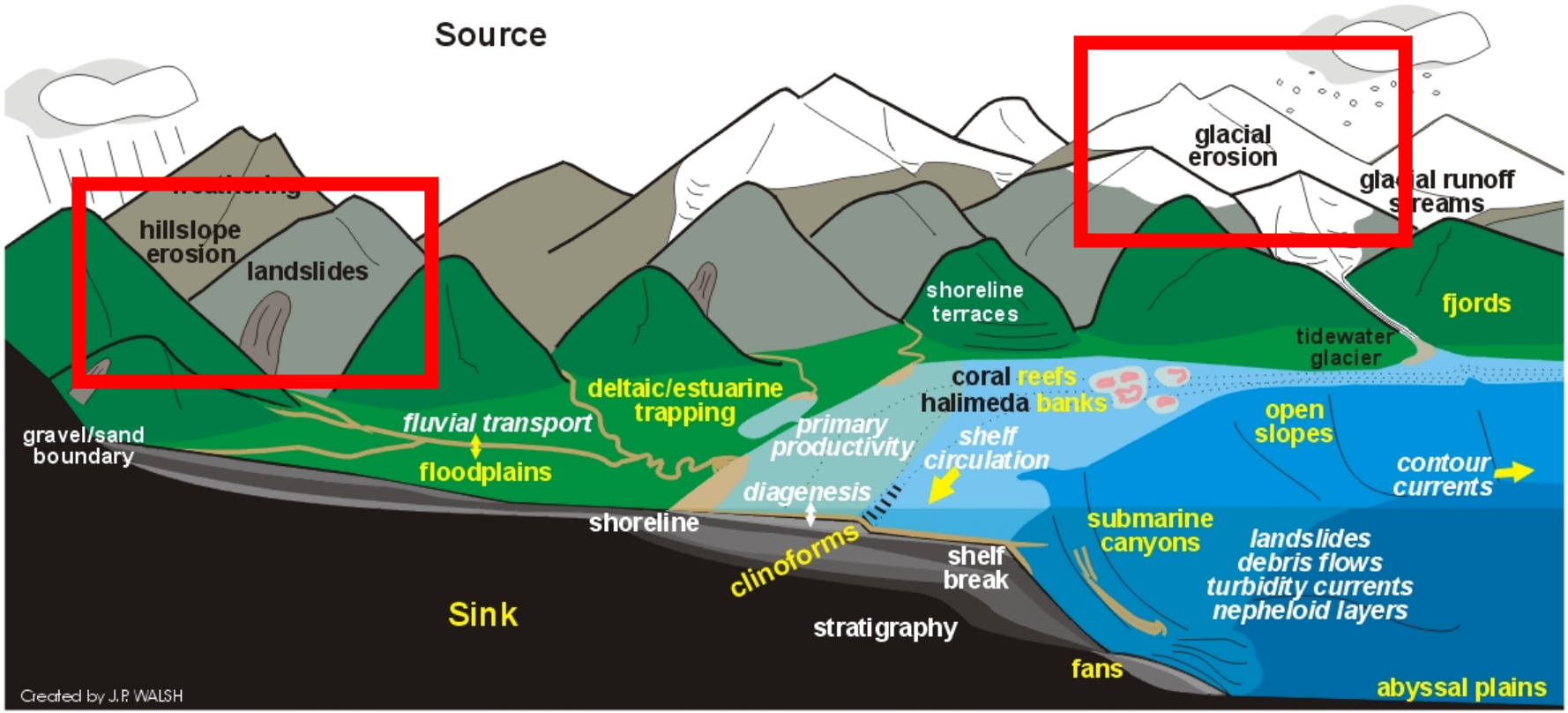
Mountains: Erosion

Erosion


Source
hillslope erosion
landslides
glacial erosion
glacial runoff streams
shoreline terraces
fjords
tidewater glacier
deltaic/estuarine trapping
fluvial transport
floodplains
gravel/sand boundary
coral reefs
halimeda banks
primary productivity
shelf circulation
open slopes
contour currents
diagenesis
shoreline
clinoforms
shelf break
submarine canyons
landslides
debris flows
turbidity currents
nepheloid layers
Sink
stratigraphy
fans
abyssal plains
Created by J.P. WALSH

Sediment Regime

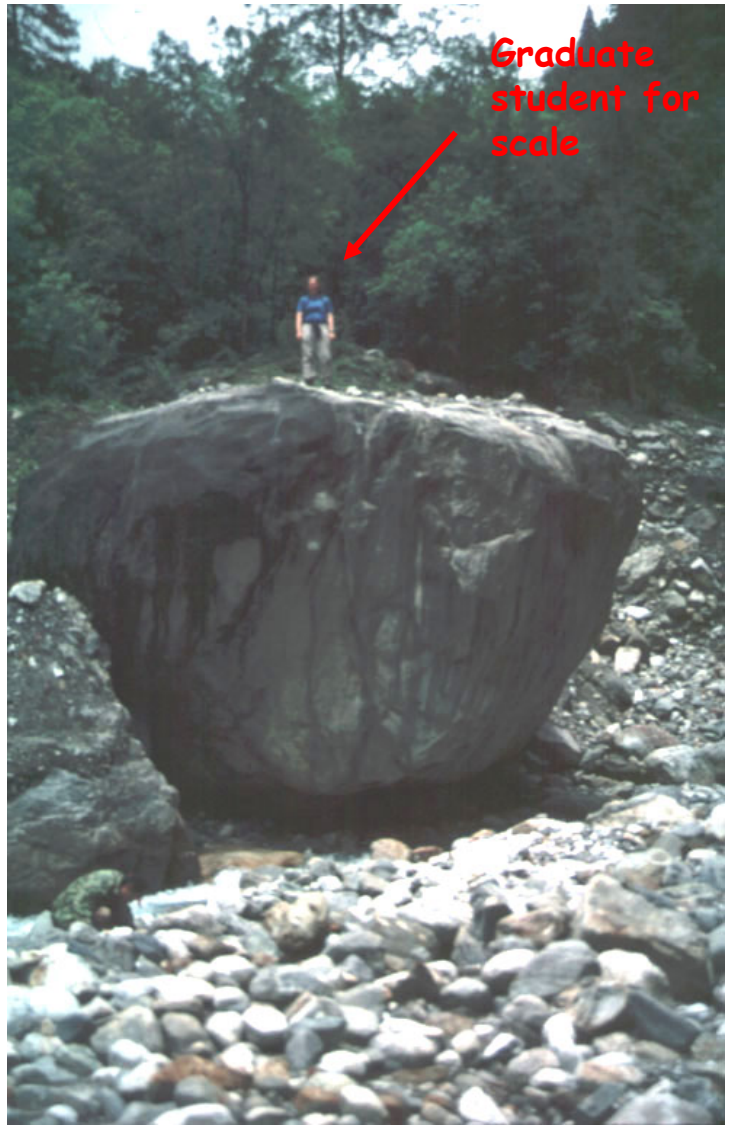
- Sediment "regime" of a river is set by the amount and size of material delivered from both hillslopes and upstream.

- The amount or rate of sediment supply depends on the processes that govern sediment delivery to rivers.

Sediment Supply to Rivers

Size and composition of sediment delivered to rivers reflects:

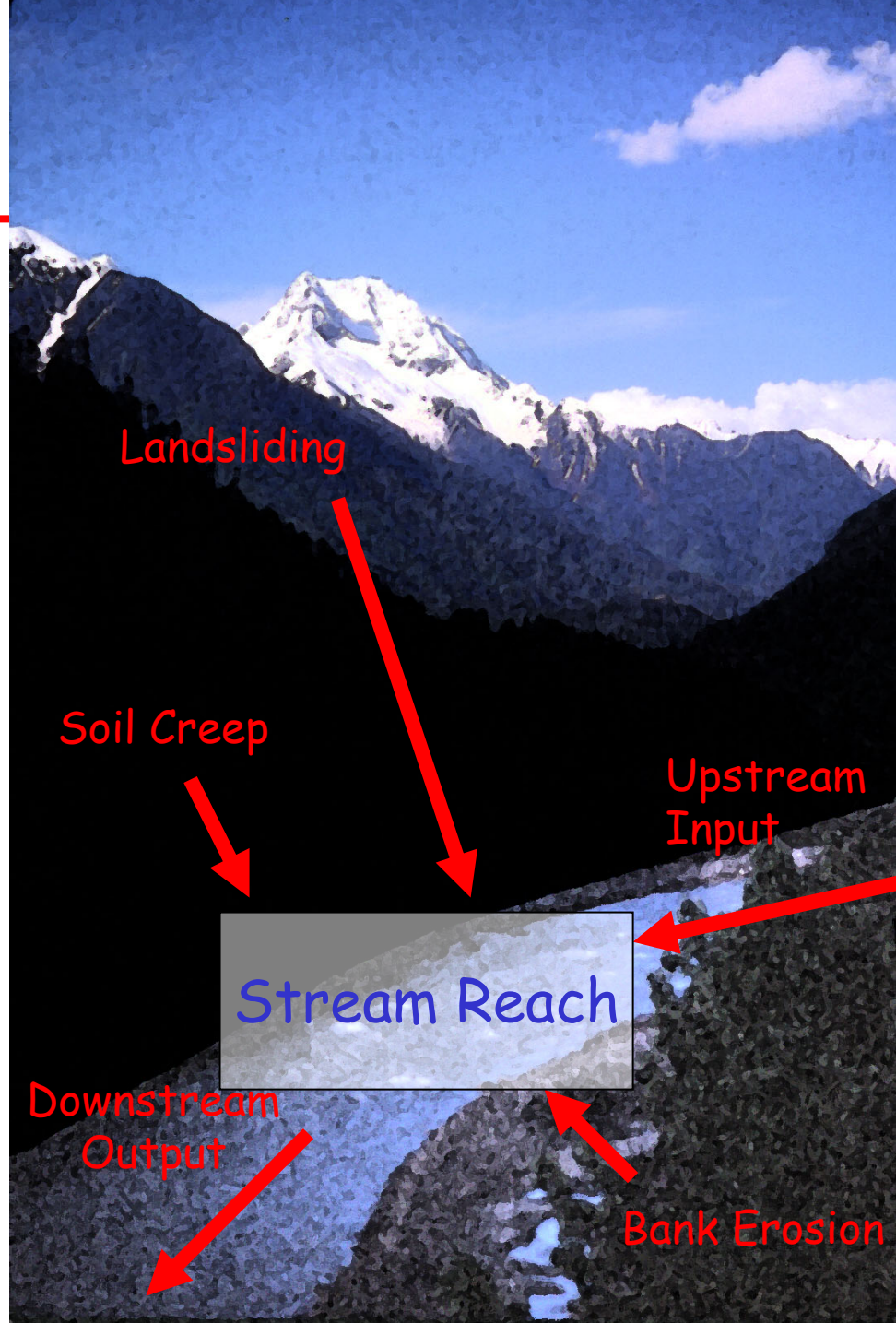
- soil properties
- rock properties
- the process that delivered it.



Sediment Budget

$$I - O = \Delta S$$

Sediment inputs from upstream and across channel banks are balanced by either downstream sediment transport or changes in sediment storage.



Erosional Processes

- Soil "Creep"
- Overland Flow
- Landslides
- Glaciers
- River incision into bedrock
- Bank Erosion

Erosional Processes

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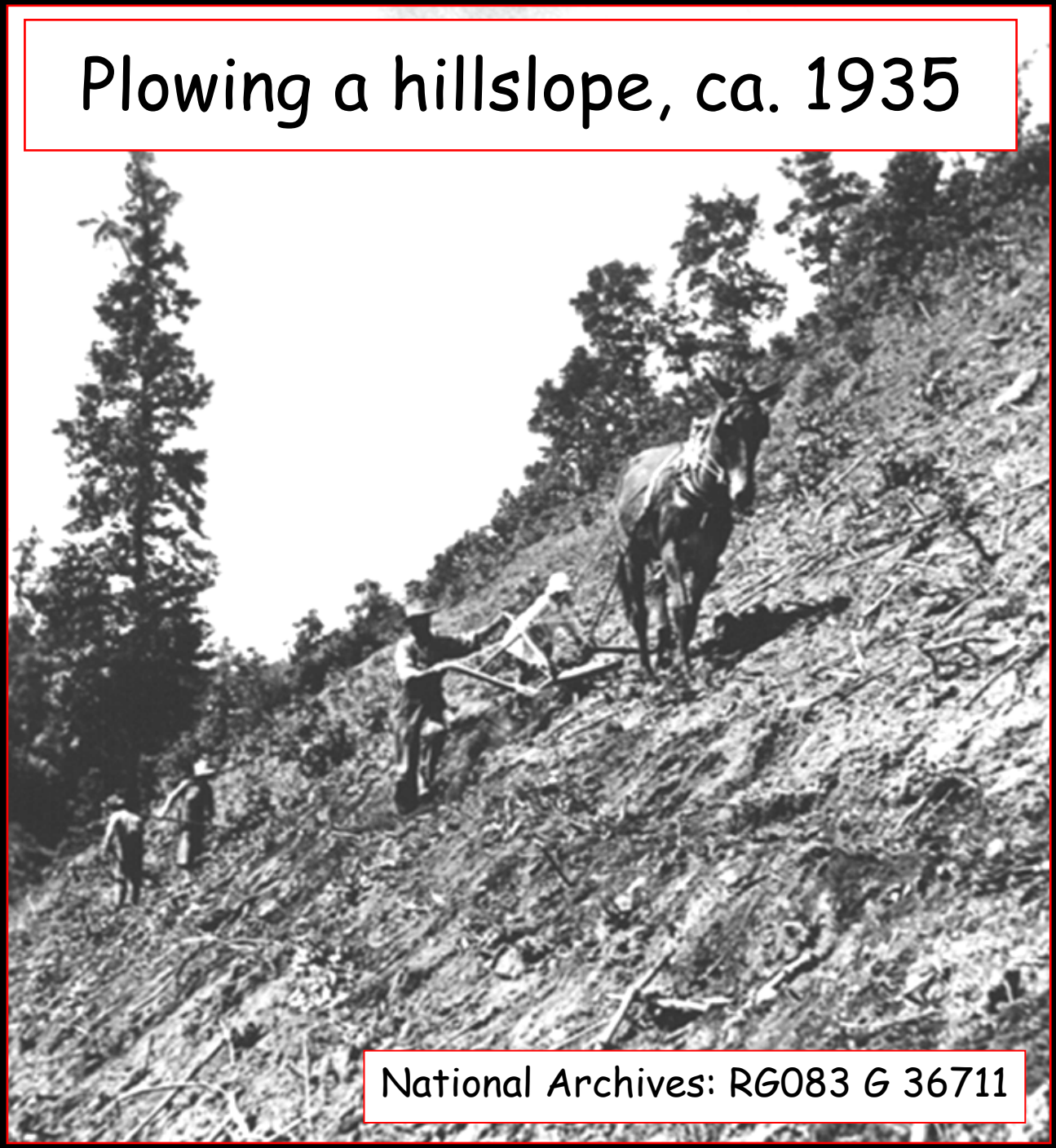
Soil creep is the gradual, non-catastrophic downslope movement of weathered material under the influence of gravity (i.e., not by flowing water).

The burrowing activity of animals results in a net downslope transport of material that in some environments can be the dominant sediment transport process.

Tree-throw can uproot rocks and also usually results in a net downslope transport of soil and broken rock.

Plowing a hillslope, ca. 1935

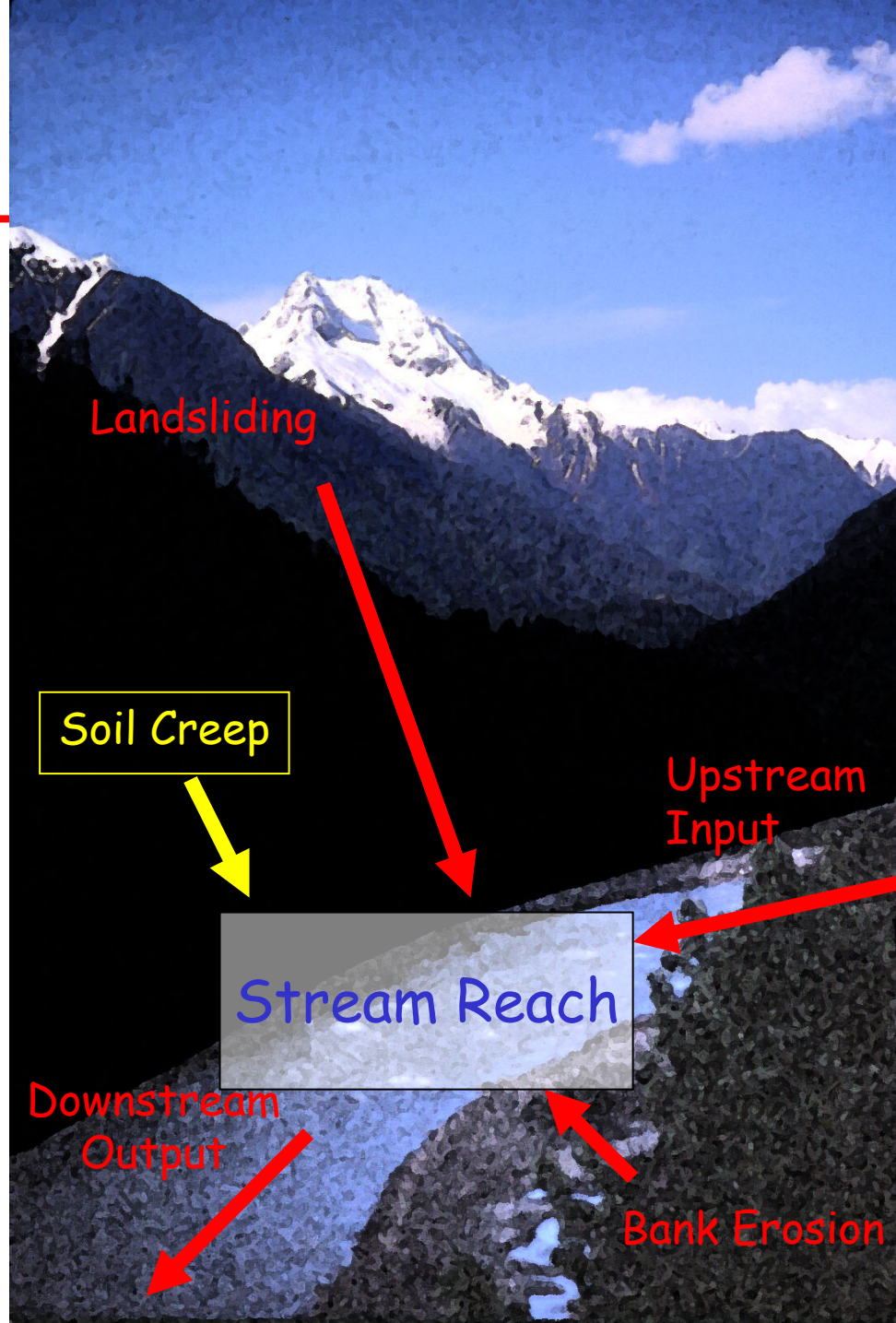


National Archives: RG083 G 36711

Soil Creep

Slow, steady input of material across channel banks, or delivered to valley bottom.

Typical rates of 0.1 to 1 mm yr^{-1}.



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Erosion by overland flow occurs once enough flow accumulates to overcome the erosion resistance of the ground surface.

Precipitation that runs off as overland flow can cause substantial erosion once enough flow accumulates to incise the ground surface.

Badlands environments are an extreme example where X_c may be just cm's!

Unchanneled valleys occur where the erosion resistance of the ground surface is high relative to the amount of overland flow; X_c is very large.

Entrenched channels and gullies can develop in landscapes where overgrazing decreases the erosion resistance of the valley floor.

Overland Flow

Erosion by overland flow is rare in forested mountain landscapes because:

- rainfall tends to infiltrate into the ground;

- the ground has substantial erosion resistance due to vegetation.

Erosion by overland flow is most common in disturbed or semi-arid landscapes

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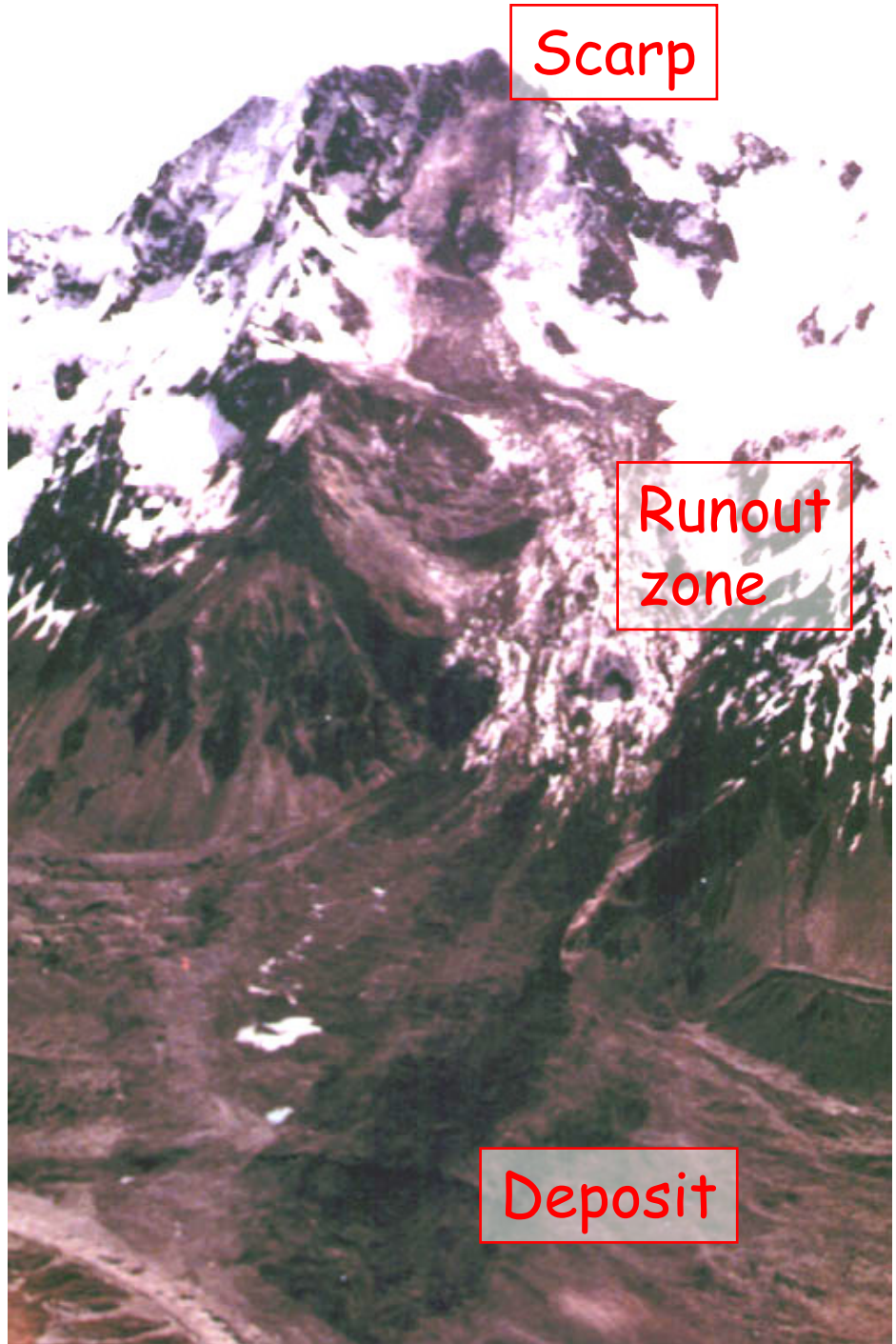
Landslides involve the downslope movement of soil and/or rock under the influence of gravity and may be either slow and gradual or rapid and catastrophic.

Bedrock landslides

Bedrock landslides can limit the relief of mountain ranges, such as happened at Mt. Cook, New Zealand when the top 10 meters of summit fell away in a massive landslide/avalanche on December 14, 1991.



Bedrock landslides

- Earth Flows
  - Lots of internal deformation; typically slow.

Earthflow in New Zealand

Soil landslides

- Debris Flows
  - Lots of internal deformation; rapid.

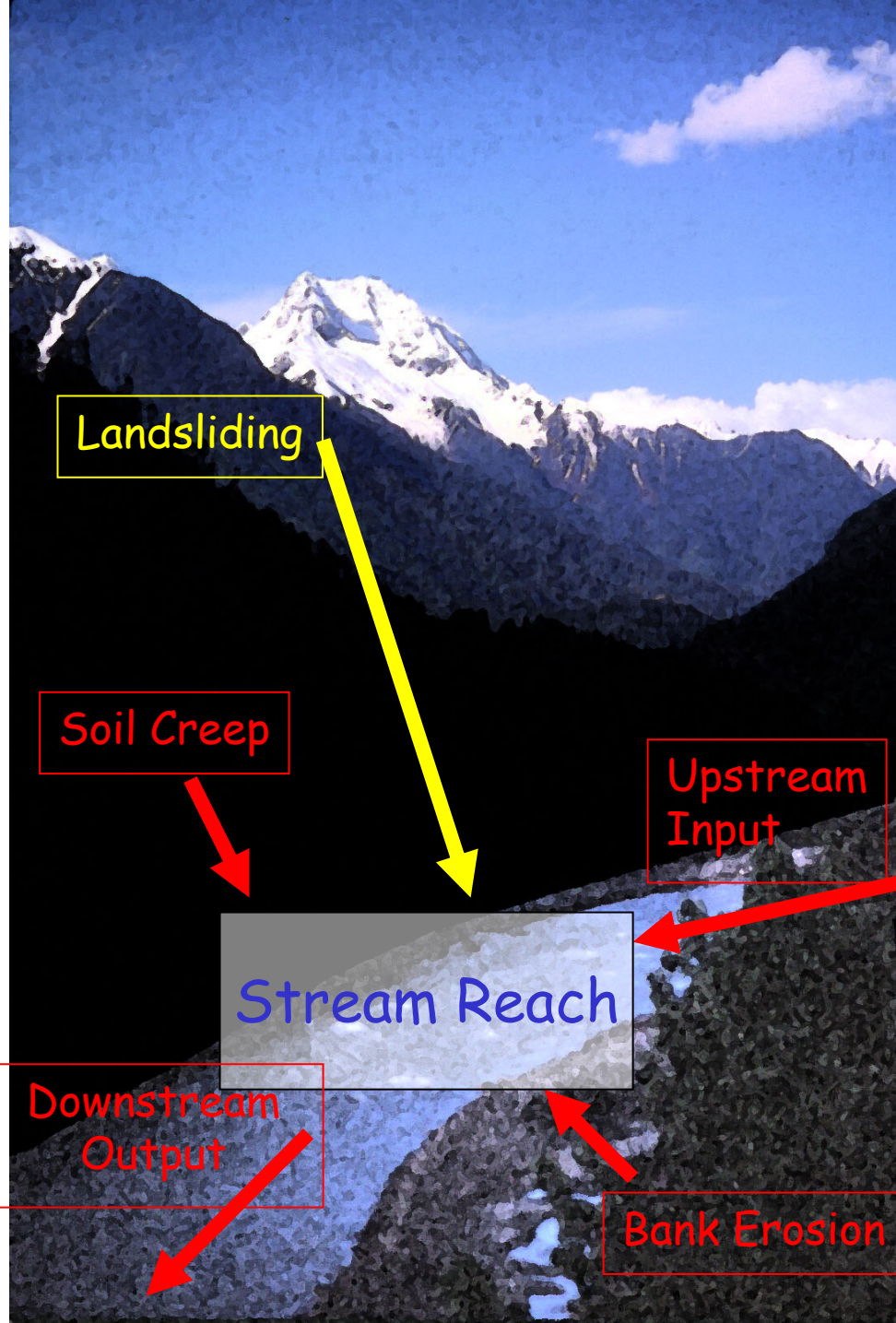
Failure typically occurs along well-defined shear plane at soil-bedrock interface.

Debris flows along Tolt River

Landsliding

Rapid, infrequent inputs of large volumes of sediment.

Rates of delivery set by landslide frequency, which is often centuries to millennia at a point.



Erosional Processes

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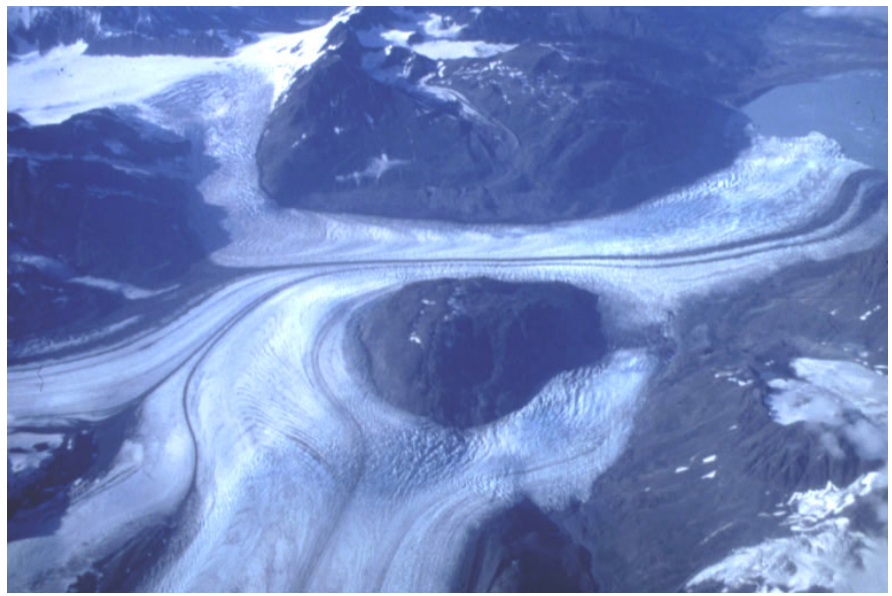
Glaciers can both entrain loose surface materials and gouge deeply into bedrock.



Glacial Erosion

Rapid erosion of material from above perennial snow line.

Rates can exceed 10 mm yr^{-1}.

Processes of erosion and rates depend on temperature, glacier size, precipitation rate, etc...

Erosional Processes

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Rivers can carve deeply into bedrock and such incision provides another source of sediment.

In the world there is nothing more submissive and weak than water. Yet for attacking that which is hard and strong nothing can surpass it.

- Lao-Tzu, 6th century B.C.

River Incision

Erosion = f (discharge, channel width, slope)

More water in a narrower channel down a steeper slope means faster river incision

Rates of bedrock river incision typically range from <0.01 mm yr^{-1} to 1 mm yr^{-1}, but can exceed 5 mm yr^{-1} in extreme topography.

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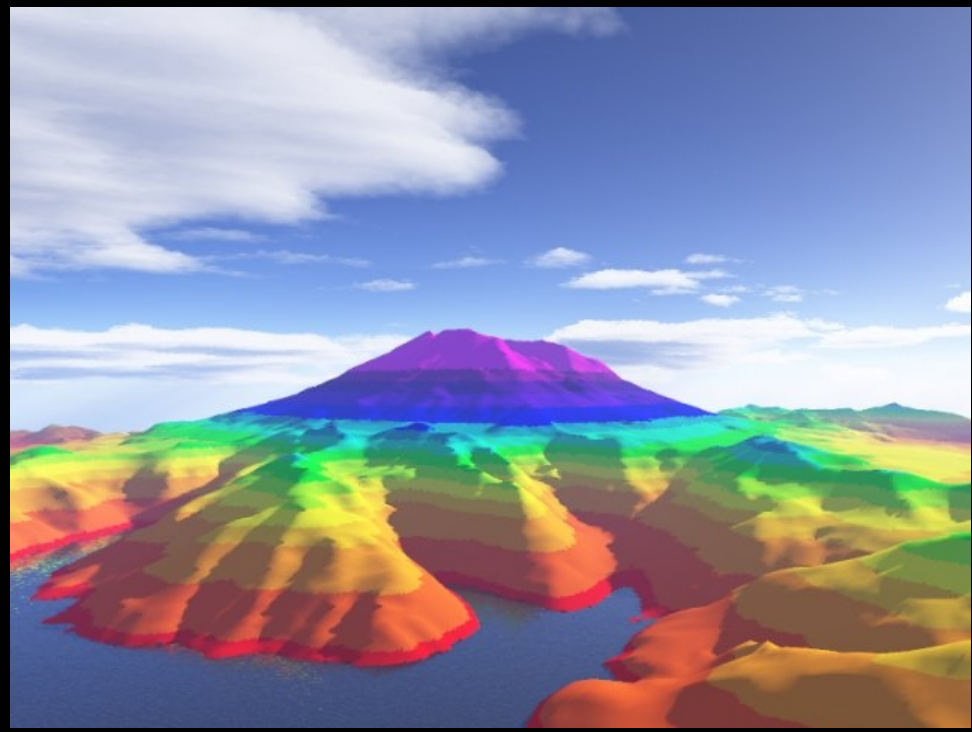
Bank erosion recycles material stored on the valley bottom, typically in the floodplain.

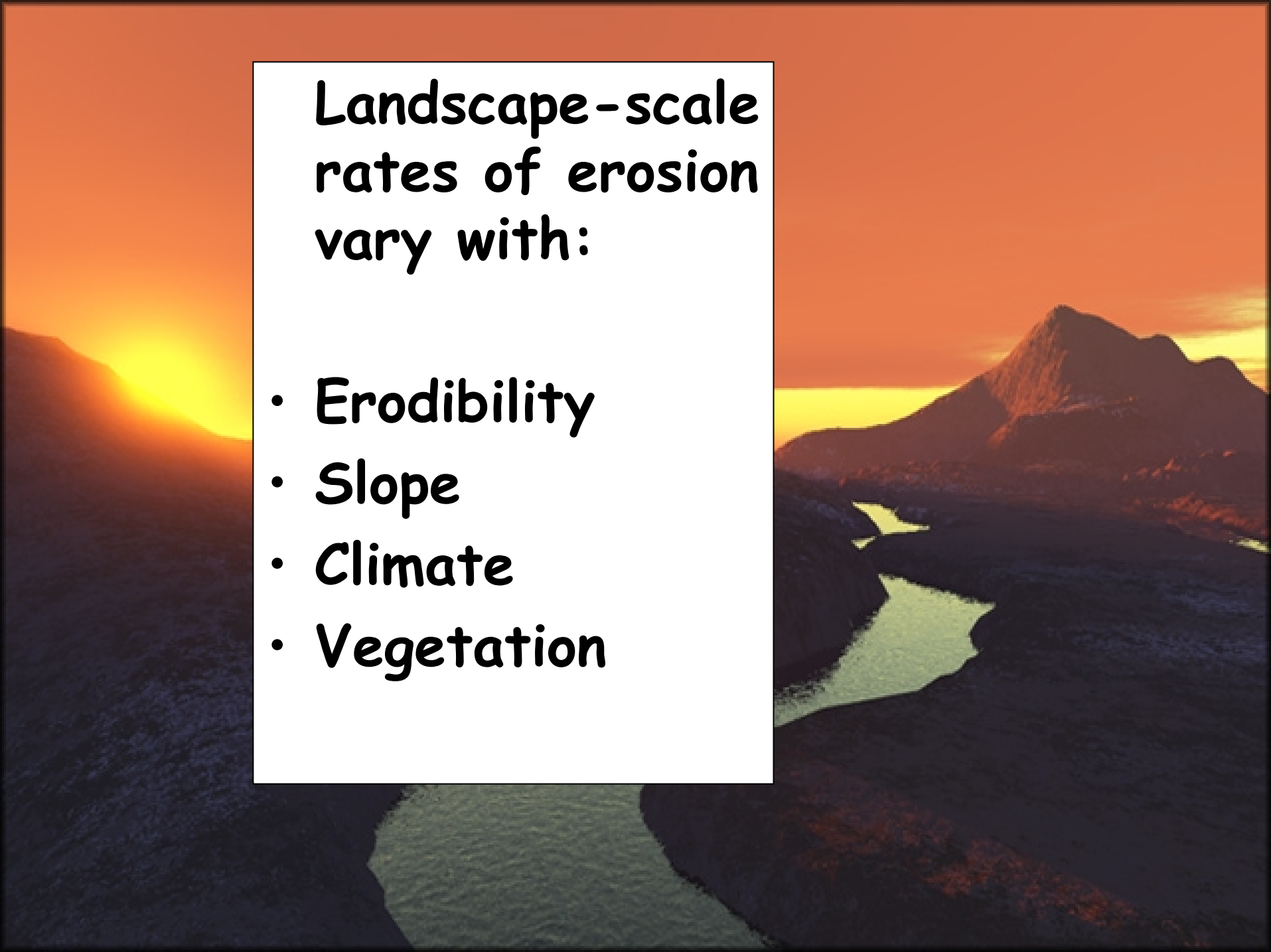
The rate of bank erosion defines a turnover time for valley bottom landforms.

What controls erosion?

Potential process drivers:

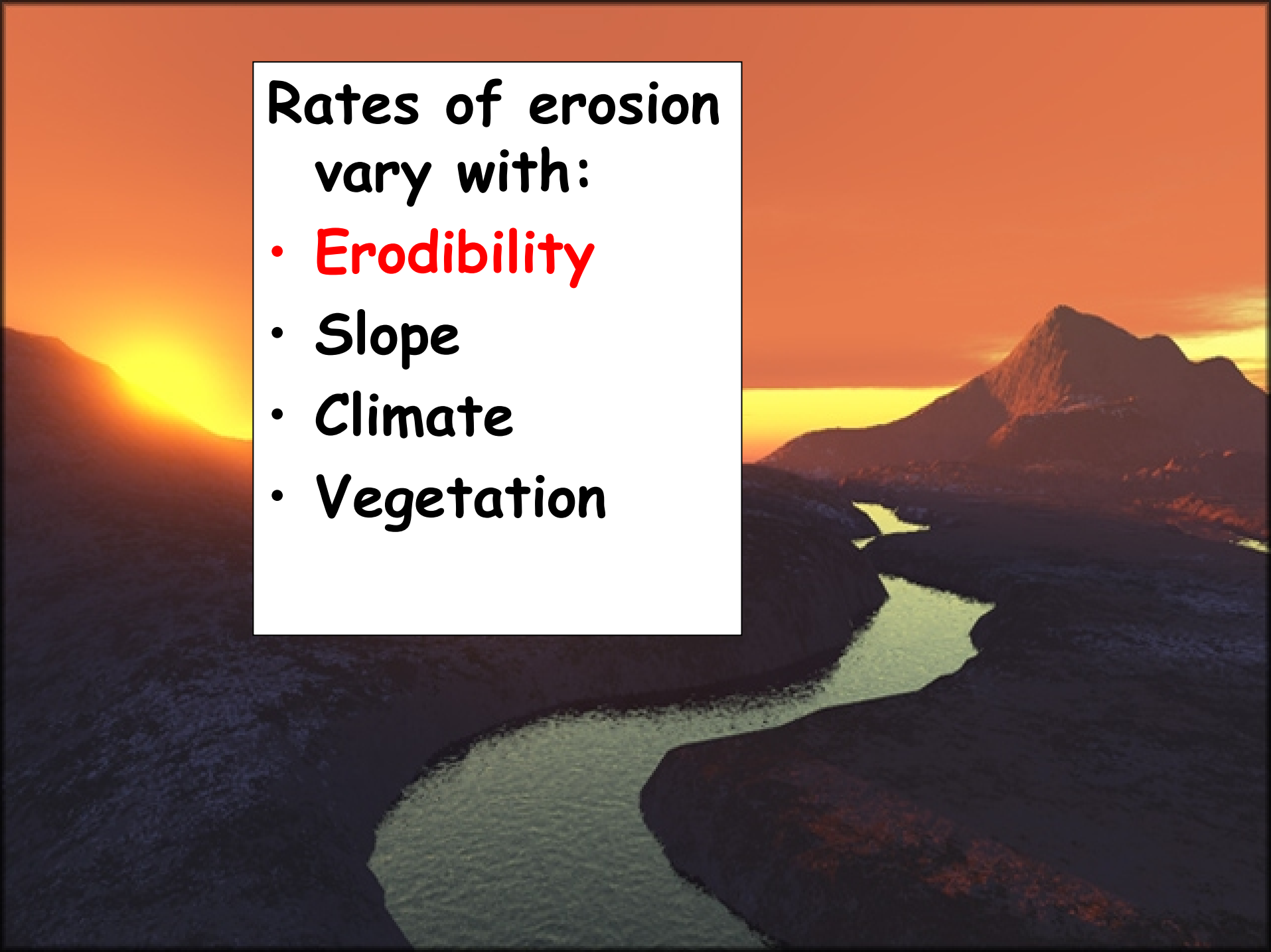
- Climate
- Topography
- Vegetation





Landscape-scale rates of erosion vary with:

- Erodibility
- Slope
- Climate
- Vegetation



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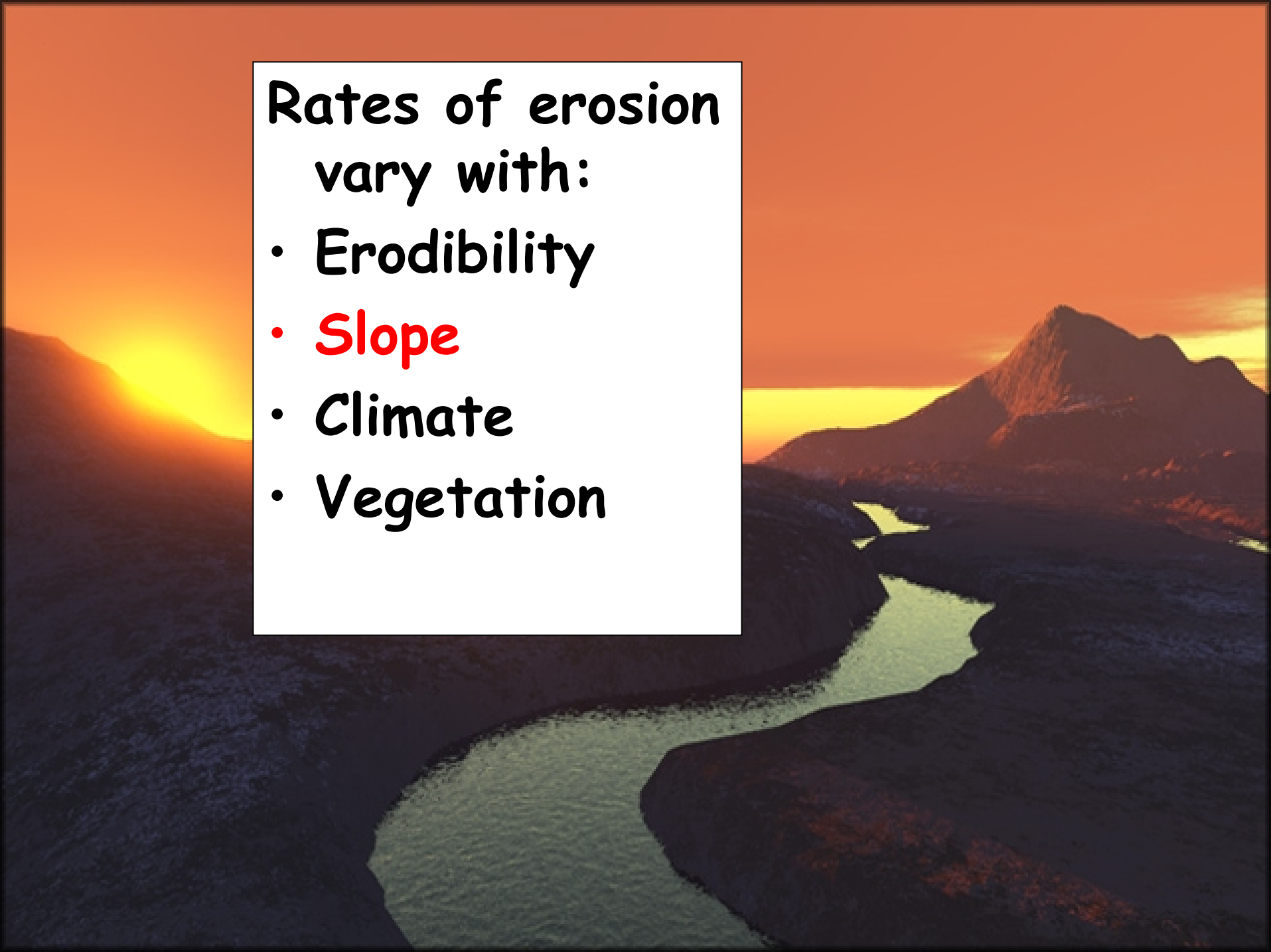
Erodibility

There is at least a 5 order of magnitude range in bedrock erodiblity



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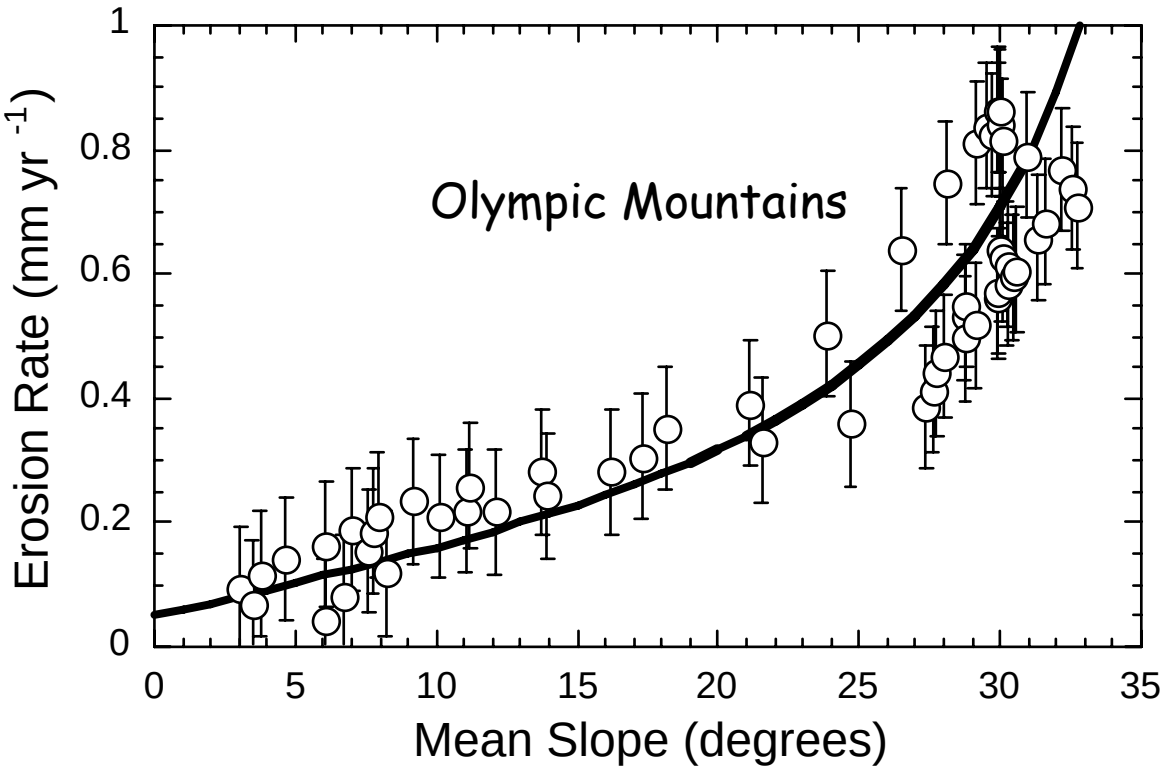
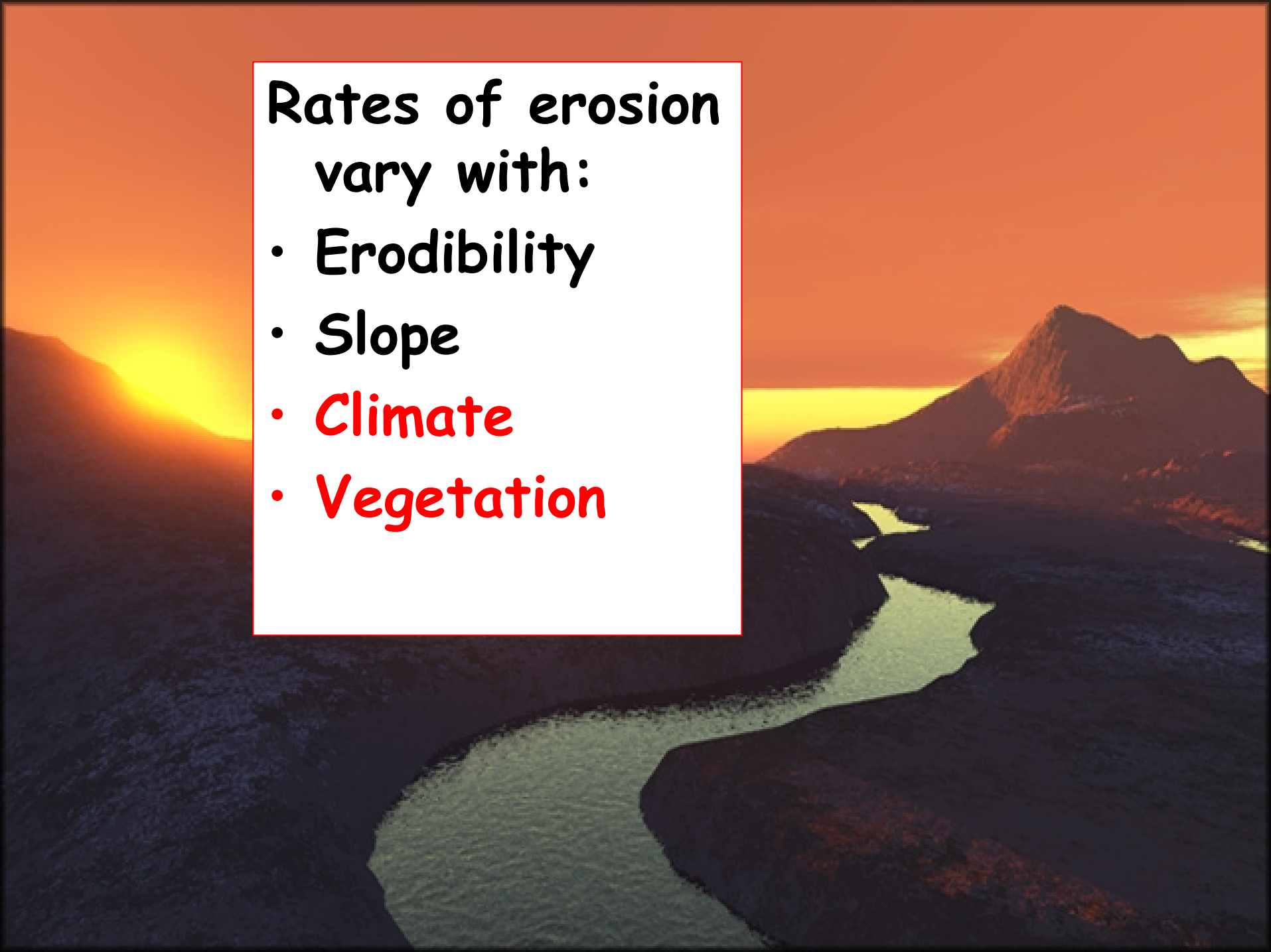
Erosion rate versus slope





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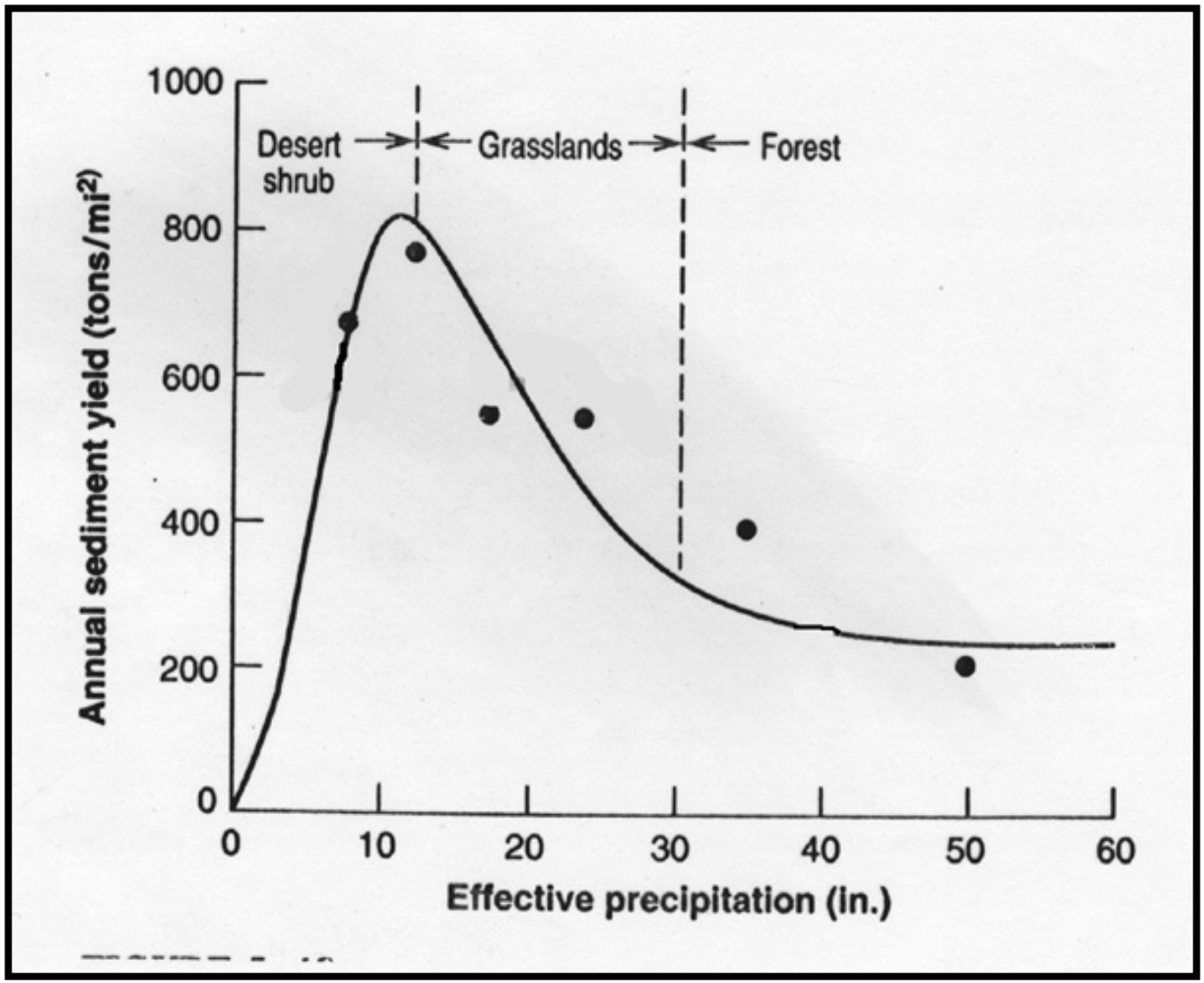
Effect of Precipitation and Vegetation on Sediment Yields



Class Concept: Rivers and beaches are part of sediment transfer systems