Lesson 8 cont’d

Sedimentary rocks and processes

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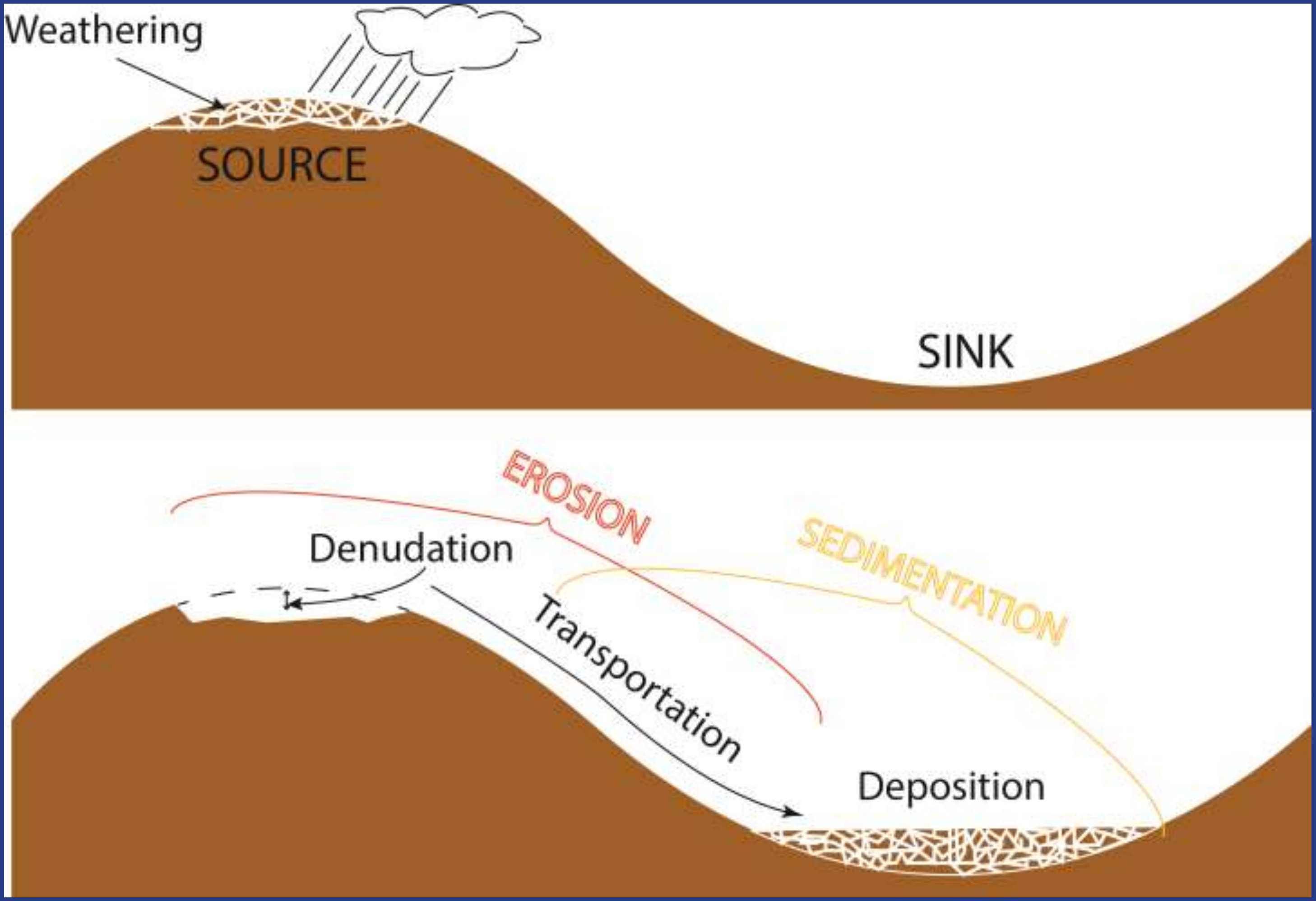
Earlier we had listed the sedimentary processes. They are what create the sedimentary rocks.

All sedimentary processes do two things: transportation of the material prepared by weathering away from source regions and its deposition in sink regions. All sedimentary rocks have a source and a sink.



Clastic sedimentary rocks

Conglomerates
Sandstones
Siltstones
Claystones and *Shales*

Organic sedimentary rocks

Limestones
Dolomites
Other carbonate rocks
Cherts
Coals

Chemical sedimentary rocks

Banded iron deposits
Evaporites

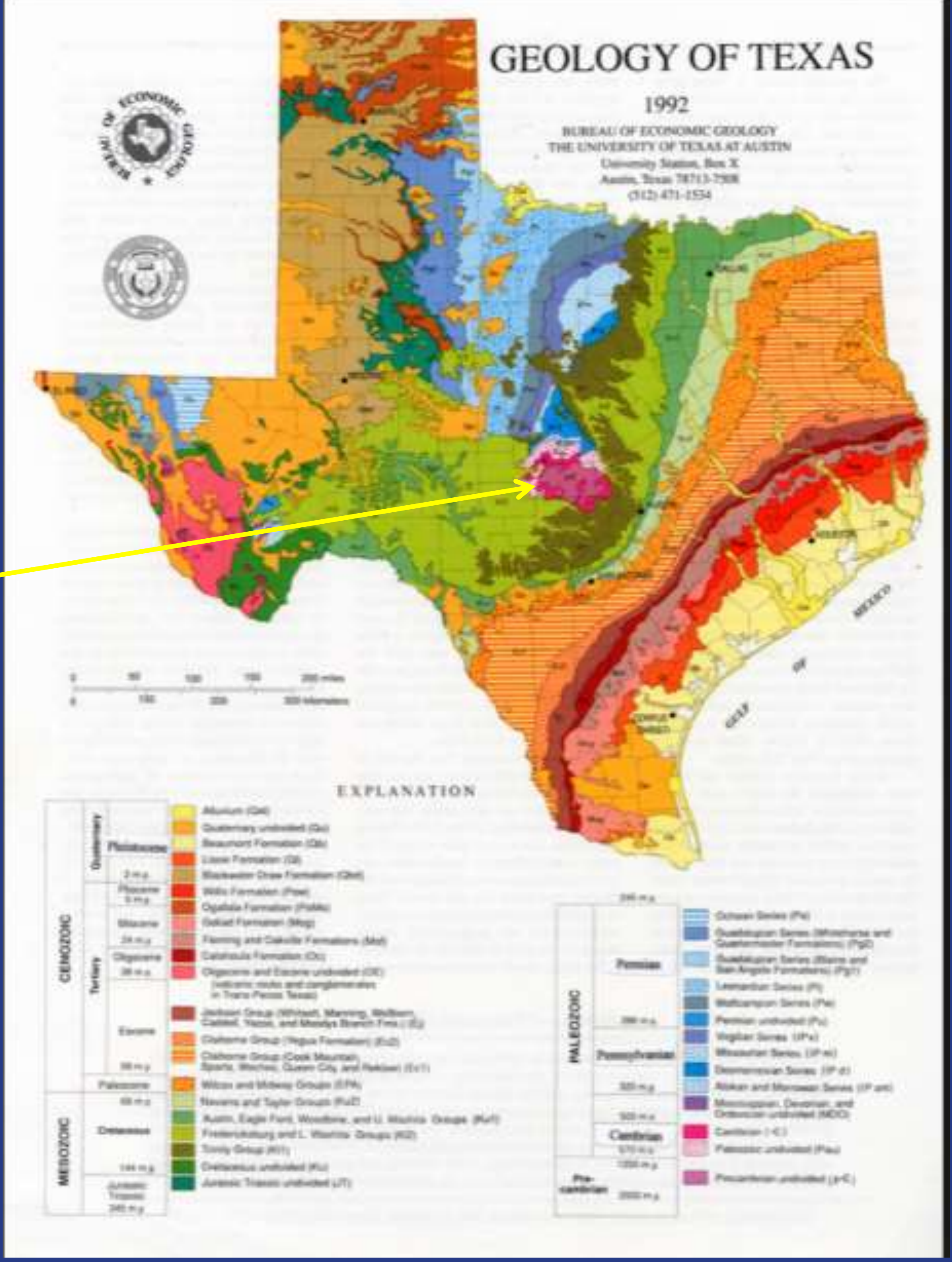
Notes:

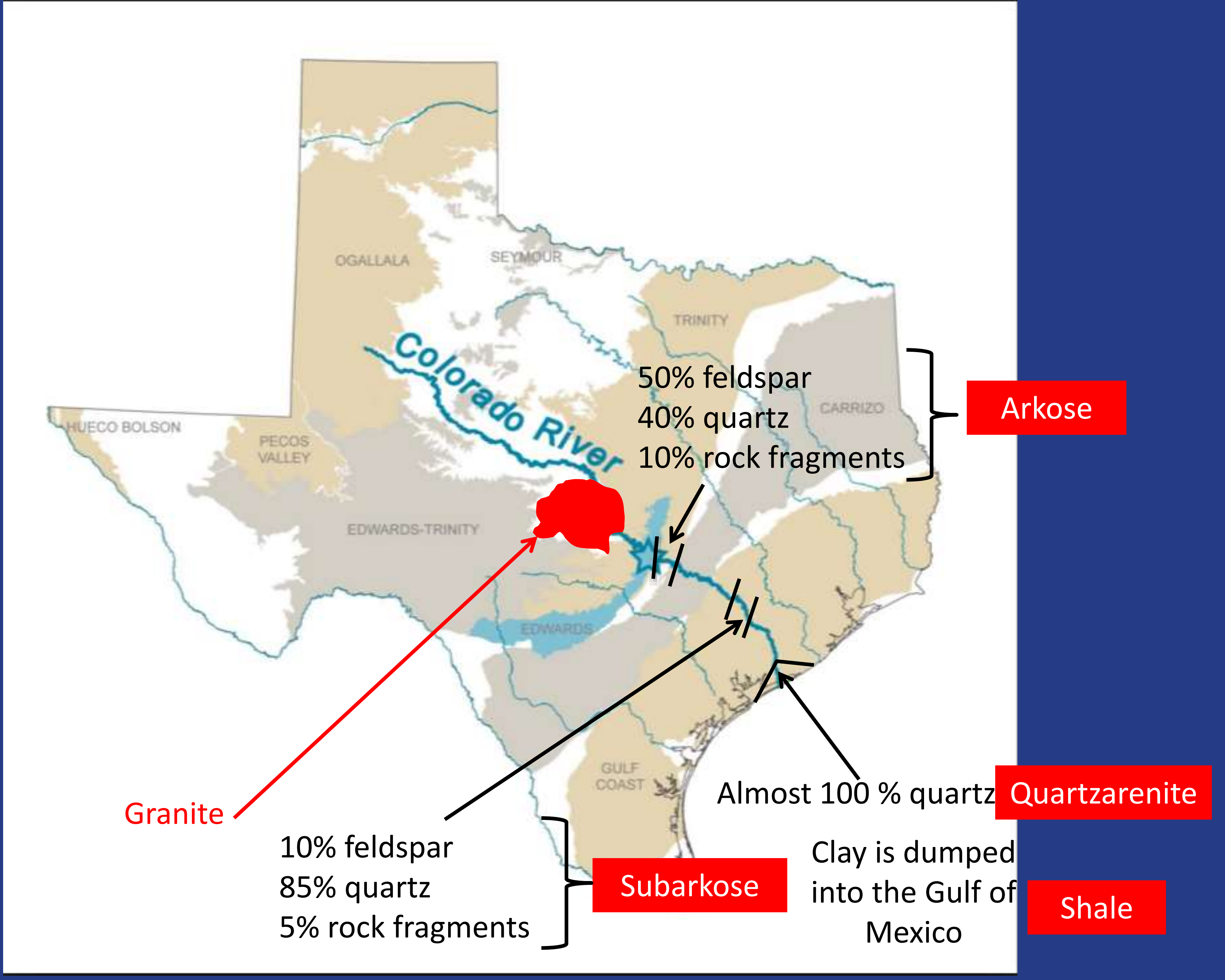
1. Some carbonate rocks form as organic sediments and then become granulated to turn into clastic sediments. Corals sands are examples.
2. Some chemical sediments form by the help of organisms. Banded iron formations are examples.

Let us begin with clastic sedimentary rocks which are the easiest to study among all sedimentary rocks.

Let us first consider what happens during transport. We take the Colorado River in Texas as an example.

Granites


GEOLOGY OF TEXAS
1992
BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
EXPLANATION



OGALLALA
SEYMOUR
TRINITY
Colorado River
CARRIZO
HUECO BOLSON
PECOS VALLEY
EDWARDS-TRINITY
EDWARDS
GULF COAST
50% feldspar
40% quartz
10% rock fragments
Arkose
Granite
10% feldspar
85% quartz
5% rock fragments
Subarkose
Almost 100 % quartz
Quartzarenite
Clay is dumped into the Gulf of Mexico
Shale

How do these different clastic sedimentary rock types form along the course of the Colorado River of Texas?

There are two mechanisms which we are already familiar with from our consideration of weathering:

CHEMICAL

MECHANICAL

Water dissolves away the ferro-magnesian minerals that had been left over from weathering and turns the feldspars into clays. With the feldspars and the ferromagnesian minerals gone, the framework of the granite dissolves and the quartz crystals become free.

What happens to them?

All particles produced by the disintegration of the granite must obey Stoke's Law:

$$V = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} g R^2$$

Density of mineral or rock grain (ρ_p)

Density of water (ρ_f)

Fall velocity in water (V)

Viscosity of water (μ)

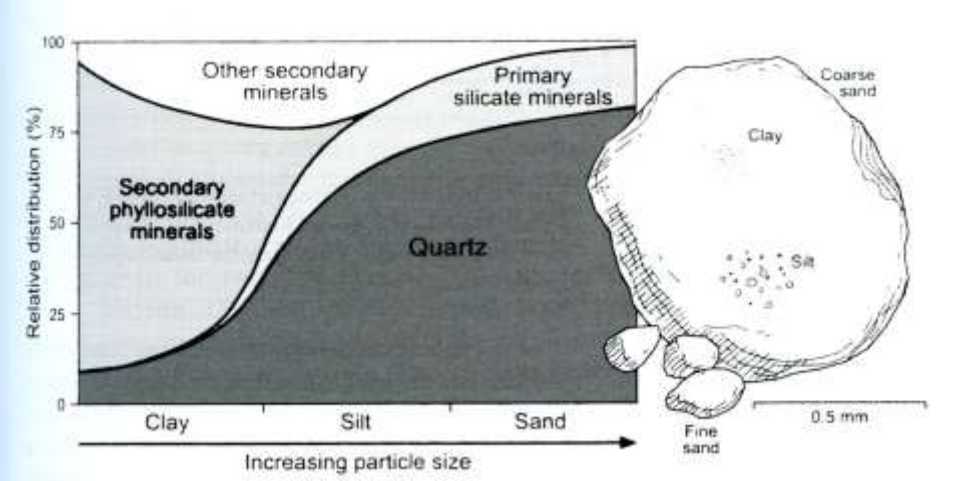
Gravity (g)

Radius of rock or mineral grain (R)

Basic message of Stoke's equation: the larger and the denser a mineral or a rock fragment is, the faster it will fall to the bottom of the water.

Let us now remember the sizes and compositions of our grains:

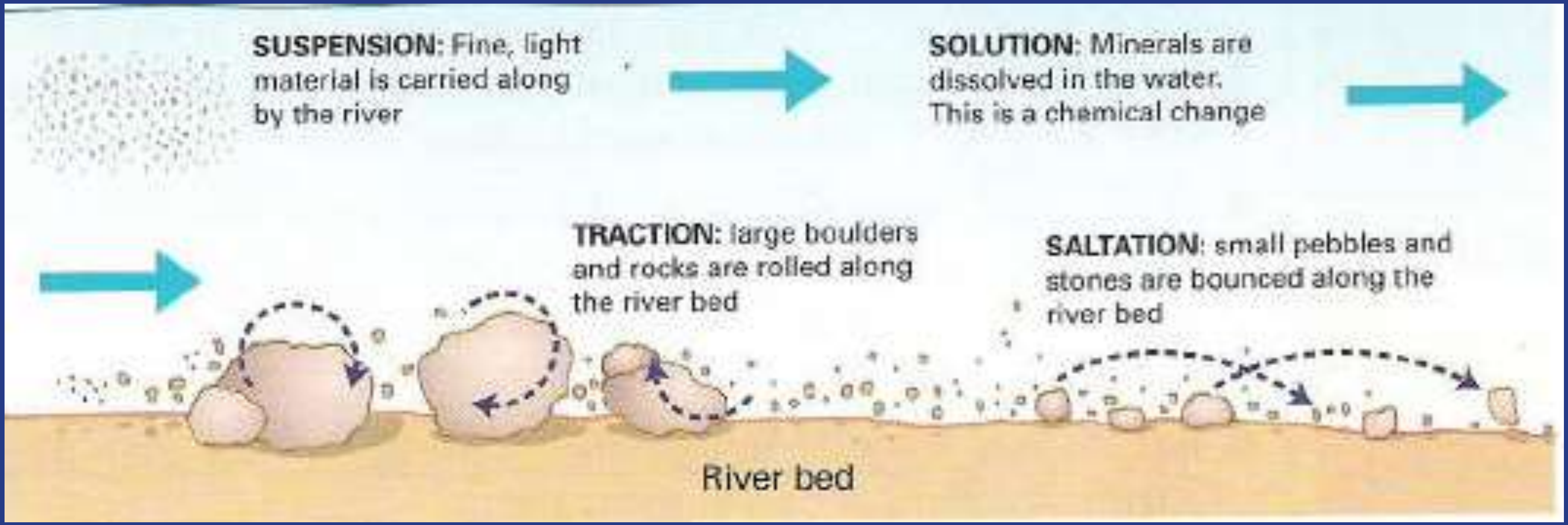
Soil fraction	Diameter	Description
Gravel	Larger than 2 mm	Coarse
Sand	0.05 - 2 mm	Gritty
Silt	0.002 - 0.05 mm	Floury
Clay	Smaller than 0.002 mm	Sticky when wet



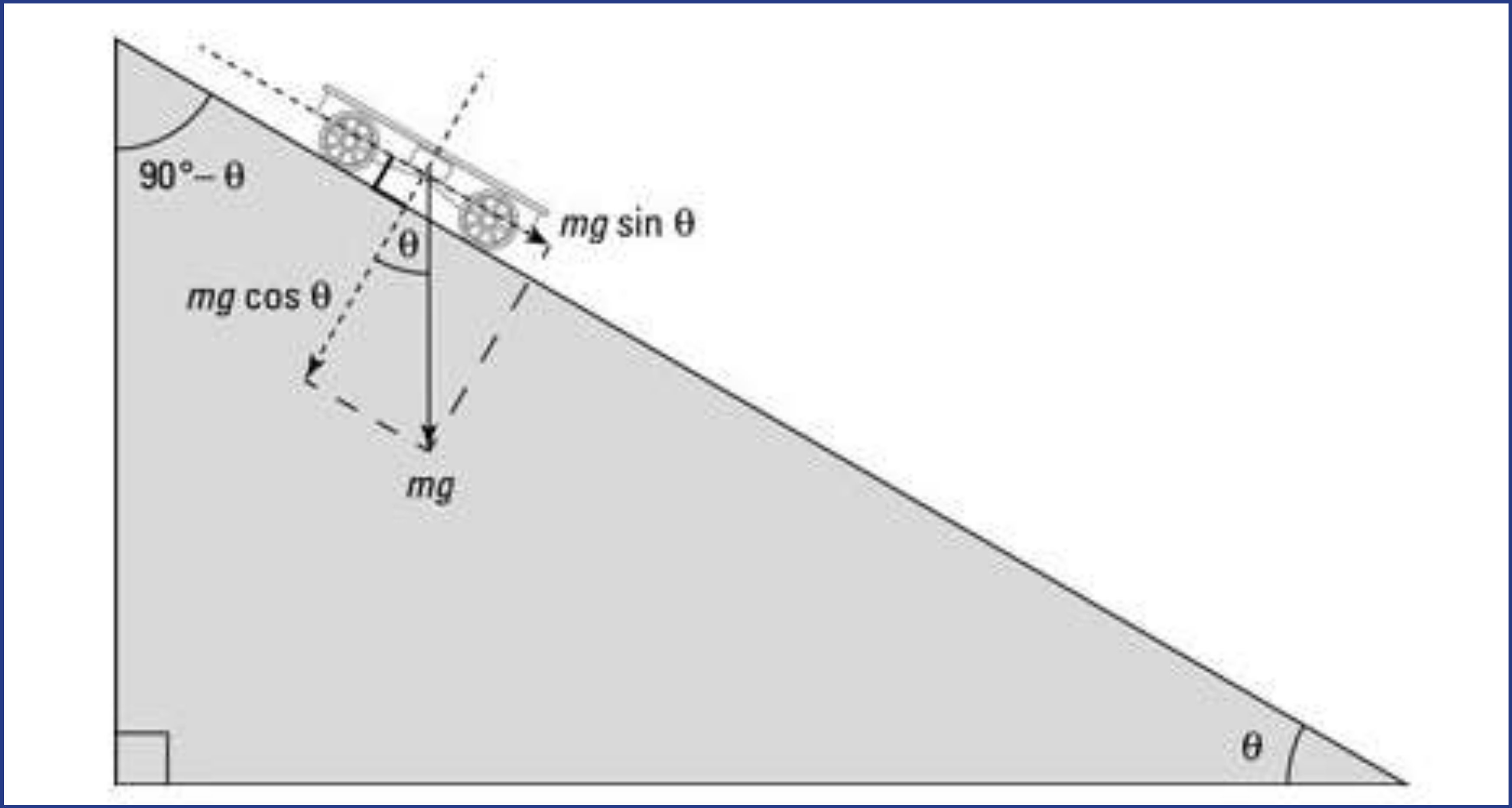
The densities of the clay minerals here produced are around 2.35 g/cm^3. By contrast quartz is 2.65 to 2.66. Similarly the rock fragments are closer to 2.65 to 2.7

Thus, the clay minerals are both small and light, so they will float away, but the rock fragments and quartz will sink to the bottom.

How do these mineral grains get carried by the flowing stream of the Colorado?

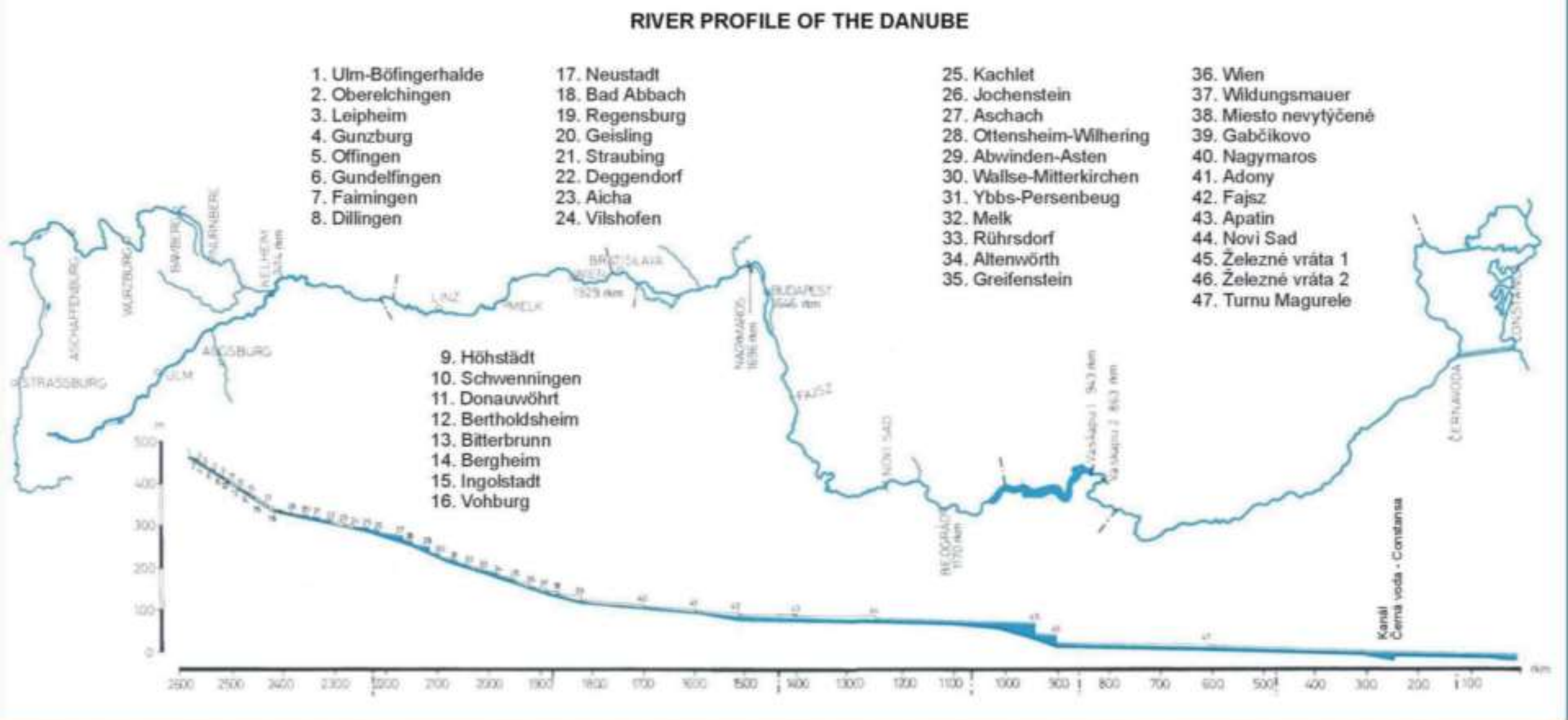


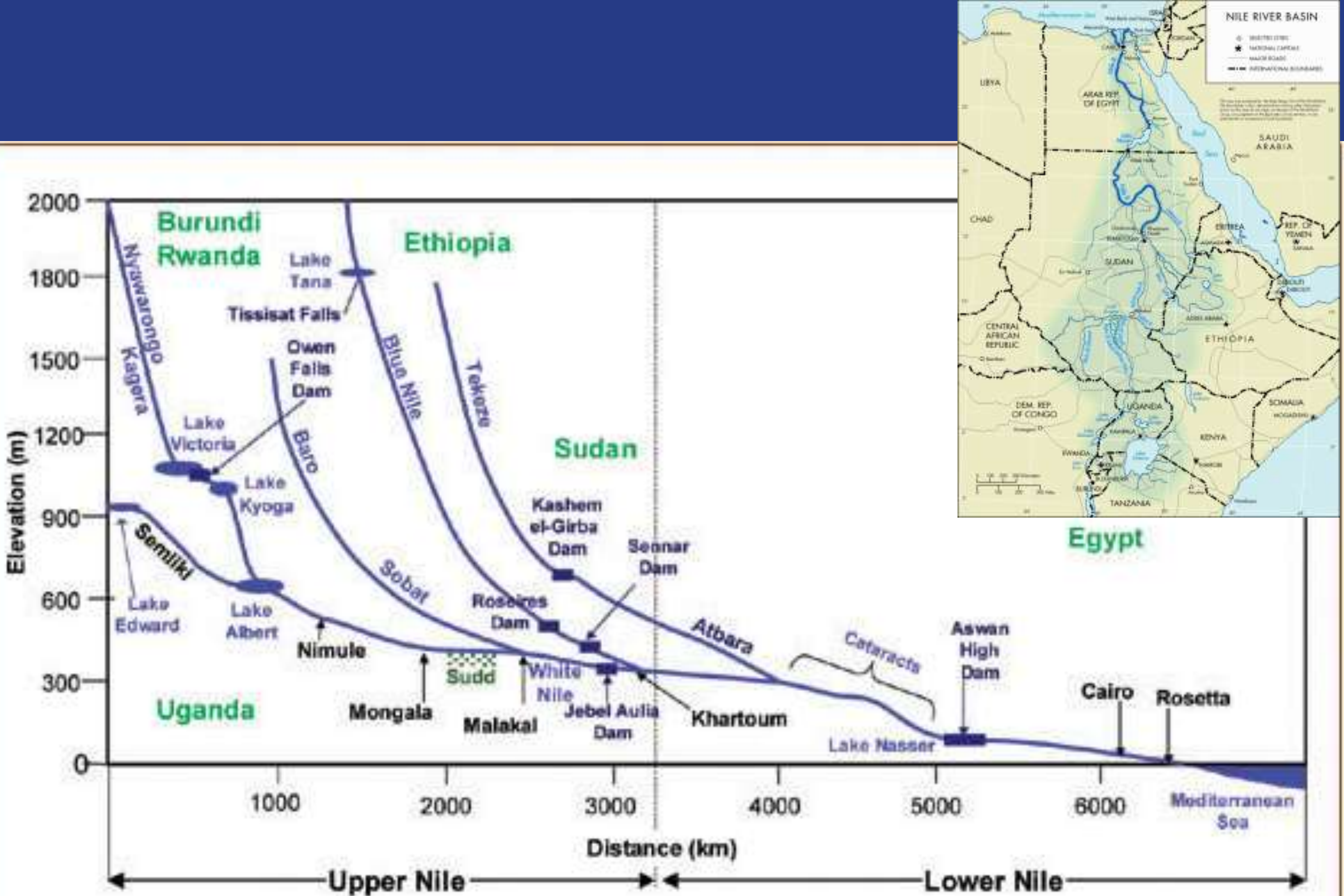
How flowing water will carry its load is dependent on its density, velocity and the weight of its load. Since force=mass X acceleration, for a fixed force, as the mass increases the acceleration must decrease.



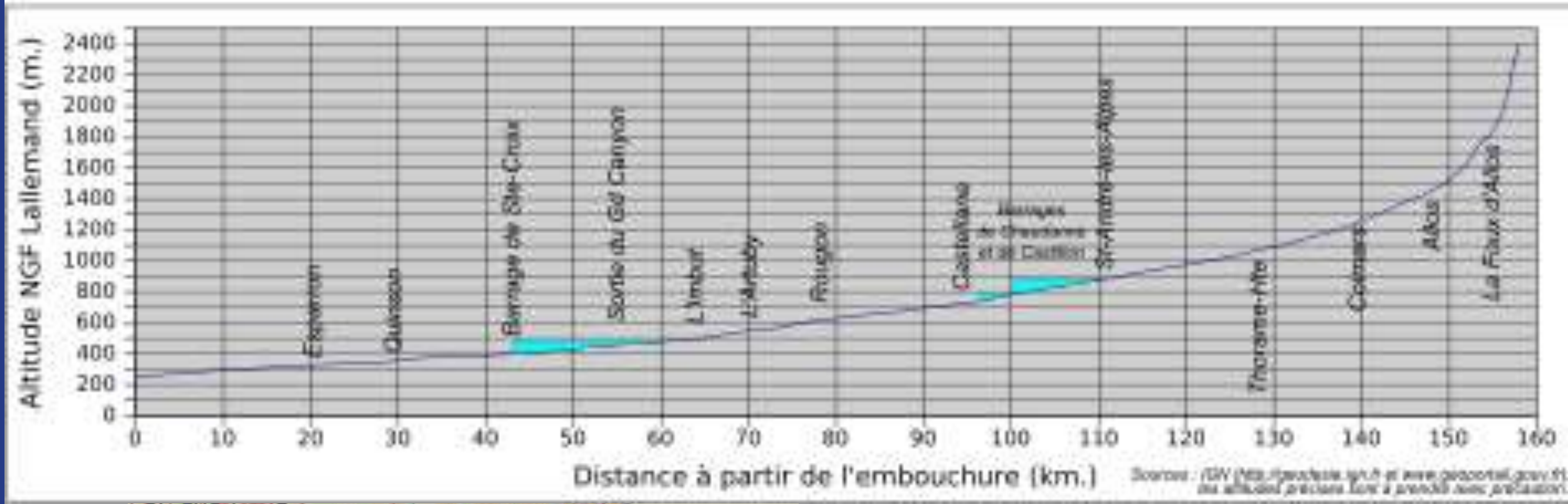
But the speed of the flow of the river is dependent entirely on its slope. As the slope decreases the velocity decreases. Rivers usually go from a high-slope upper course through a medium-slope middle course and a low-slope lower course. Let us look at some river profiles first.

The profile of the Danube

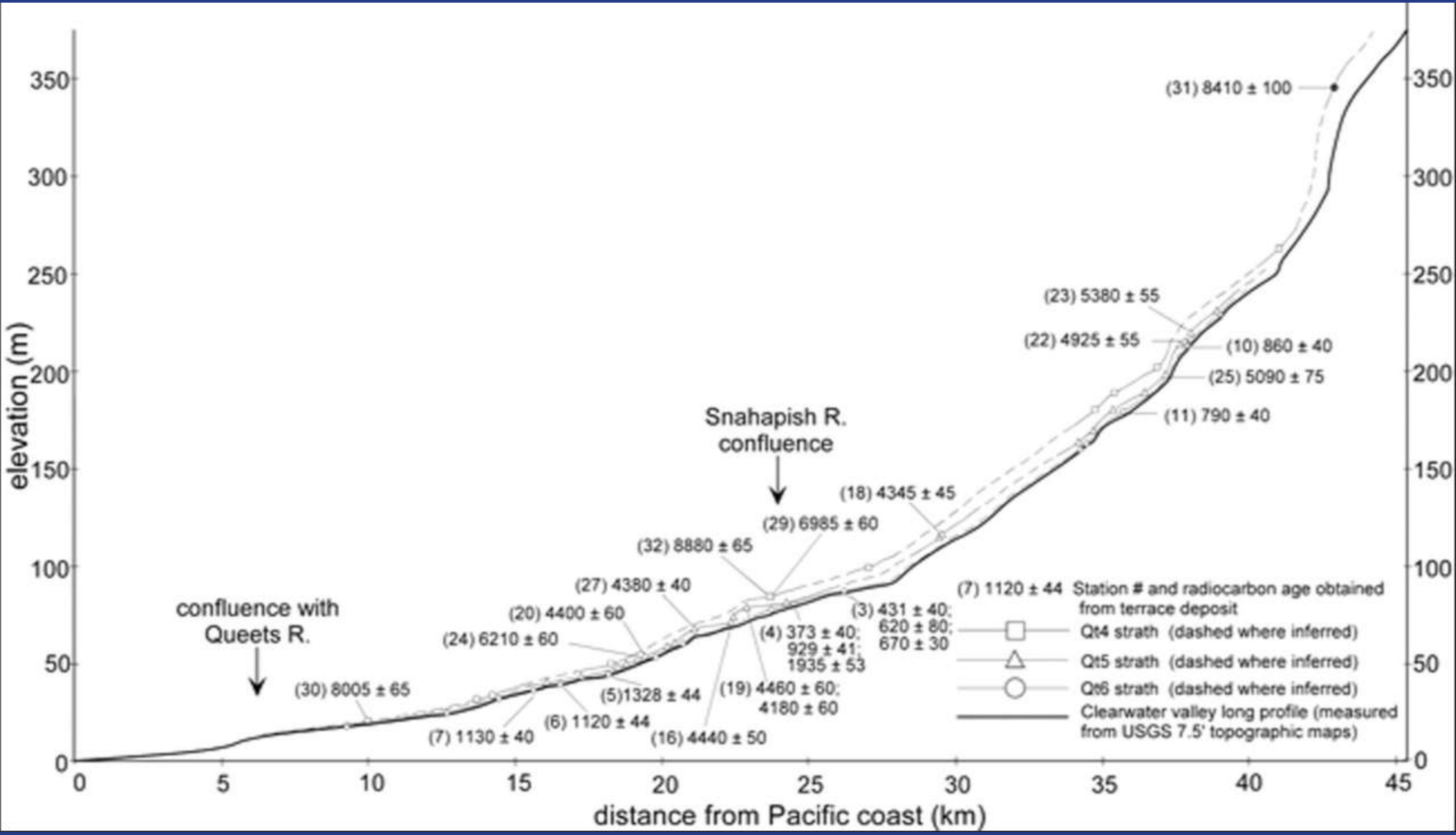




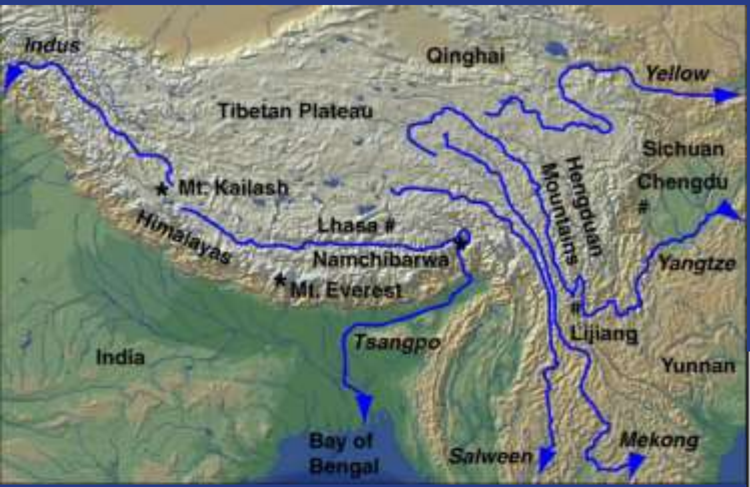
Longitudinal profile of the Nile

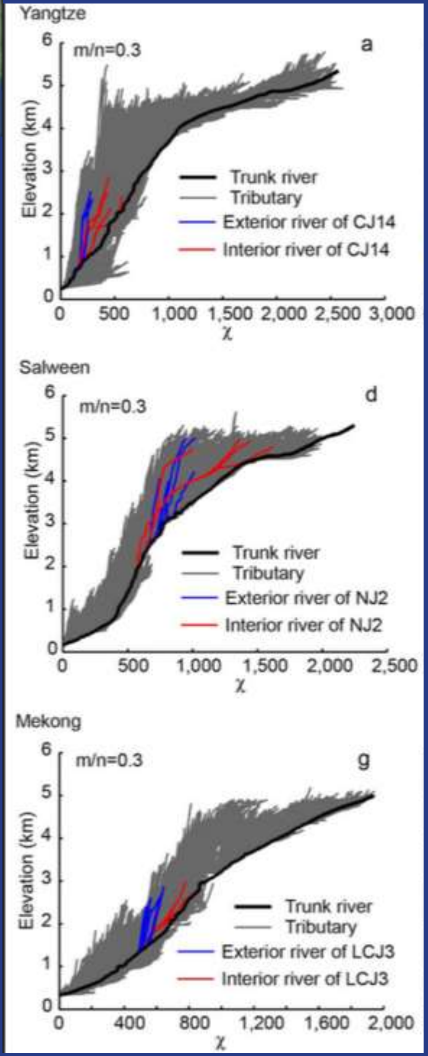


The longitudinal profile of the Verdon River, France.



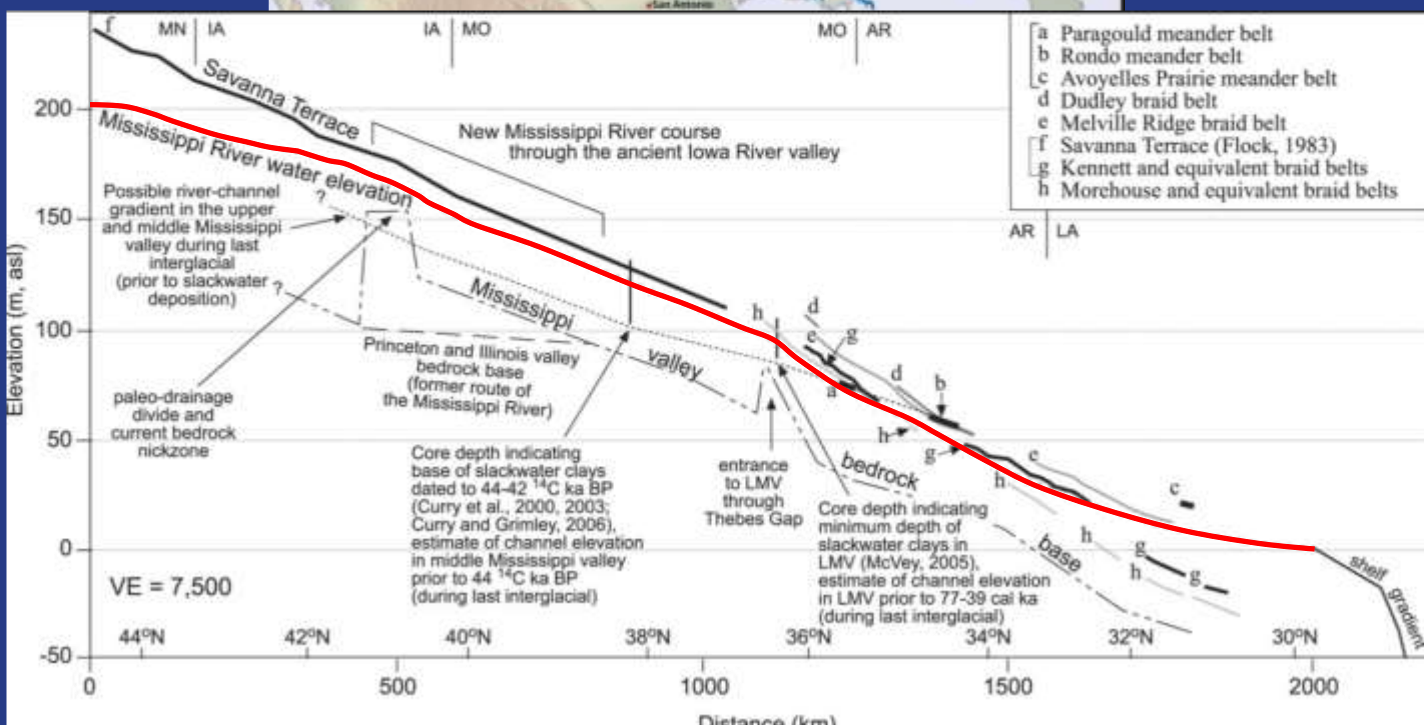
The longitudinal profile of the Clearwater River, Olympic Peninsula, Washington State, USA.

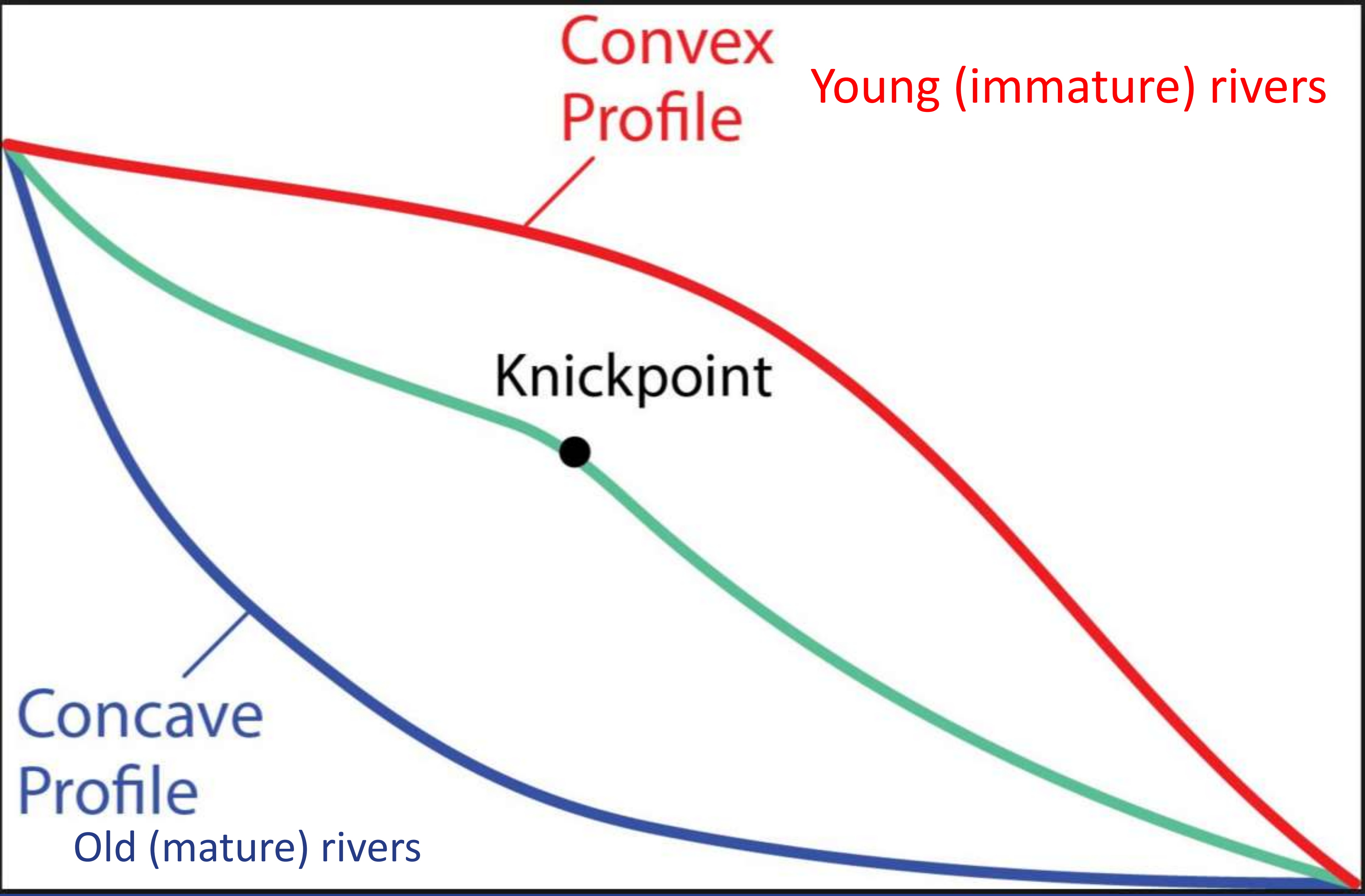




The profiles of three major rivers in a region of very young and rapid uplift.

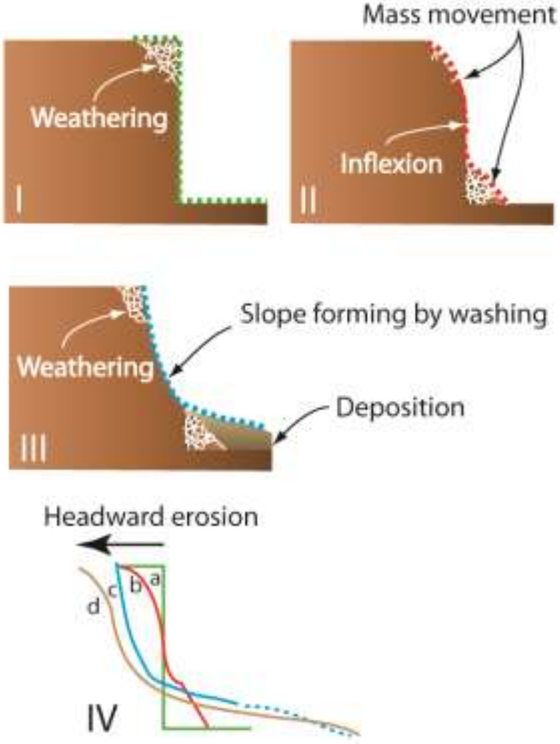

Missouri
Yellowstone
Mississippi
Platte
Kansas
Arkansas
Ohio
Red
Chicago

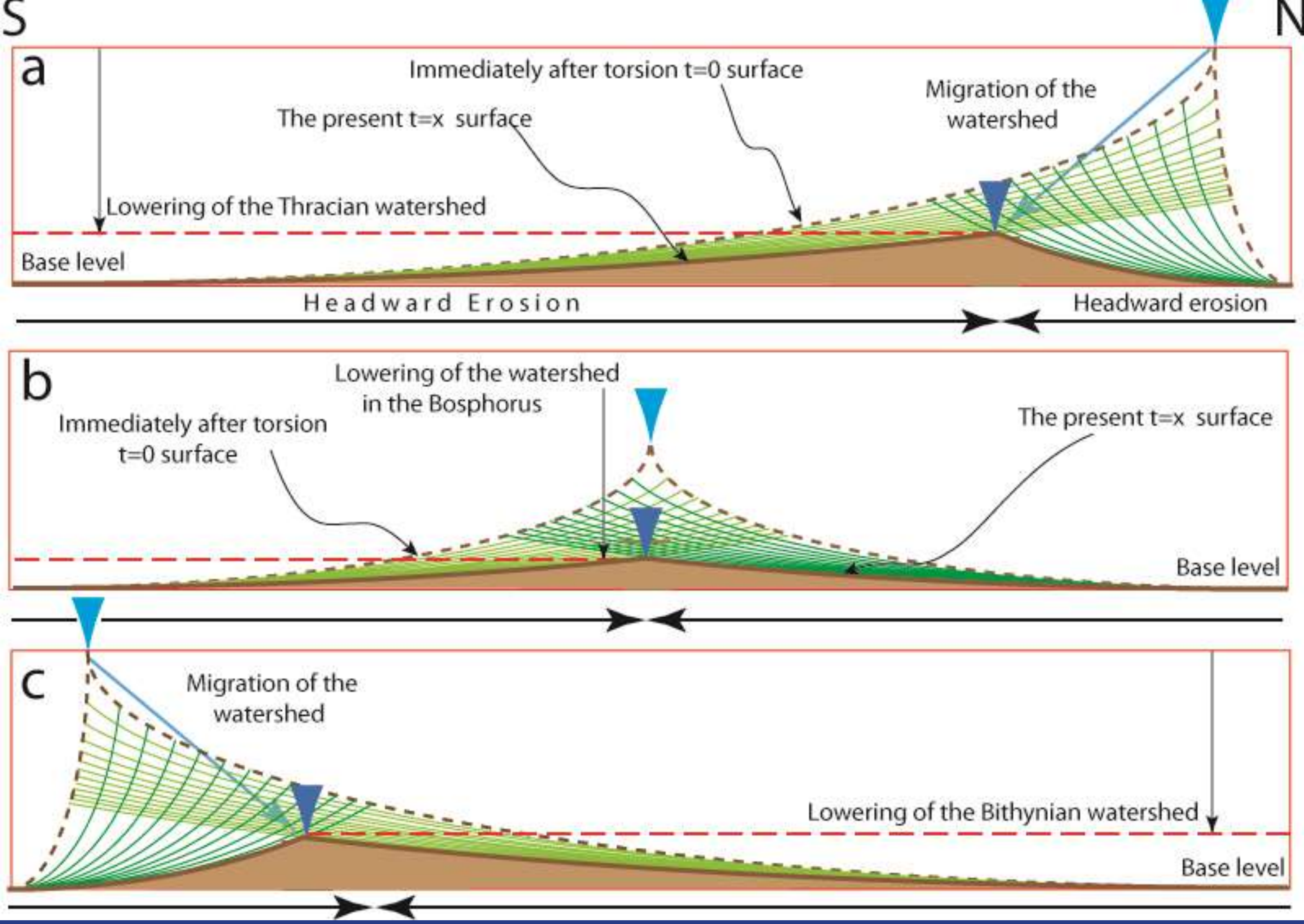

Savanna Terrace
Mississippi River water elevation
New Mississippi River course through the ancient Iowa River valley
MN
IA
MO
AR
LA
a Paragould meander belt
b Rondo meander belt
c Avoyelles Prairie meander belt
d Dudley braid belt
e Melville Ridge braid belt
f Savanna Terrace (Flock, 1983)
g Kennett and equivalent braid belts
h Morehouse and equivalent braid belts
Possible river-channel gradient in the upper and middle Mississippi valley during last interglacial (prior to slackwater deposition)
Mississippi valley bedrock base
Princeton and Illinois valley bedrock base (former route of the Mississippi River)
paleo-drainage divide and current bedrock nickzone
Core depth indicating base of slackwater clays dated to 44-42 14C ka BP (Curry et al., 2000, 2003; Curry and Grimley, 2006), estimate of channel elevation in middle Mississippi valley prior to 44 14C ka BP (during last interglacial)
entrance to LMV through Thebes Gap
Core depth indicating minimum depth of slackwater clays in LMV (McVey, 2005), estimate of channel elevation in LMV prior to 77-39 cal ka (during last interglacial)
shelf gradient
VE = 7,500
Elevation (m, asl)
Distance (km)
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
200
150
100
50
0
-50
500
1000
1500
2000



Evolution of river profiles

The origin of upwards convex and upwards concave slopes by weathering, mass wasting and fluvial erosion.





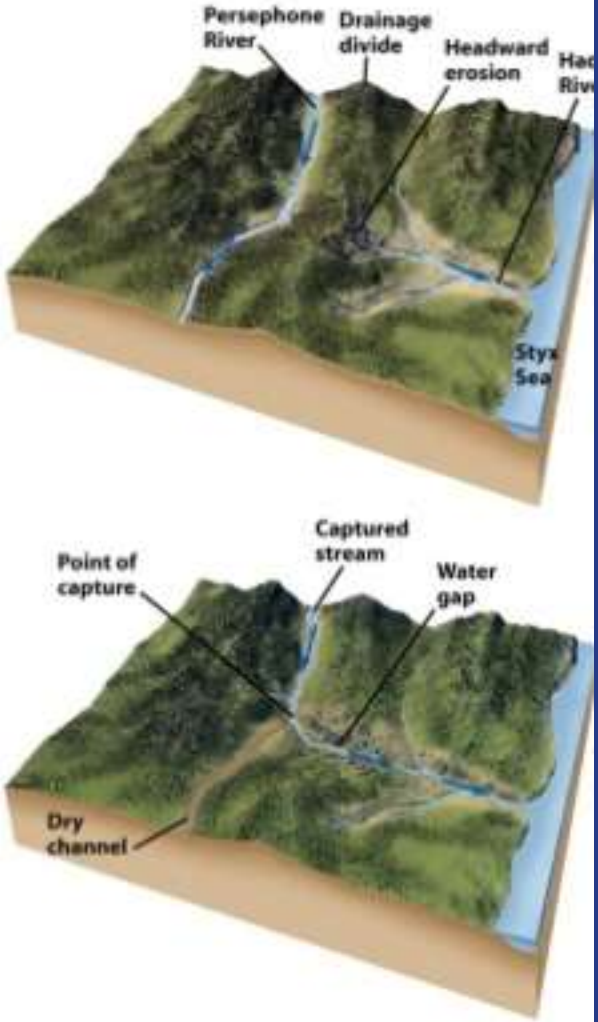
The evolution of valley profiles in the Thracian-Bithynian isthmus under the assumption of a dry climate in the late Pleistocene

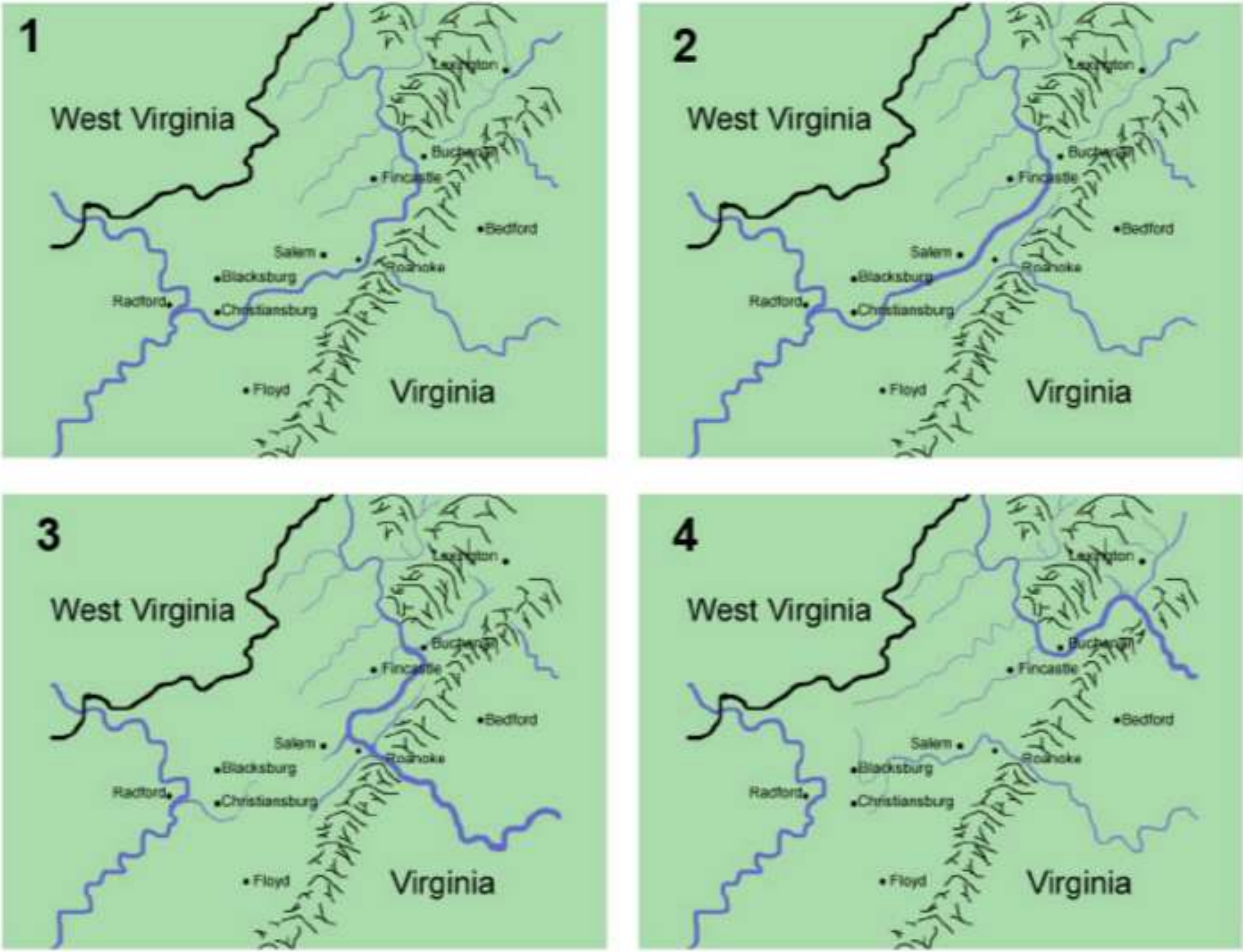
Headward erosion: Nemrut Caldera, eastern Turkey

Drainage Evolution

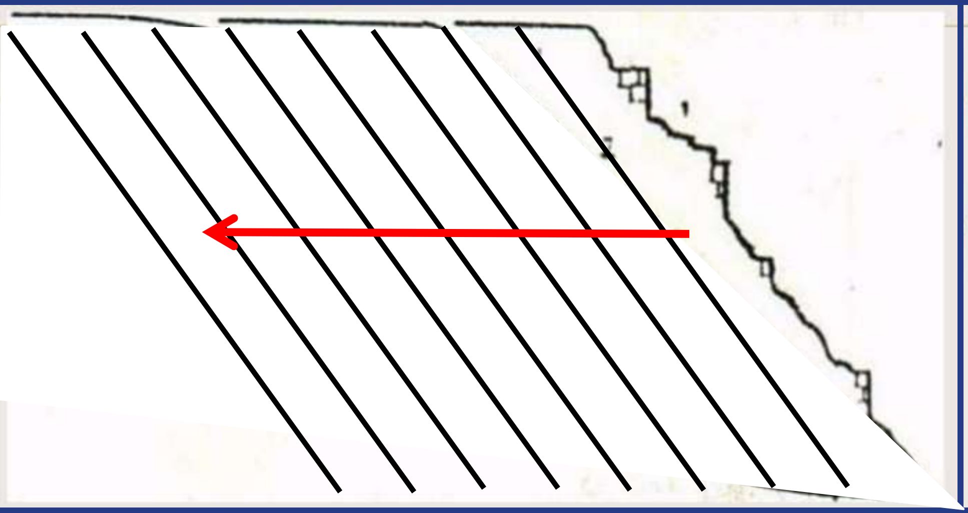
Stream piracy

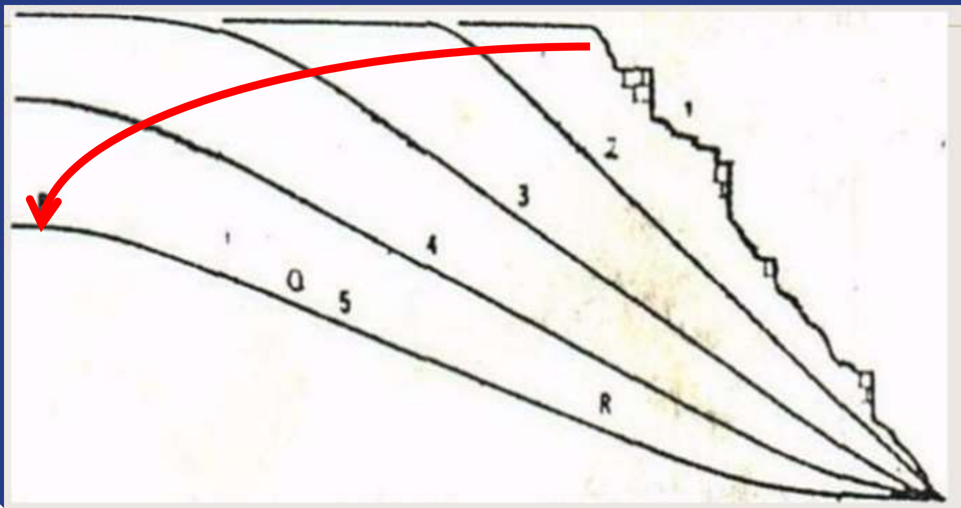
- One stream captures flow from another
- Results from headward erosion
- A stream with more vigorous erosion (steeper gradient), intercepts another stream
- Captured stream flows into the new stream
- Below capture point, old stream dries up




1
West Virginia
Lexington
Buchanan
Fincastle
Bedford
Salem
Roanoke
Blacksburg
Radford
Christiansburg
Floyd
Virginia
2
West Virginia
Lexington
Buchanan
Fincastle
Bedford
Salem
Roanoke
Blacksburg
Radford
Christiansburg
Floyd
Virginia
3
West Virginia
Lexington
Buchanan
Fincastle
Bedford
Salem
Roanoke
Blacksburg
Radford
Christiansburg
Floyd
Virginia
4
West Virginia
Lexington
Buchanan
Fincastle
Bedford
Salem
Roanoke
Blacksburg
Radford
Christiansburg
Floyd
Virginia

How do slopes evolve? How do we go from a highly dissected plateau to a fairly flat, low-lying plain? There have been two main ideas on this question, both of which are probably true depending on what climatic belt one is in.





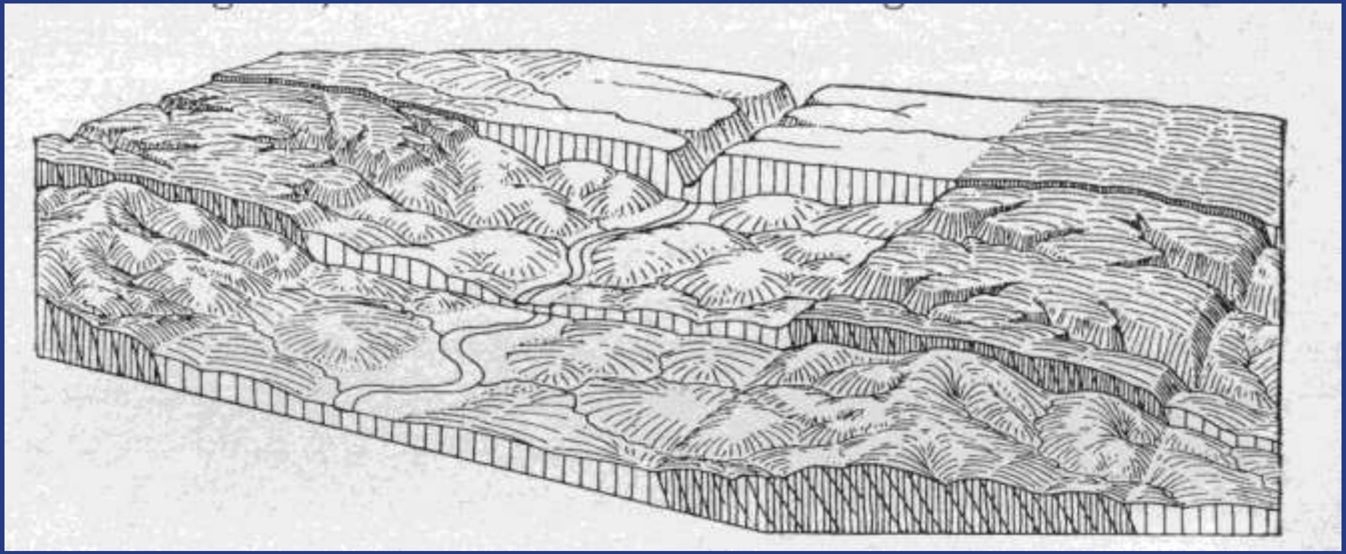
Slope retreat (Walther Penck)

Arid morphology

Slope degradation (William Morris Davis)

Humid morphology

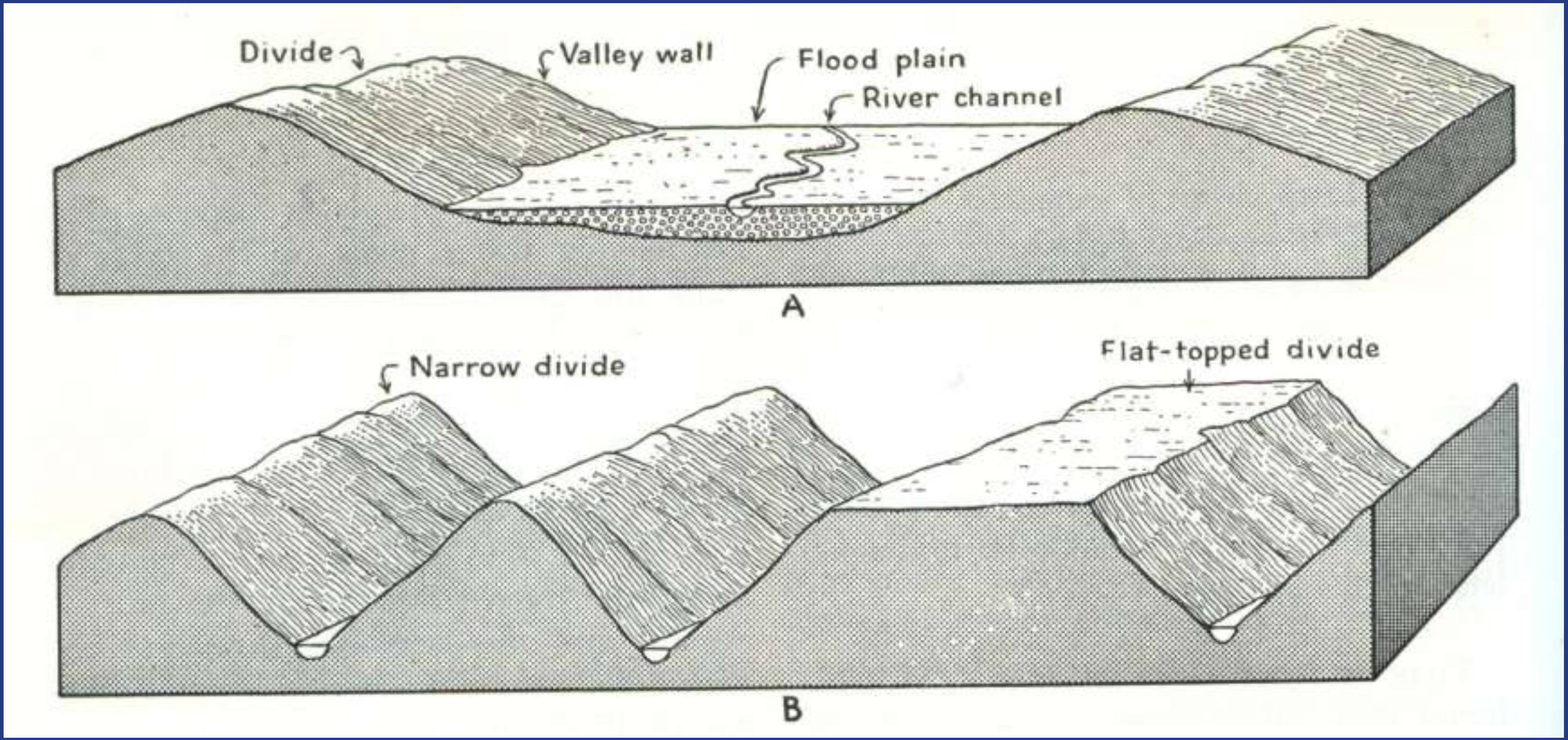
This is a view of the central part of the North American continent from about 10,000 m height. Notice that not one topographic eminence disturbs the flatness of the area seen. This region is known to be underlain by large mountain belts created 1500 to 800 million years ago. What happened to them?



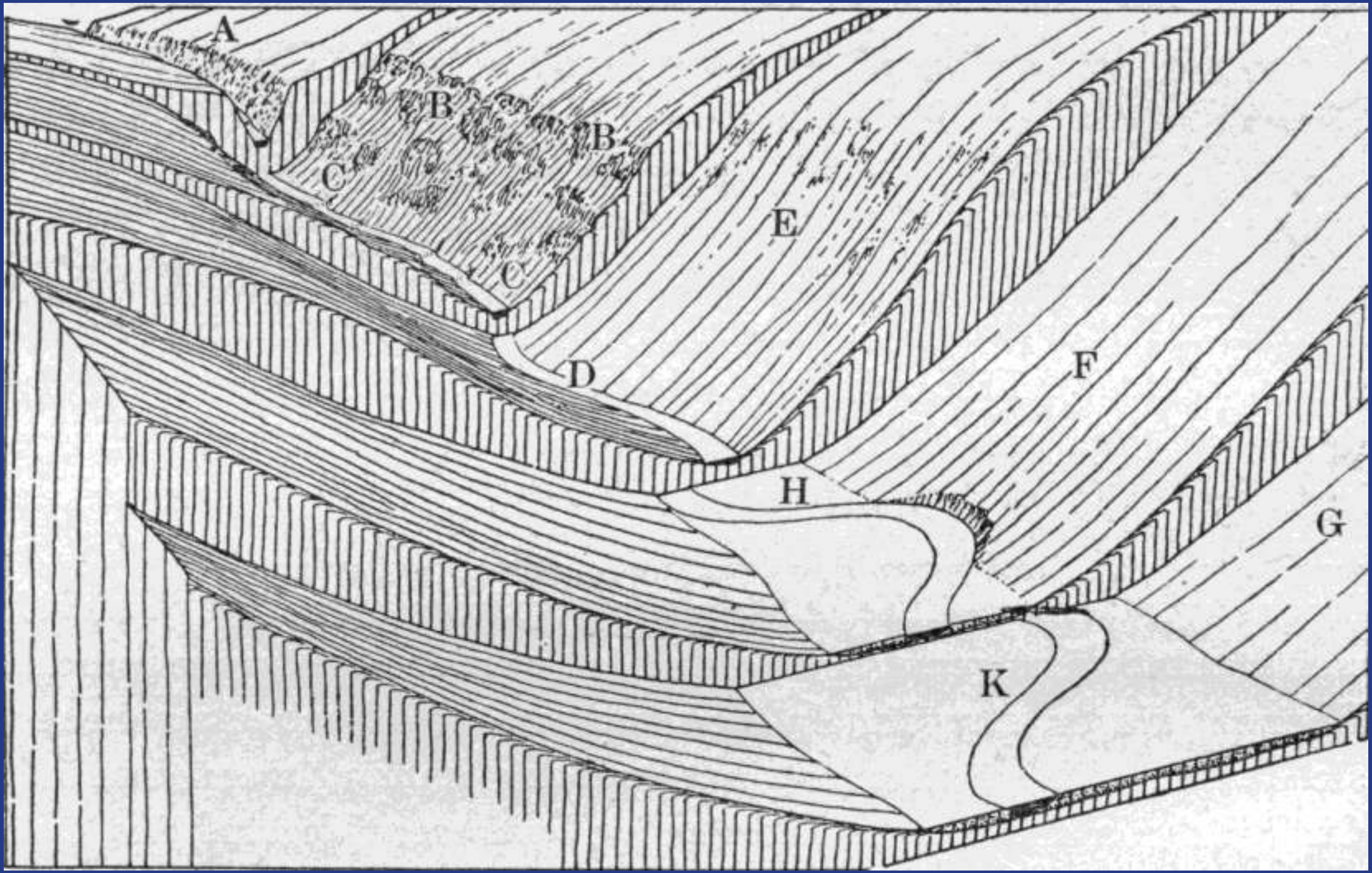
Stages of landscape development according to Davis. Notice the progressive flattening of the surface.

Dissection of a surface in a temperate climate (northern USA)

Dissection of a surface in a dry climate (western USA)

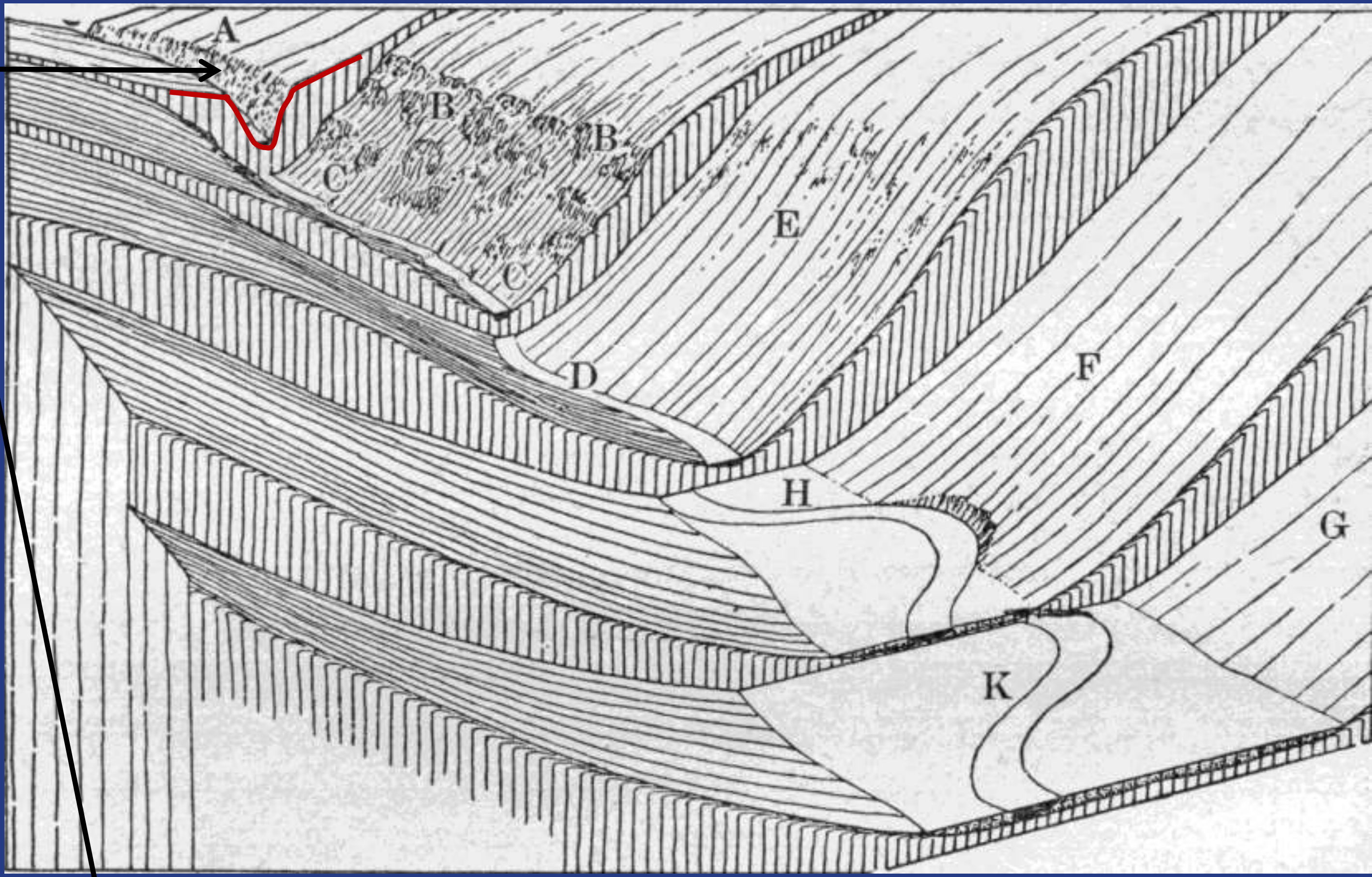


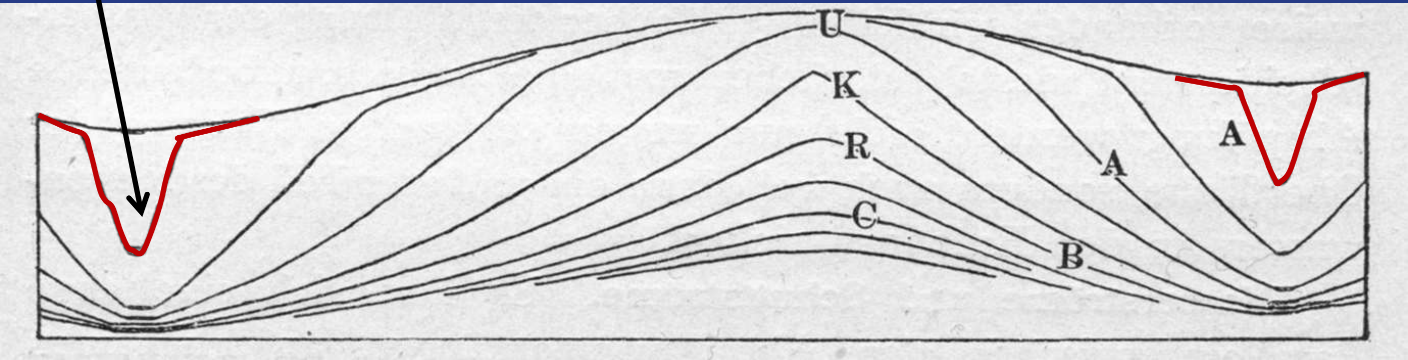
Basic geomorphological terminology of valleys



Development of a valley according to Davis.

Deep and narrow young valley cut into bedrock





Mediterranean climate (semi humid): the Gorge of Verdone, France

Arid climate: Grand Canyon of the Colorado River, Arizona, USA

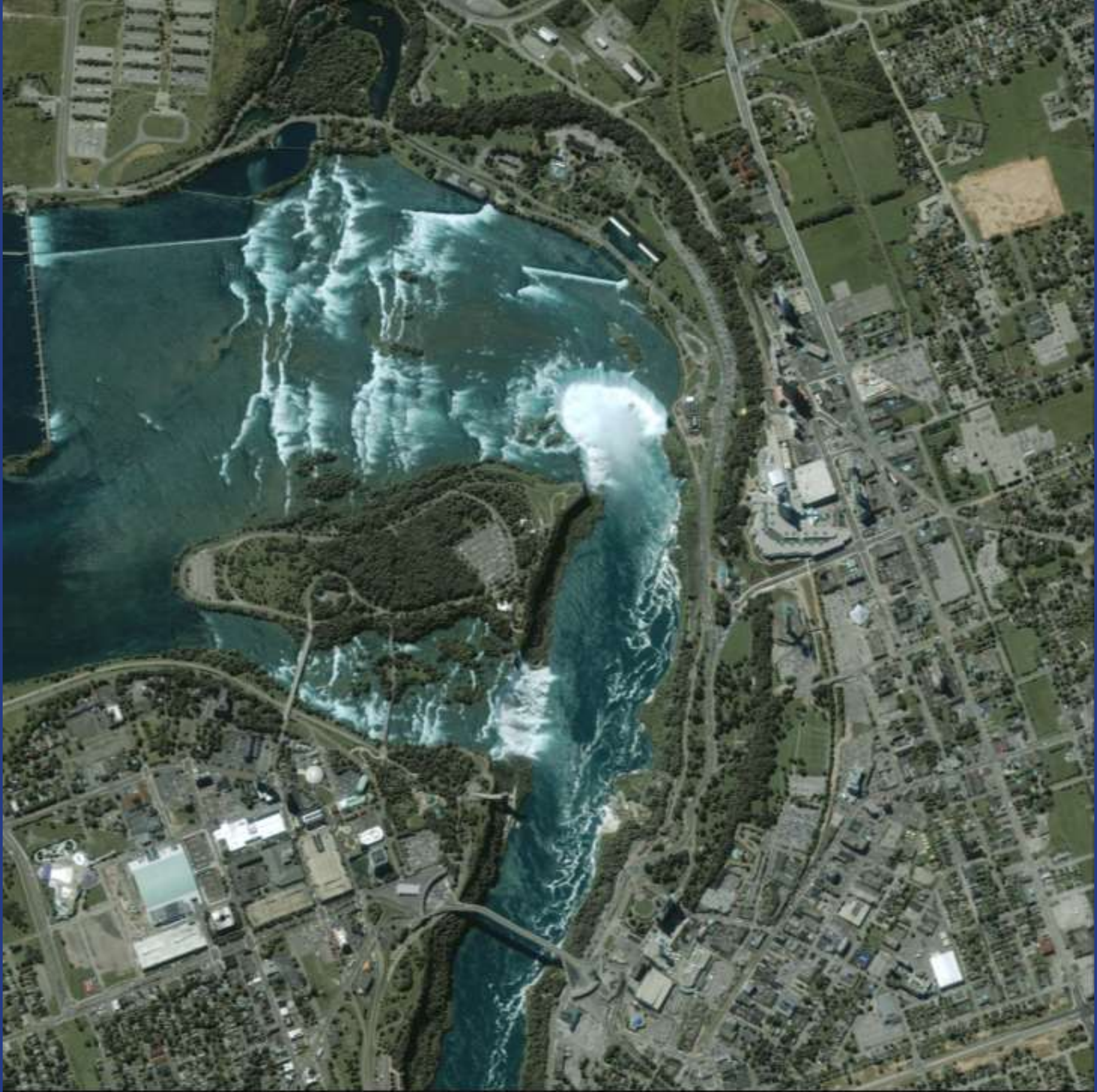
In young valleys and in the upper courses of any valley the stream comes into contact with bedrock more frequently than in the old valleys or in the lower courses of any valley.

In young valleys and in the upper courses of any valley, the gradients are steeper and the erosive power of the river is greater. It is in these areas that we see most of the erosive features of the rivers, such as:

1. Water falls

2. Rapids

3. Potholes (=devil’s cauldrons)



WATERFALLS

The Niagara Falls, USA and Canada, has the highest rate of flow of any waterfall in the world, with a vertical drop of some 50 m.

Lockport Dolomite

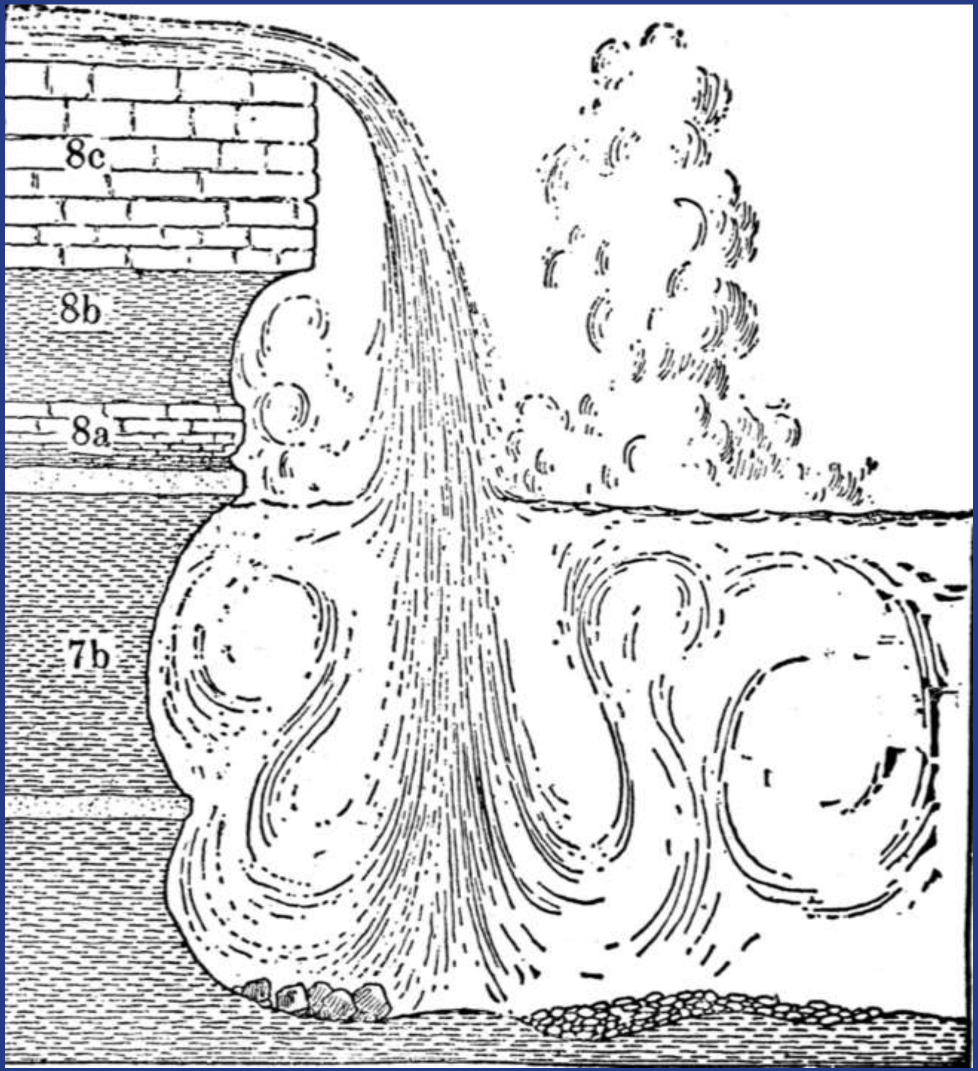
Rochester Shale

Clinton Limestone and Shale

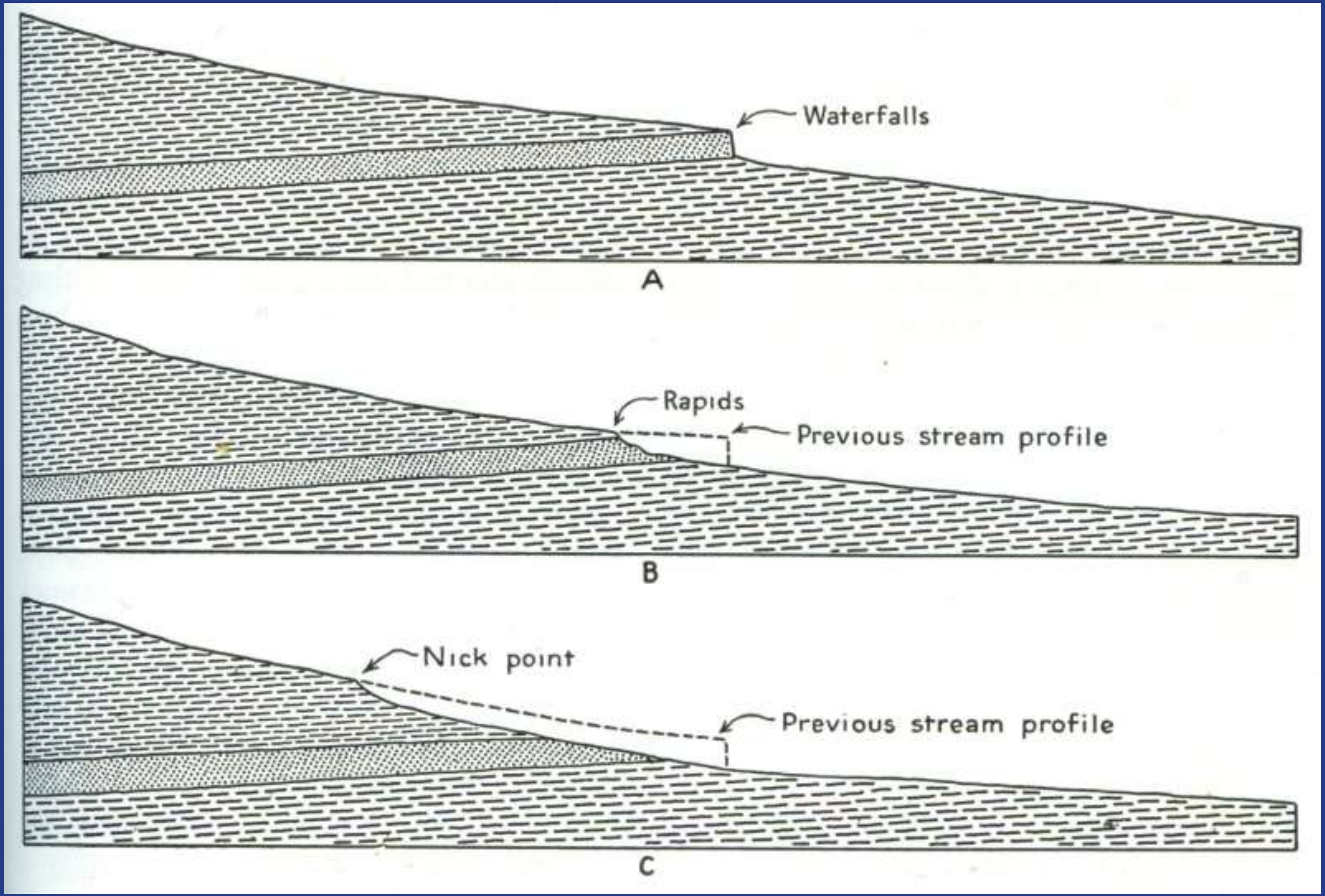
Medina Sandstone

Cataract Shale and Sandstone

Queenston Shale

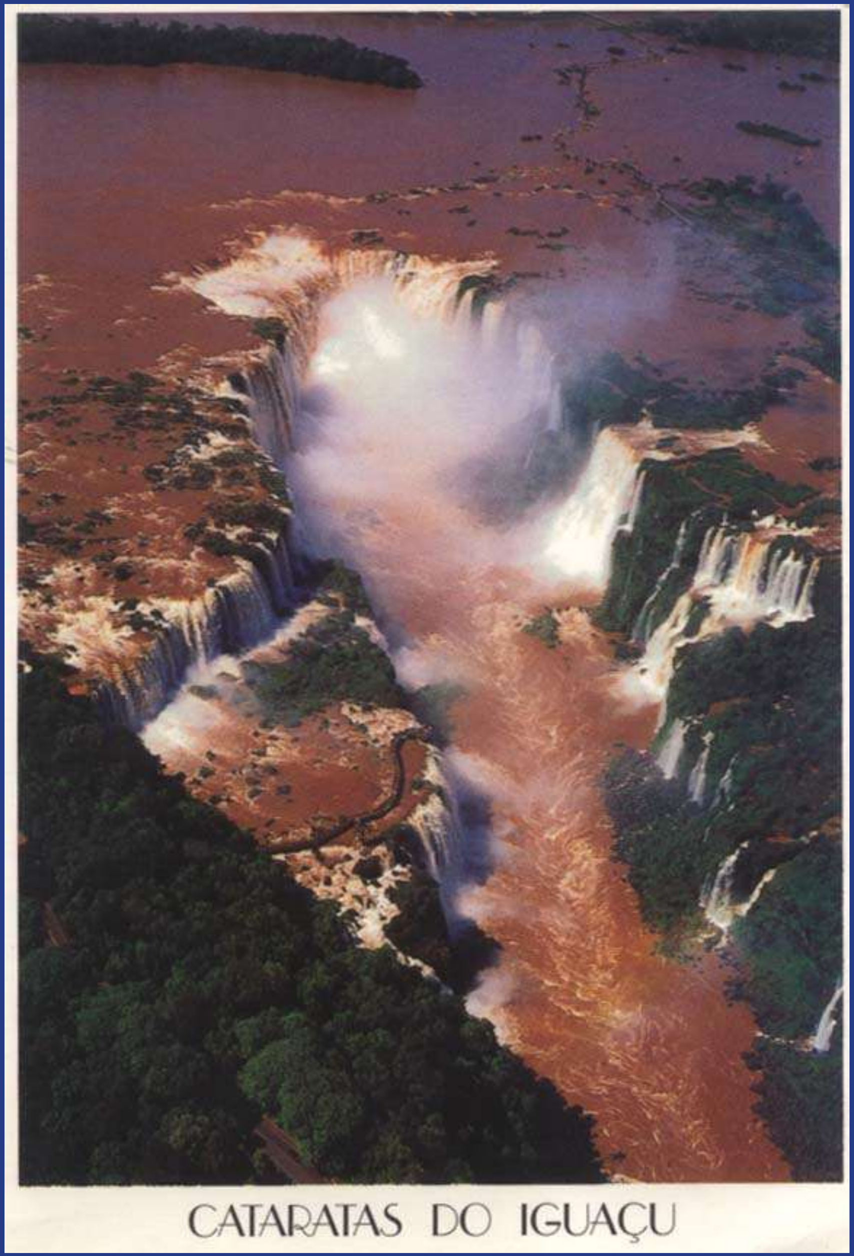


The geology of the Niagara Falls



Retreat and eventual destruction of a waterfall (inspired by the Niagara case)

J. P. Hackert’s painting of the Tivoli Falls near Rome, Italy

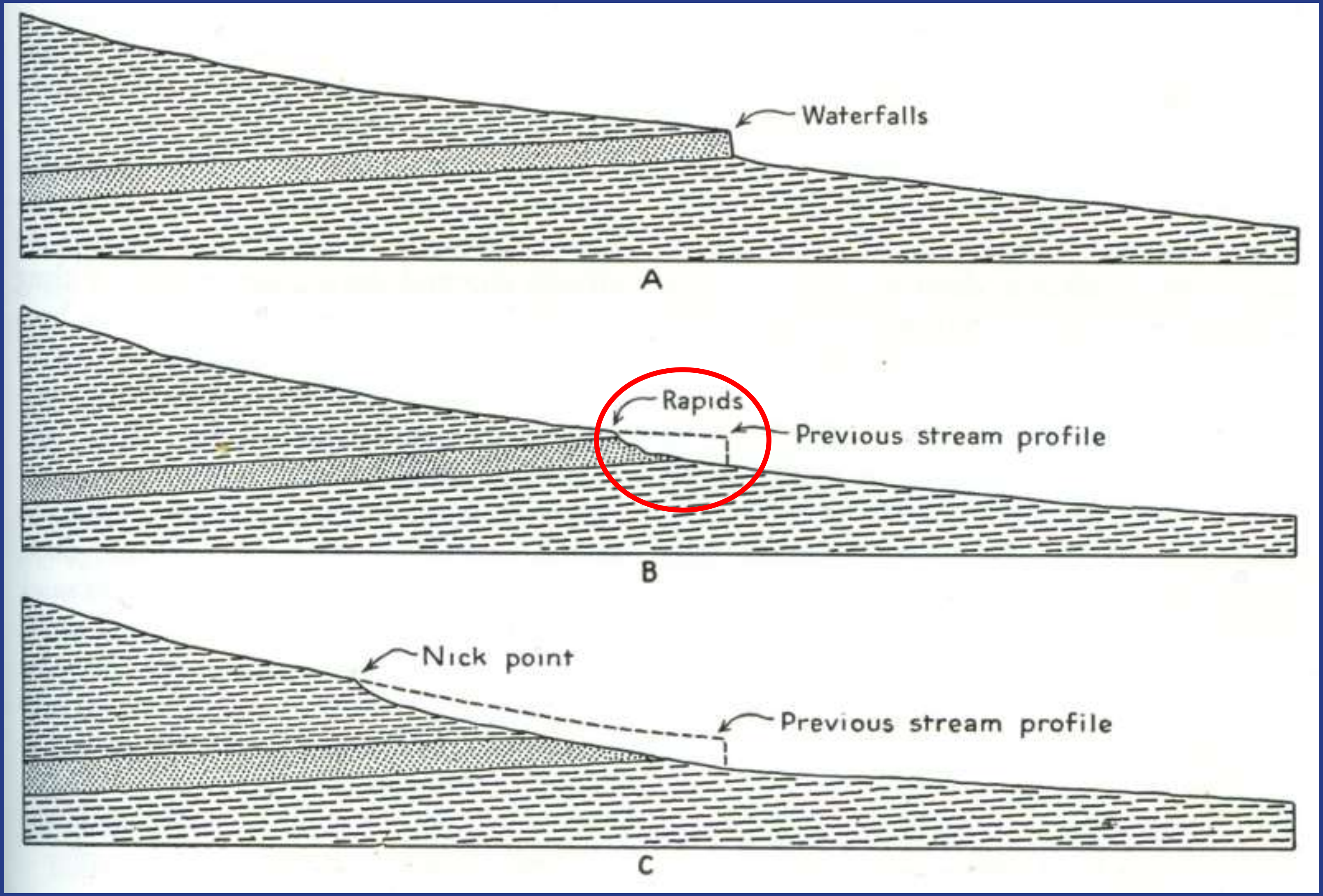


The Iguaçu Falls, Brazil

Angel Falls, Venezuela, on the Orinoco River, is the highest waterfall in the world. Its drop is 1000 metres and the waters reach the bottom only as vapour

The Victoria Falls (Mosi oa Tunya=smoke that thunders) on the Zambezi River at the border between Zambia and Zimbabwe, Africa. The Falls were discovered by the great Scottish geographer, missionary and humanist David Livingstone in 1855.

RAPIDS

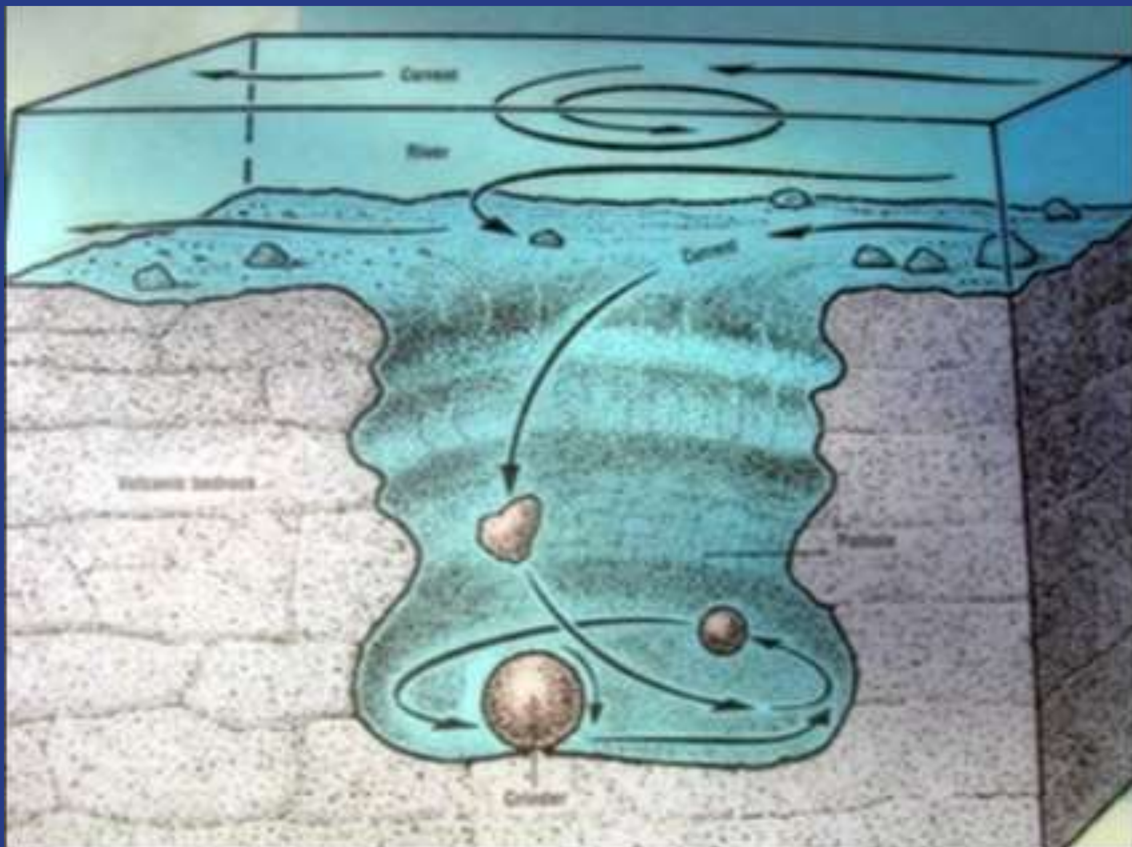

Waterfalls
A
Rapids
Previous stream profile
B
Nick point
Previous stream profile
C

The rapids of “Sweet’s Falls” in the upper Gauley River, West Virginia, USA

Blakeney Rapids, Mississippi River, Ontario, Canada

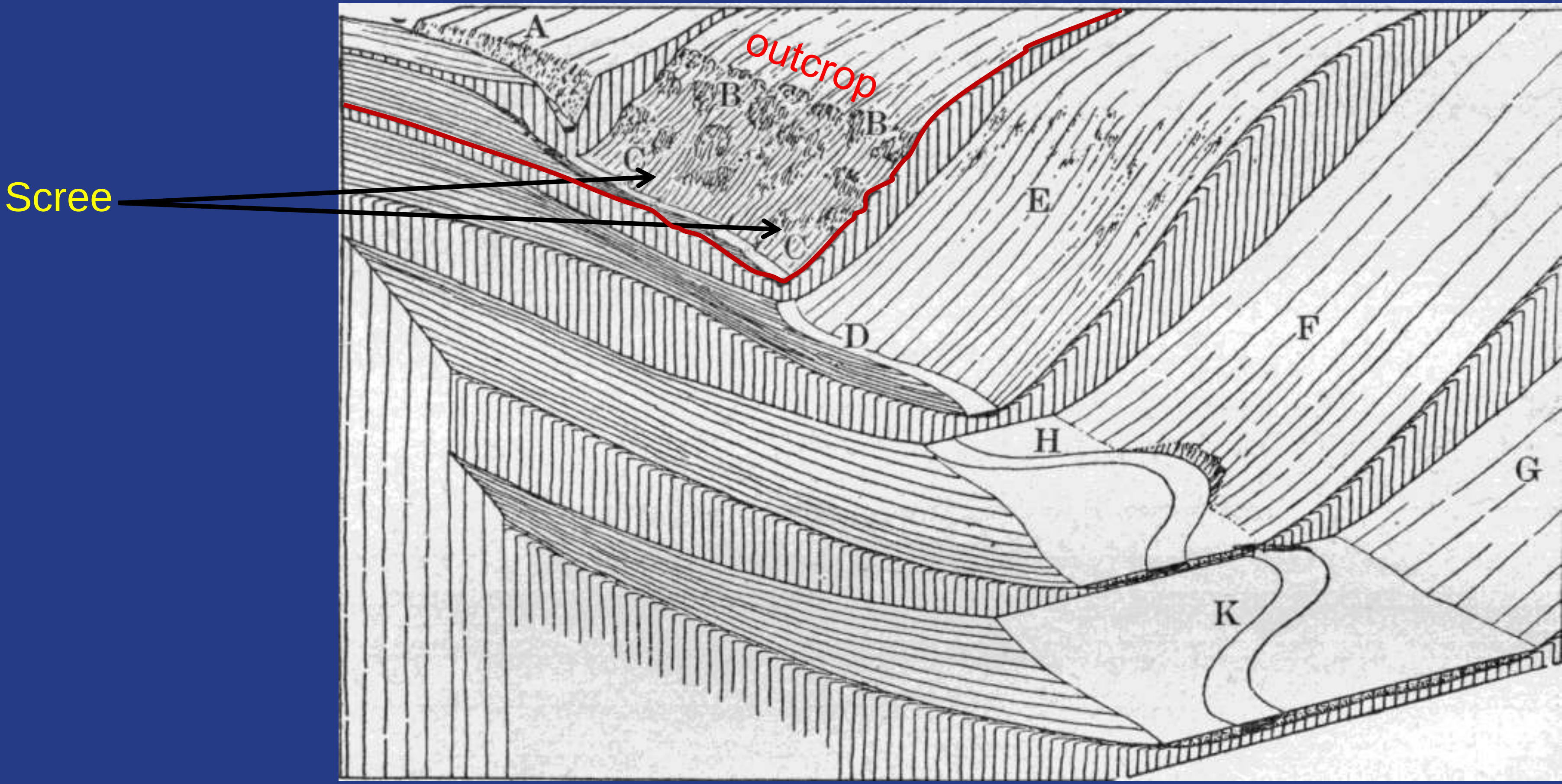
Rapids below the falls at Fonferek Glen, Wisconsin, USA

POTHOLES (=DEVIL'S CAULDRONS)



Potholes, location unknown

Bourke’s Luck Potholes, Blyde river Canyon, South Africa


Scree
outcrop
A
B
B
C
C
D
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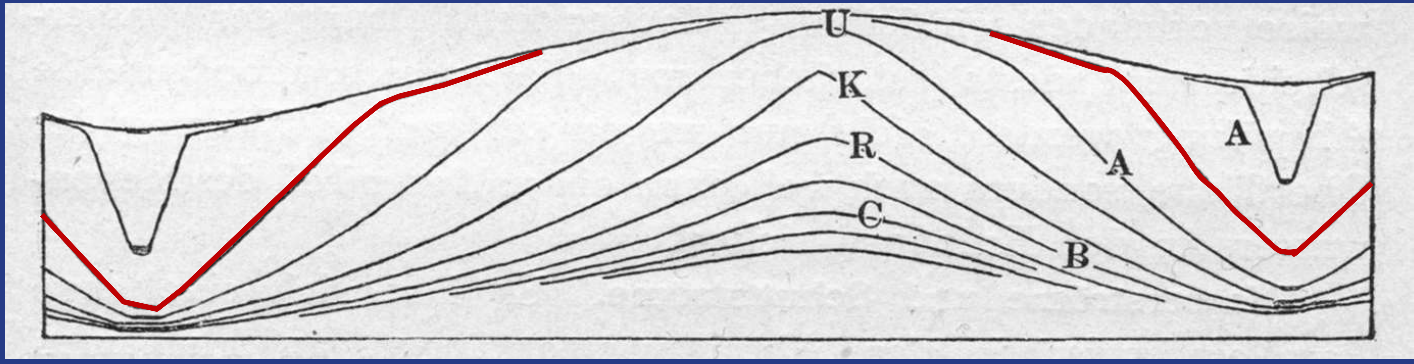
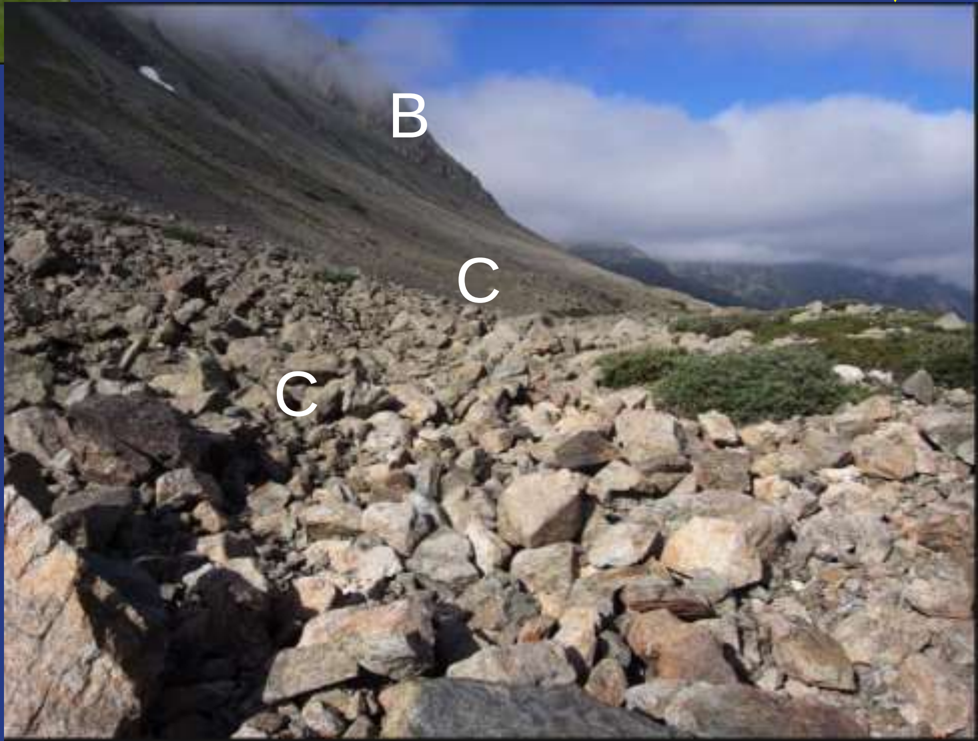
F
G
H
K

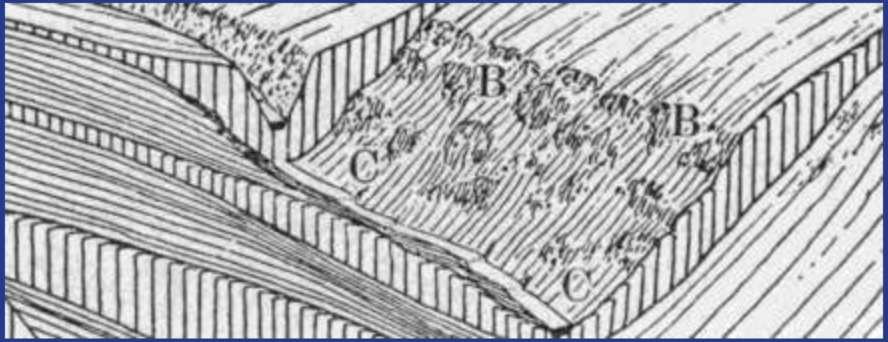

U
K
R
C
B
A
A

Mediterranean climate
(semi humid)

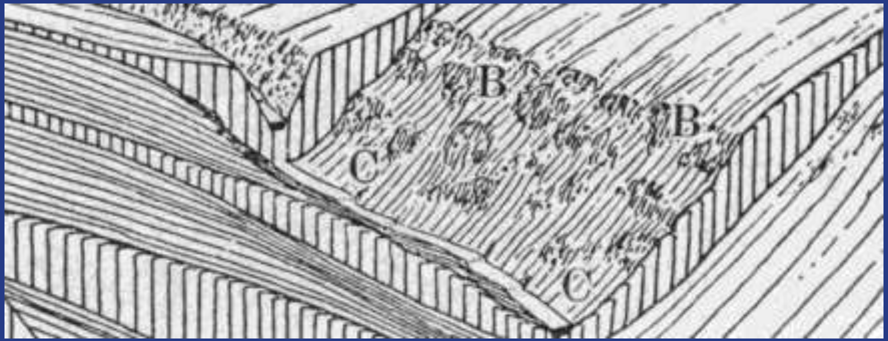
Scree in the Albula Pass



Albula Pass, Graubünden, Switzerland



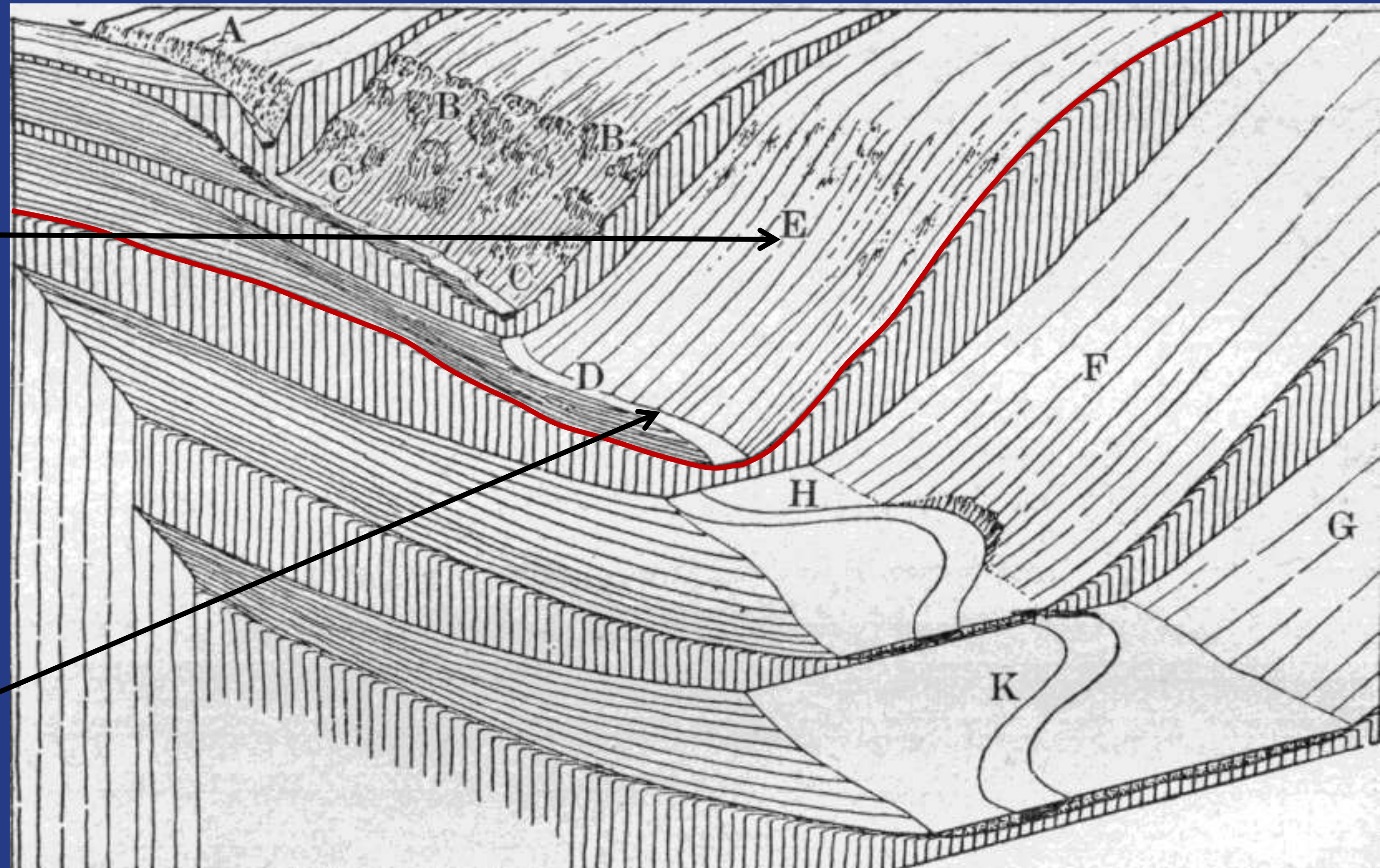
Arid climate

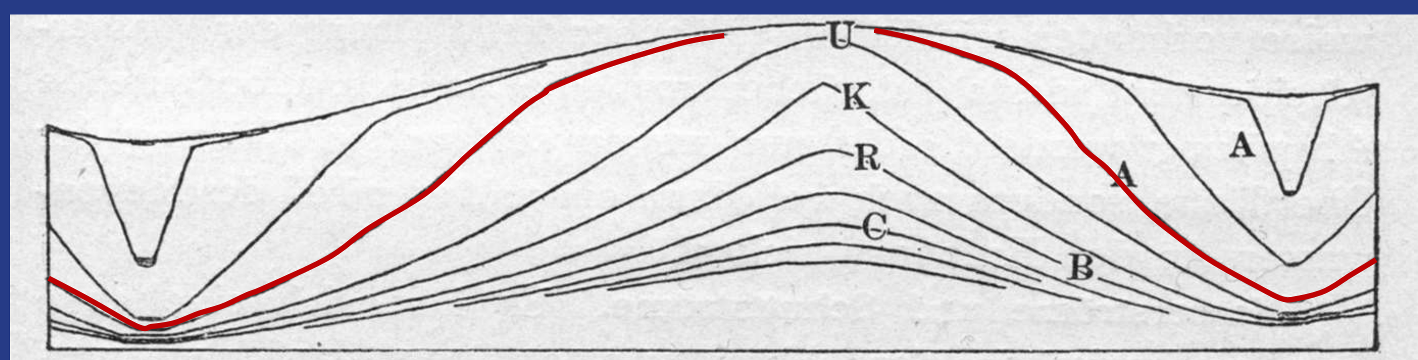


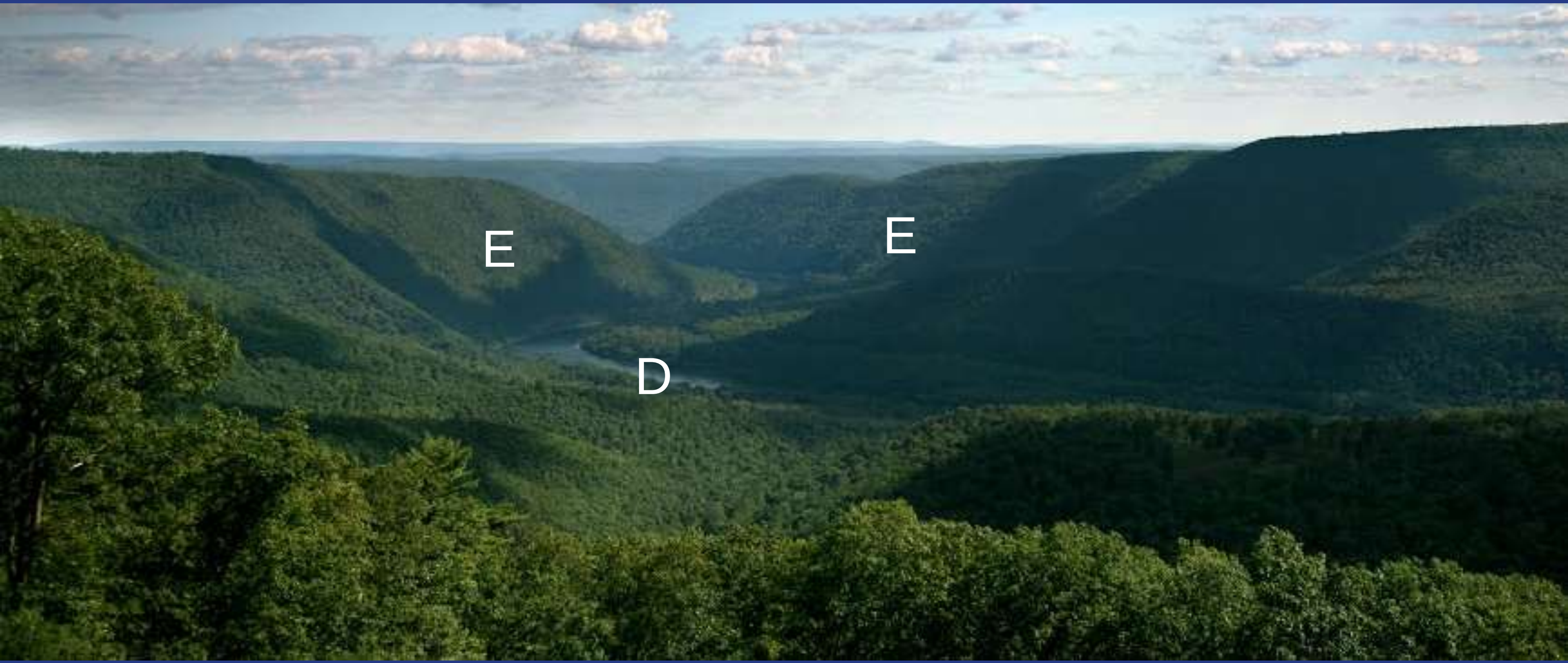
The valley of Ladakh, Transhimalaya, Xizang Autonomous Region (Tibet) , China.

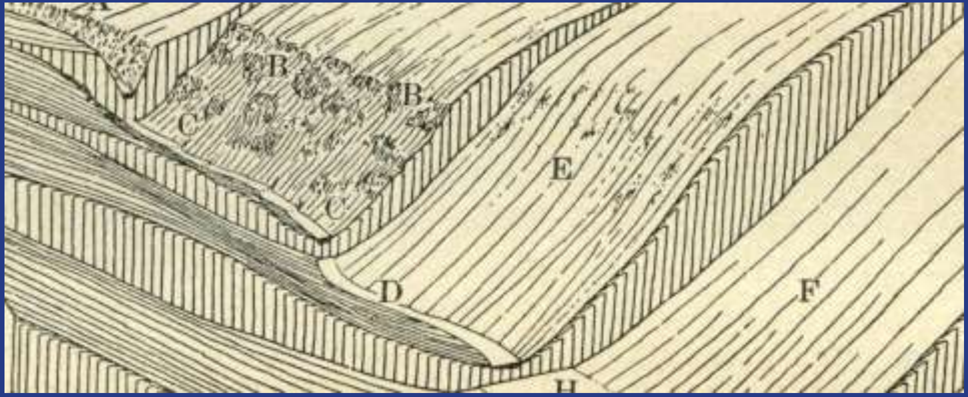
Scree covered slopes, small outcrops, if any

The stream approaches a point where it erodes very little



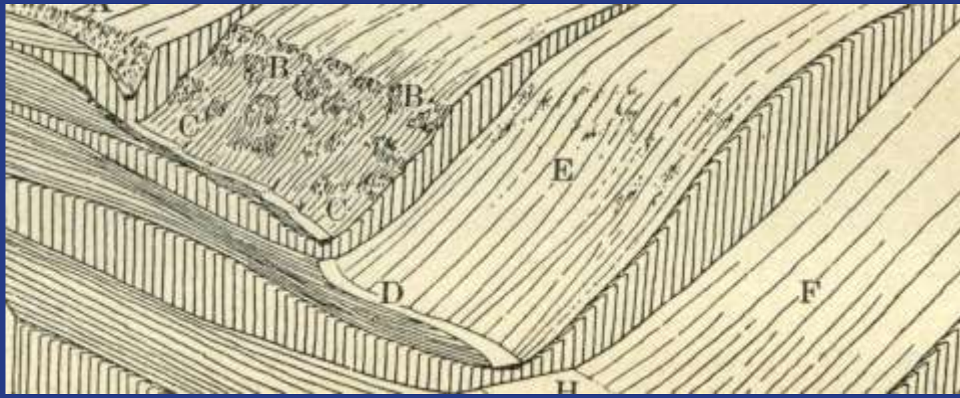




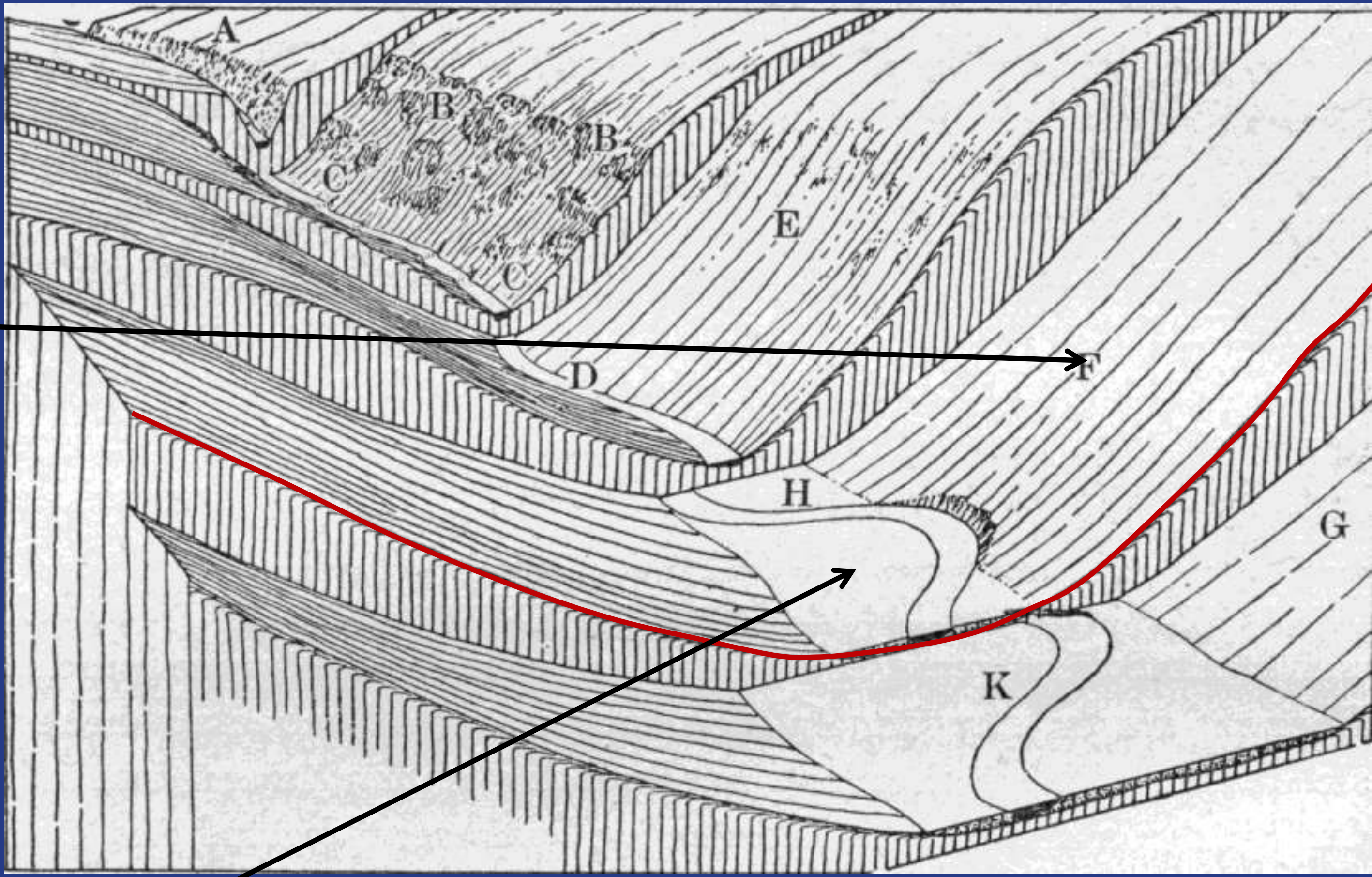


Hyner State Park in the Pennsylvanian Appalachians, USA, Sesquehanna River Valley

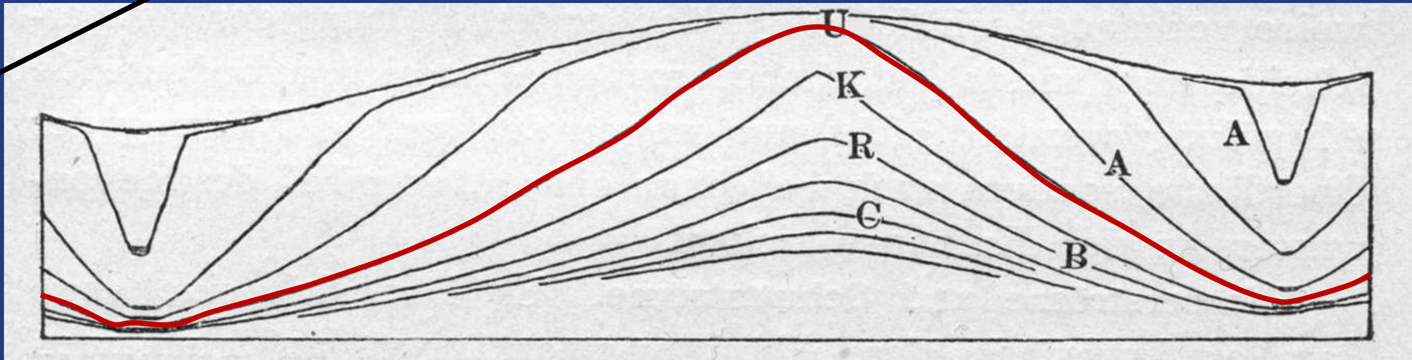

E
E
D (only in flood time)

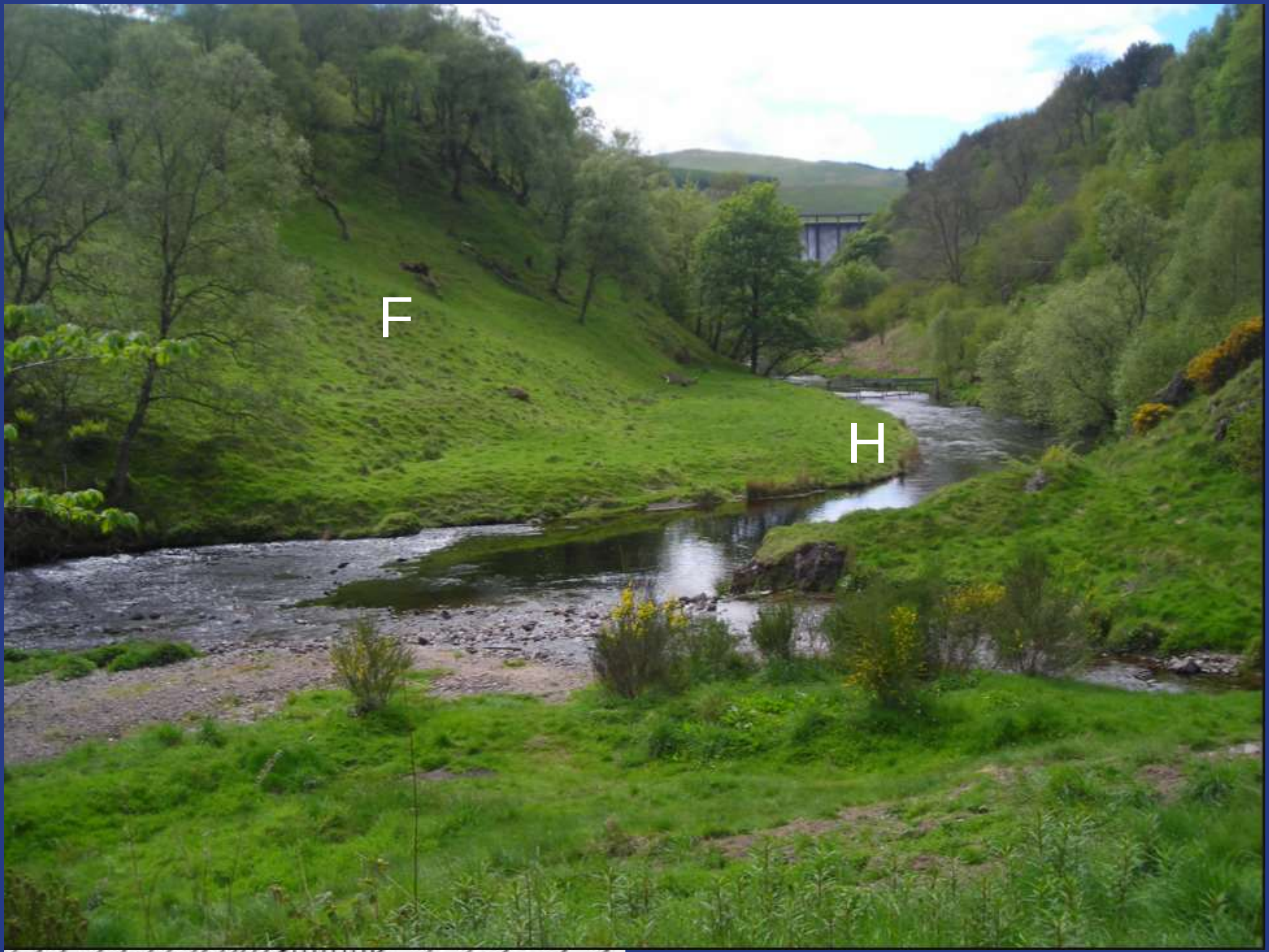

B
B
C
C
E
D
F
H

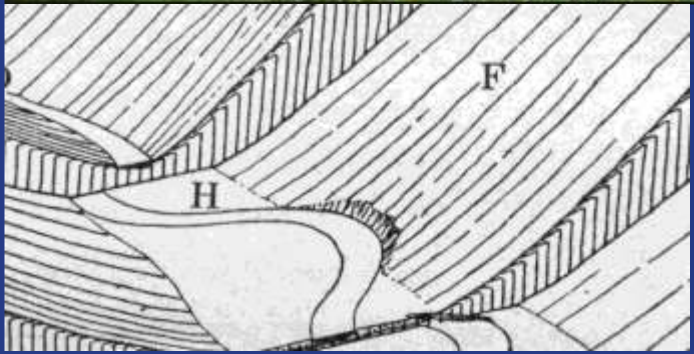
Valley slopes become gentler and the scree cover extends farther up



Valley bottom becomes wider and a flood plain appears.



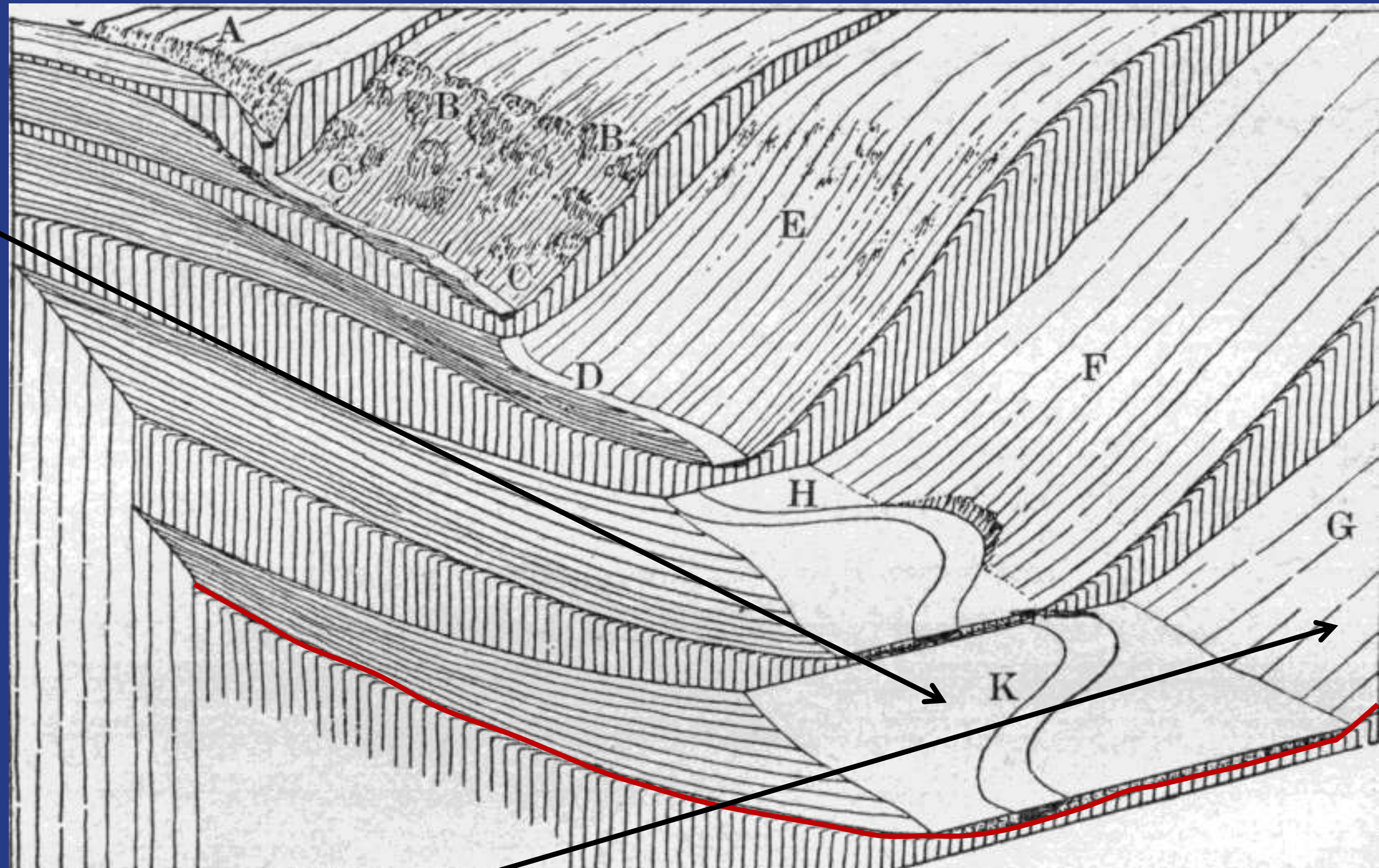


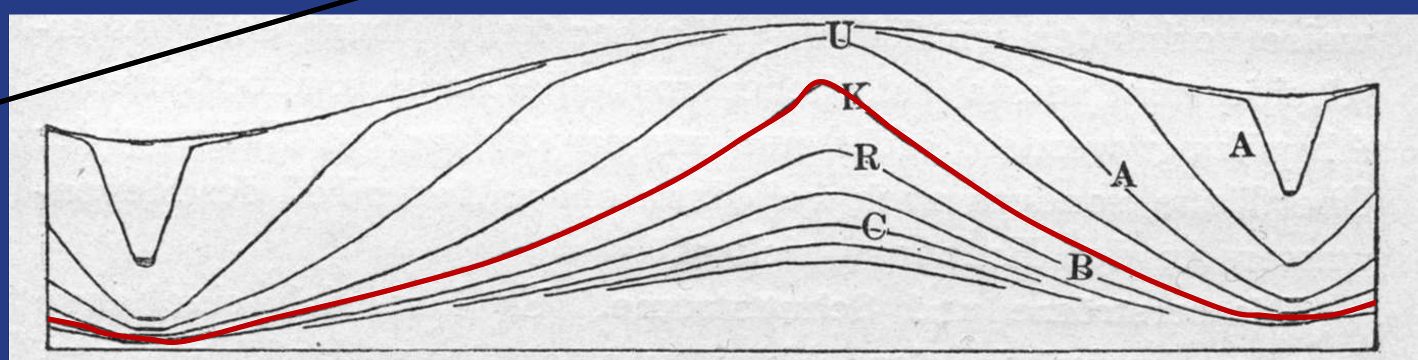


The mature river valley of the Dover River, England, with a newly-developing flood plain.

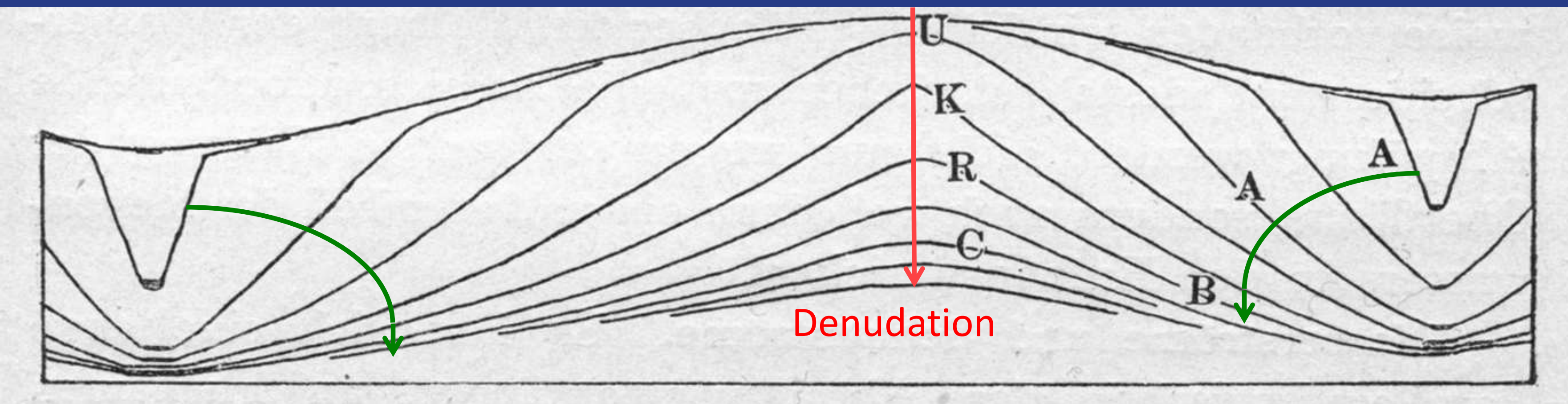
Flood plain becomes wider

The slope scree becomes finer grained as the valley slopes become ever gentler



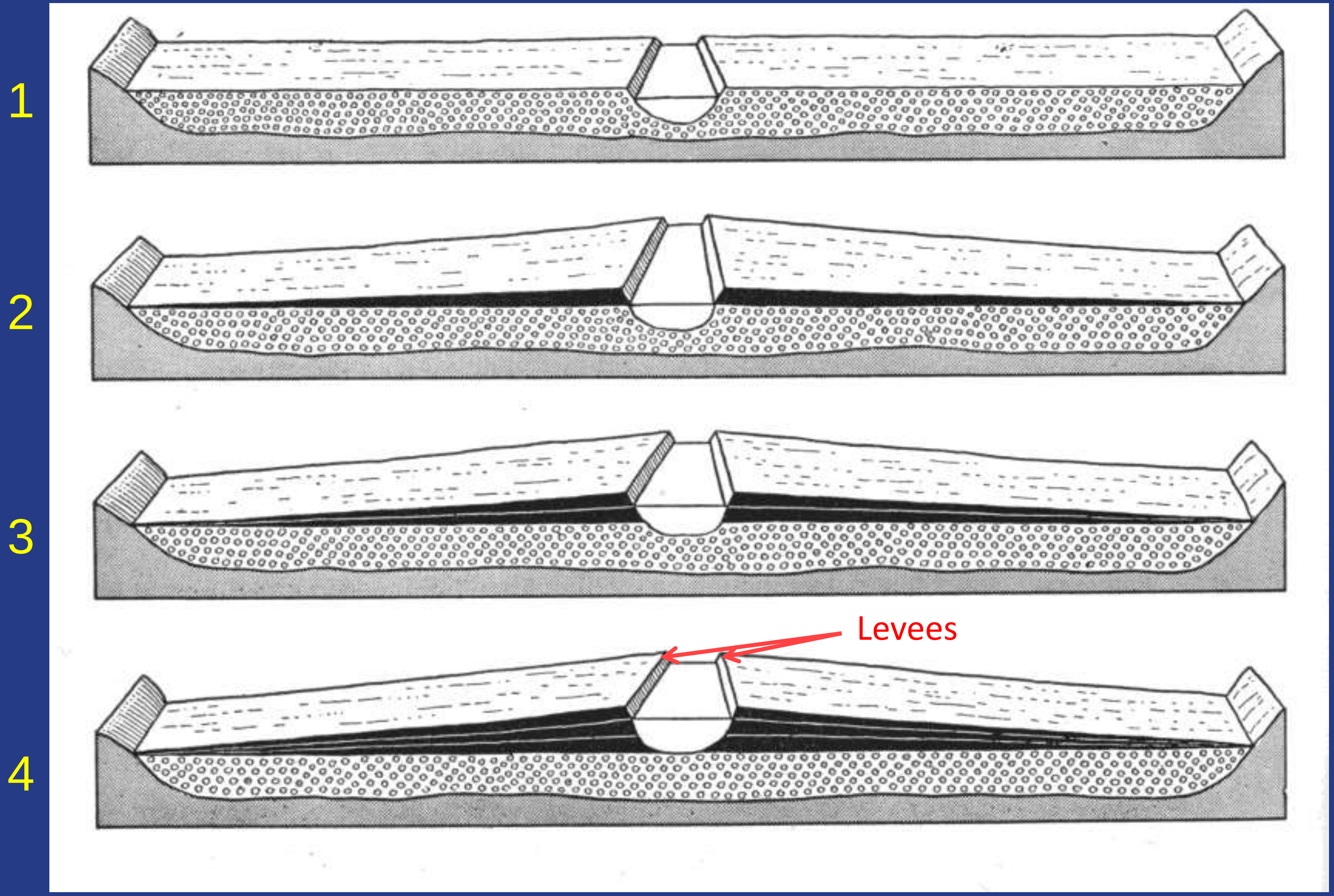


A mature valley. Notice the far slopes. Do they present a problem for the Davisian model?



Slope flattening or slope degradation

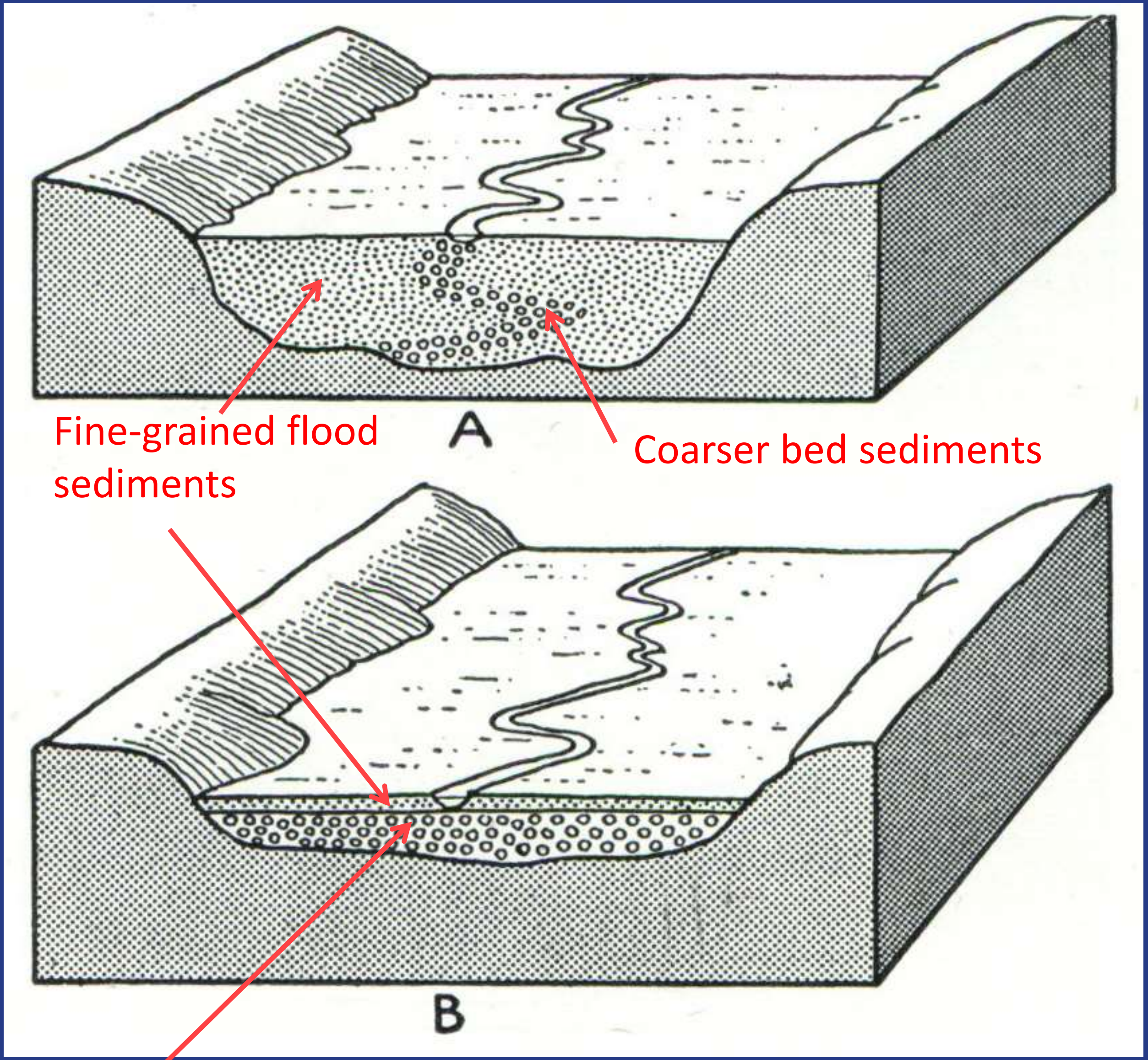
Basic summary of Davis' model of valley evolution



Aggradation of a flood plain and the origin of natural levees

Fast aggrading flood plain

Slowly aggrading or erosional flood plain



Coarser bed sediments distributed across the entire flood plain (because the river has more time to wander)

From Leet and Judson 1958

A braided stream in the Tien Shan Mountains, Kyrgyzstan