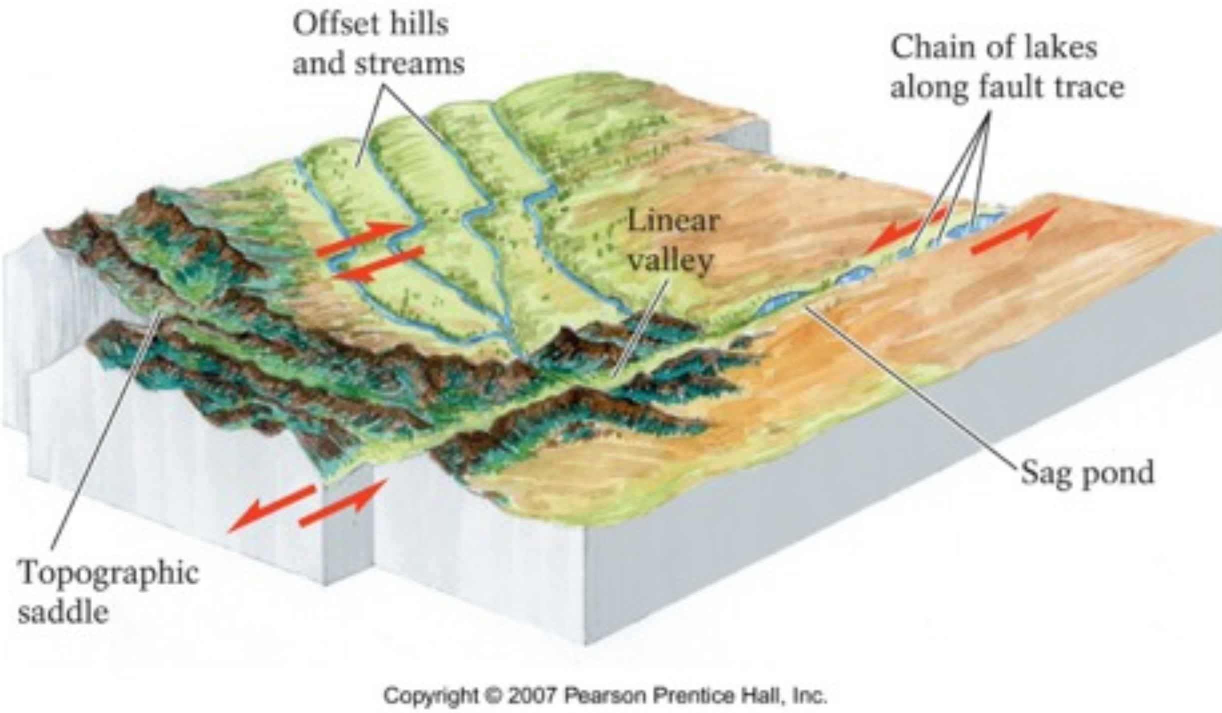
Strike slip fault features

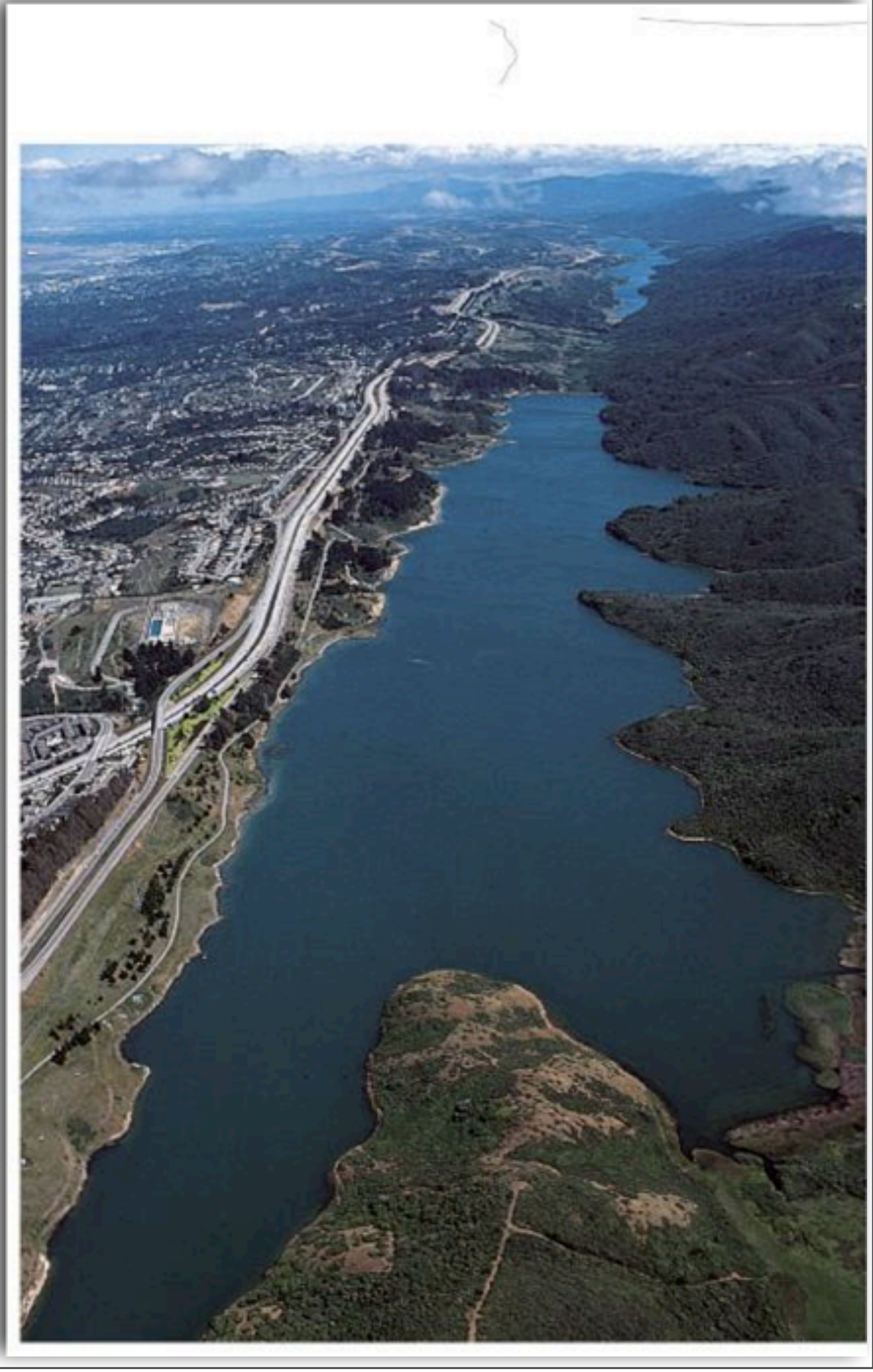


right-lateral strike-slip

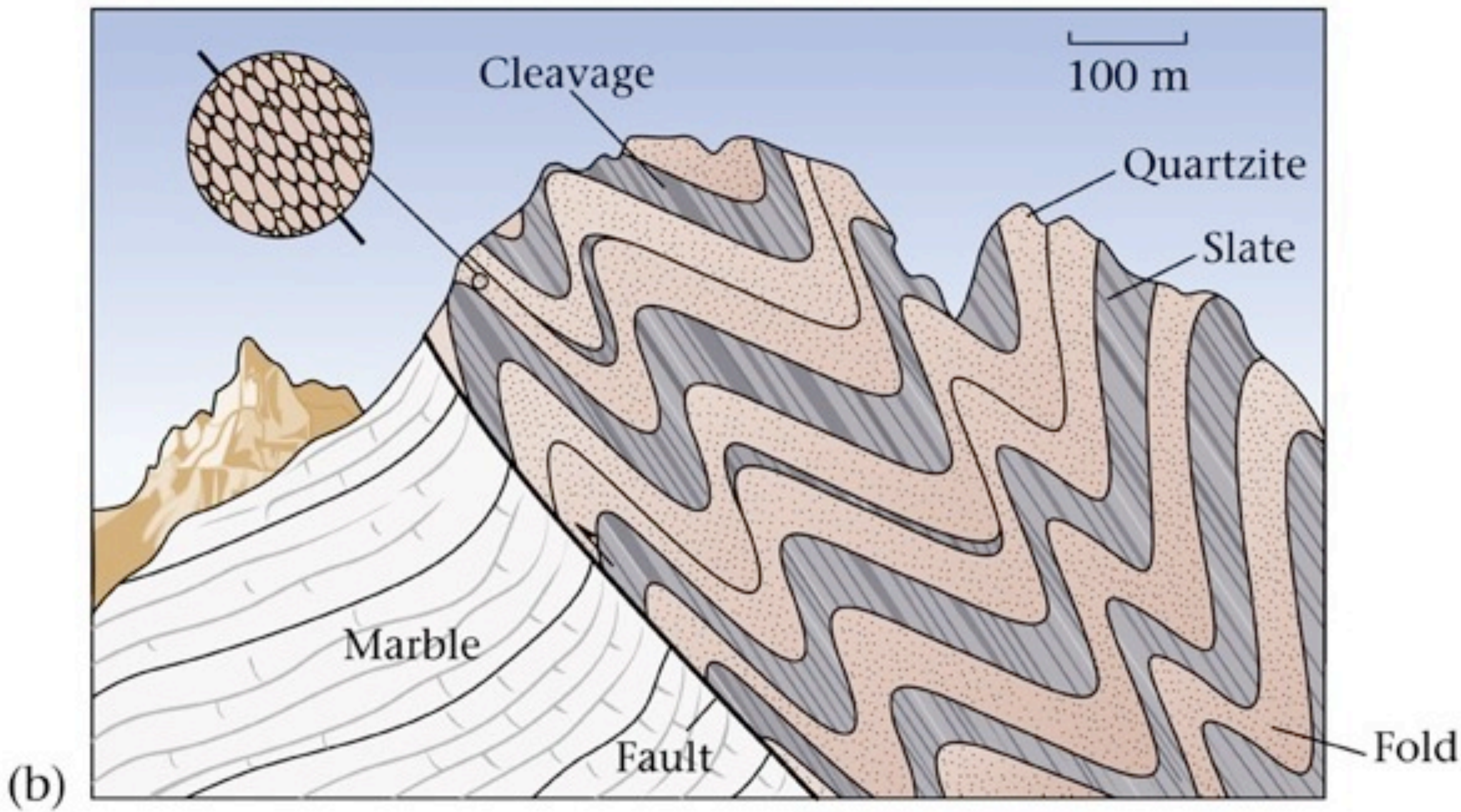
left-lateral strike-slip

Strike slip fault features



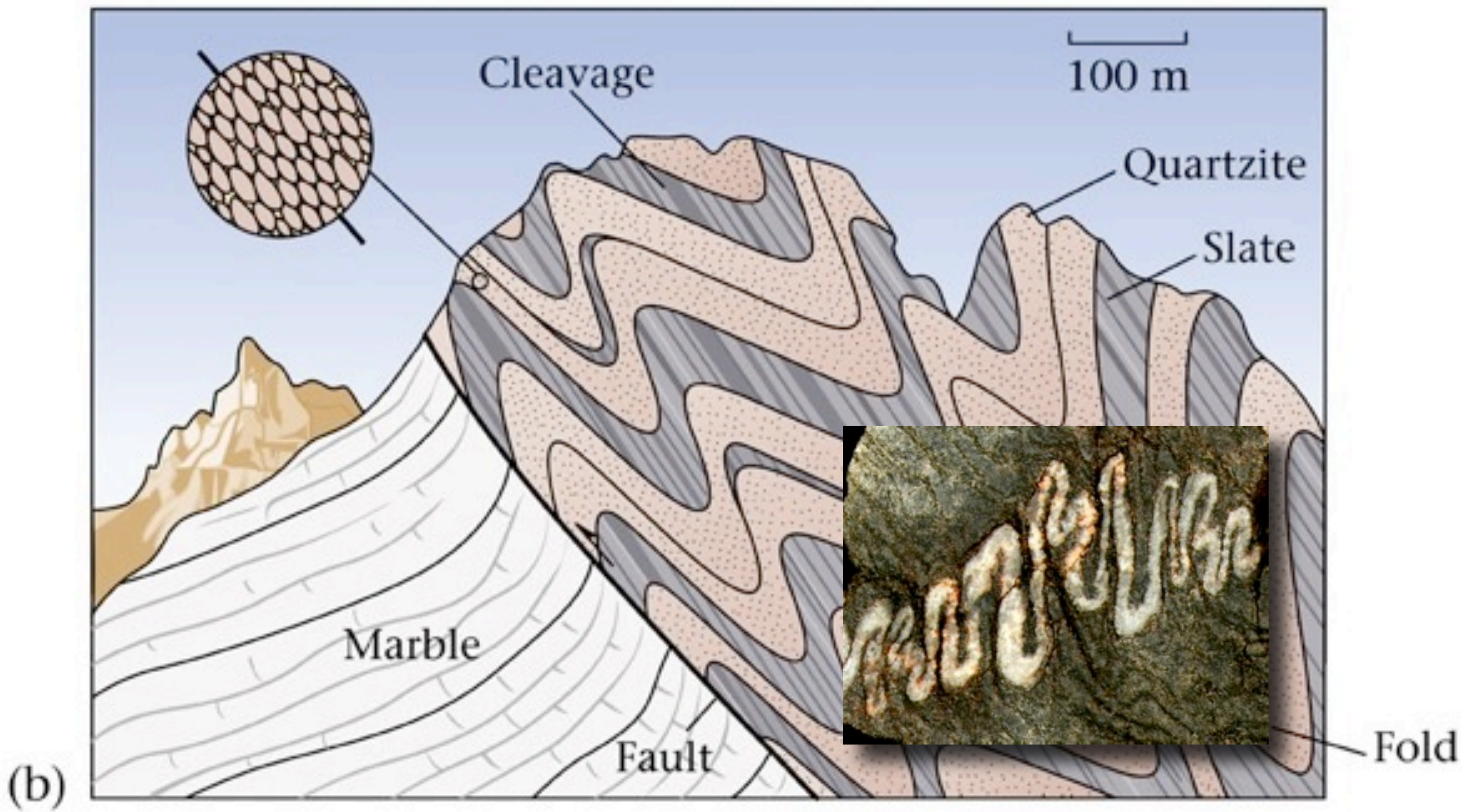


Brittle and Ductile Deformation



Folding

Brittle and Ductile Deformation



Folding

Why folding and not faulting?

Why folding and not faulting?

Heat

Pressure

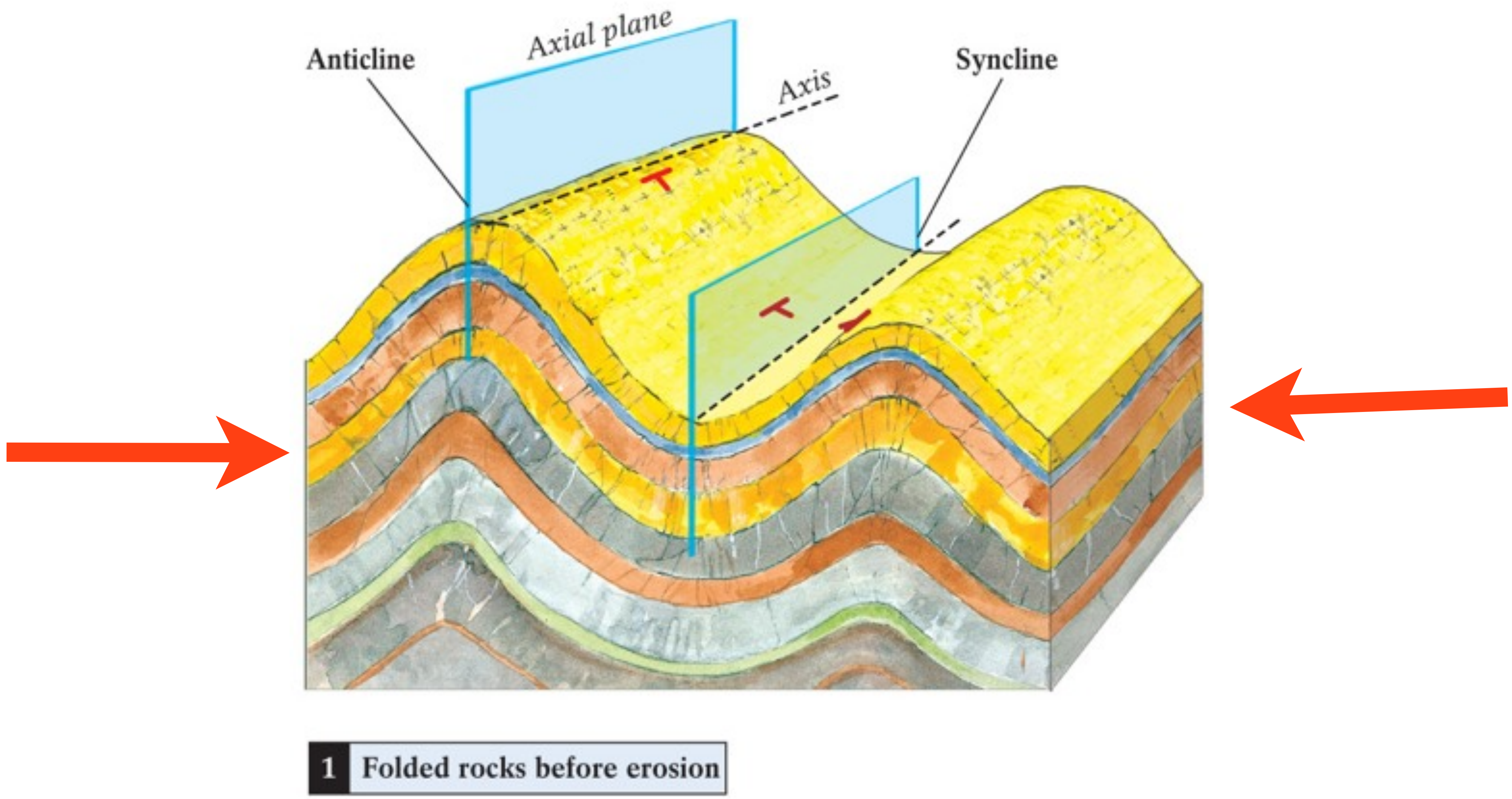
Composition

Strain Rate

Are the rocks of the Grand Canyon dipping?

Are the oldest rocks on the top or the bottom?

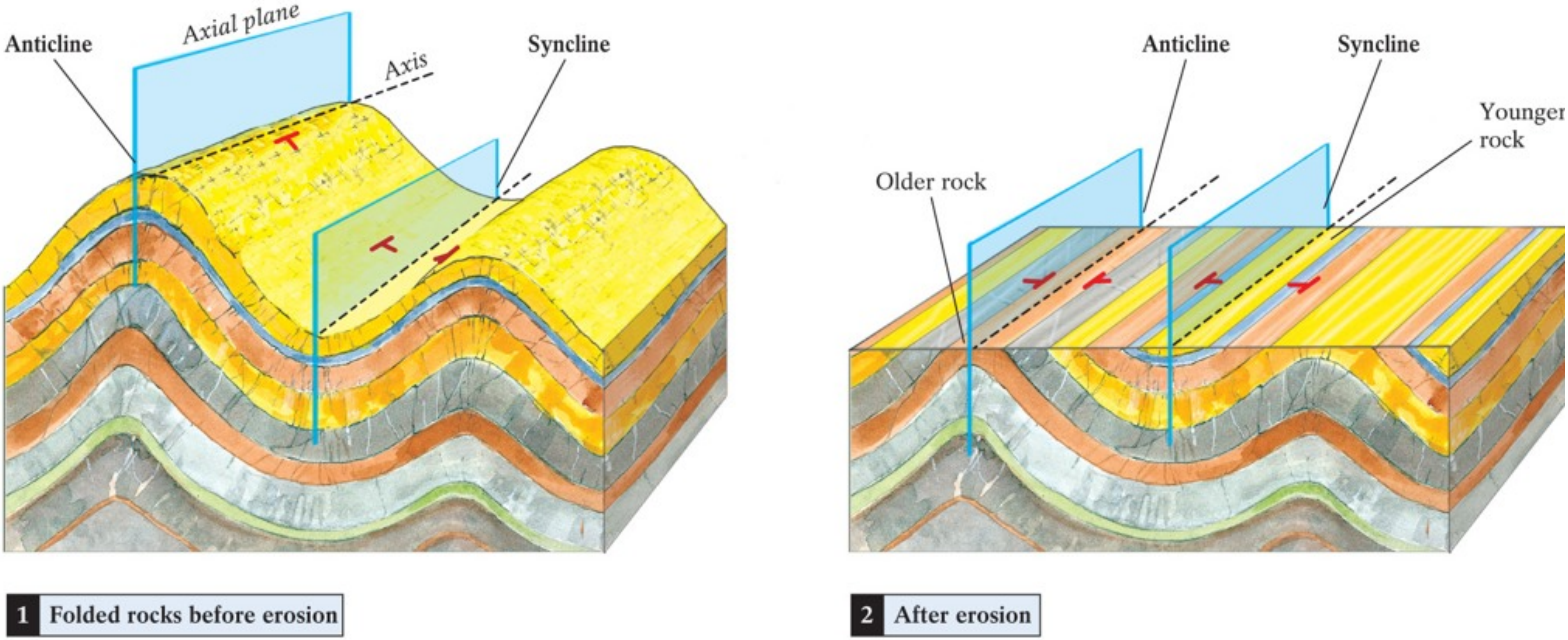
Compressional stress results in Folding



Anticline - Rock layers dip way from the axis of the fold.

Syncline - Rock layers dip toward the axis of the fold.

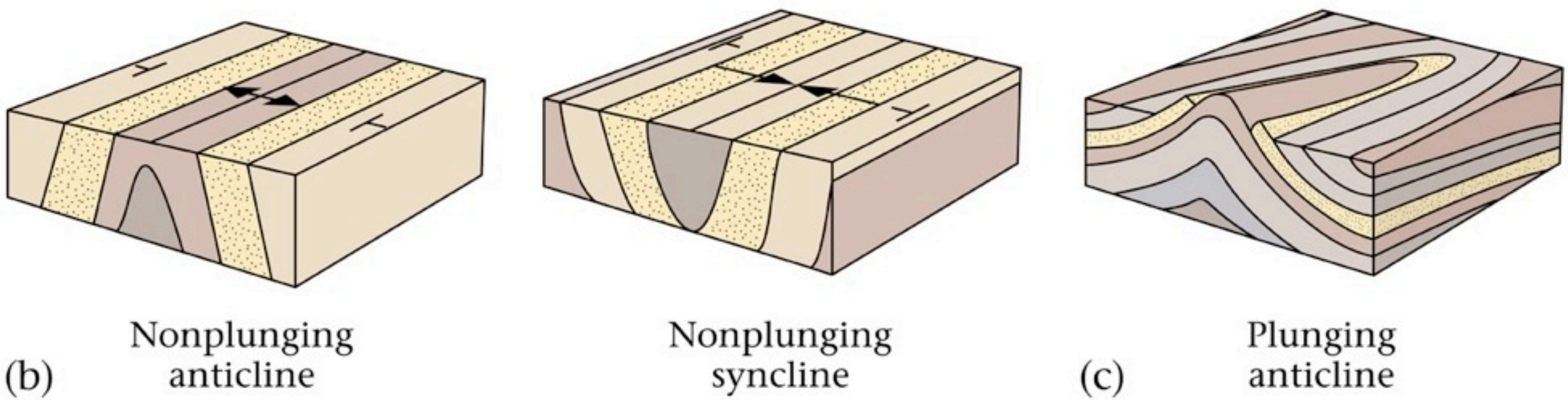
Compressional stress results in Folding



Anticline - Rock layers are older near the axis of the fold.

Syncline - Rock layers are younger near the axis of the fold.

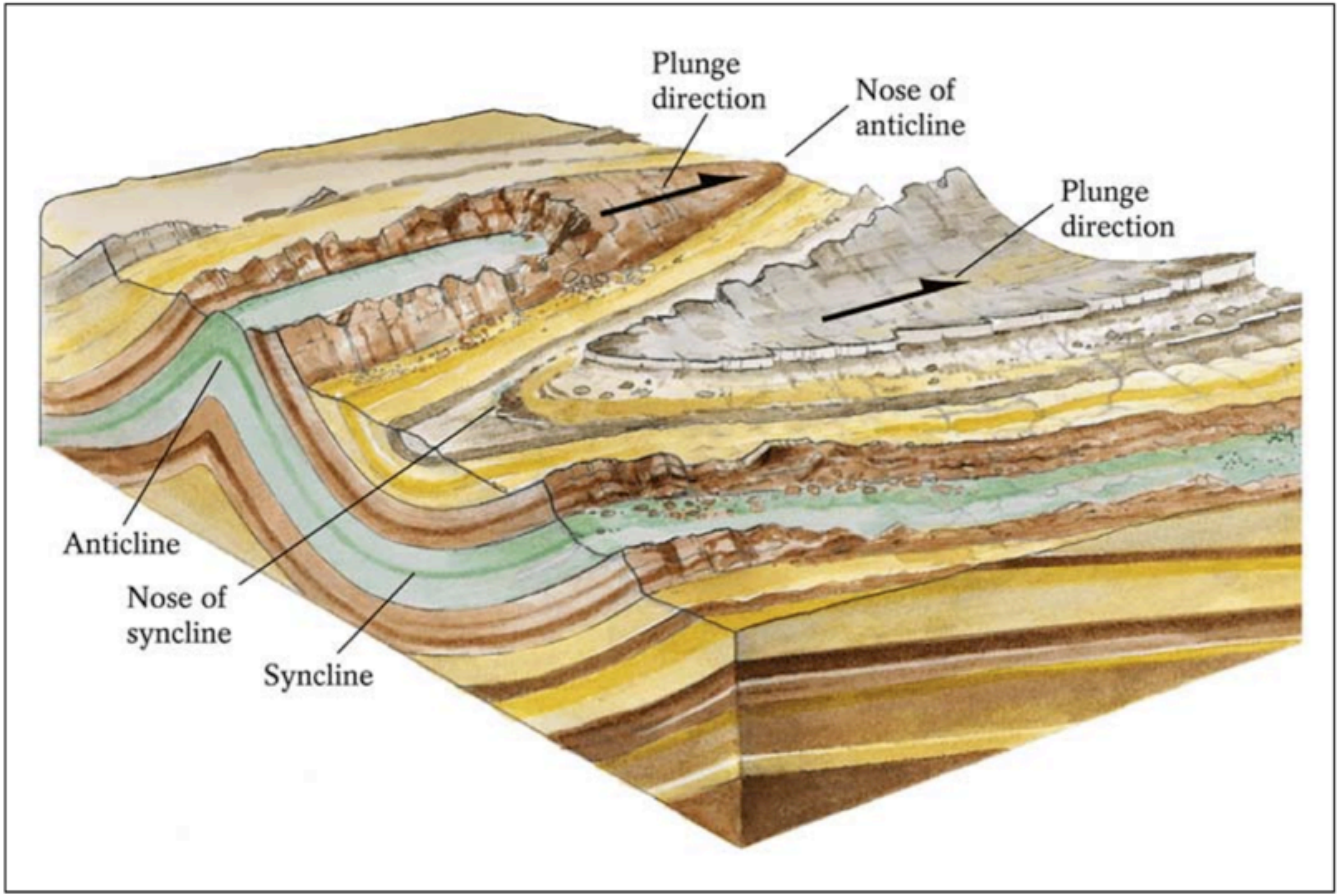
Compressional Folding



Non-plunging folds (upright folds), rock layers have a consistent strike that parallels the fold axis at the surface.

Plunging folds form curving paths at the surface near the fold axis.

Plunging Folds



Anticlines close toward the direction of plunge, whereas synclines open toward the direction of plunge

Split Mountain and the Green River in Utah

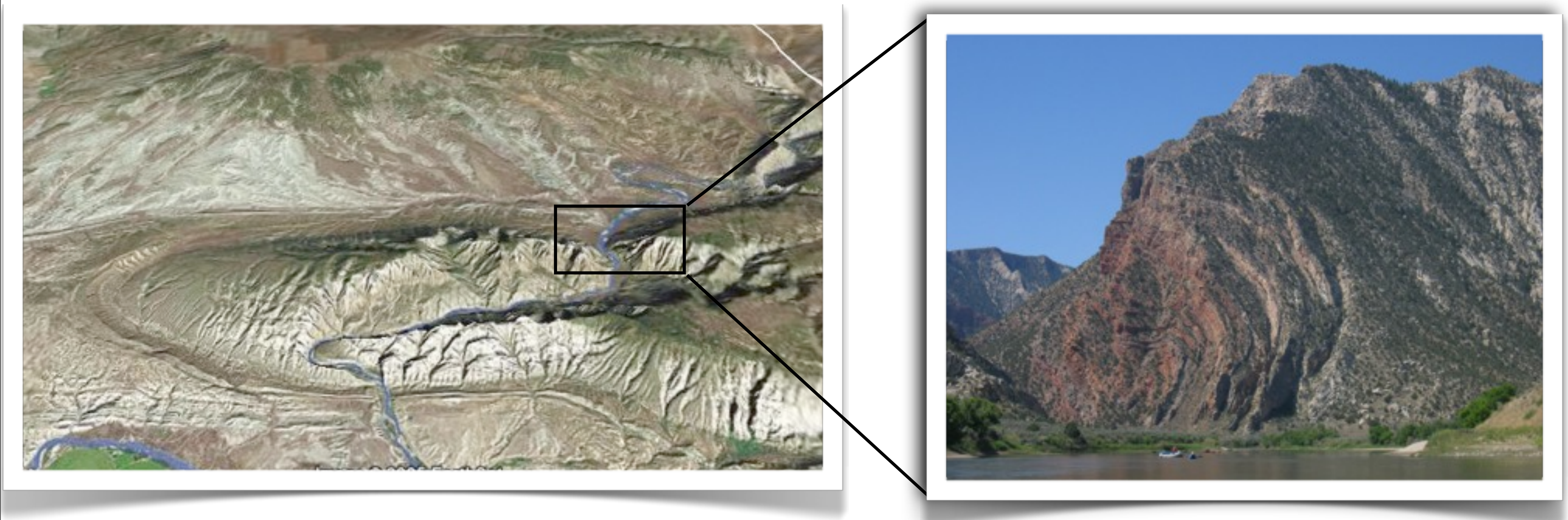
Is this fold plunging?

Split Mountain and the Green River in Utah

Is this fold plunging?

Is this fold an anticline or a syncline?

Split Mountain and the Green River in Utah



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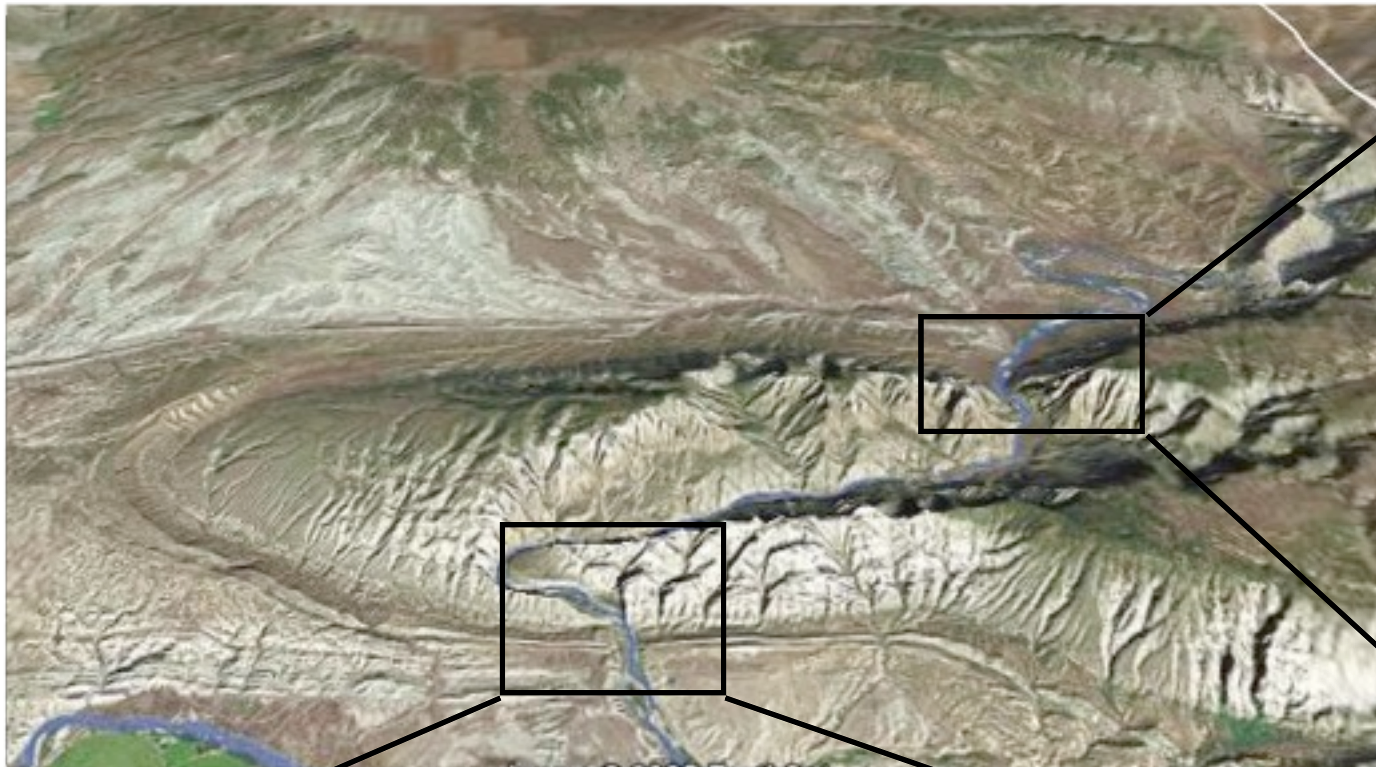
Is this fold an anticline or a syncline?

Split Mountain and the Green River in Utah



Is this fold plunging?

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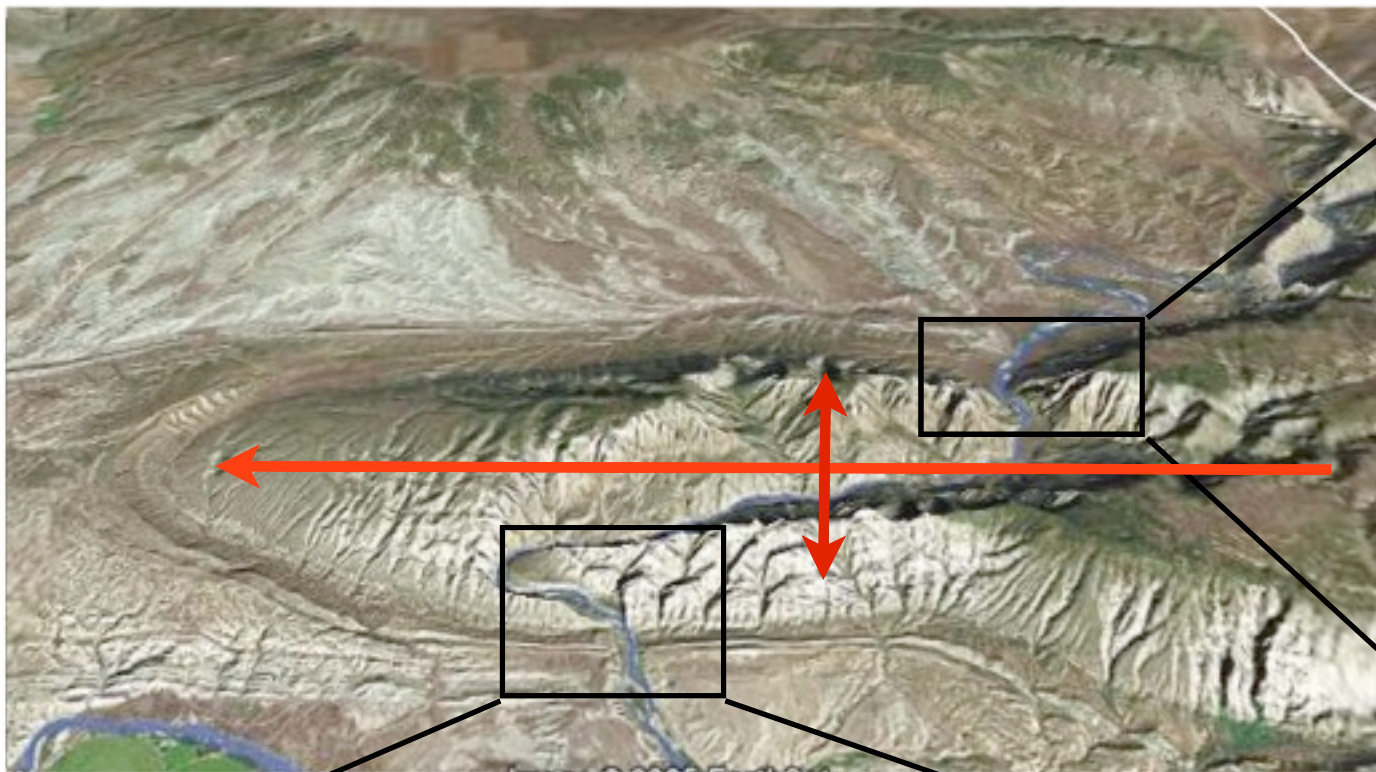
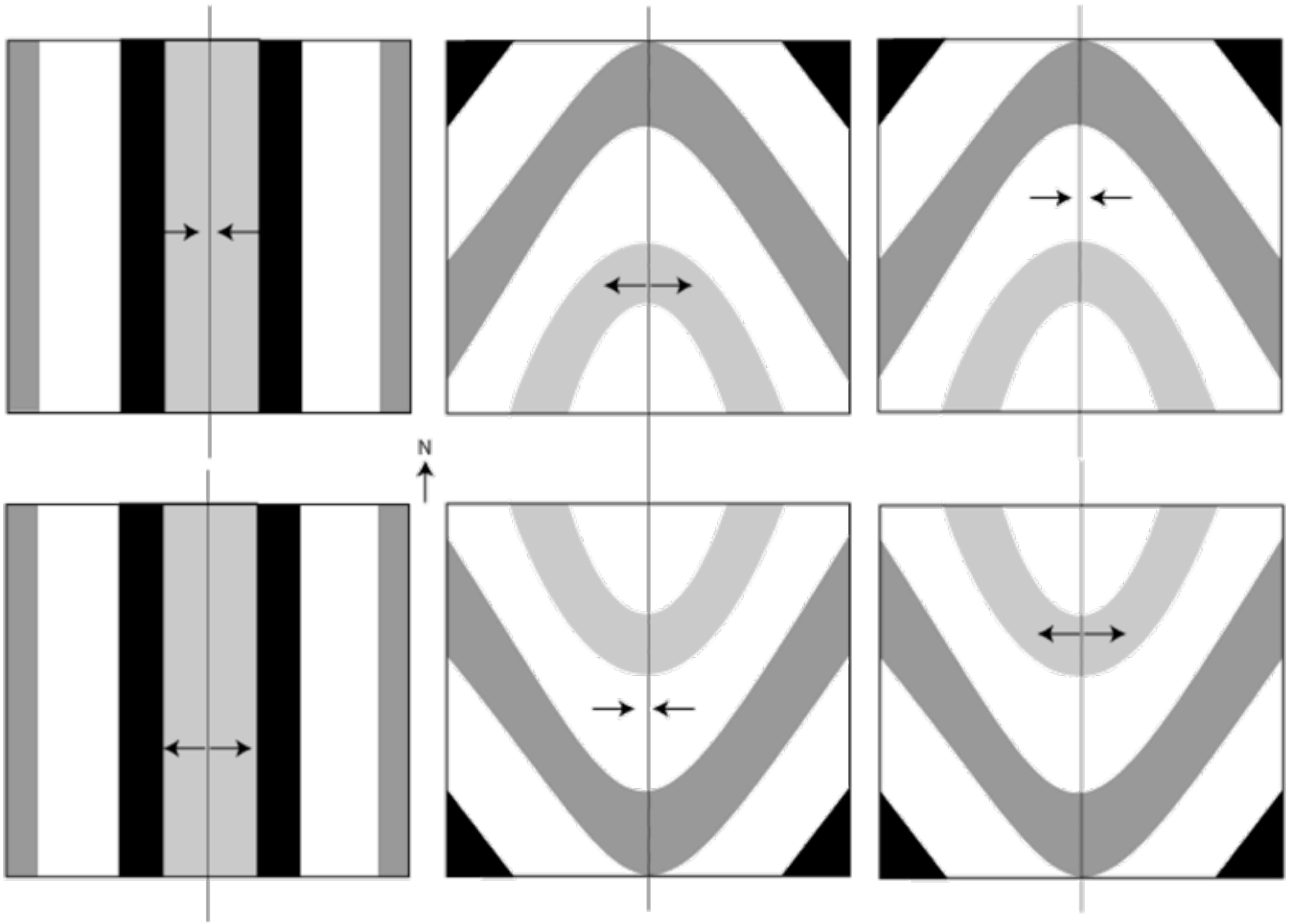


Is this fold plunging?

Is this fold an anticline or a syncline?

In Class: Group Exercise



Strain in Rocks

Ductile

Shearing

Brittle

Ductile and Brittle

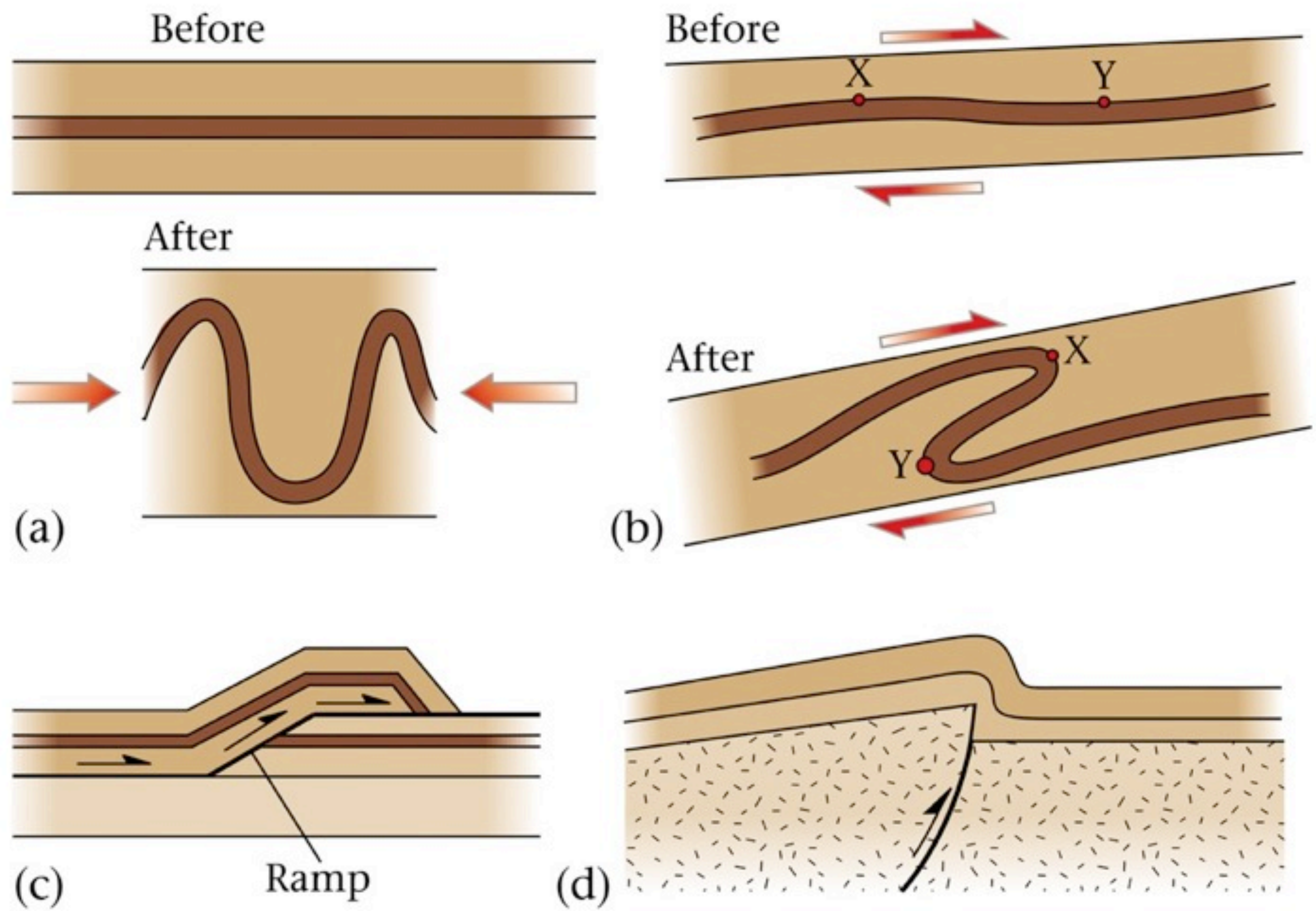


FIGURE 9.19

Strain in Rocks

Ductile

Shearing

Brittle

Ductile and Brittle

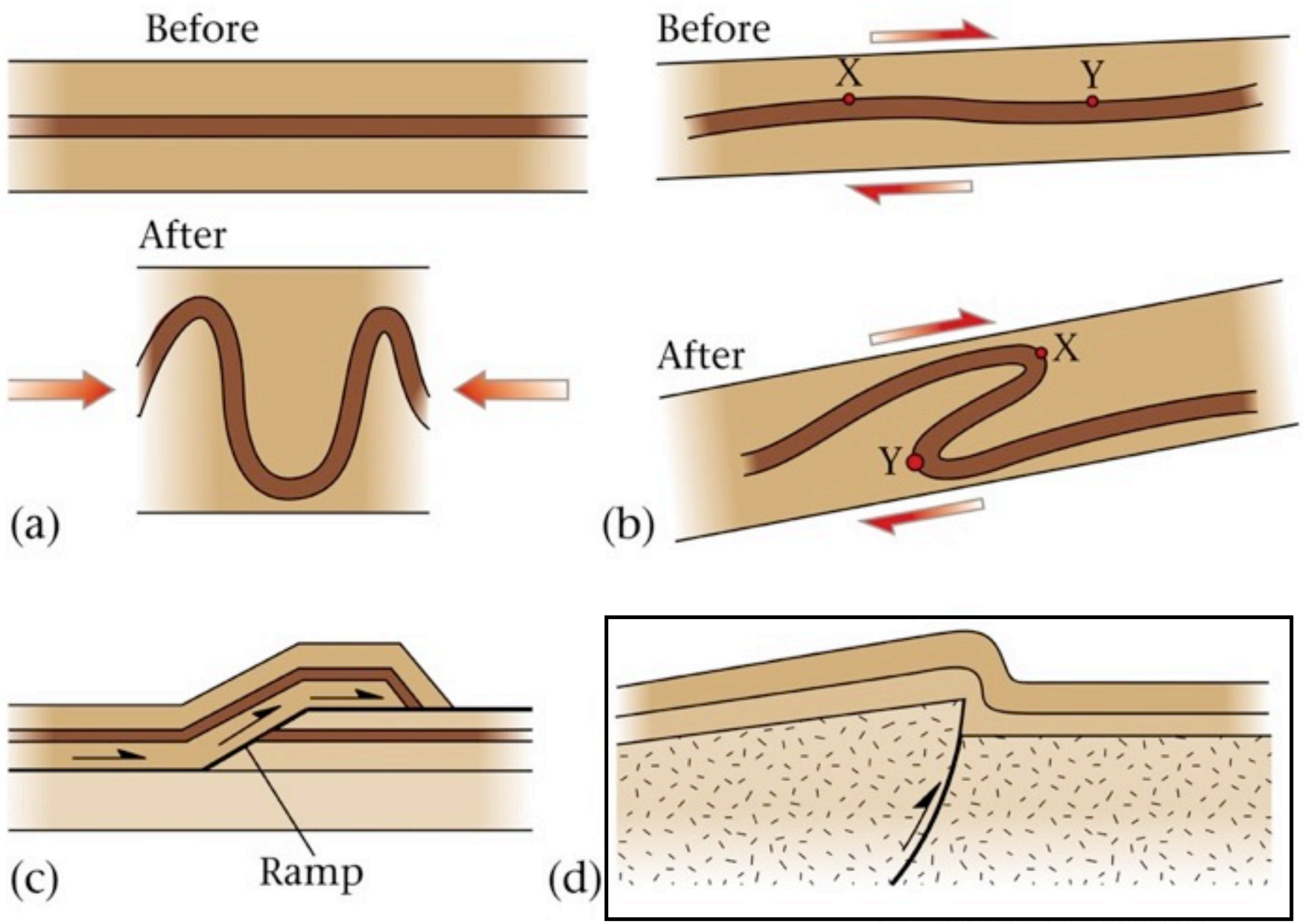
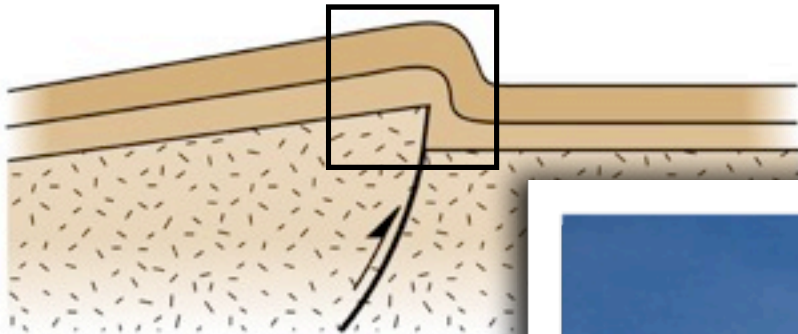
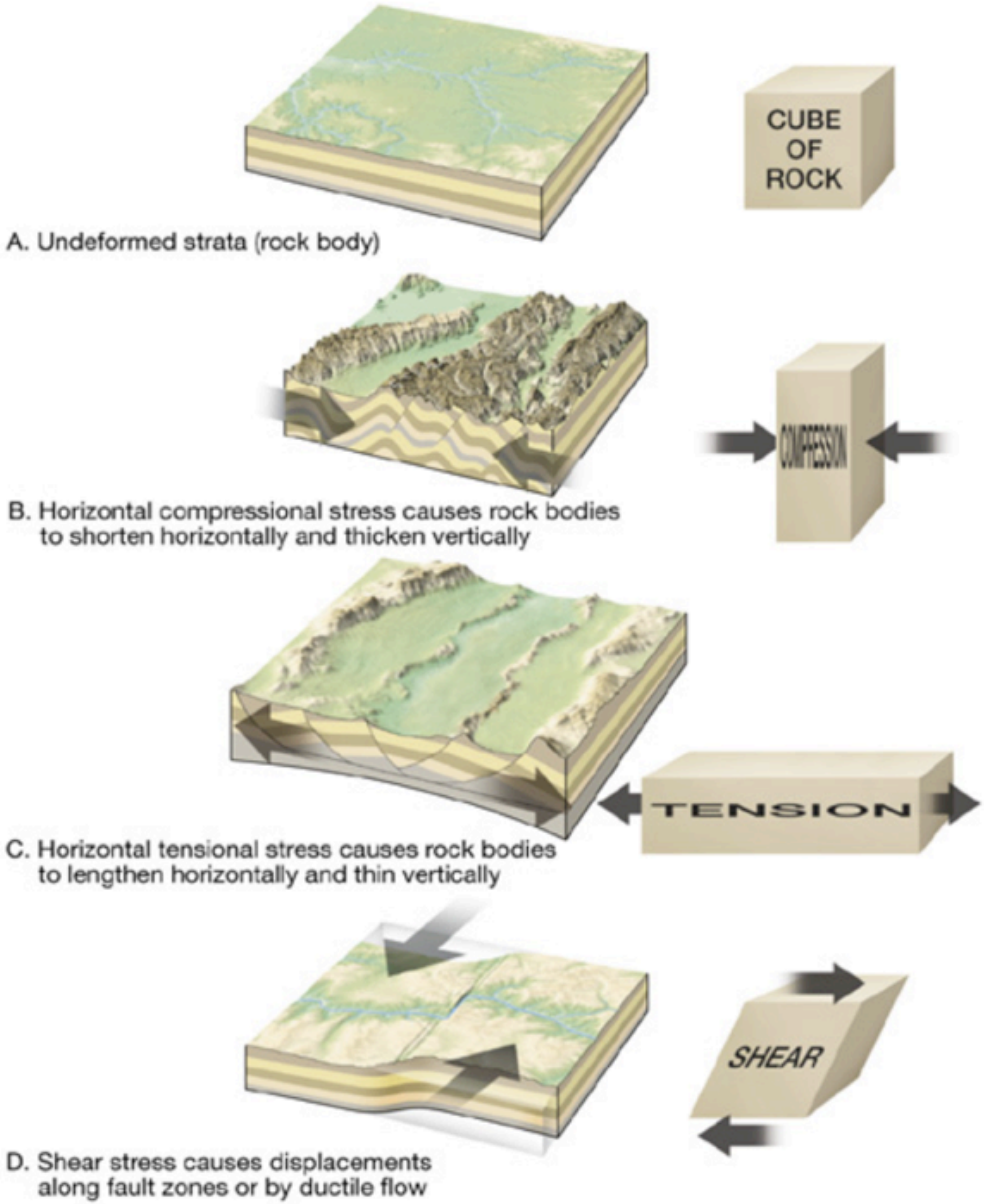


FIGURE 9.19

Compressional Strain in Rocks



Crustal Deformation



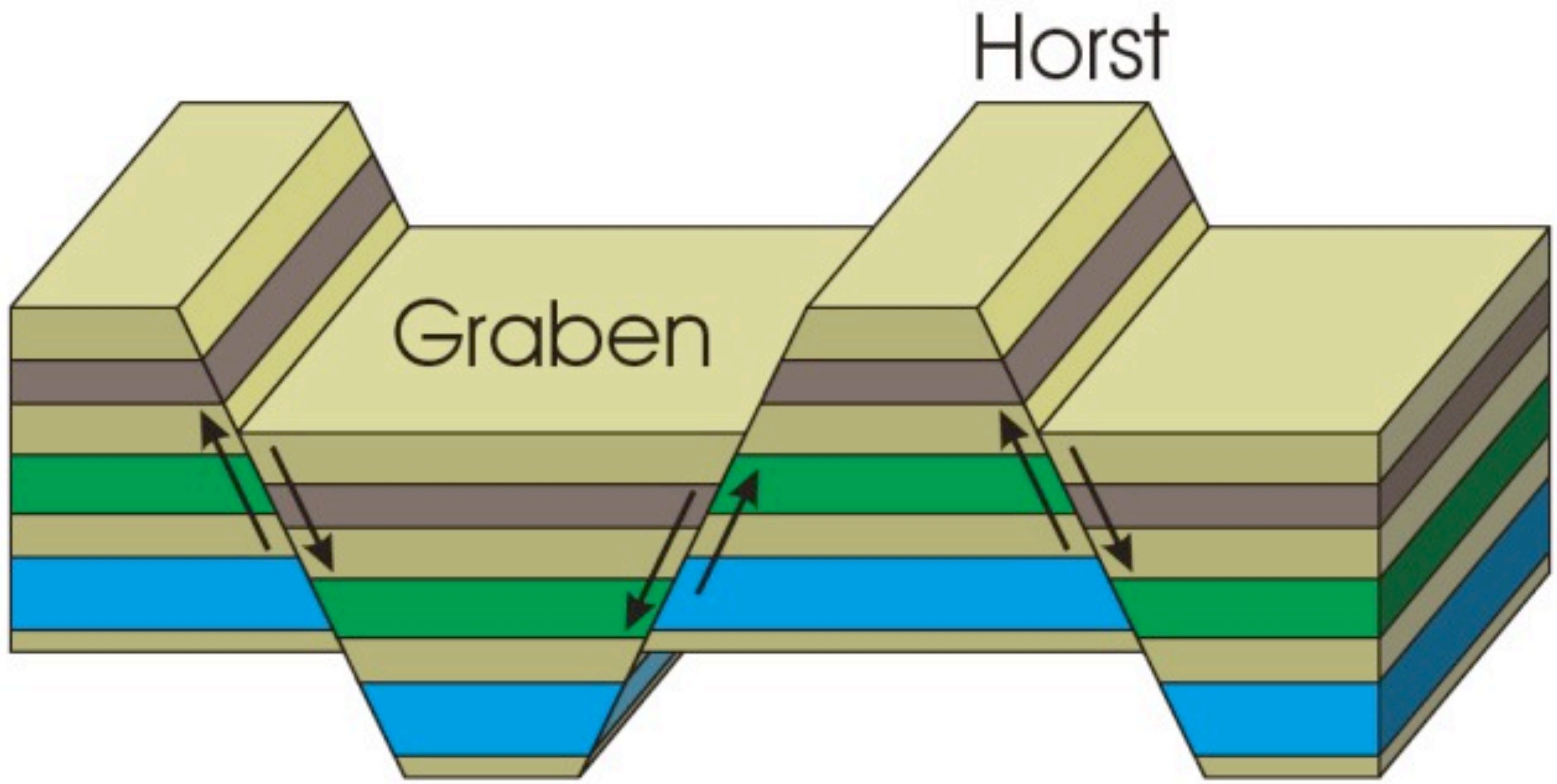
Crustal Thickening, shortening

Crustal Thinning, extension

Crustal Translation

Extensional Mountain Building

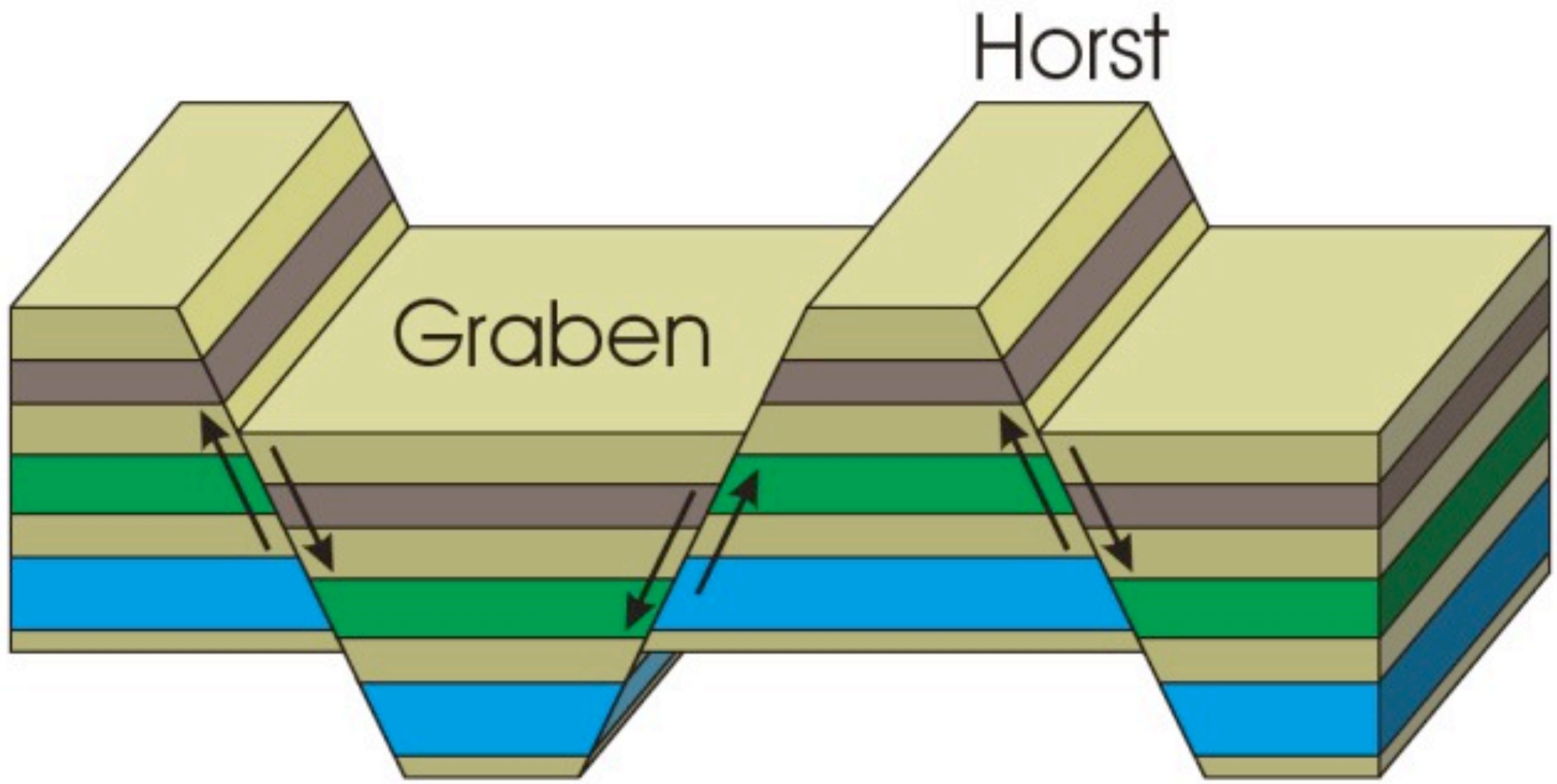
Extension results in normal dip-slip faulting



Which is the hangingwall and which is the footwall?

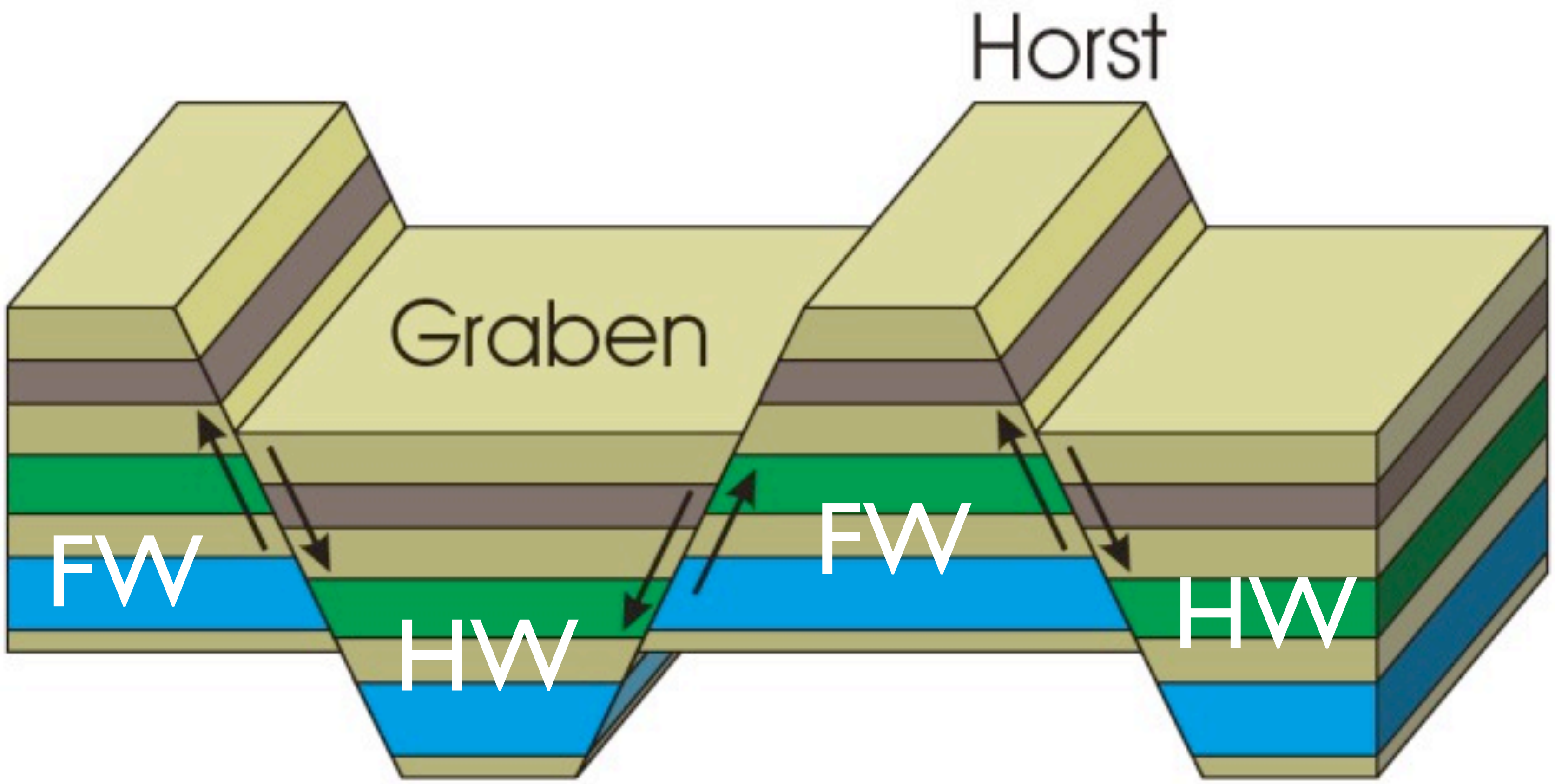
Extensional Mountain Building

Extension results in normal dip-slip faulting



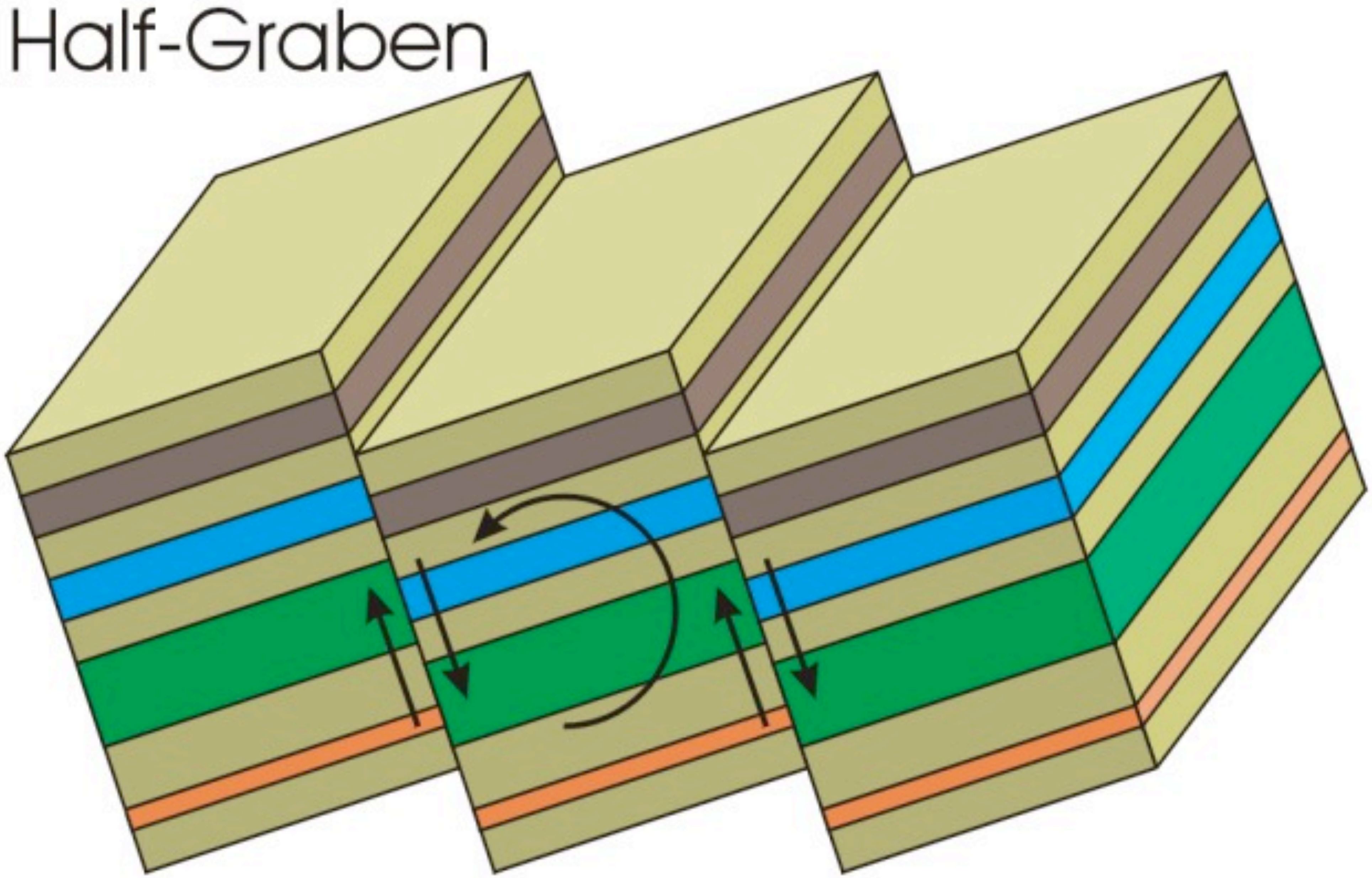
Extensional Mountain Building

Extension results in normal dip-slip faulting



Extensional Mountain Building

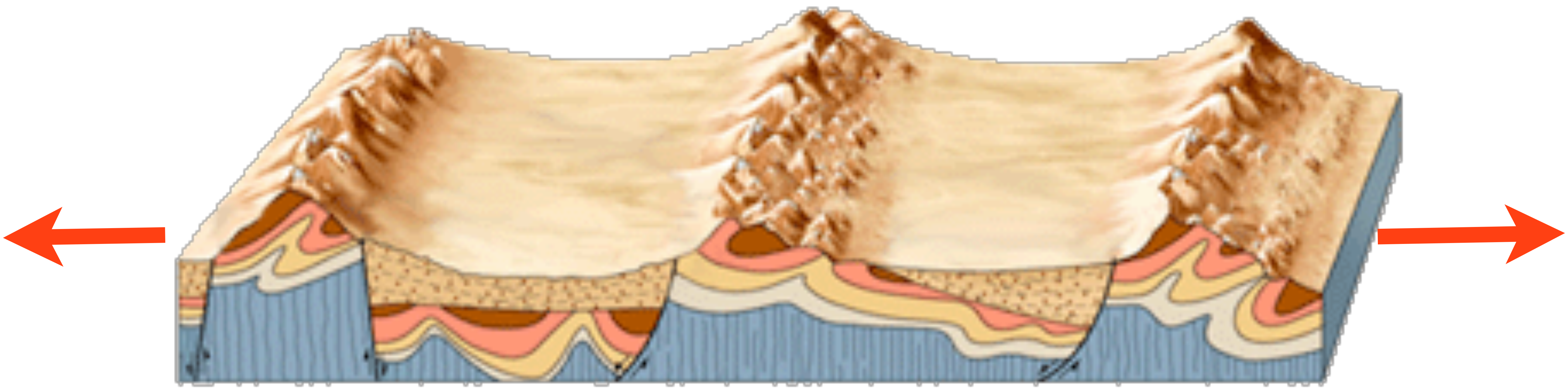
Extension results in <u>normal</u> dip-slip faulting, thinning and rotation



Which is the hanging wall and which is the footwall?

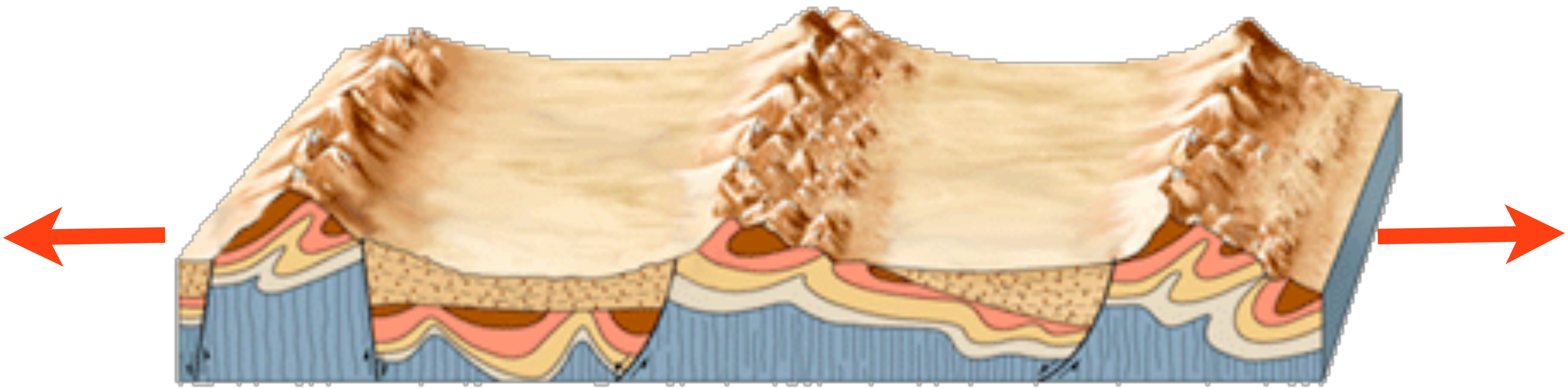
Extensional Mountain Building

Extension results in normal dip-slip faulting



Extensional Mountain Building

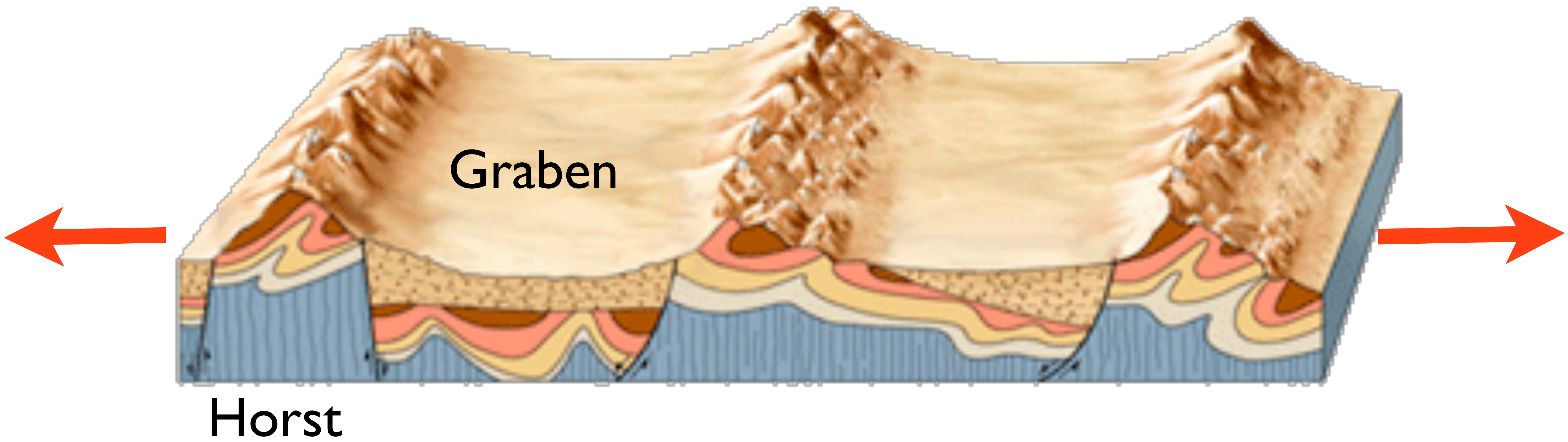
Extension results in normal dip-slip faulting



Horst

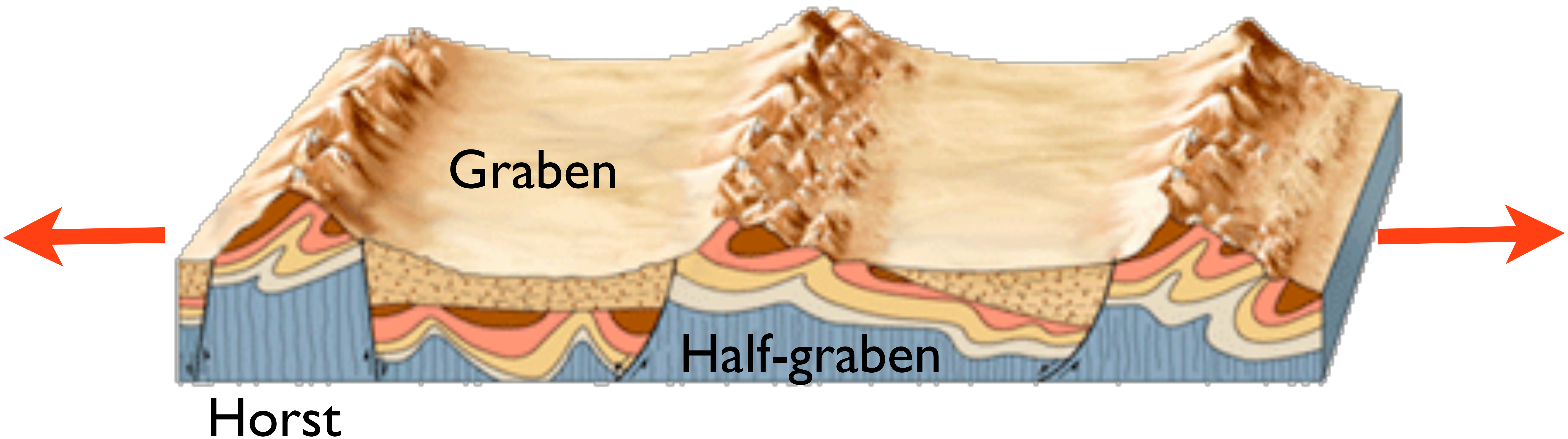
Extensional Mountain Building

Extension results in normal dip-slip faulting

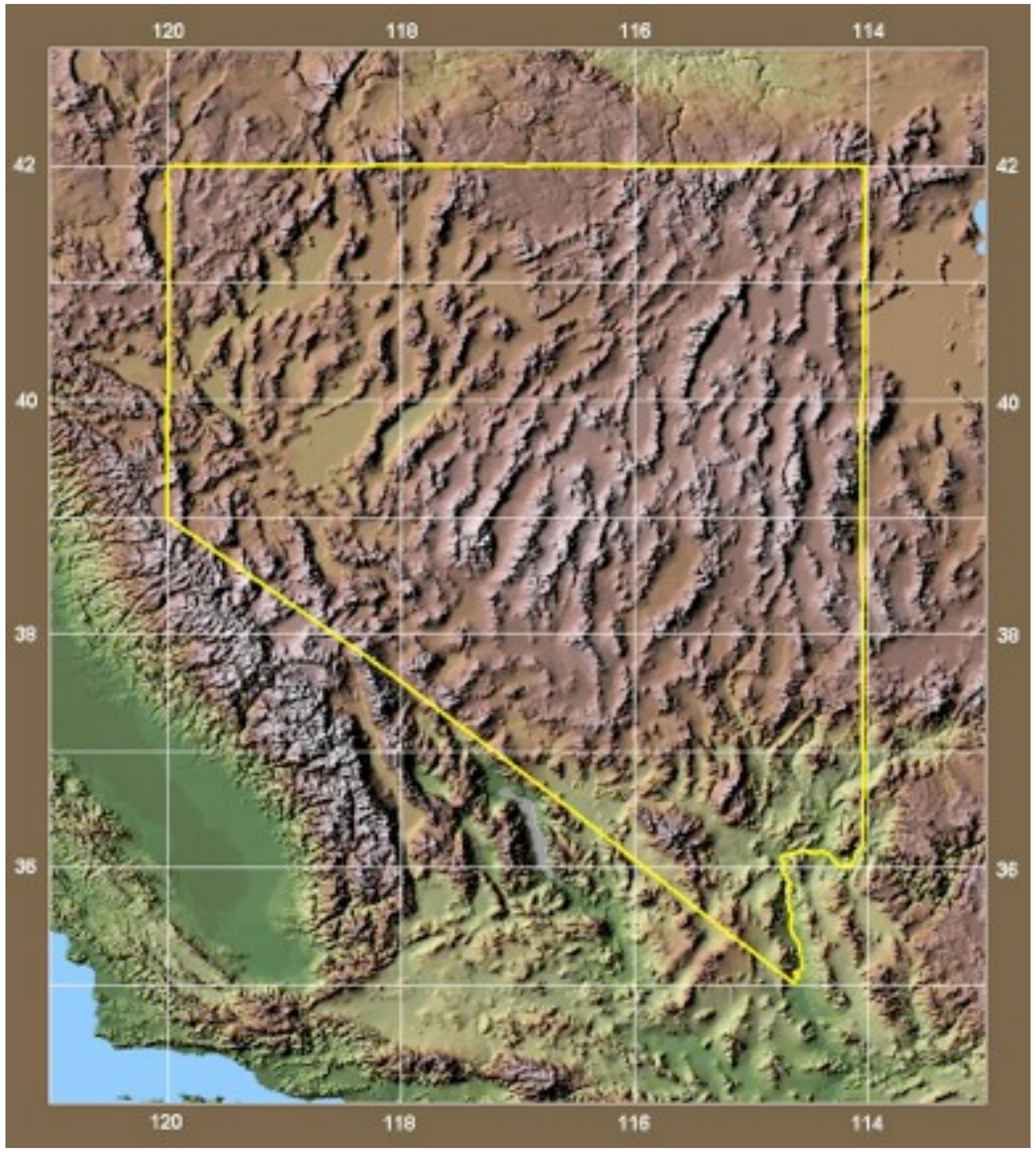


Extensional Mountain Building

Extension results in normal dip-slip faulting

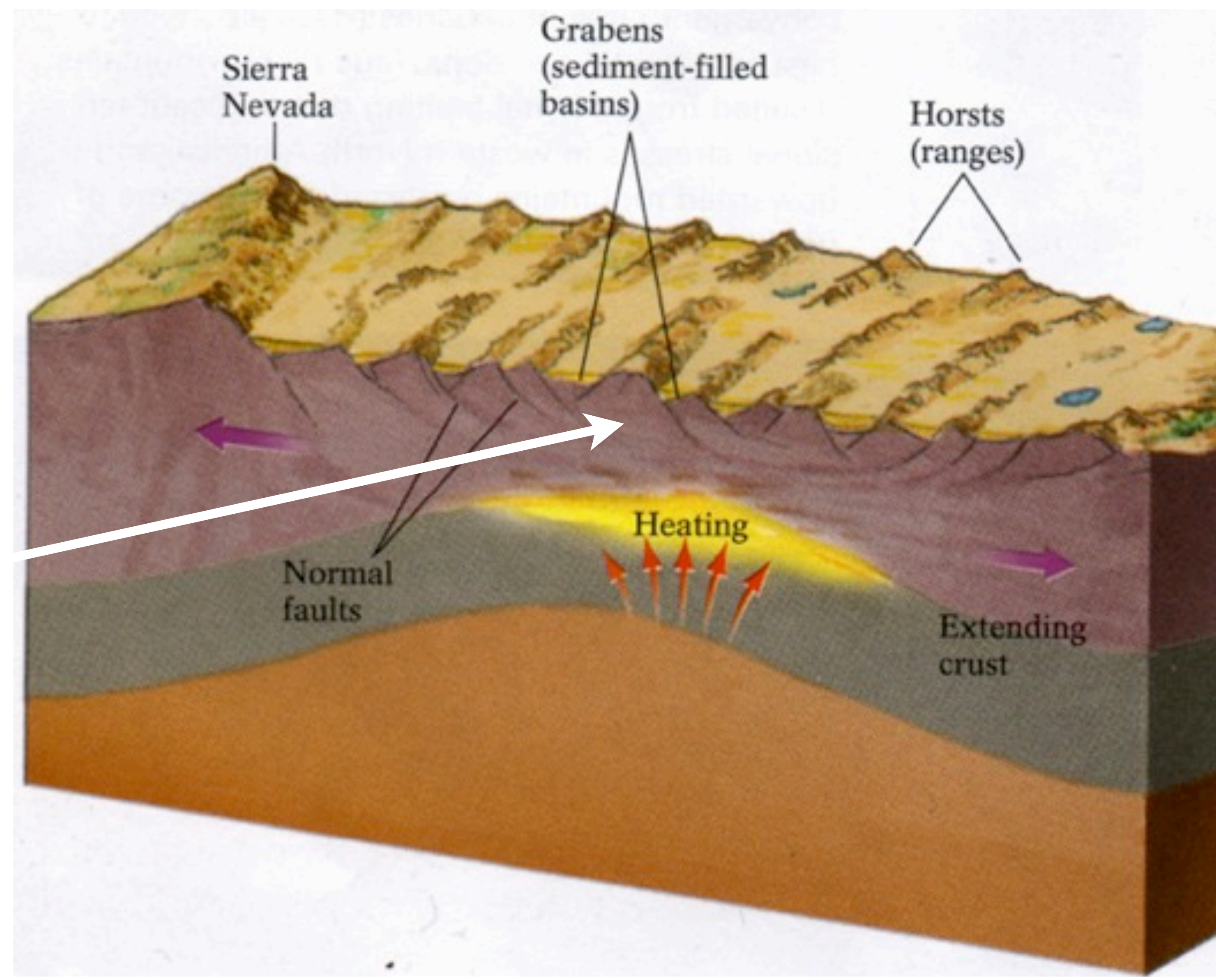


Extensional Mountain Building



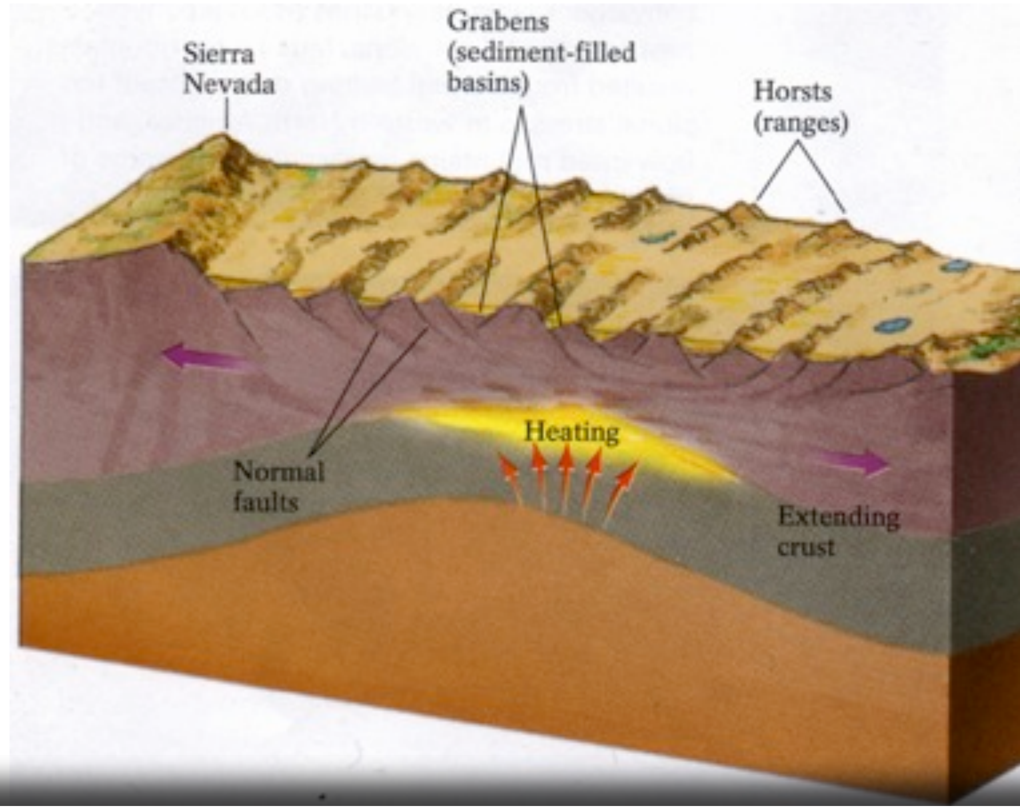
Basin and Range

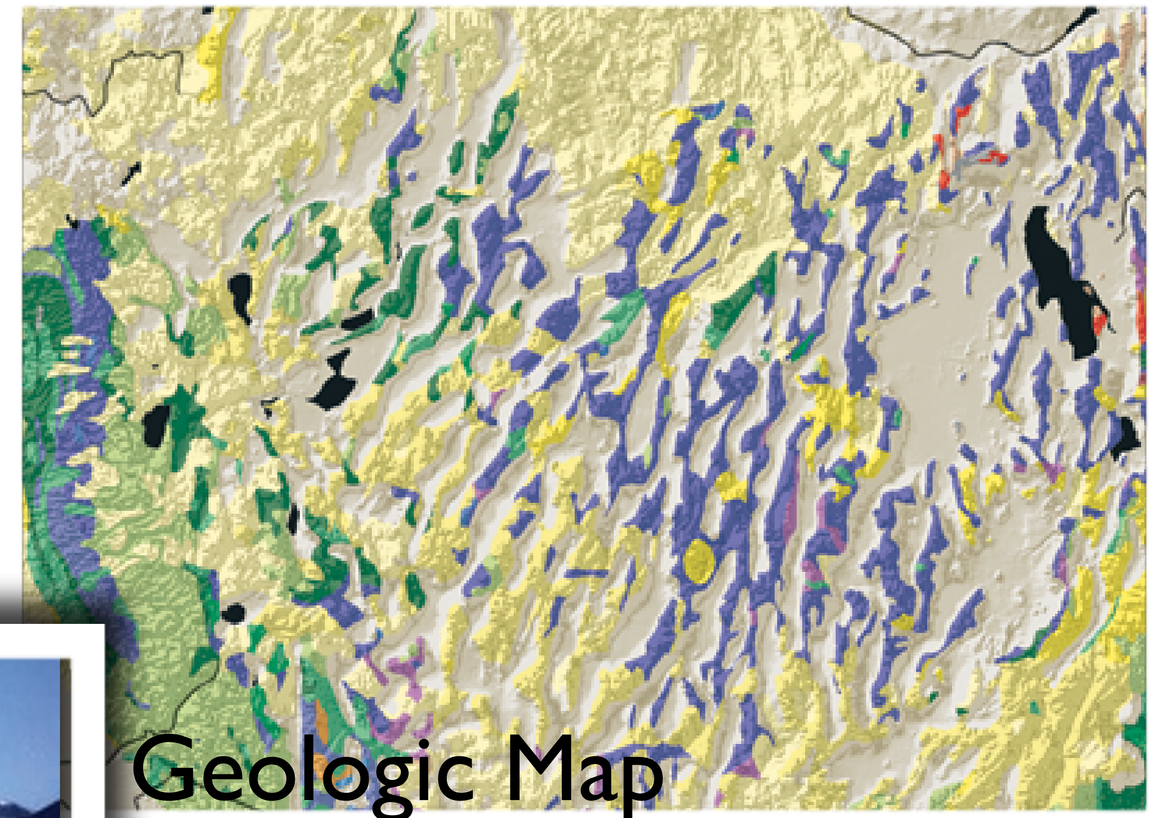
Extension thins the crust

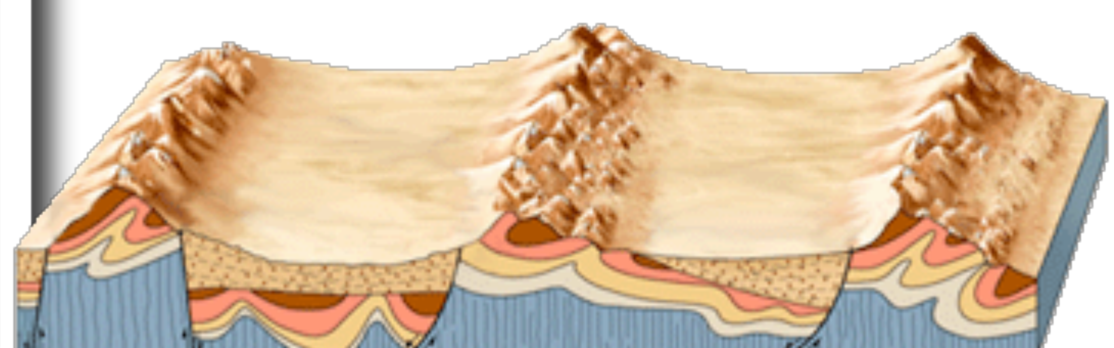


Basin and Range

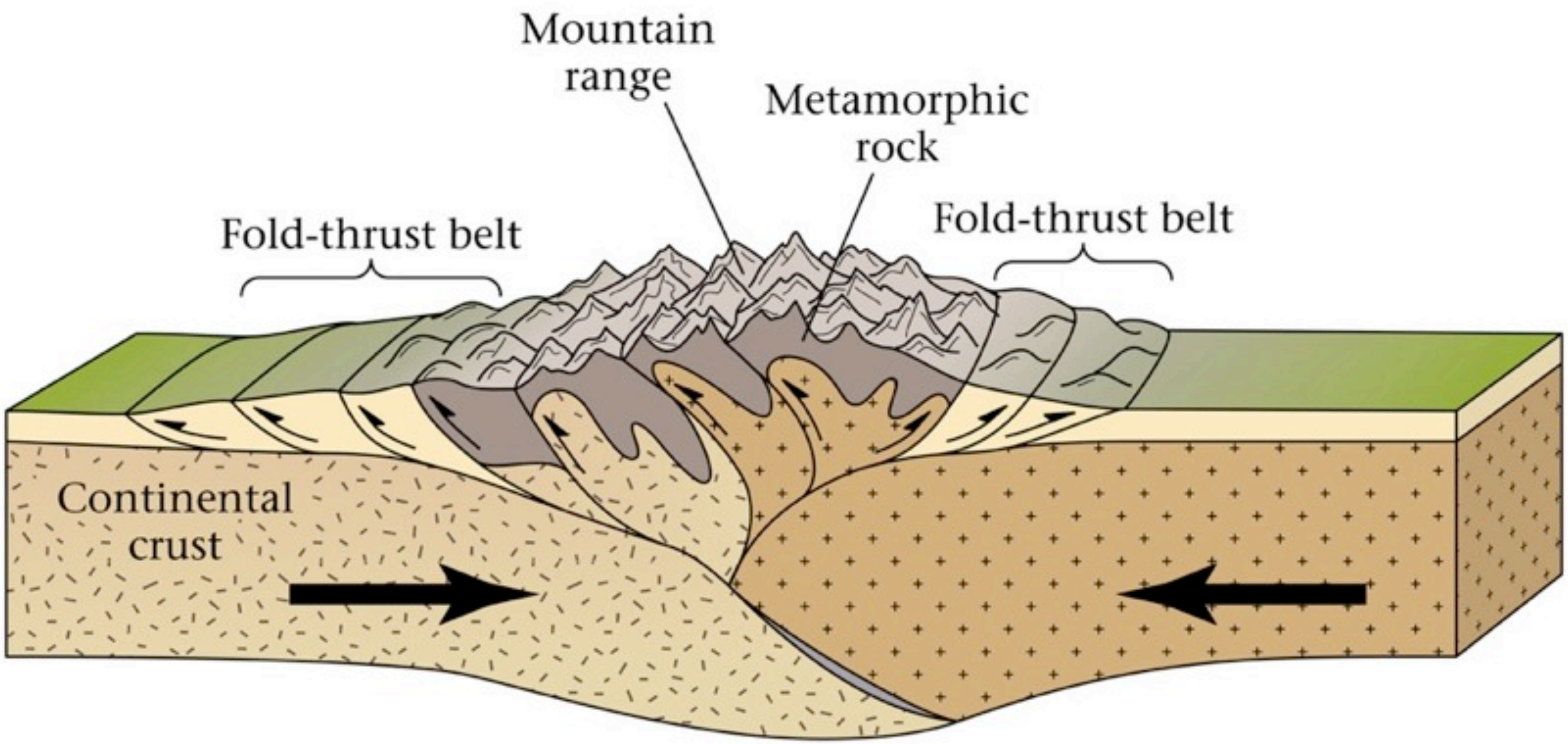
Extensional Mountain Building





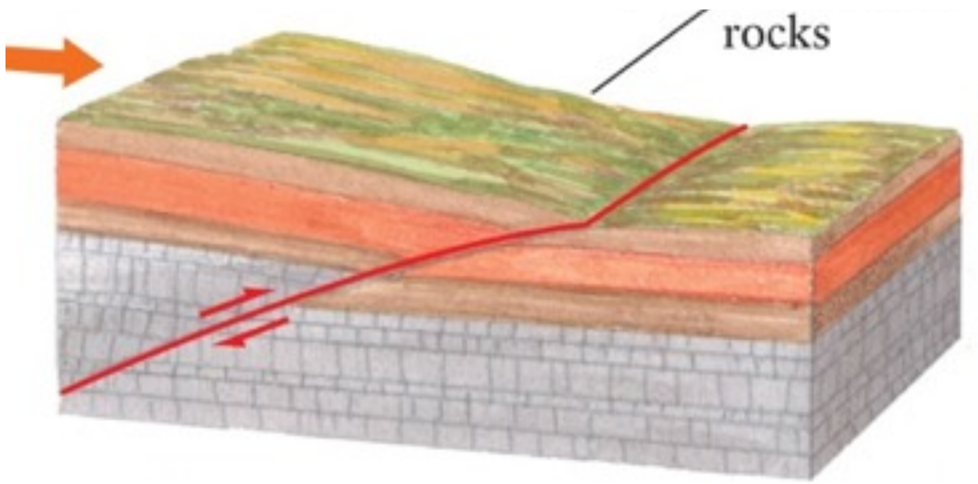


Compressional Mountain Building

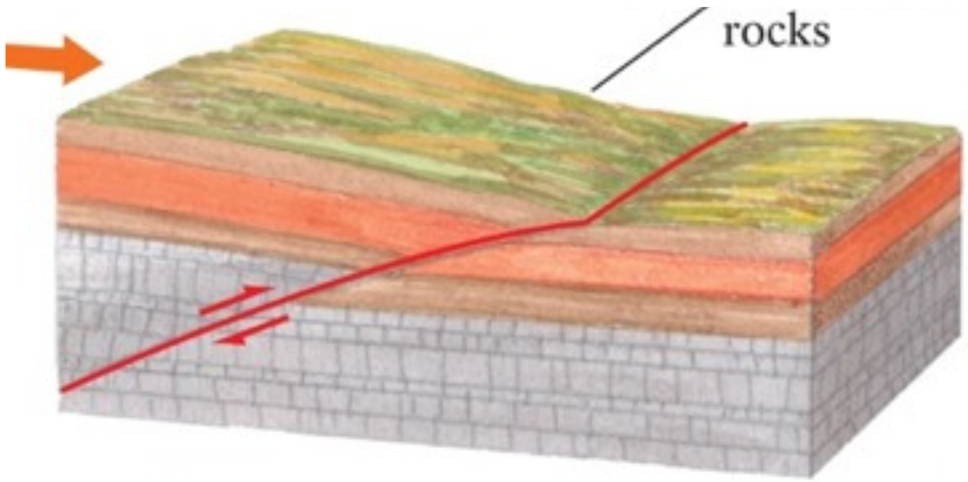


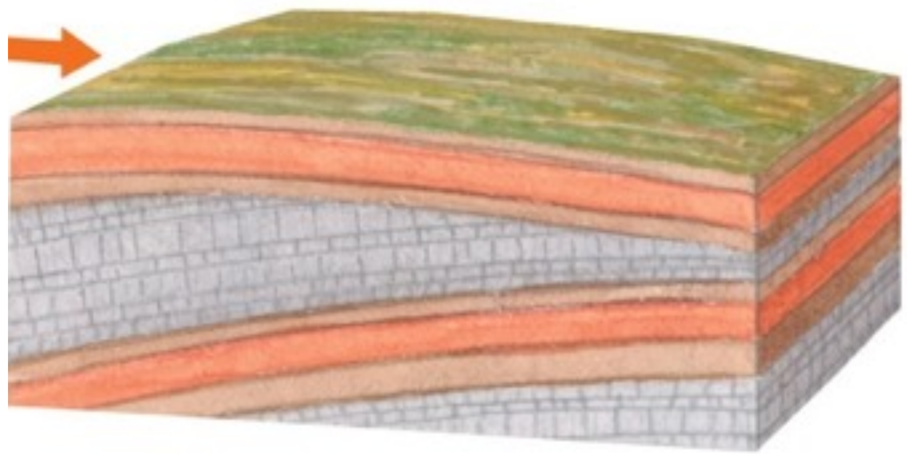
Shortening thickens the crust by folding and reverse faulting

Compressional Mountain Building

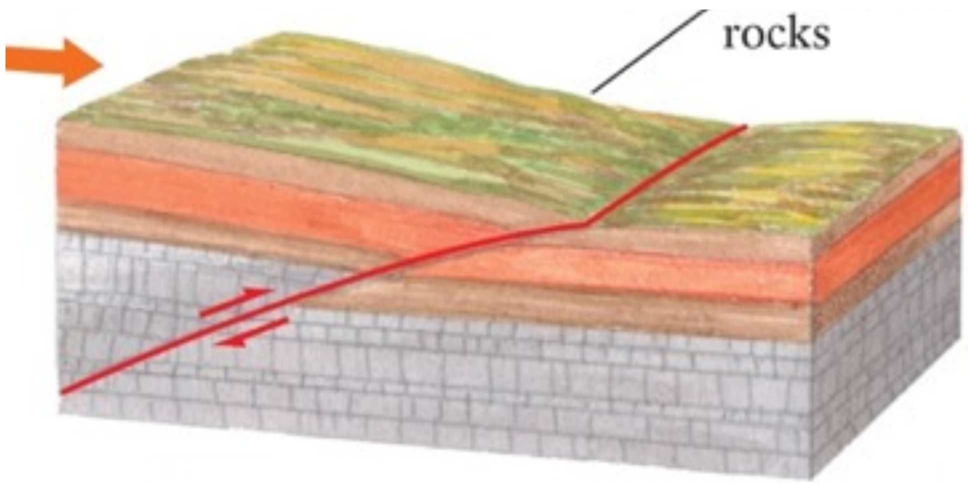


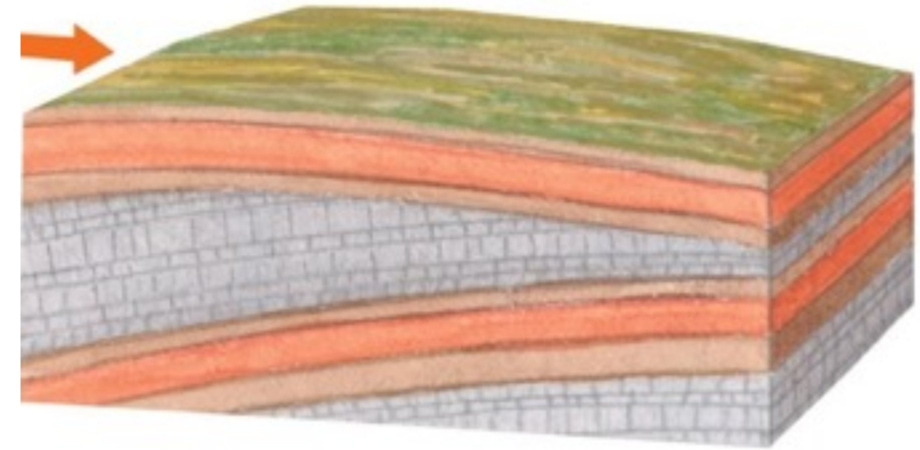
Compressional Mountain Building

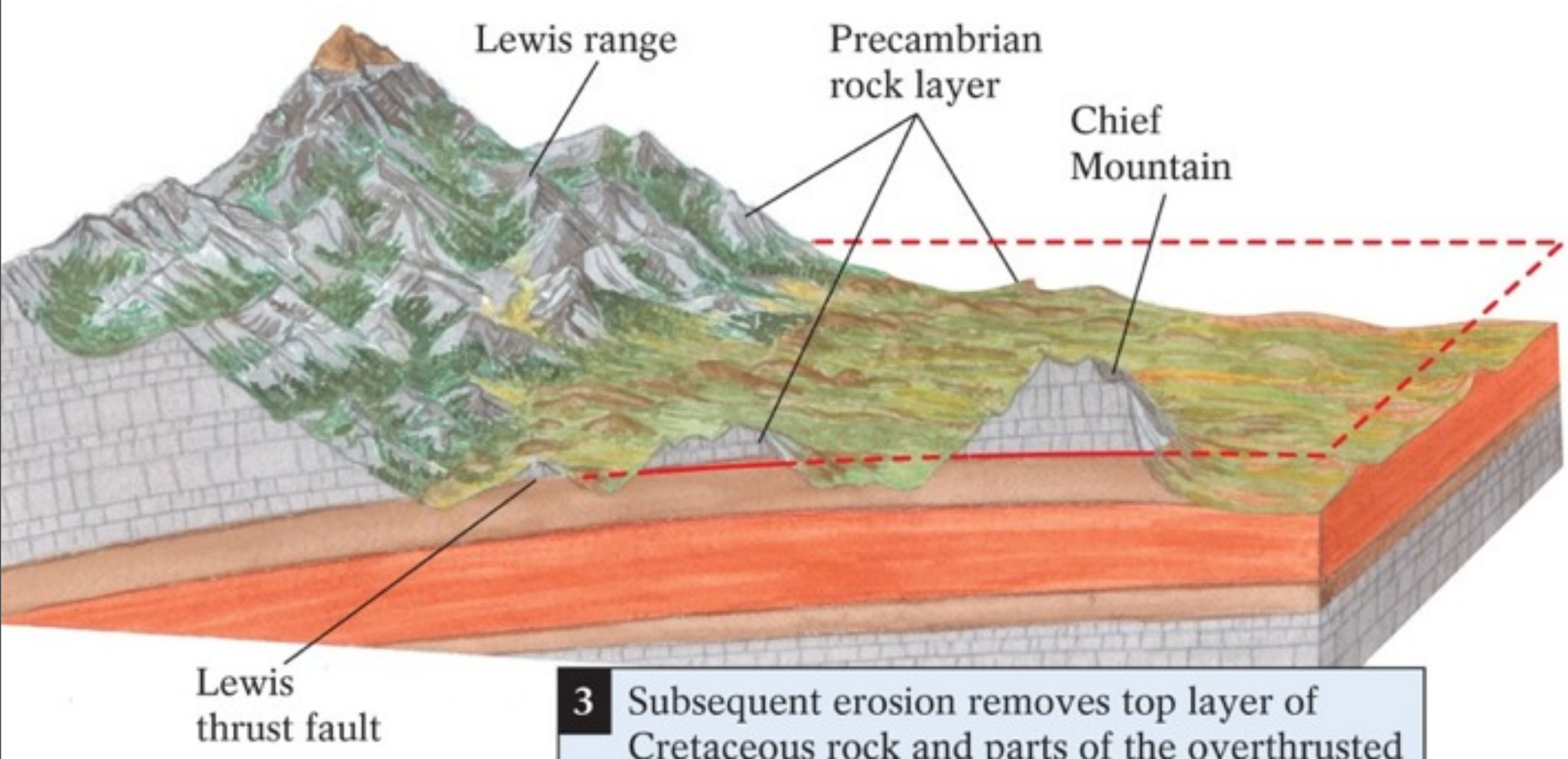




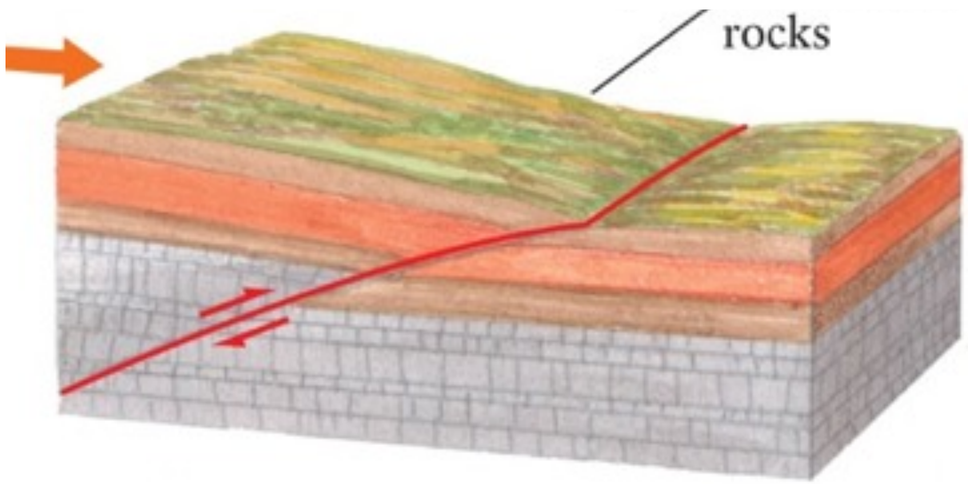
Compressional Mountain Building

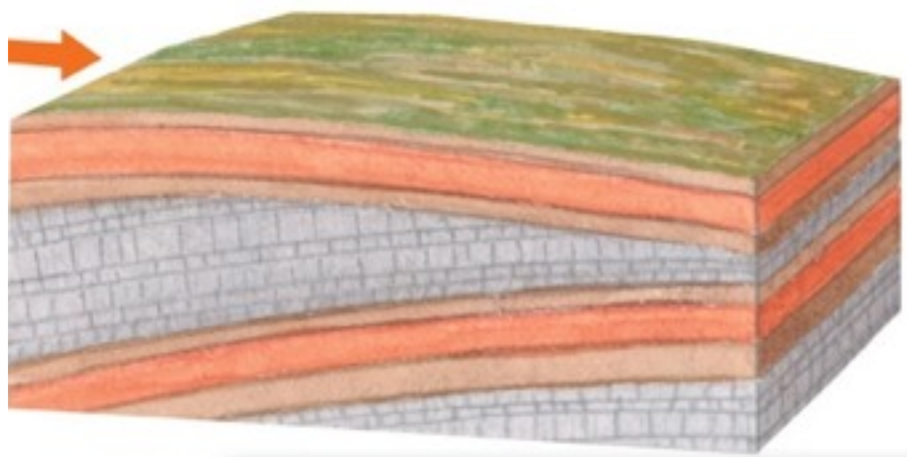


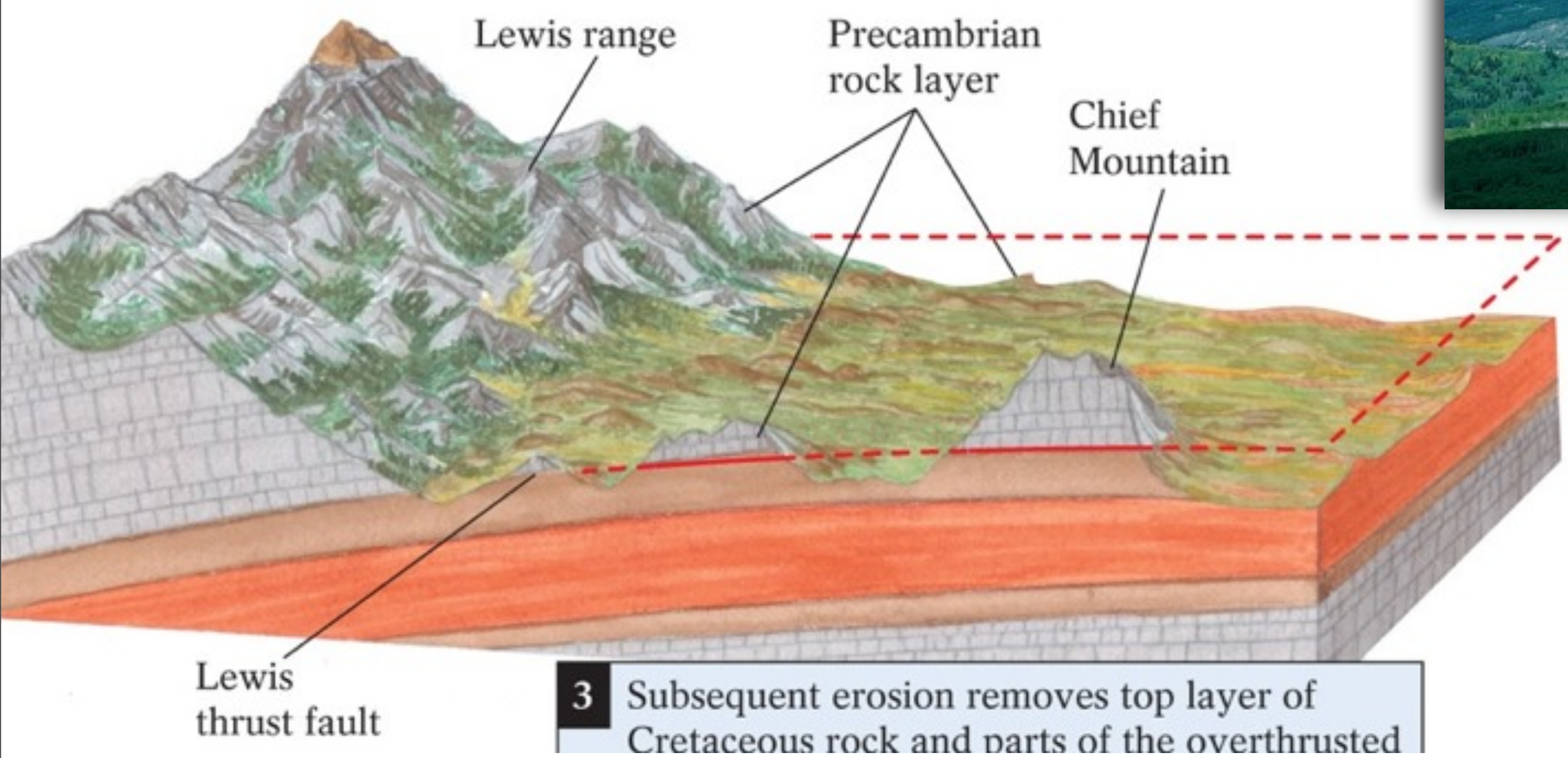




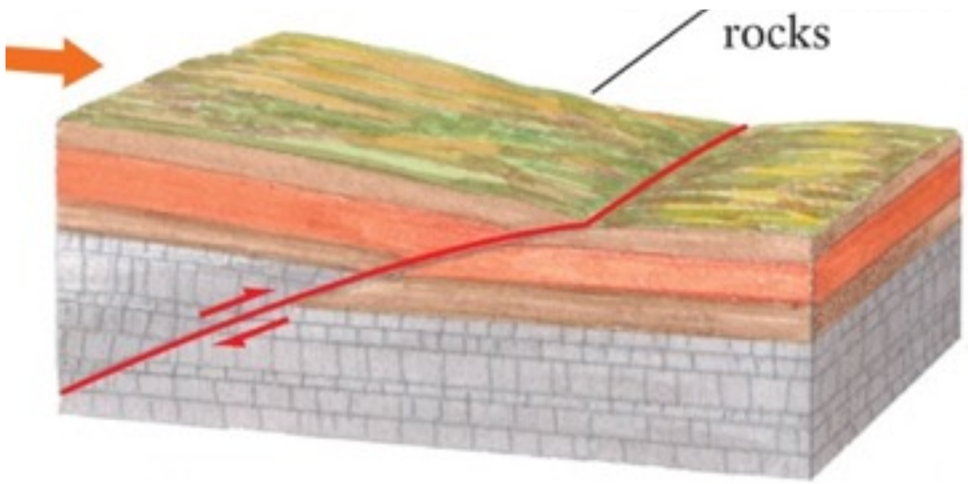
Compressional Mountain Building

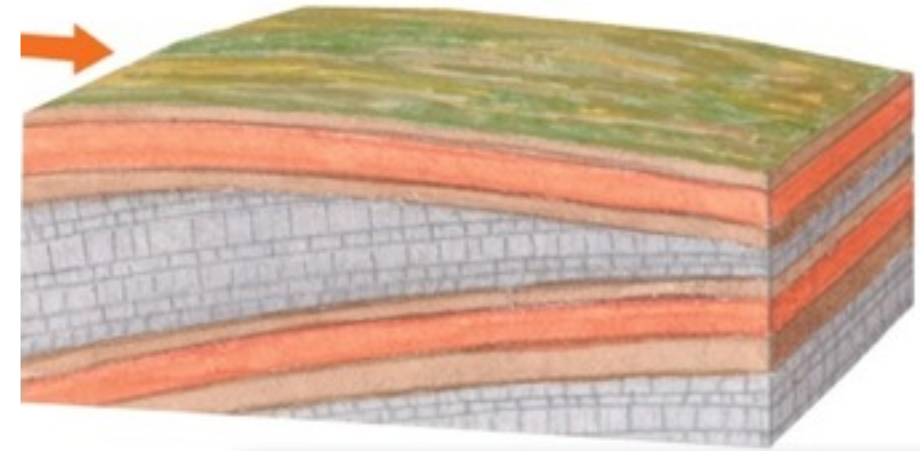




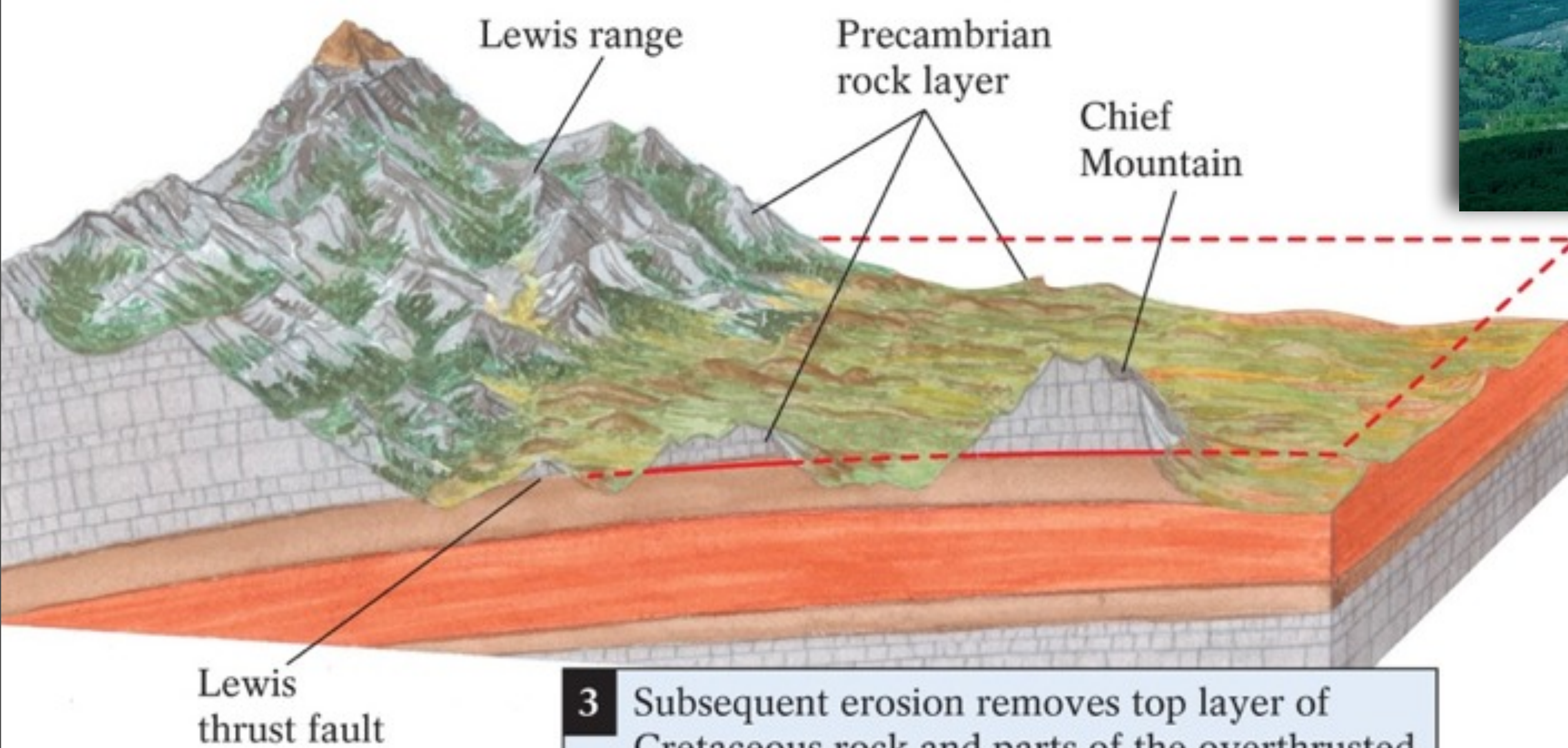


Compressional Mountain Building

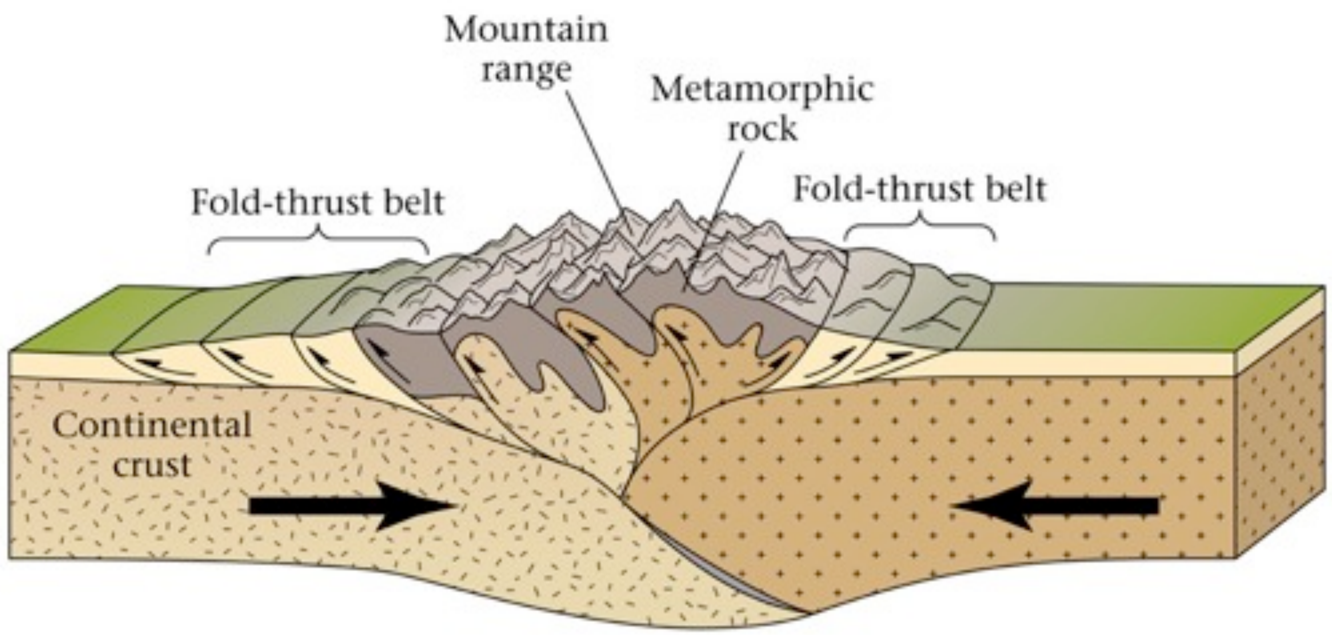




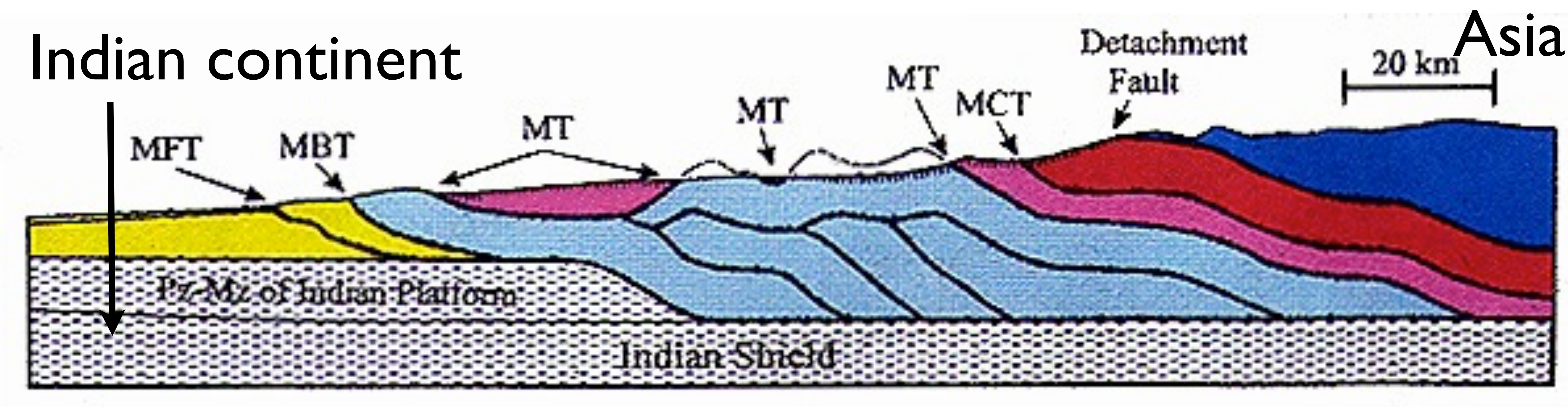
Is older or younger on top?



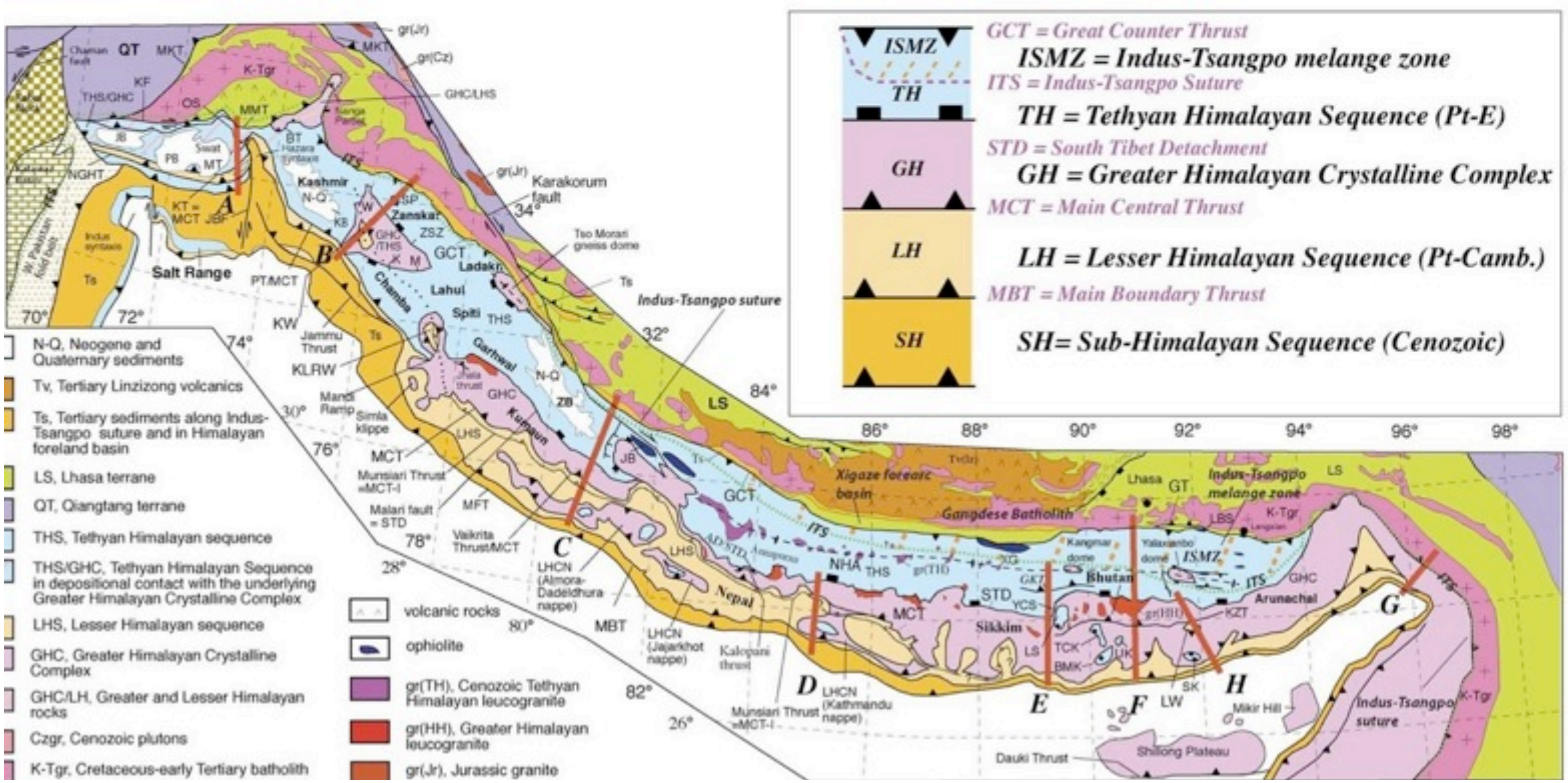
Compressional Mountain Building

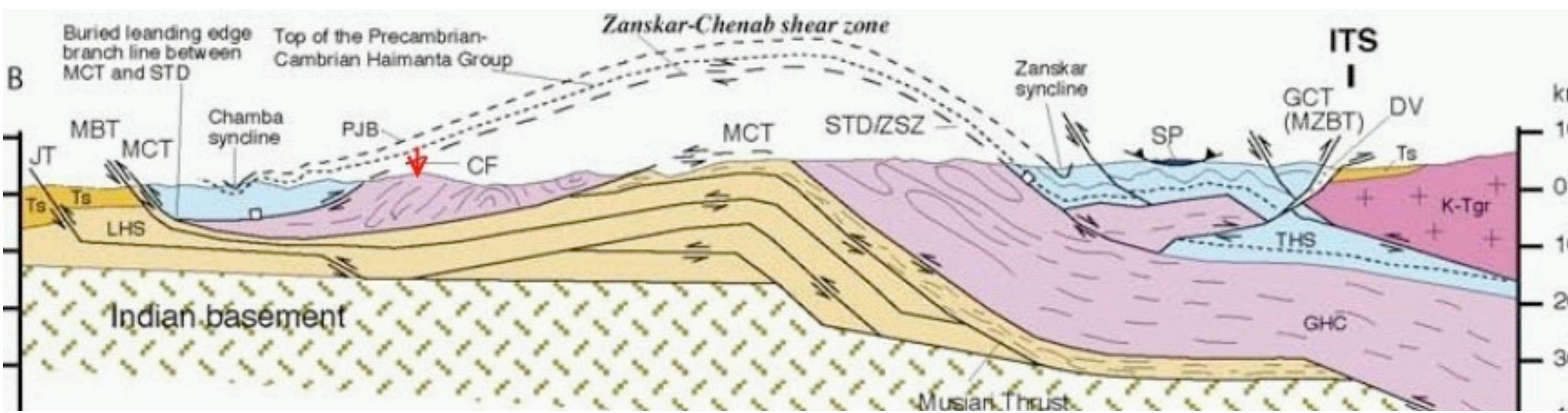


Lt. blue - Metamorphic Rx
Reds/Dark Blue- ~250 Ma Marine
Yellow - < 50 Ma foreland sediments



Himalayan Mountains Structure





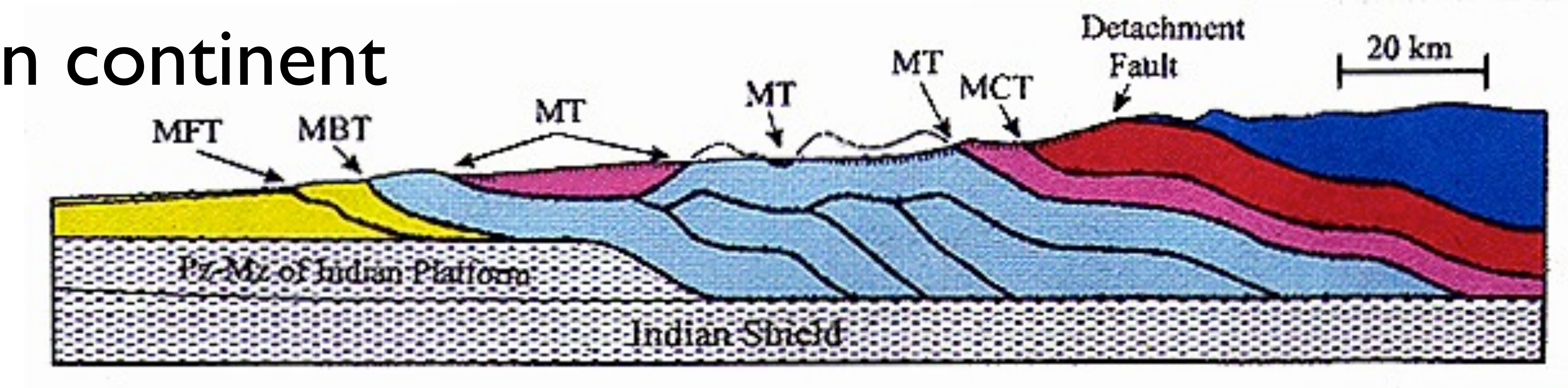
Compressional Mountain Building

Indian continent

Asia

Asia

Indian continent



Bonnet et al. (2007) video

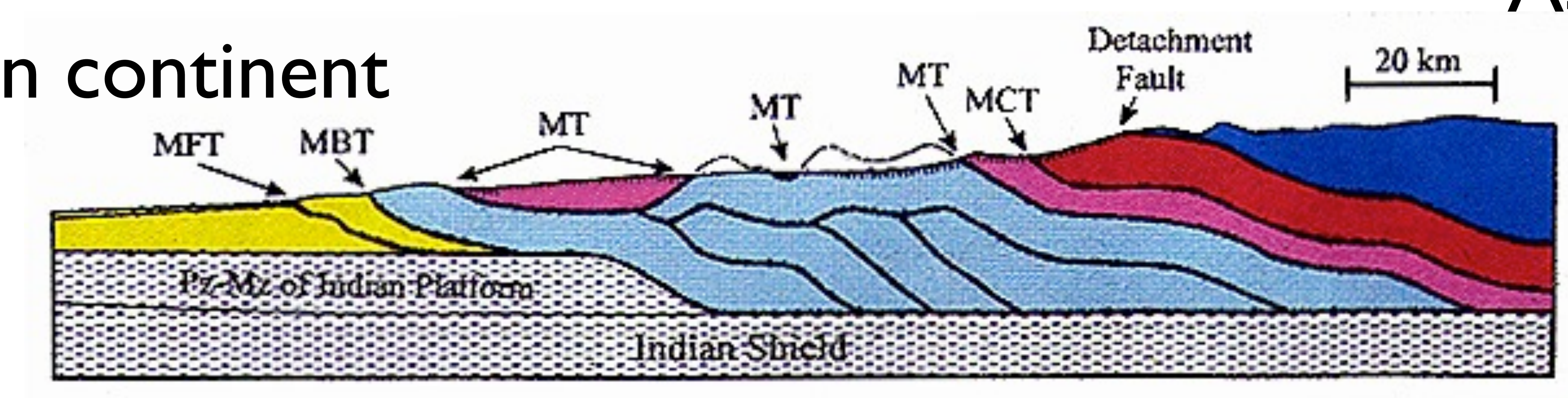
Compressional Mountain Building

Indian continent

Asia

Asia

Indian continent



Bonnet et al. (2007) video

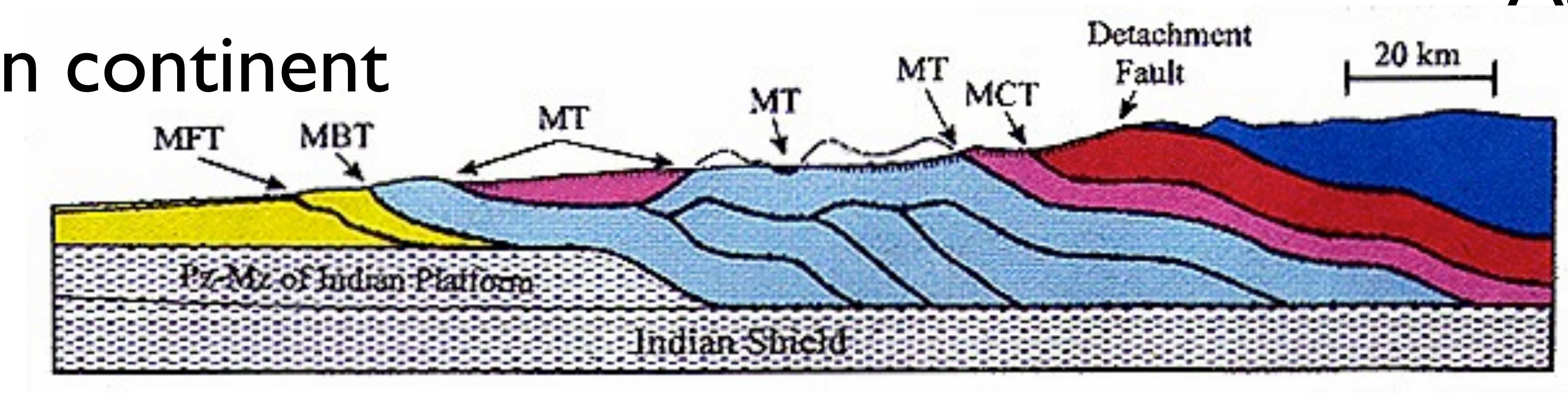
Compressional Mountain Building

Indian continent

Asia

Asia

Indian continent



Bonnet et al. (2007) video

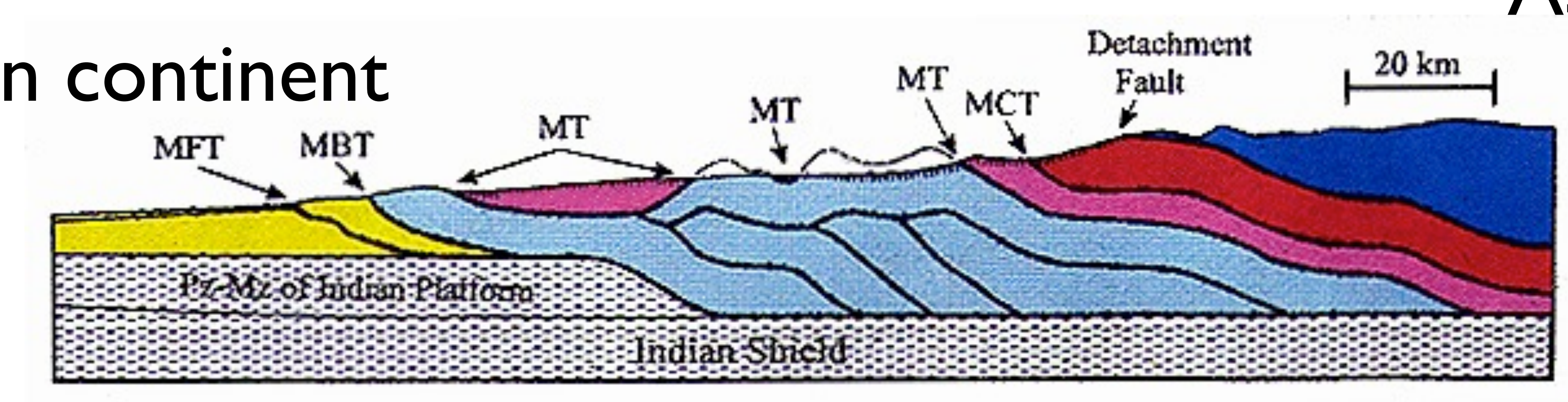
Compressional Mountain Building

Indian continent

Asia

Asia

Indian continent



Bonnet et al. (2007) video

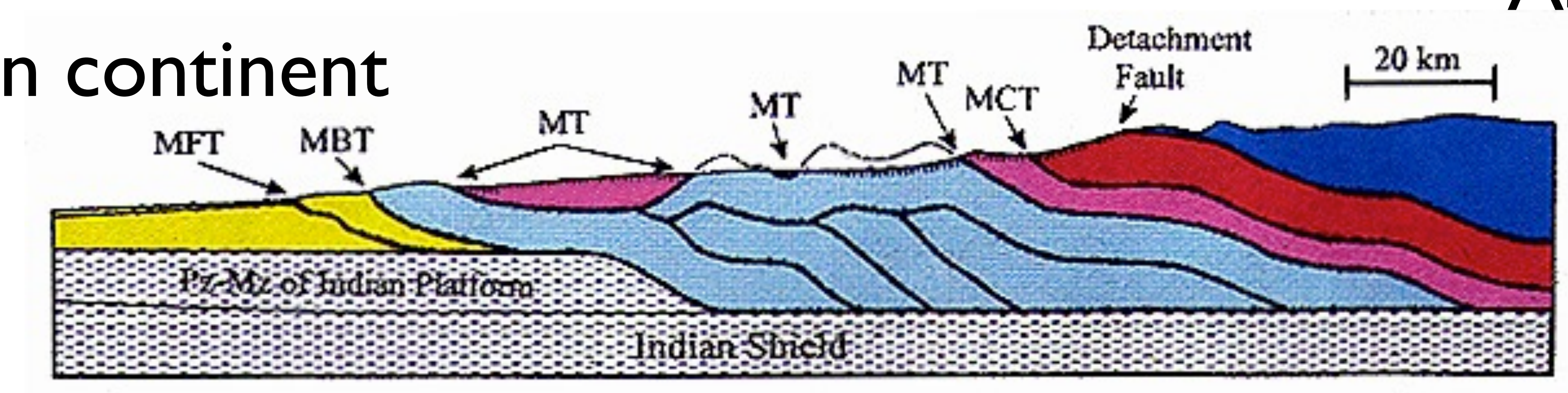
Compressional Mountain Building

Indian continent

Asia

Asia

Indian continent



Bonnet et al. (2007) video

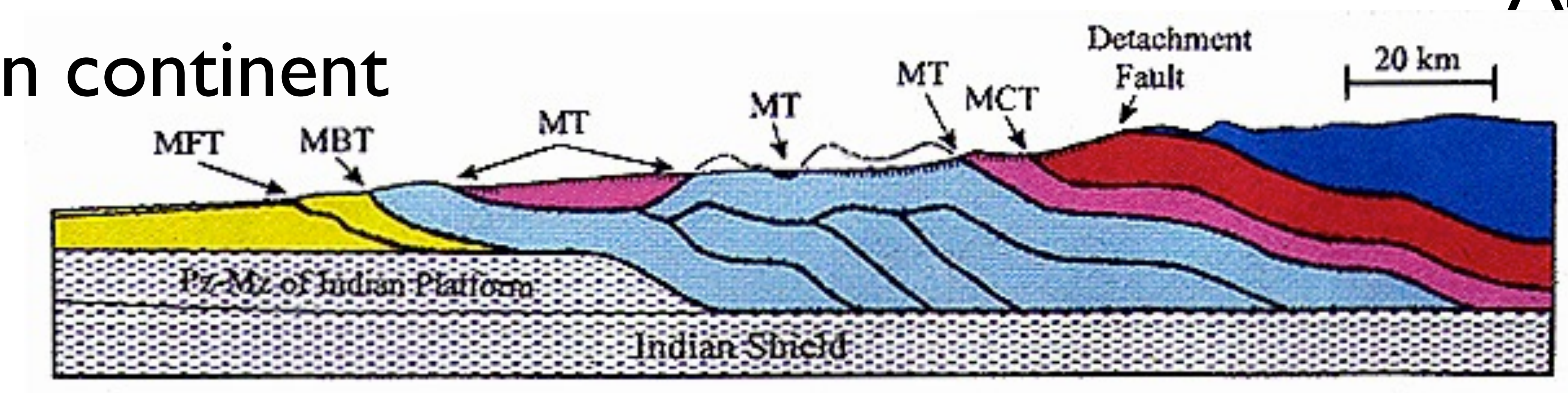
Compressional Mountain Building

Indian continent

Asia

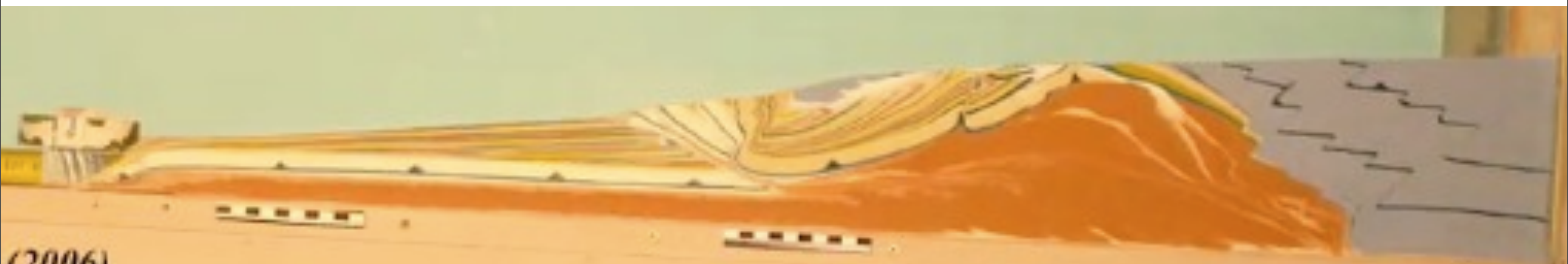
Asia

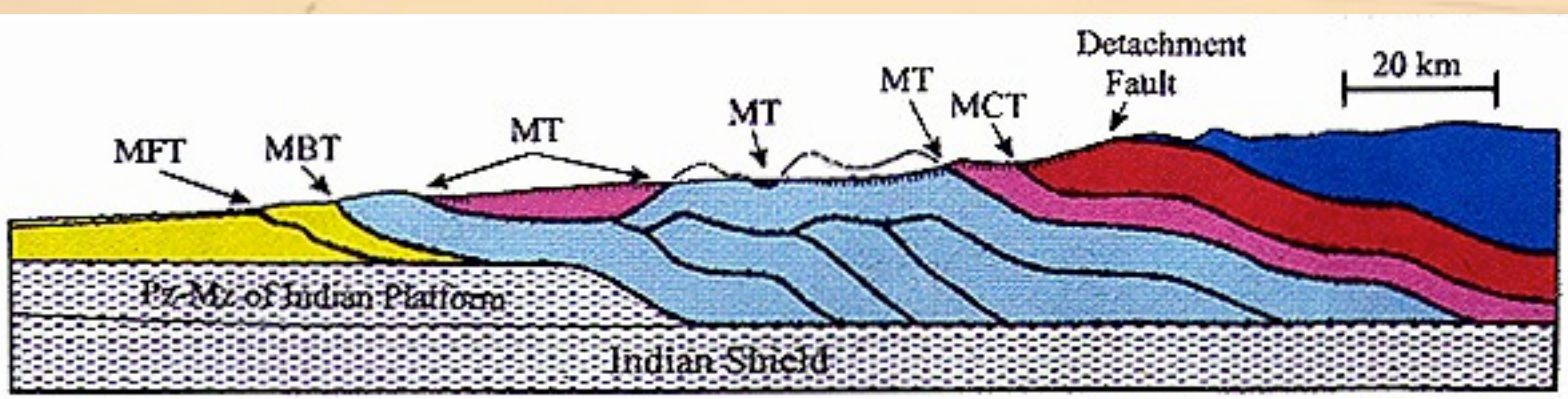
Indian continent



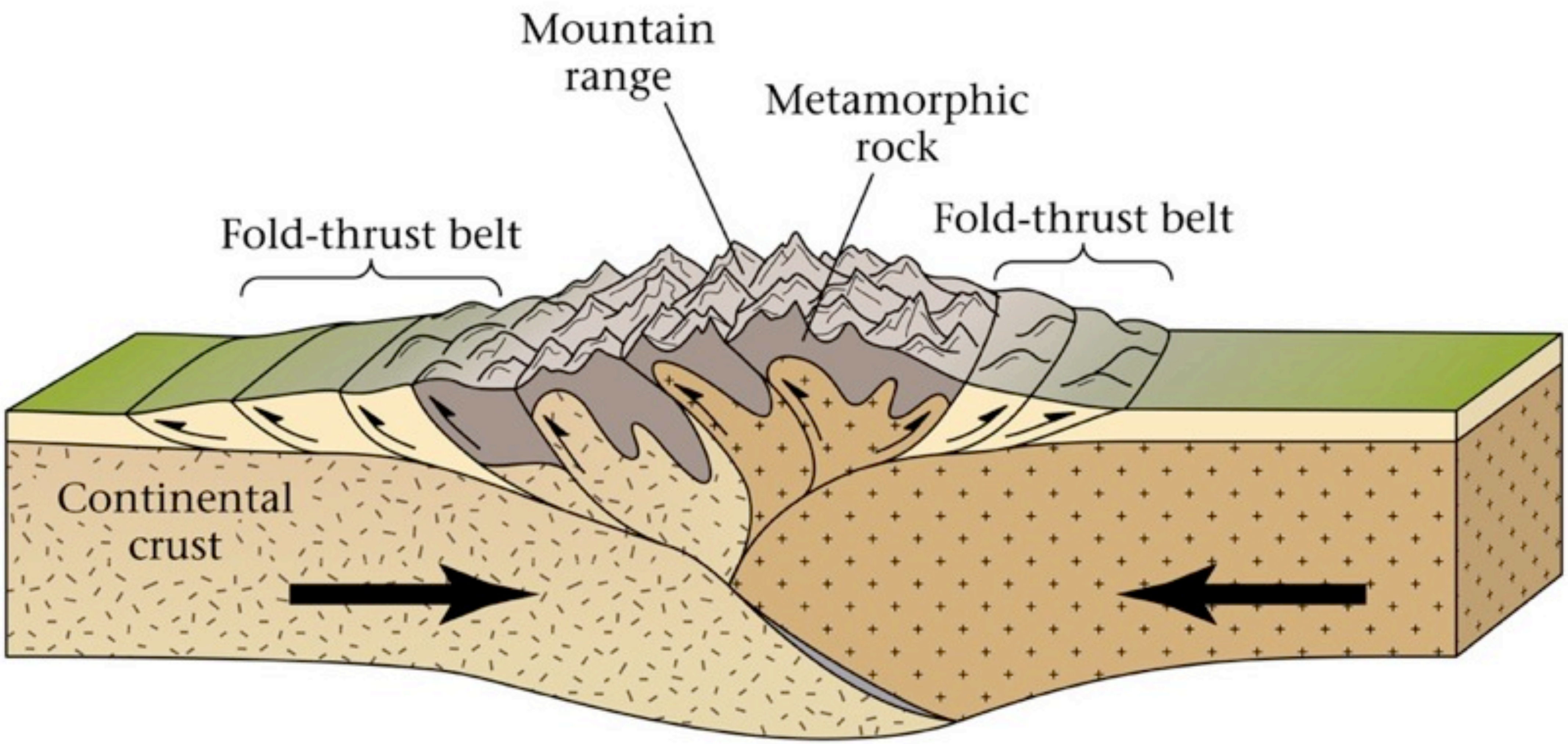
Bonnet et al. (2007) video

Indian continent



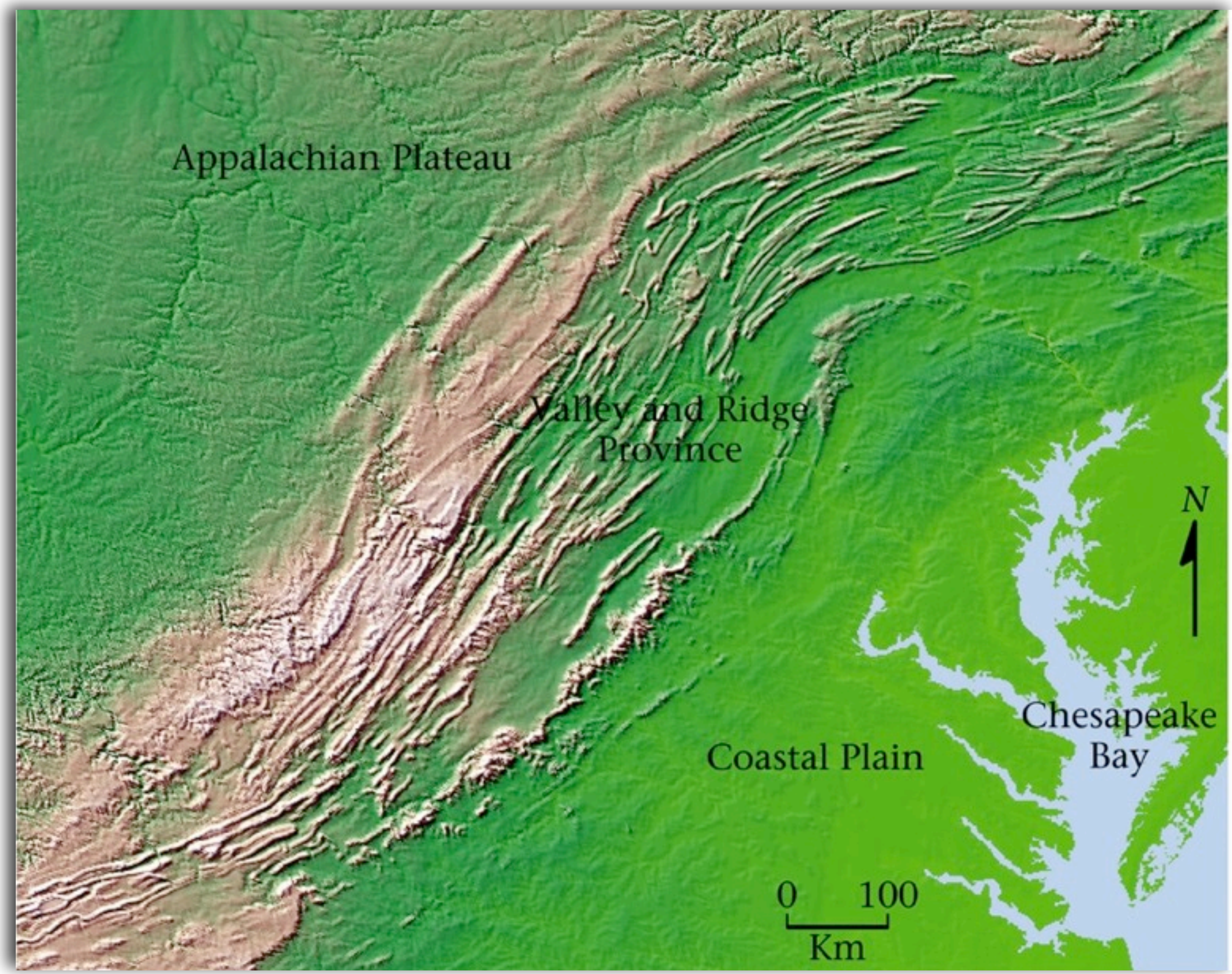


Compressional Mountain Building



Shortening thickens the crust by folding and reverse faulting

Ancient Mountains



1) Next QUIZ: Chapter 9 Review – Chapter 10 Vocabulary