Tectonic Impacts on Rivers

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Tectonics Overview

- The earth is made up of tectonic plates, which are composed of the crust and uppermost mantle
- Fault lines are the cracks in the earth's crust that bound the tectonic plates
- Faults allow the tectonic plates to move in relation to each other
- Tectonic plates are always in motion
- Earthquakes are caused by the sudden movement along the fault lines and the interaction of tectonic plates

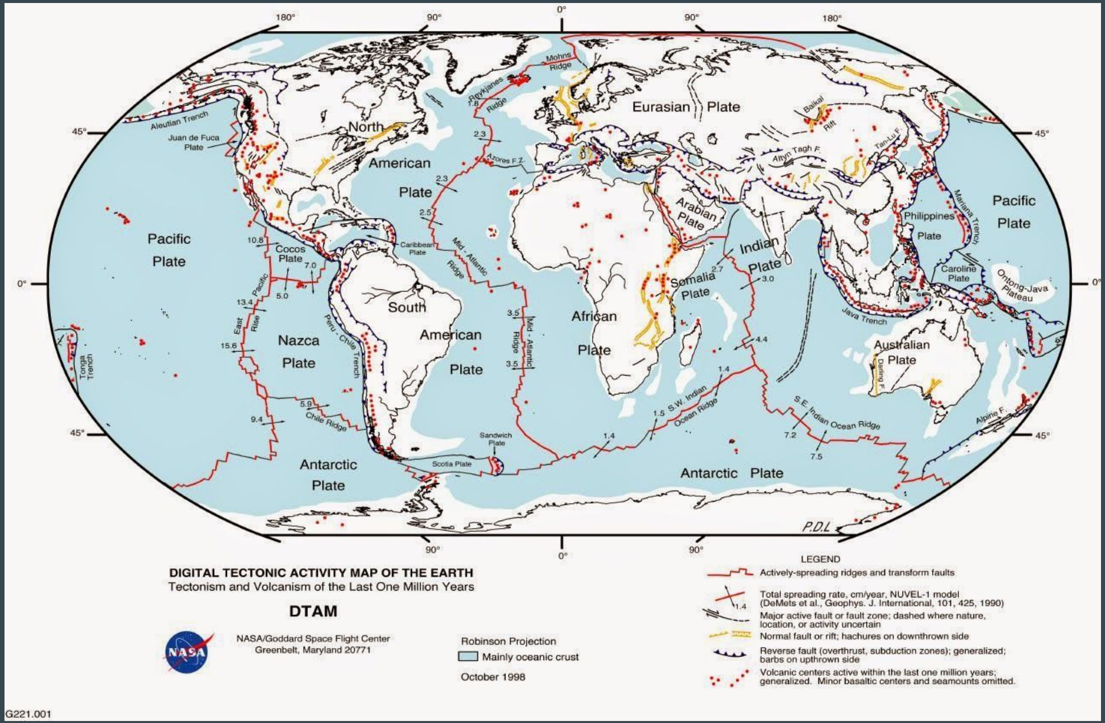

Figure 1. World map with fault lines highlighted in red

How Rivers are Affected by Tectonics

- Rivers are very sensitive to changes in topography, so tectonic activity can greatly affect stream flow characteristics
- Tectonic warping may result in longitudinal or lateral tilting of alluvial river profiles
- Rivers will show evidence of longitudinal tilting through overall morphology and knickpoints in locations where changes in the river gradient are rapid
  - Knickpoints are steep reaches that can be caused by resistant lithology, by an increase in shear stress, or by surface uplift
- Rivers show evidence of lateral tilting through intra-pattern adjustments
- There will be a change in channel pattern to adjust for changes in slope

Alluvial River Response: Longitudinal Tilting

- Domes can develop near tectonic activity that create backtilted or foretilted reaches

	Foretilted	Backtilted
Bed Response	Degradation	Aggradation
Overbank Flooding	Increase	Decrease
Bedload Grain Size	Increased grain size	Decreased grain size

Table 1: River response to longitudinal tilting

Alluvial River Response: Lateral Tilting

- There are two types of lateral channel migration as a result of lateral tilting; down-tilt avulsion (A) and down-tilt combing (B)
- Avulsion occurs when the stream pulls toward the lower part of the floodplain
    - This produces isolated sand ribbons and immature channel belts
- Combing is a slow migration by preferential downslope erosion and/or meander cutoff
    - Combing results in wide channel belts

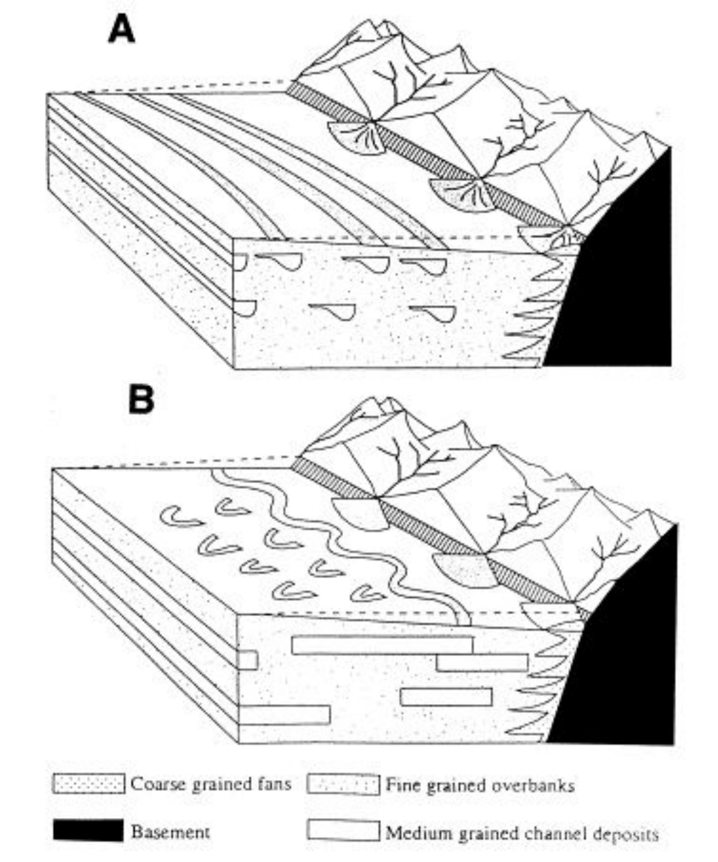

Figure 2. In the figure above, (A) depicts down-tilt avulsion and (B) depicts down-tilt combing

Alluvial River Response: Meandering

- Typically, river patterns will undergo minor variations due to lateral changes in topography
- Pattern changes can occur due to an anticlinal uplift or a synclinal subsidence
  - An anticlinal uplift is when the core folds up into a arch.
  - A synclinal subsidence is when the topography dips down.

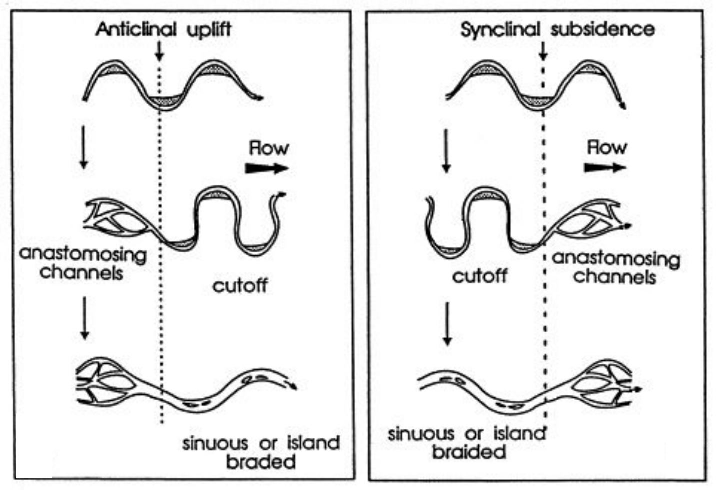

Figure 3. Meander changes due to anticlinal uplift (left) or synclinal subsidence (right)

	Increased Slope	Decreased Slope
Meandering	Increased Sinuosity	Decreased Sinuosity

Table 2: Changes in sinuosity in response to slope changes

Alluvial River Response: Sediment Transport

- Tectonic activity affects the rate and location of aggradation and/or degradation in rivers
- An uplift will cause aggradation upstream and degradation downstream in the river
- A subsidence will have the opposite effect: degradation upstream and aggradation downstream

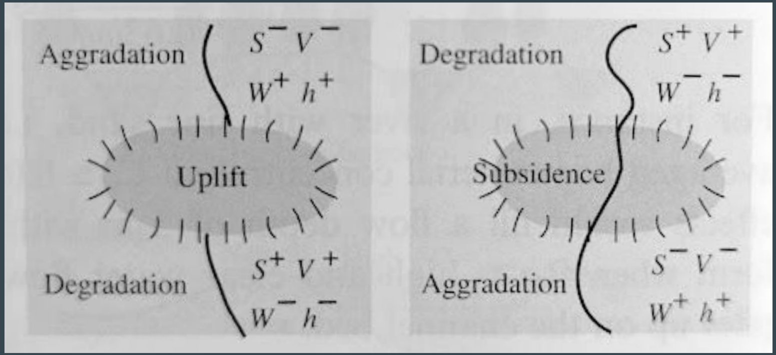

Figure 4. Effects of tectonics on sediment transport in rivers

River Response in Mountain Chains

- May avulse quickly when a tectonic event has led to a build-up of sediment in the river's path
- Incision and uplift must be balanced to maintain slope to the delta; often resulting in deep V valleys
- Uplift has been attributed to the increase in sediment in river deltas, but there may be other causes

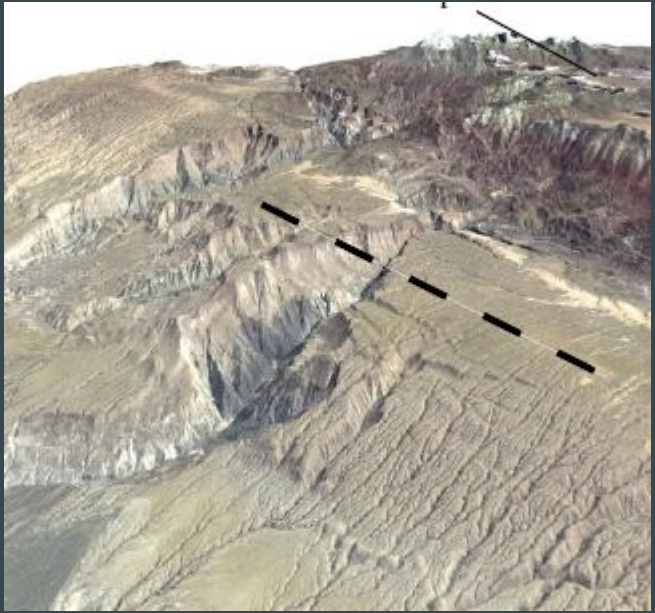

Figure 5. Tectonic buckling amplified by river incision

The Reelfoot Fault and the Mississippi River

- Sand blow deposits show signs of liquefaction during 1811 earthquake
- River boat pilots reported “backwards” flow until the river could erode a temporary damming of the river by excess sediment produced by the earthquake
- Relic meanders show changes in river pathways that align in time with seismic activity

Figure 6. Location of the Reelfoot Fault and relic meanders surrounding the fault

Evidence of Tectonic Activity in the San Diego Basin

- There are channel incisions where the river has dropped to accommodate for shelf drops
- All of the incised valleys are aligned with faults lines
- The complex coastal morphology of the San Diego basin demonstrates differences in deep sea sedimentation due to differences in active tectonic cycle locations
- Temporary lakes form where sections are cut off from the rest of the river before being reconnected either through continued seismic activity or erosion of the sediment blockage
    - Evidence of lateral tilting

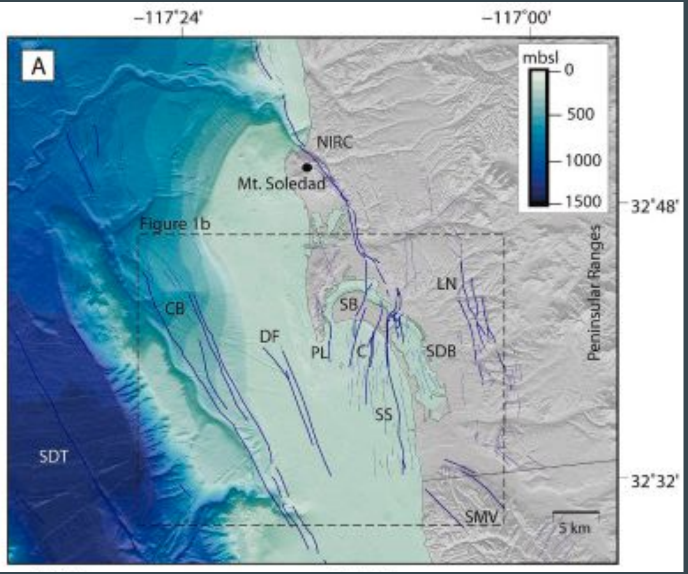

Figure 7. Map of San Diego basin, with fault lines shown in blue

Conclusion

- Tectonic activity can cause changes to rivers that is rapid and unpredictable
- Tectonic activity is in itself unpredictable
- This unpredictability makes it more difficult to design infrastructure
- There are currently no hydraulic or sediment models that can be used to model these changes though their creation is being studied by universities in California
- The ways that rivers react to tectonic activity is heavily dependent on the soil composition, so an understanding of sediment movement is important

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