
Hydrology
and rivers

Hydrology and rivers

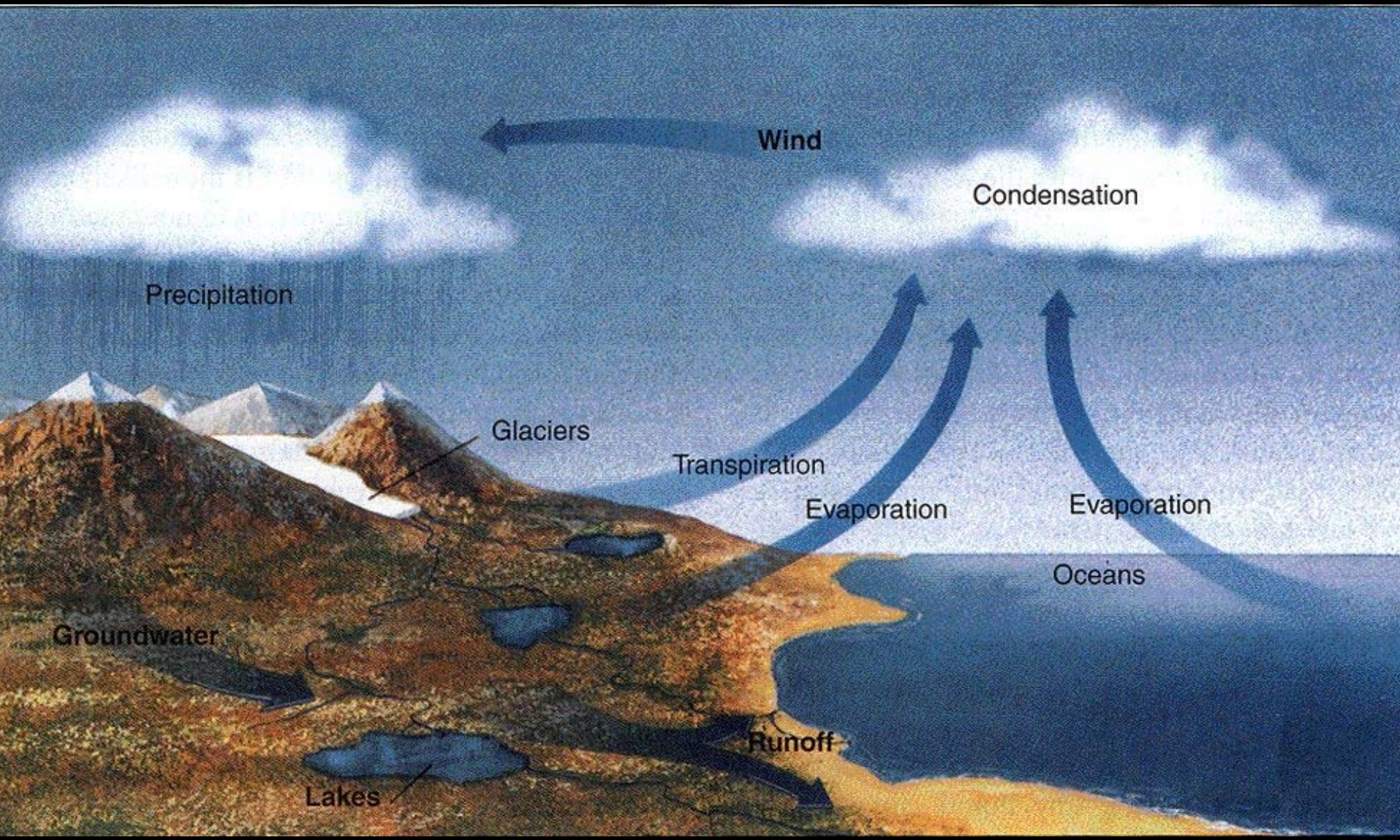
1: The hydrological cycle

2: River types

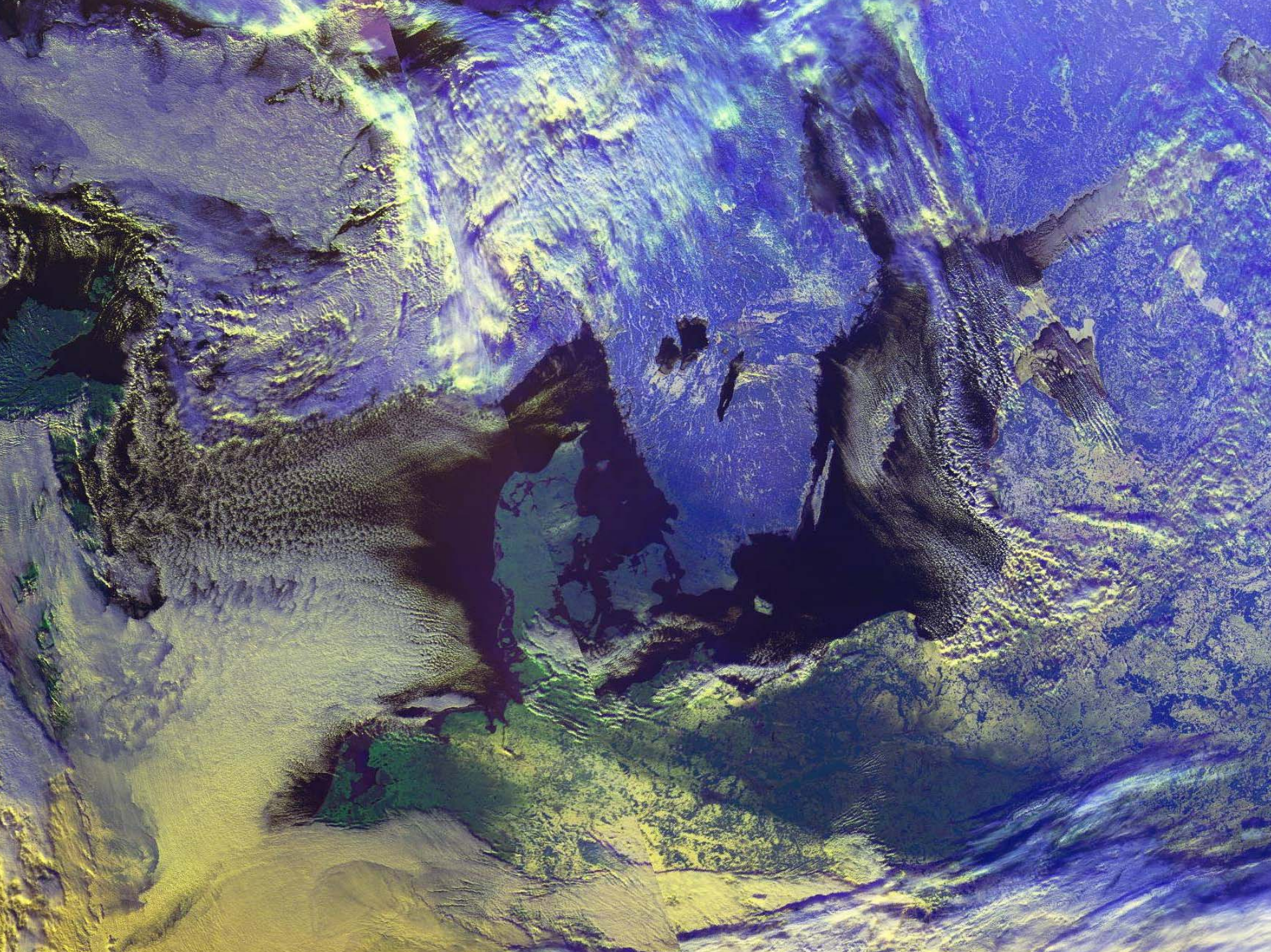
3: River processes

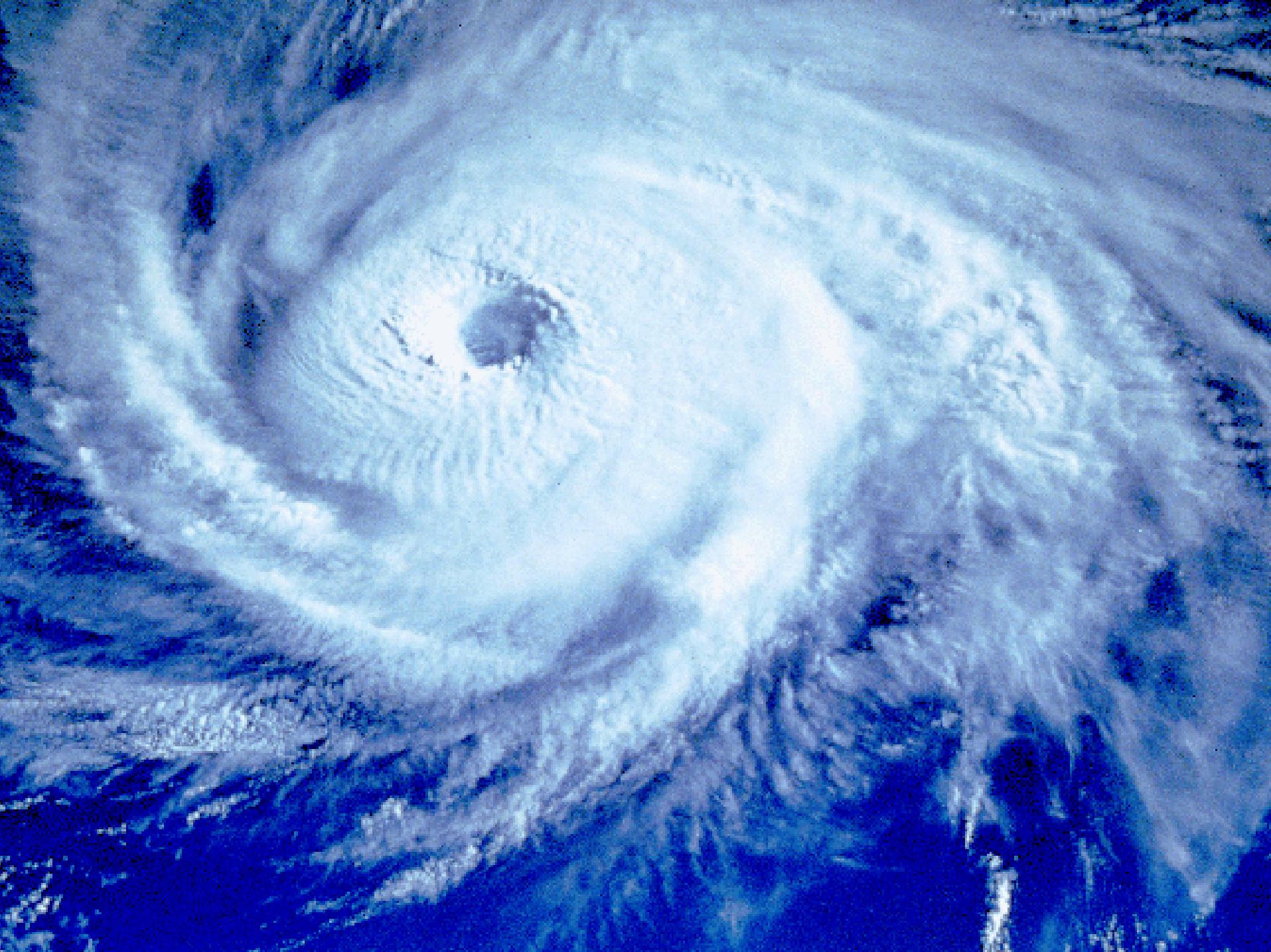
4: River profiles

5: Valley formation

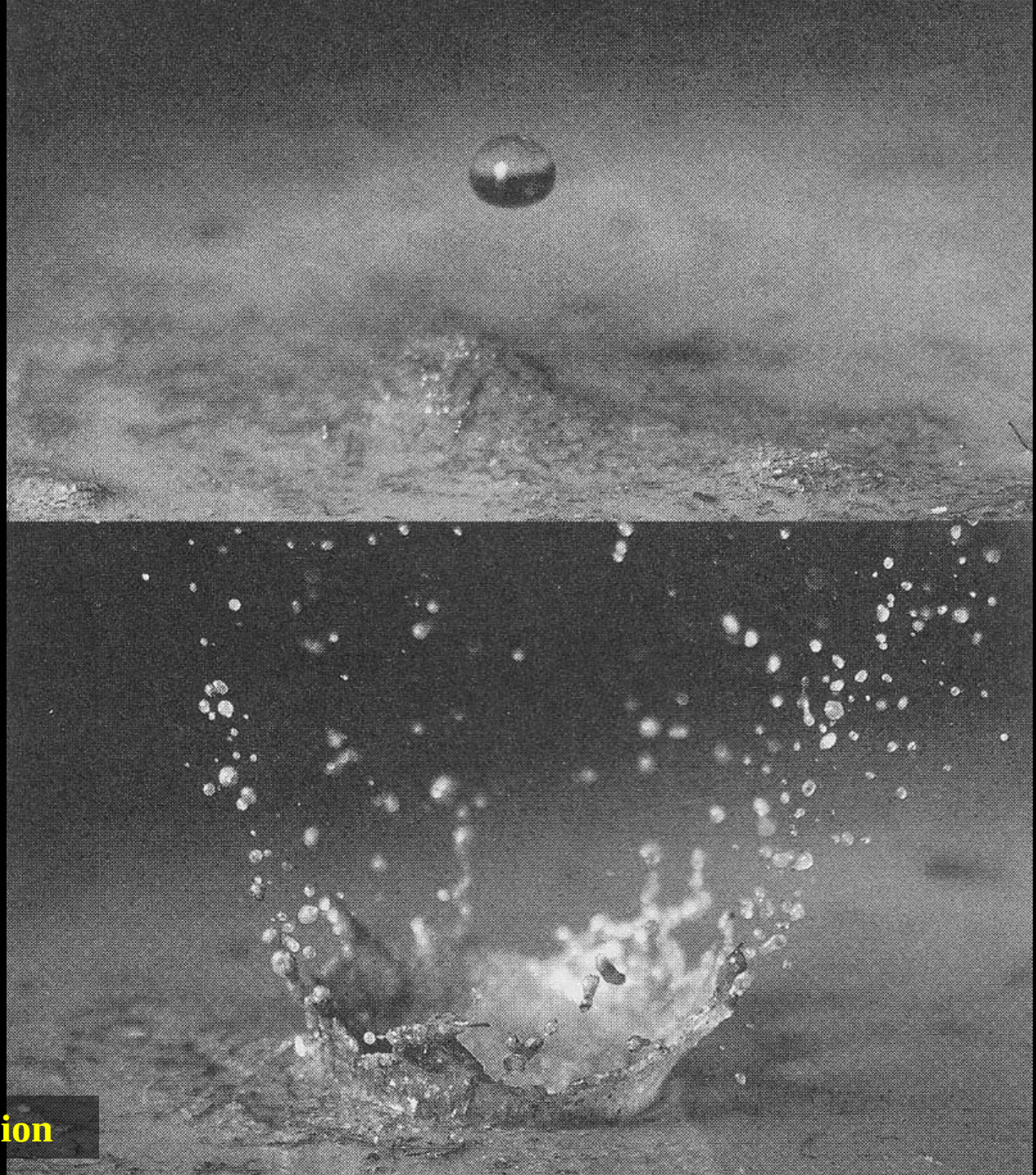


The hydrological cycle



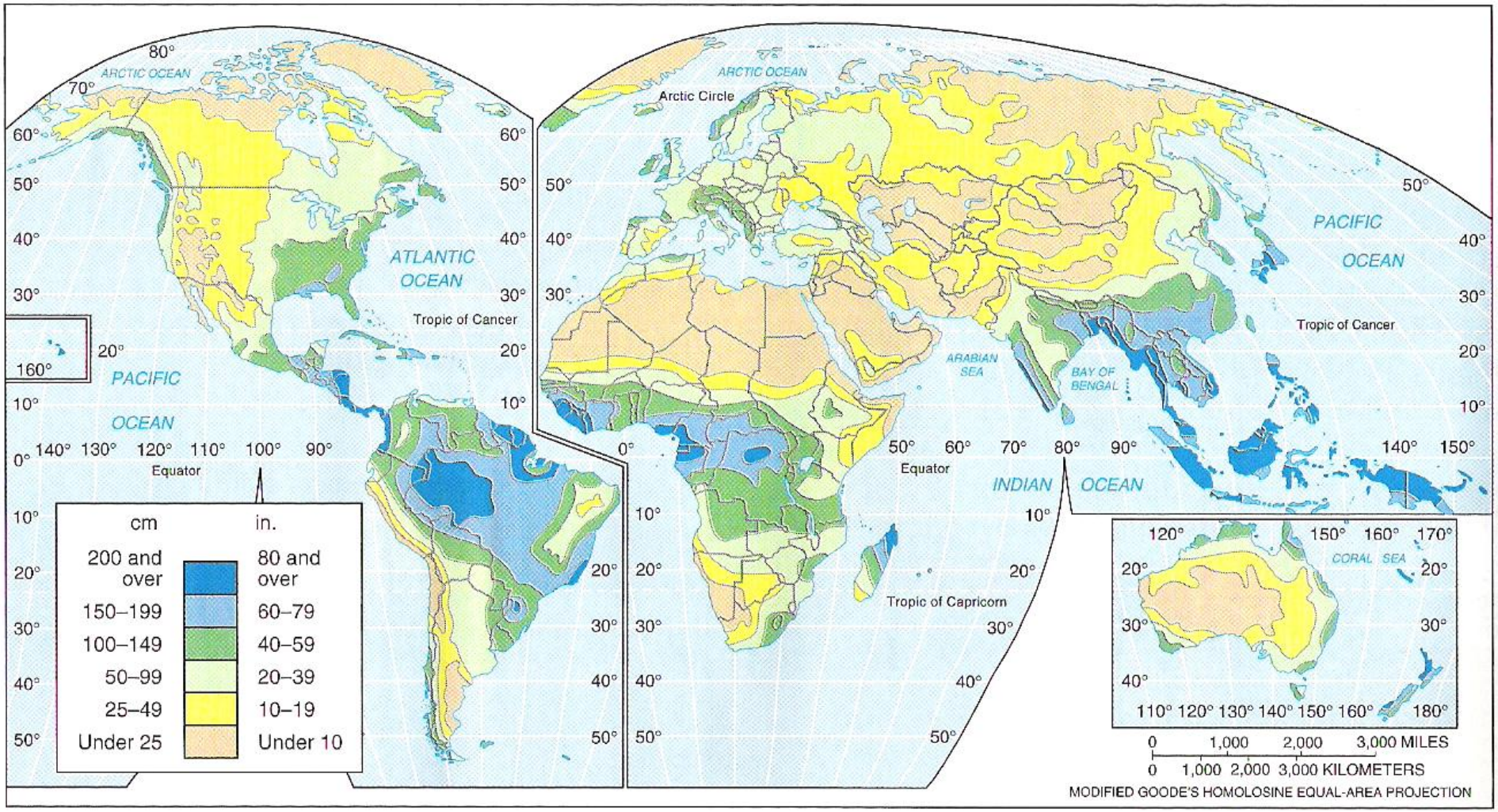



ARAMARK



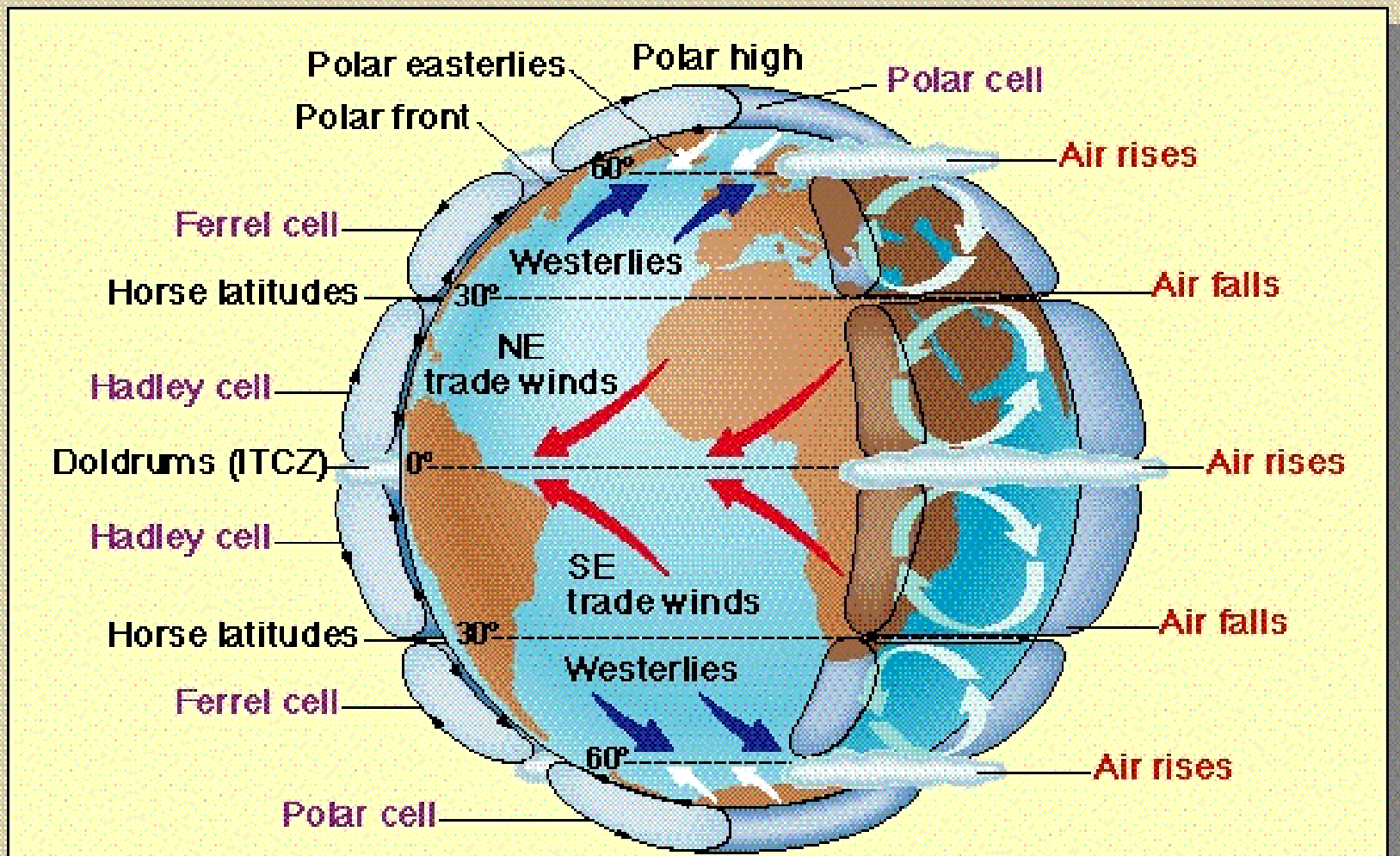
Splash erosion


Hard crystals

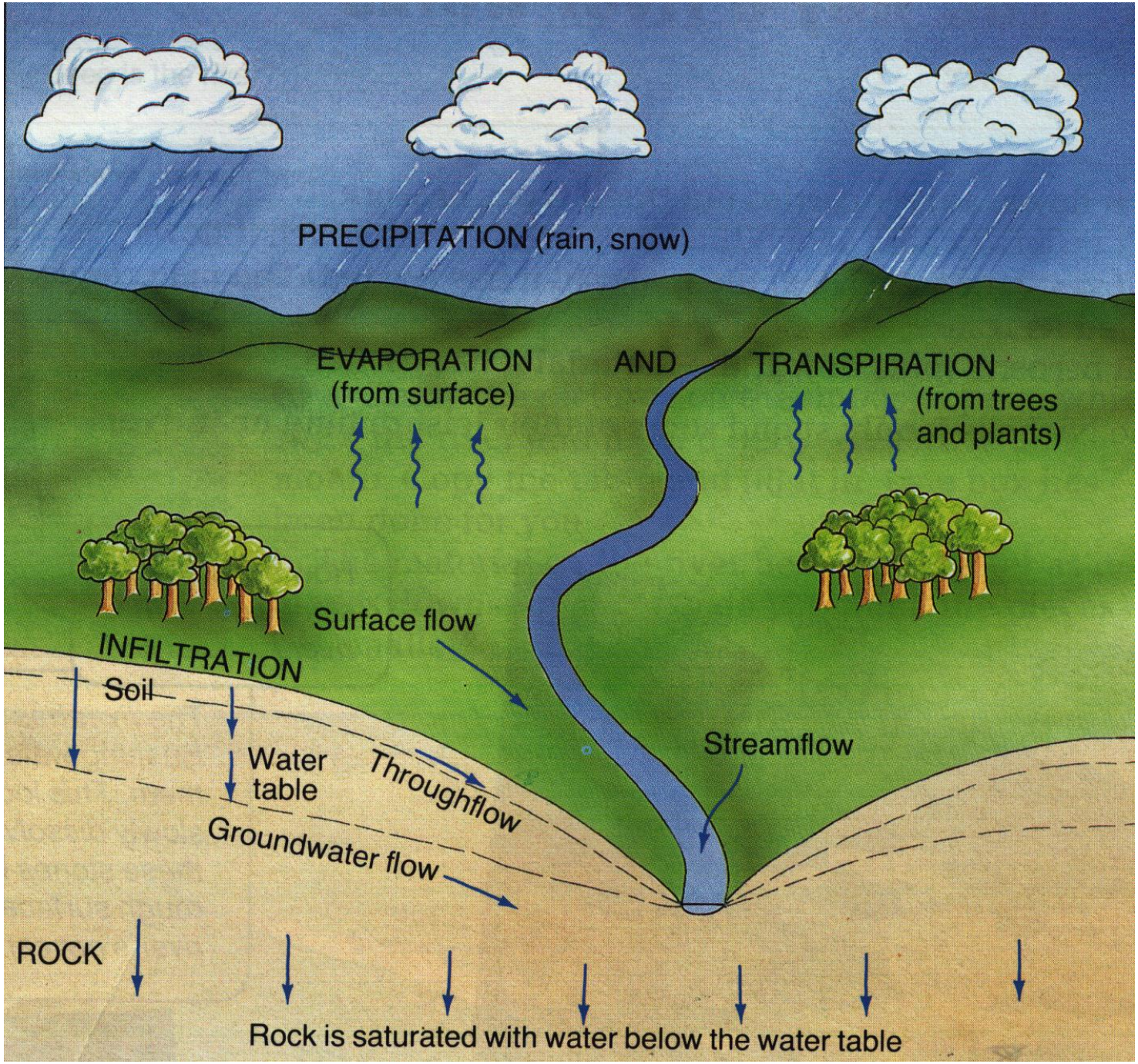


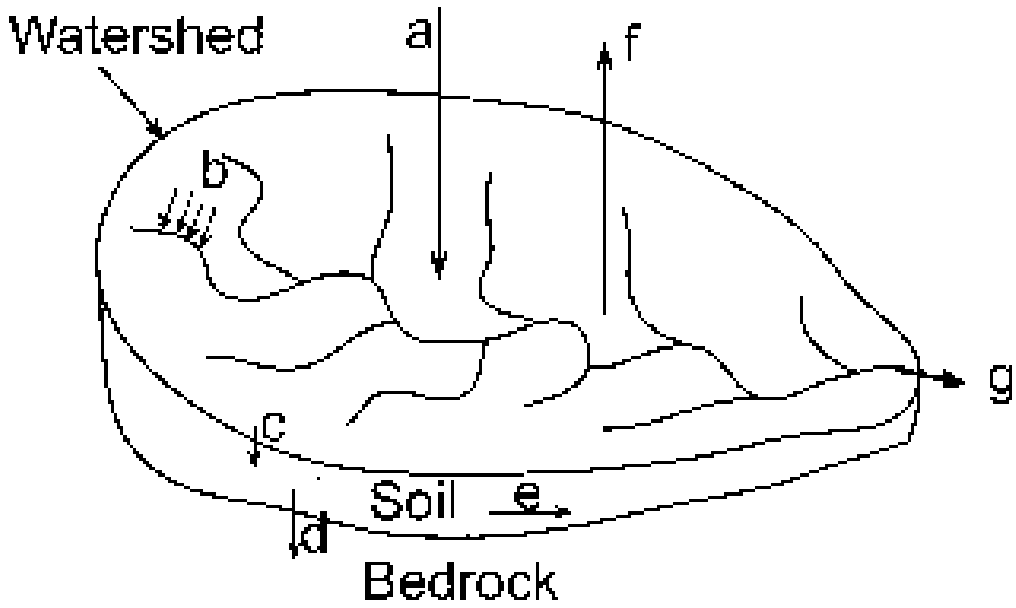
Global annual precipitation

Global Air Circulation Patterns



Global air circulation as described in the three-cell circular model. As in simpler circulation models, air rises at the equator and falls at the poles. But instead of one great circuit in each hemisphere from equator to pole, there are three. Note the influence of the Coriolis effect on wind direction.


PRECIPITATION (rain, snow)
EVAPORATION
(from surface)
AND
TRANSPIRATION
(from trees
and plants)
Surface flow
INFILTRATION
Soil
Water
table
Throughflow
Groundwater flow
Streamflow
ROCK
Rock is saturated with water below the water table



a = precipitation (input)

b = surface runoff

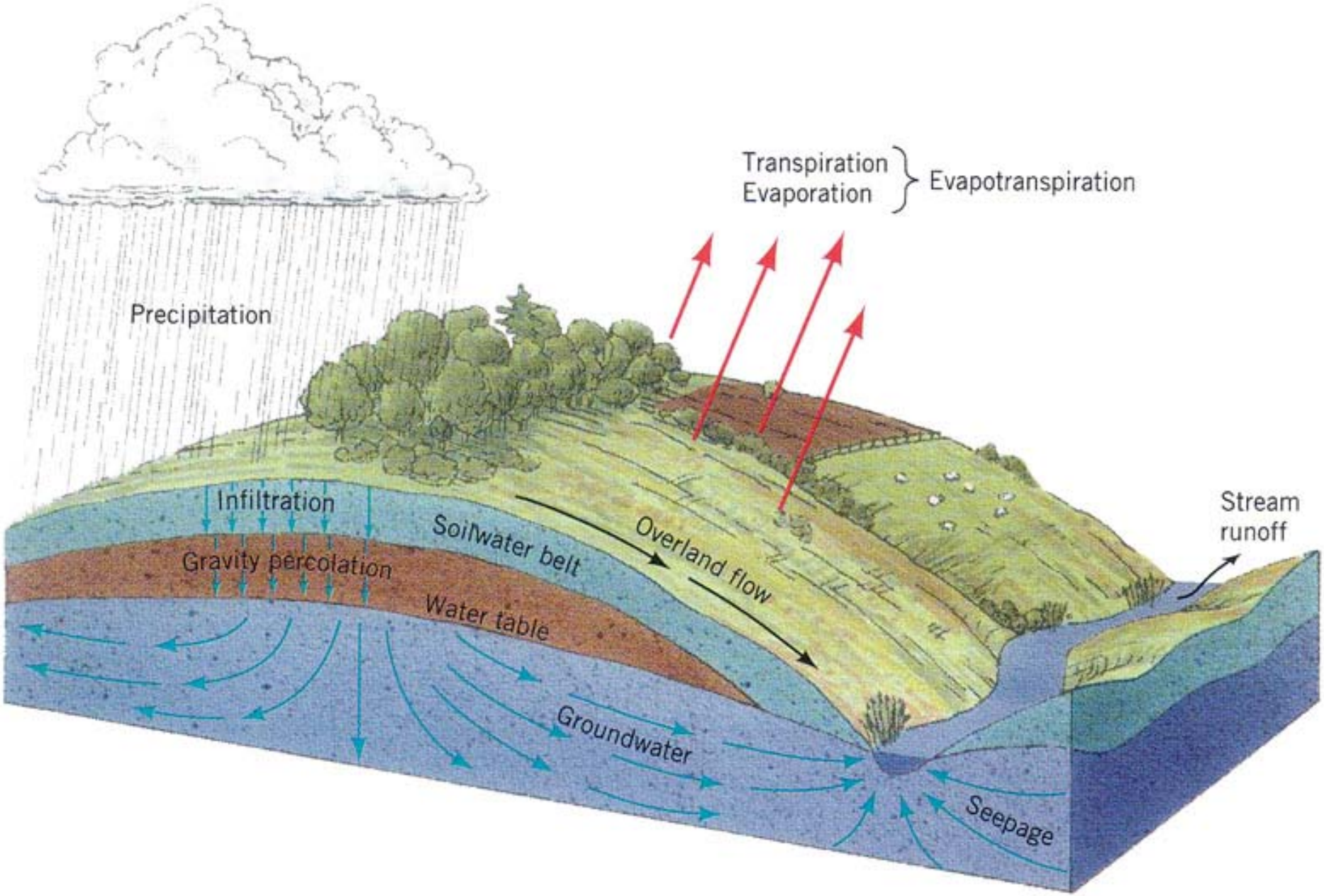
c = infiltration

d = percolation

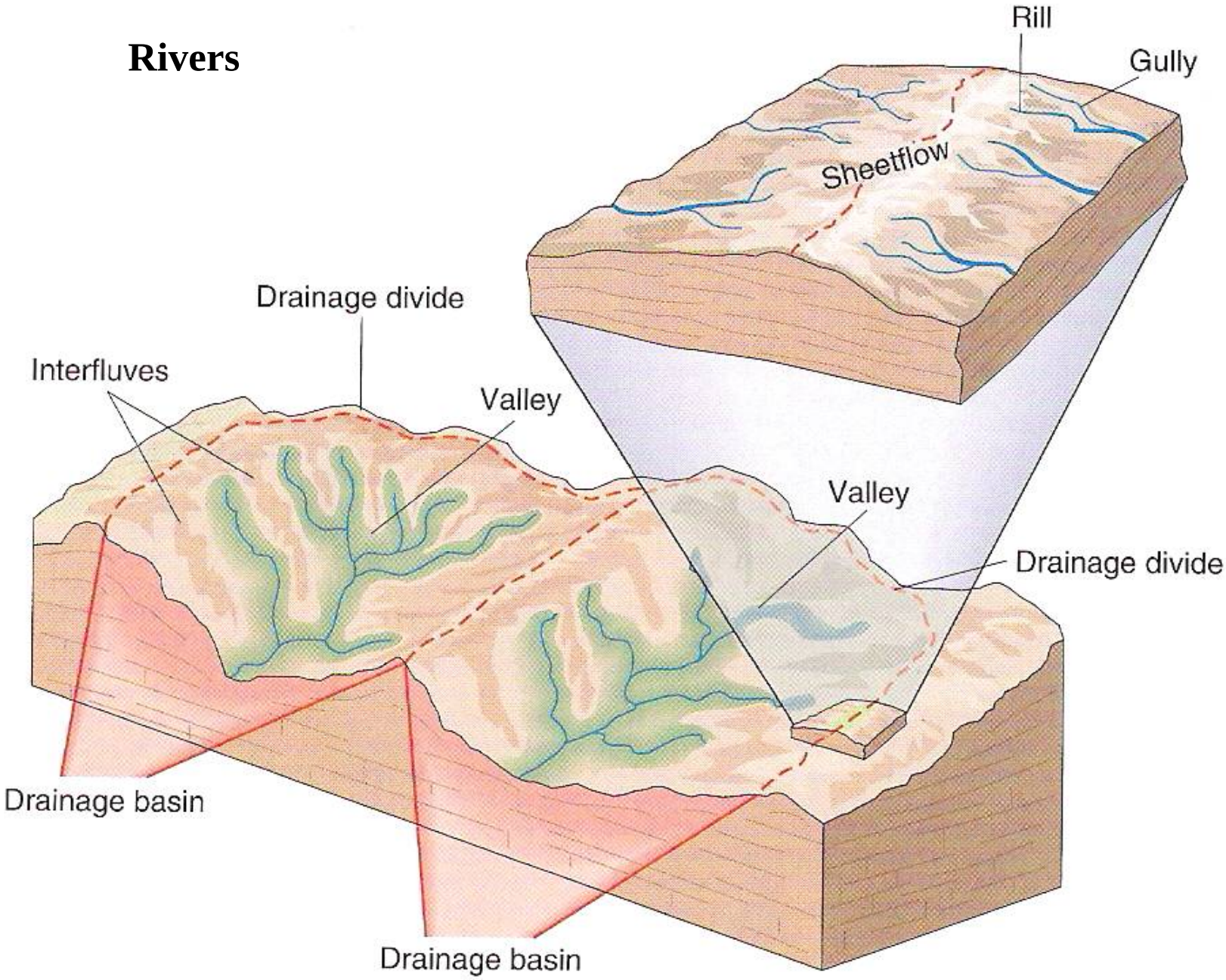
e = throughflow

f = evapotranspiration (output)

g = channel flow (output)

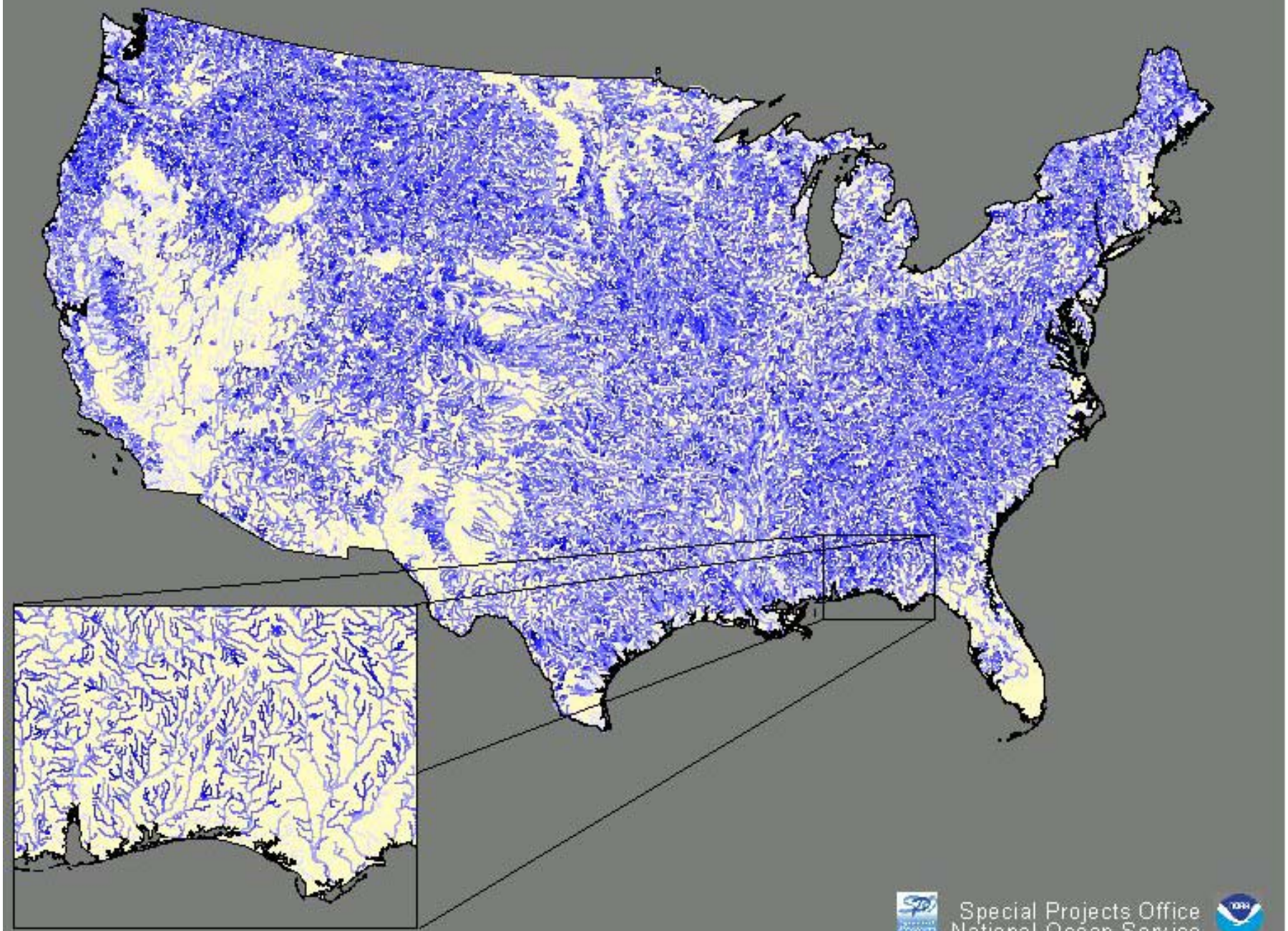

Transpiration
Evaporation
Evapotranspiration
Precipitation
Infiltration
Gravity percolation
Soilwater belt
Water table
Overland flow
Stream runoff
Groundwater
Seepage

Rivers

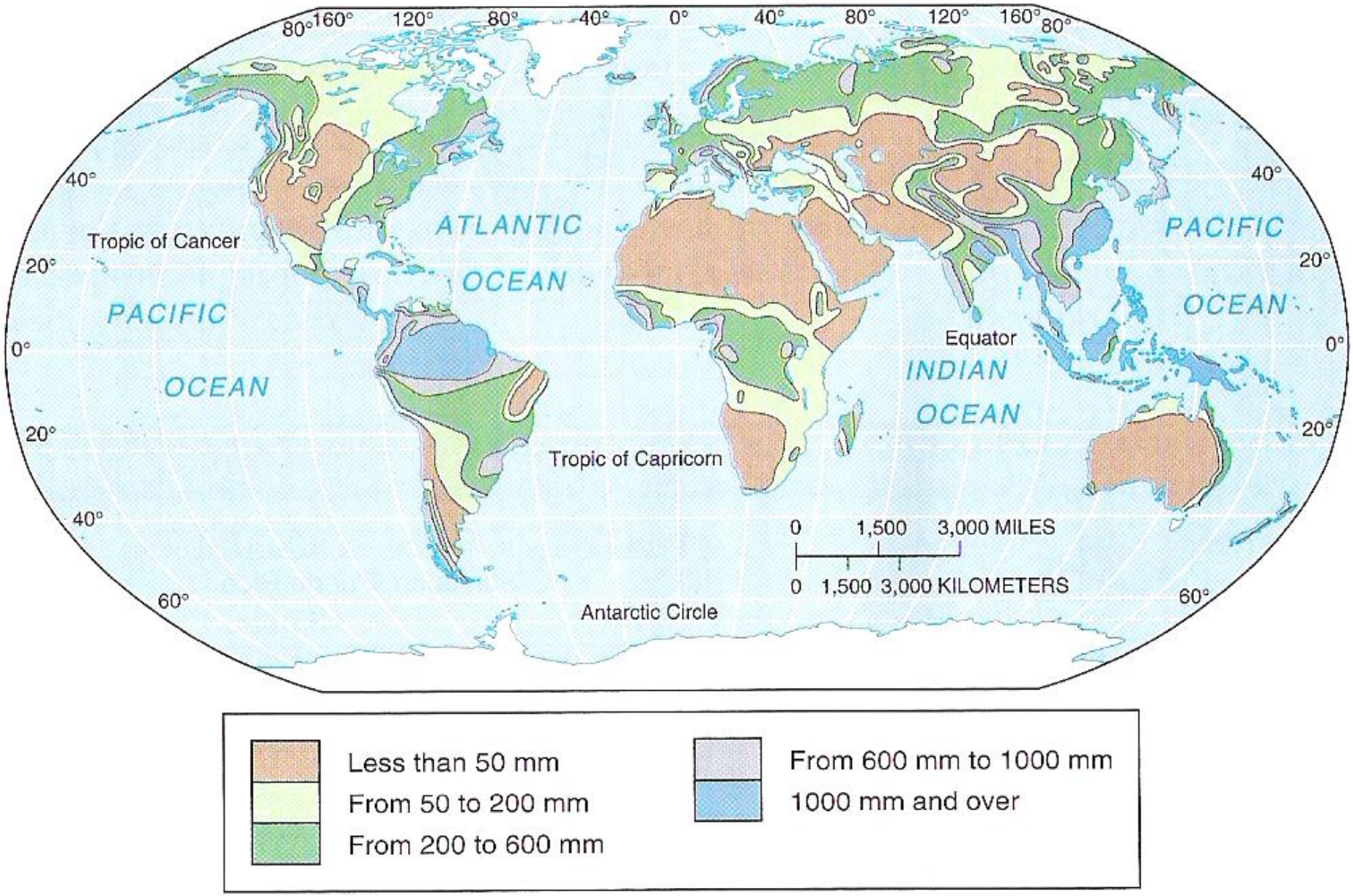

Rill
Gully
Sheetflow
Drainage divide
Interfluves
Valley
Valley
Drainage divide
Drainage basin
Drainage basin


Nile
Senegal
Niger
Gambia
L.Chad
Blue Nile
Volta
Benue
Ubangi
White Nile
L.Turkana
L.Victoria
Congo/Zaire
Kasai
L.Tanganyika
Zambezi
Limpopo
Orange

Rivers

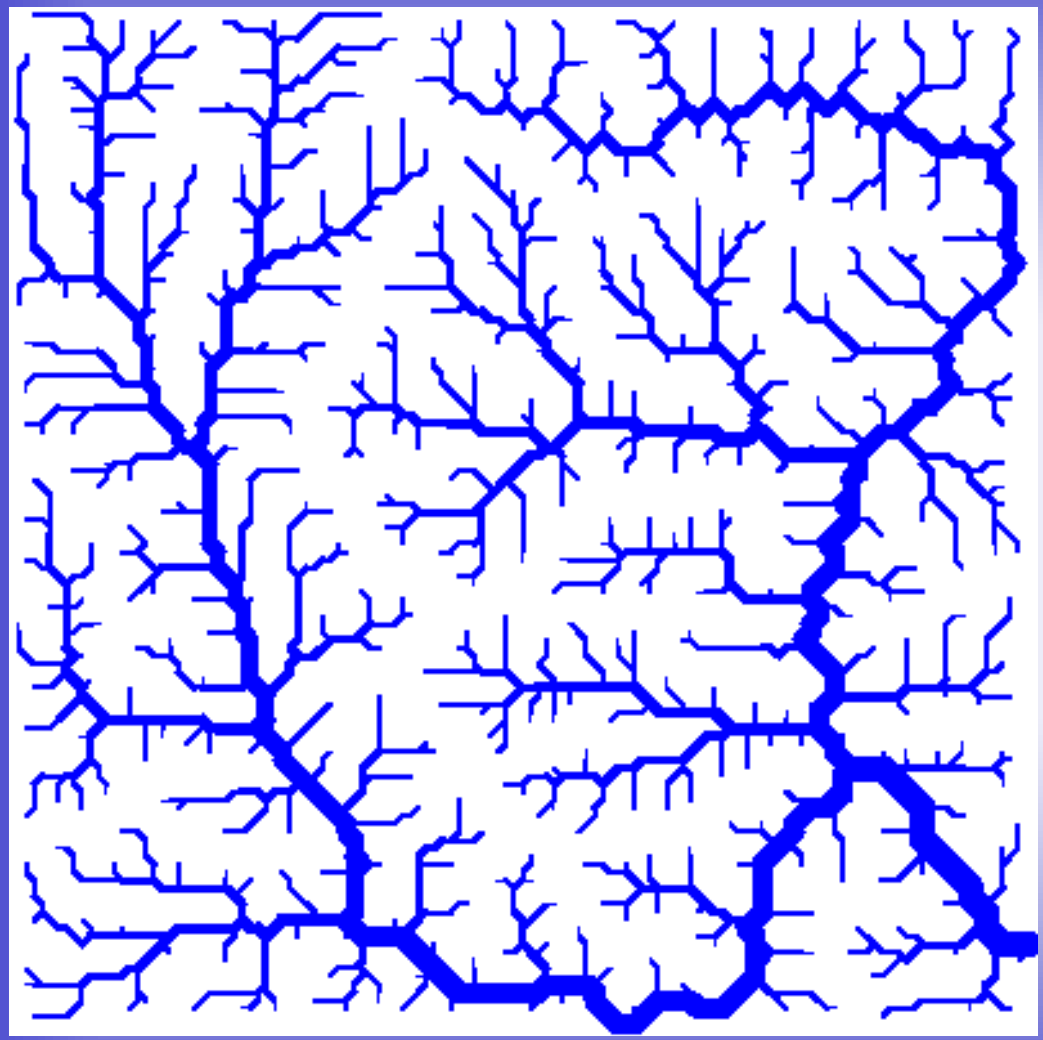


Special Projects Office
National Ocean Service

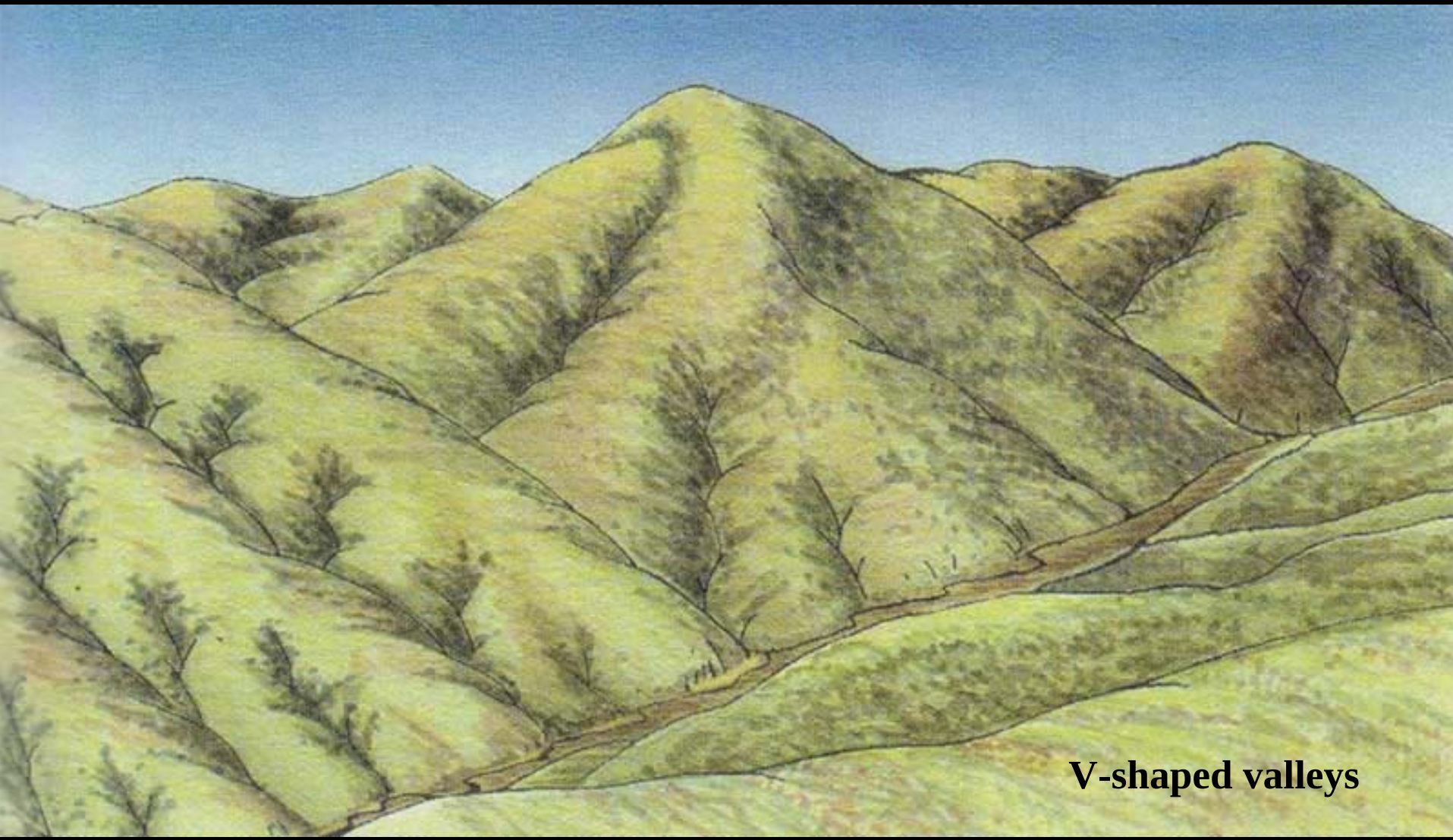


Global river runoff

River-cut valleys are typically V-shaped

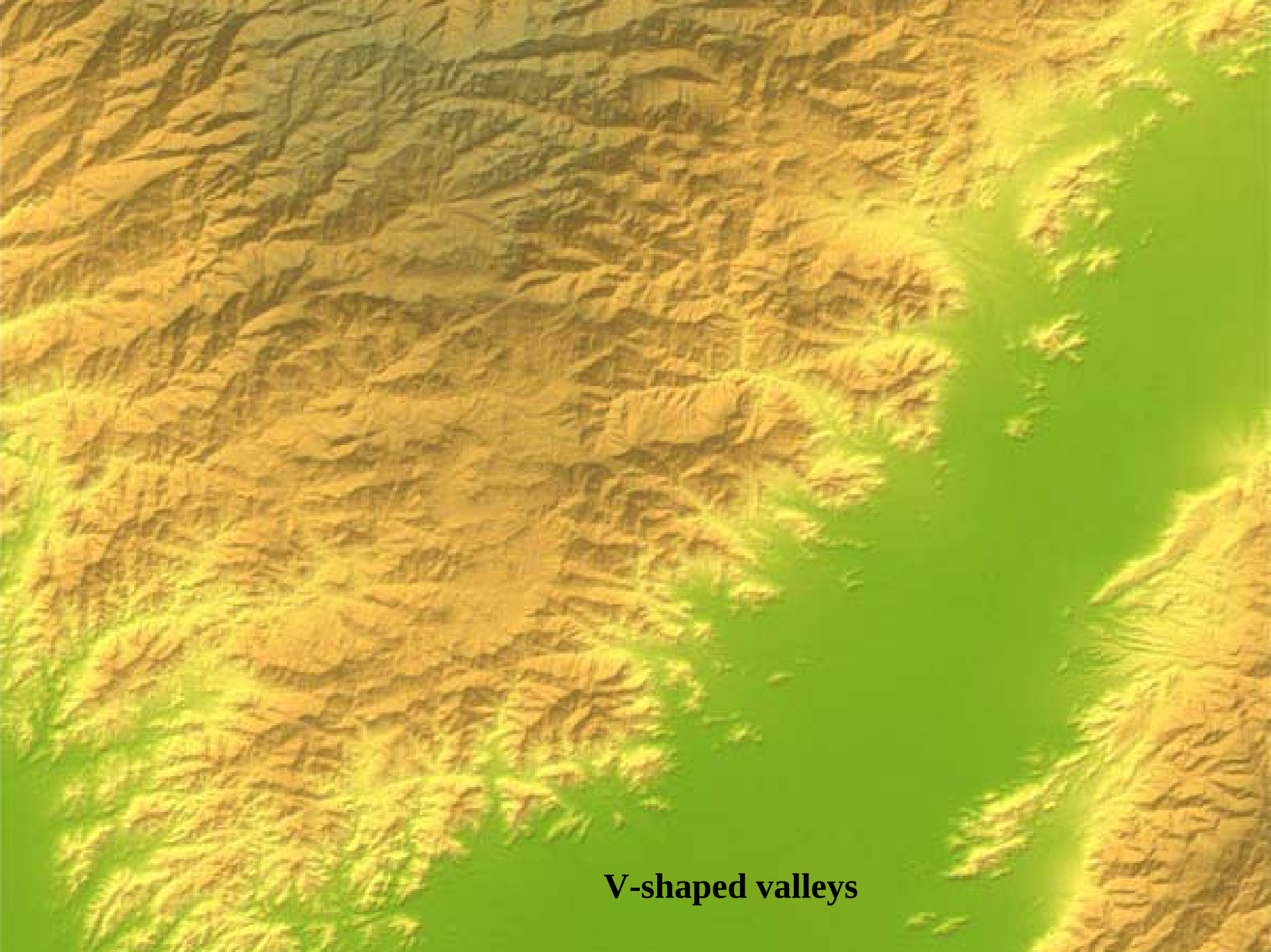


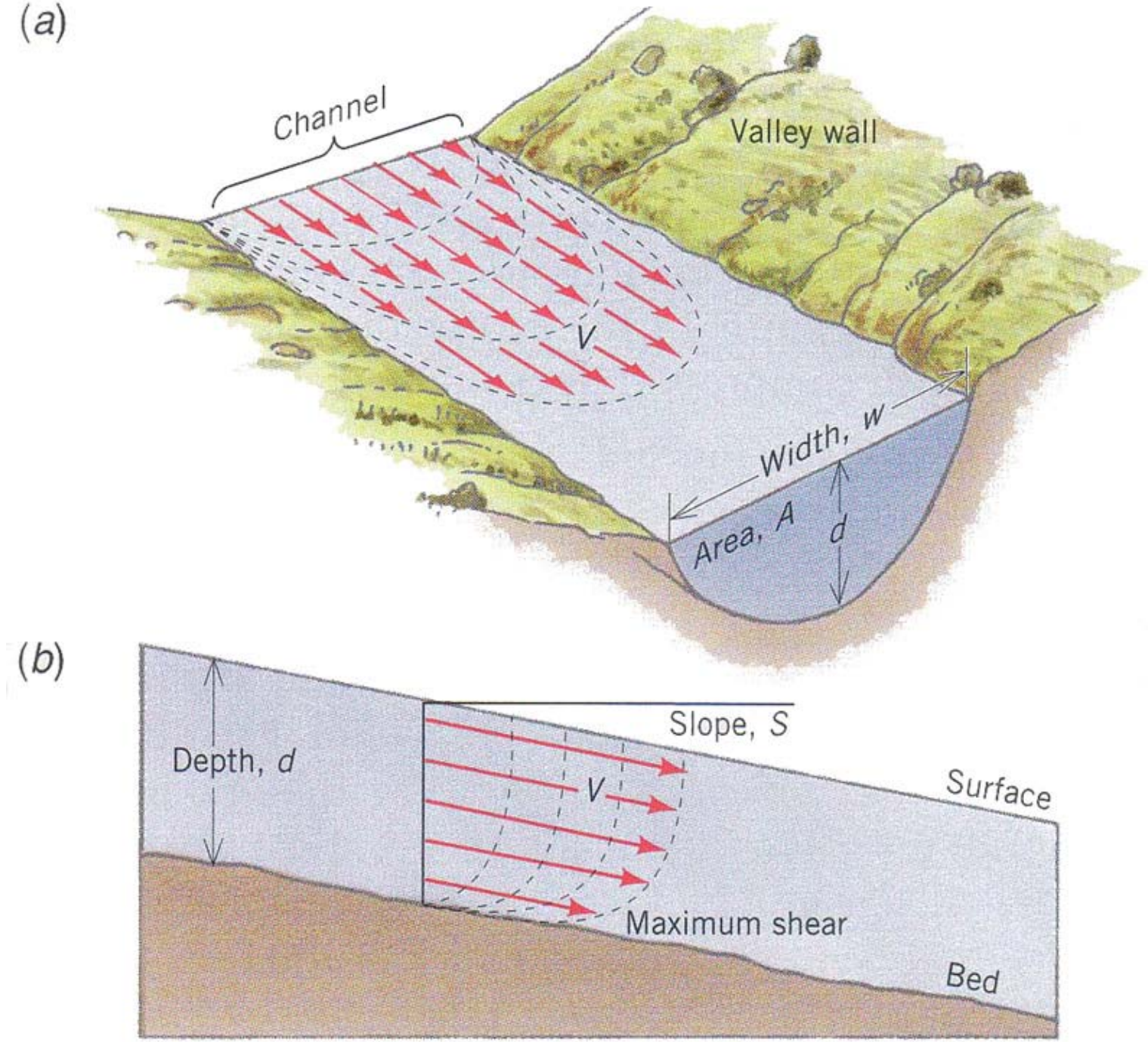
River-cut valleys typically display a dendritic pattern

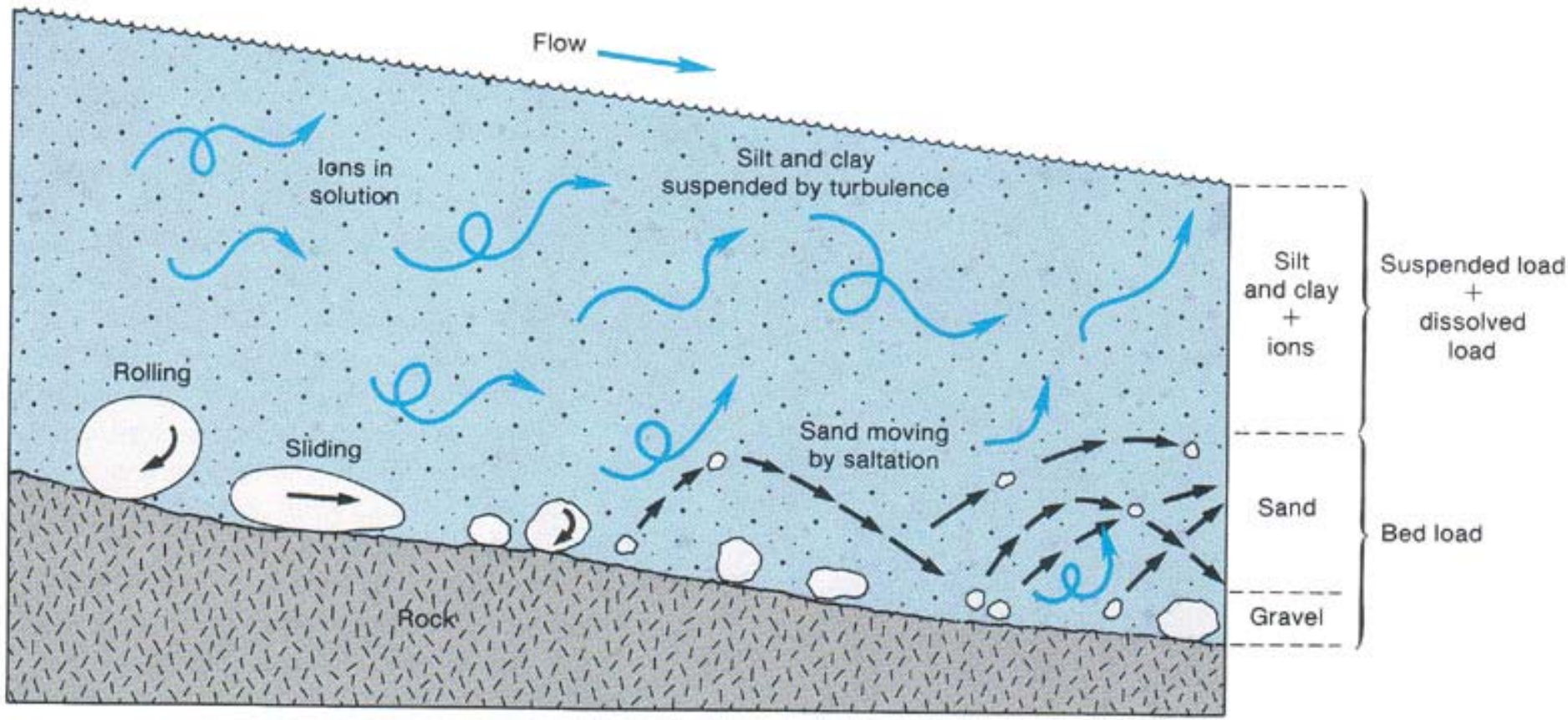

V-shaped valleys

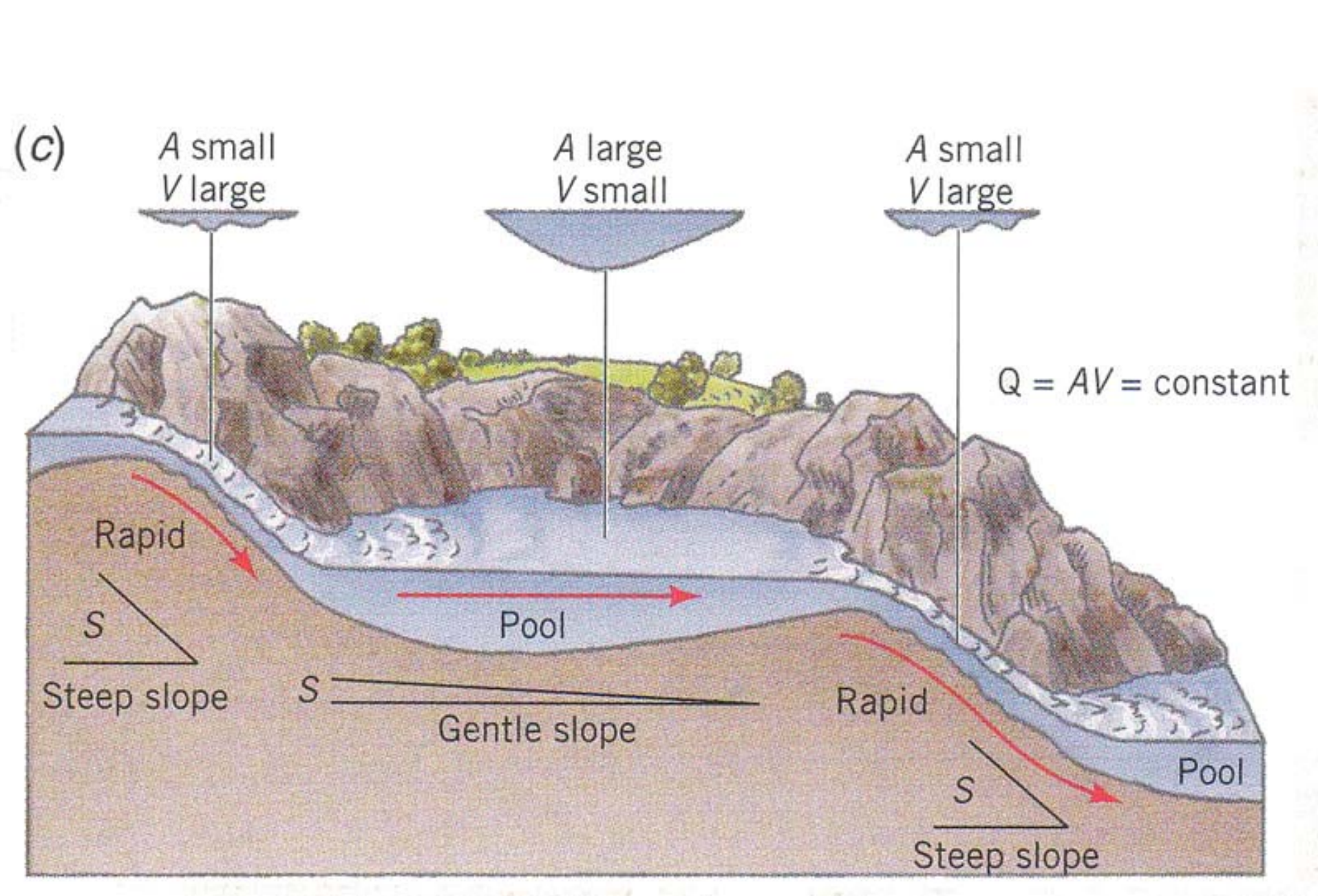
V-shaped valleys

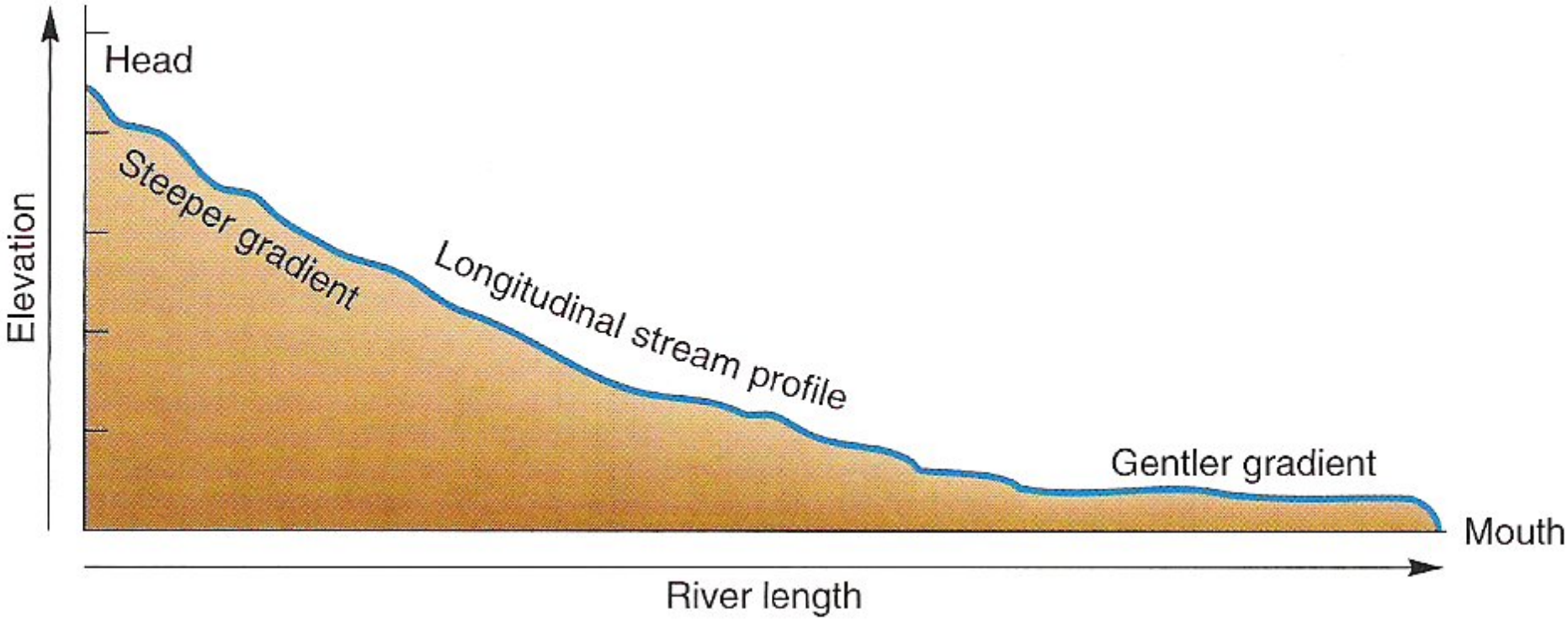
V-shaped valleys in Sahara, Algeria

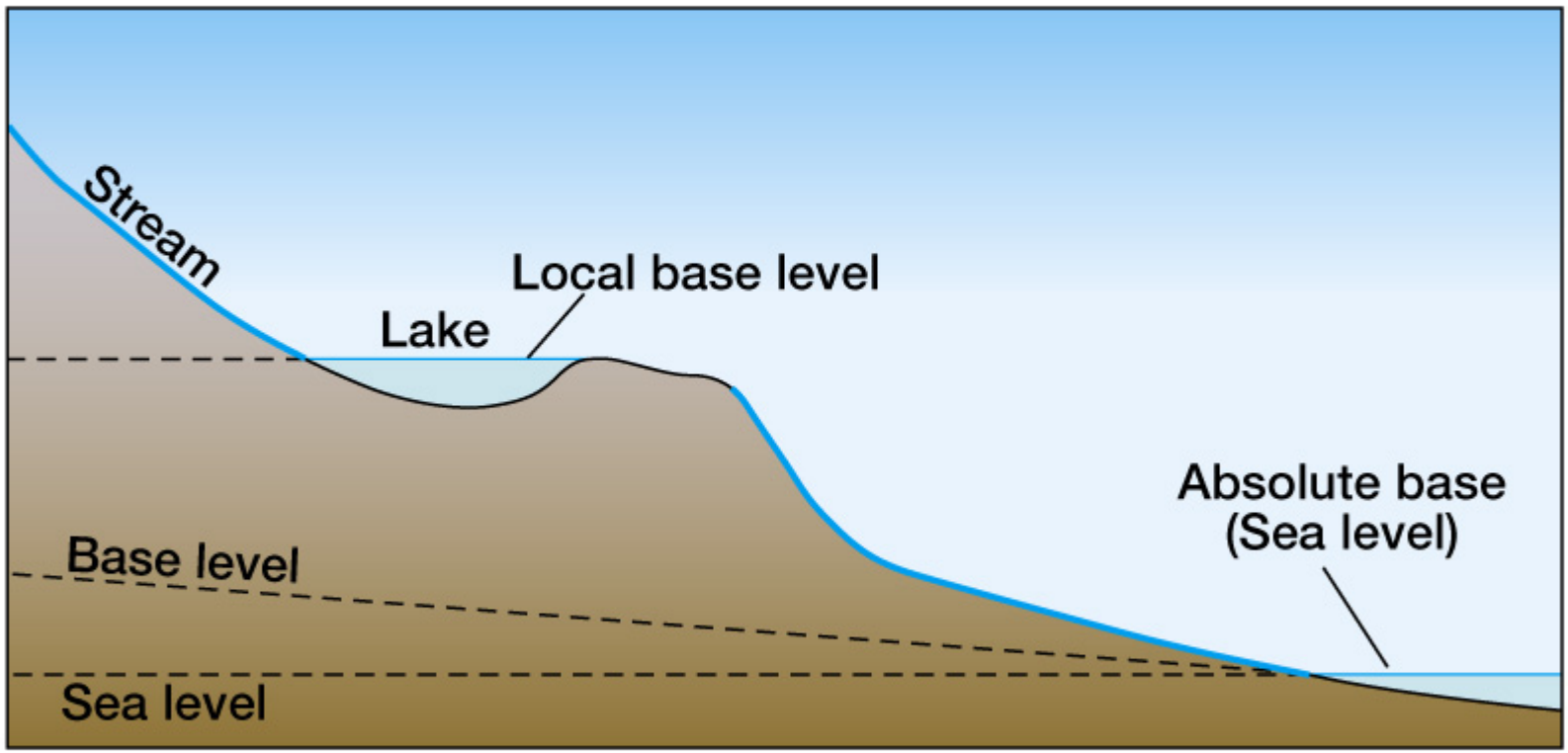

V-shaped valleys


(a)
Channel
Valley wall
V
Width, w
Area, A
d
(b)
Depth, d
Slope, S
V
Surface
Maximum shear
Bed

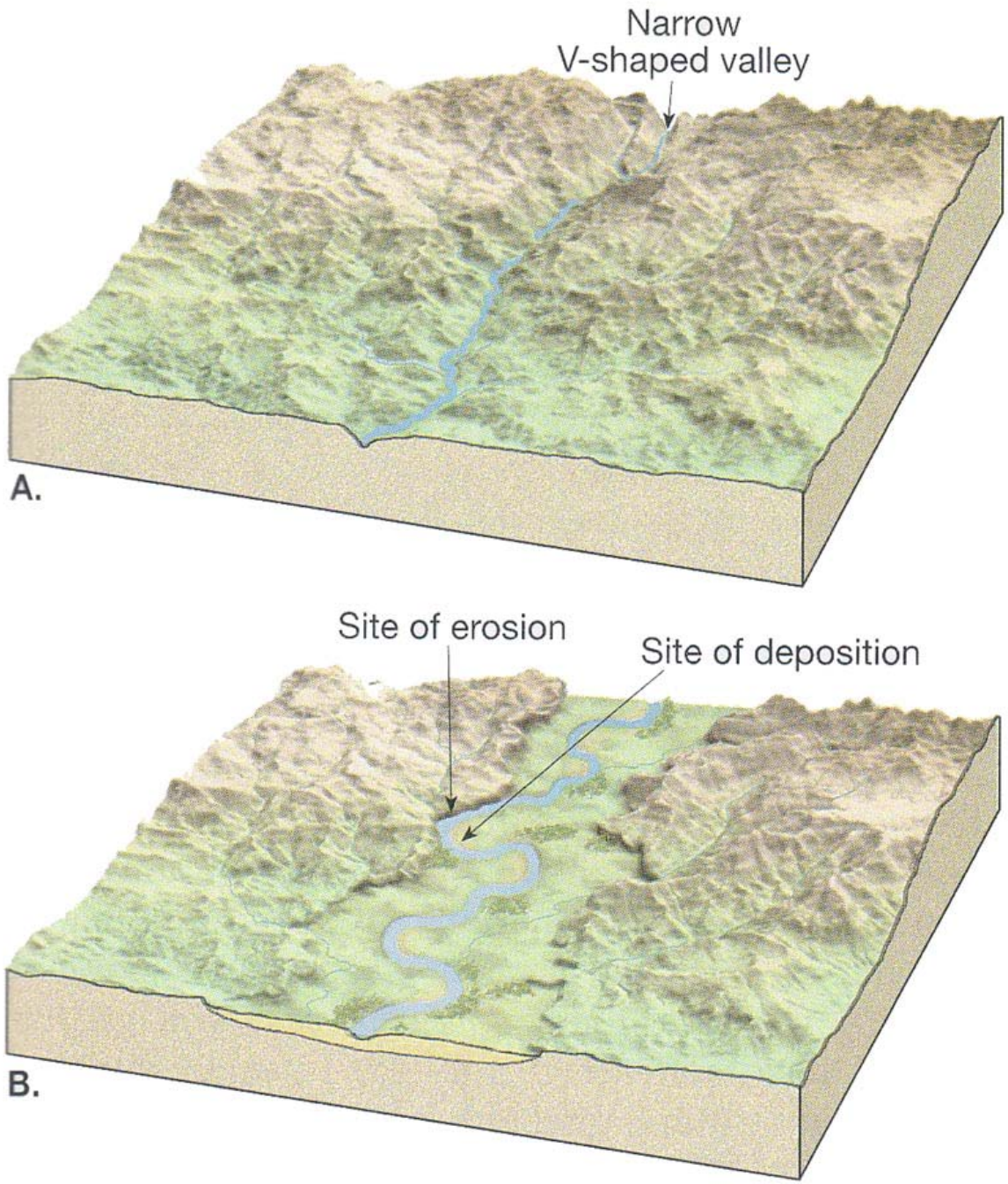

Flow
Ions in solution
Silt and clay suspended by turbulence
Rolling
Sliding
Sand moving by saltation
Rock
Silt and clay + ions
Sand
Gravel
Suspended load + dissolved load
Bed load

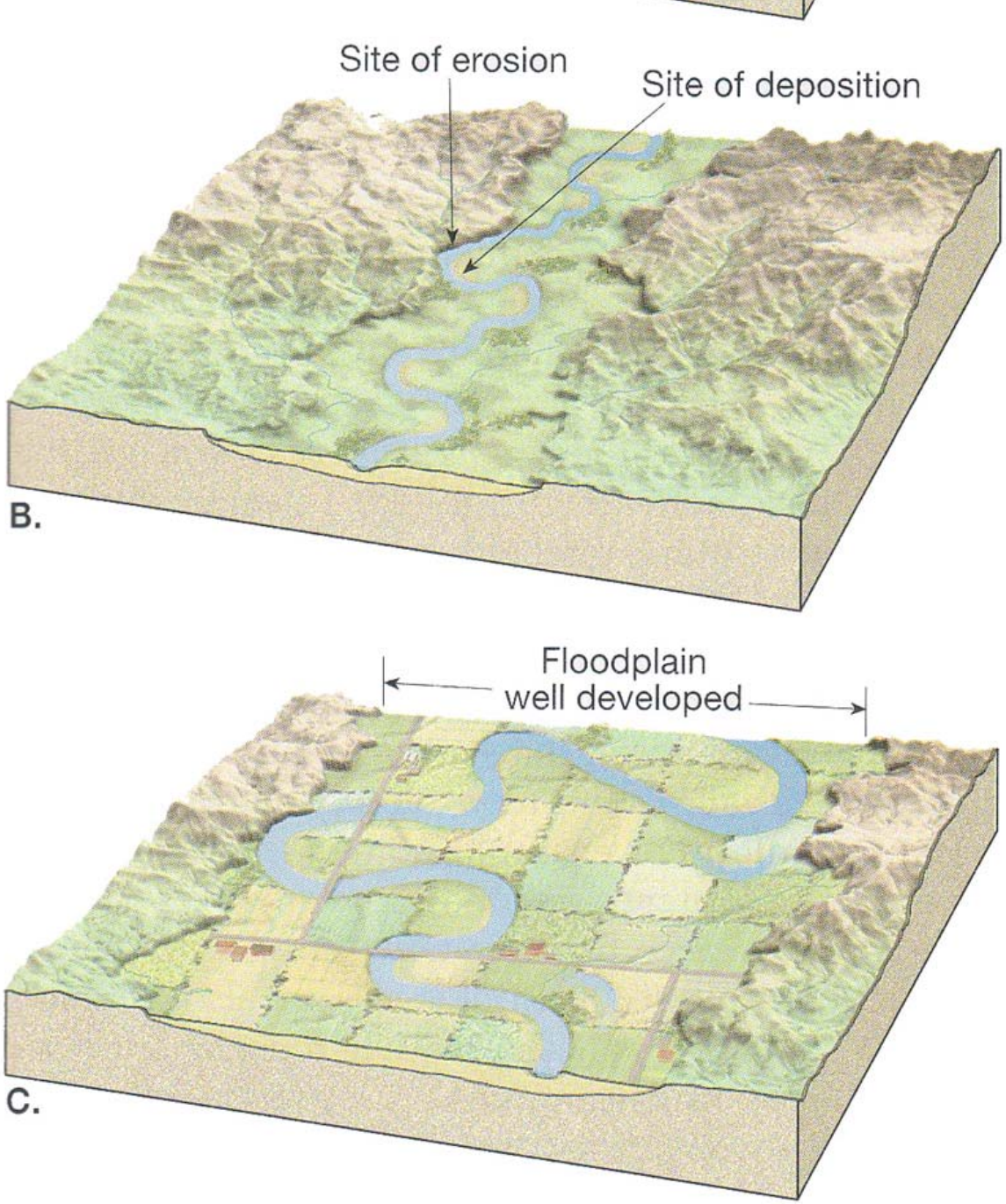

(c)
A small
V large
A large
V small
A small
V large
Q = AV = constant
Rapid
S
Steep slope
Pool
S
Gentle slope
Rapid
Pool
S
Steep slope

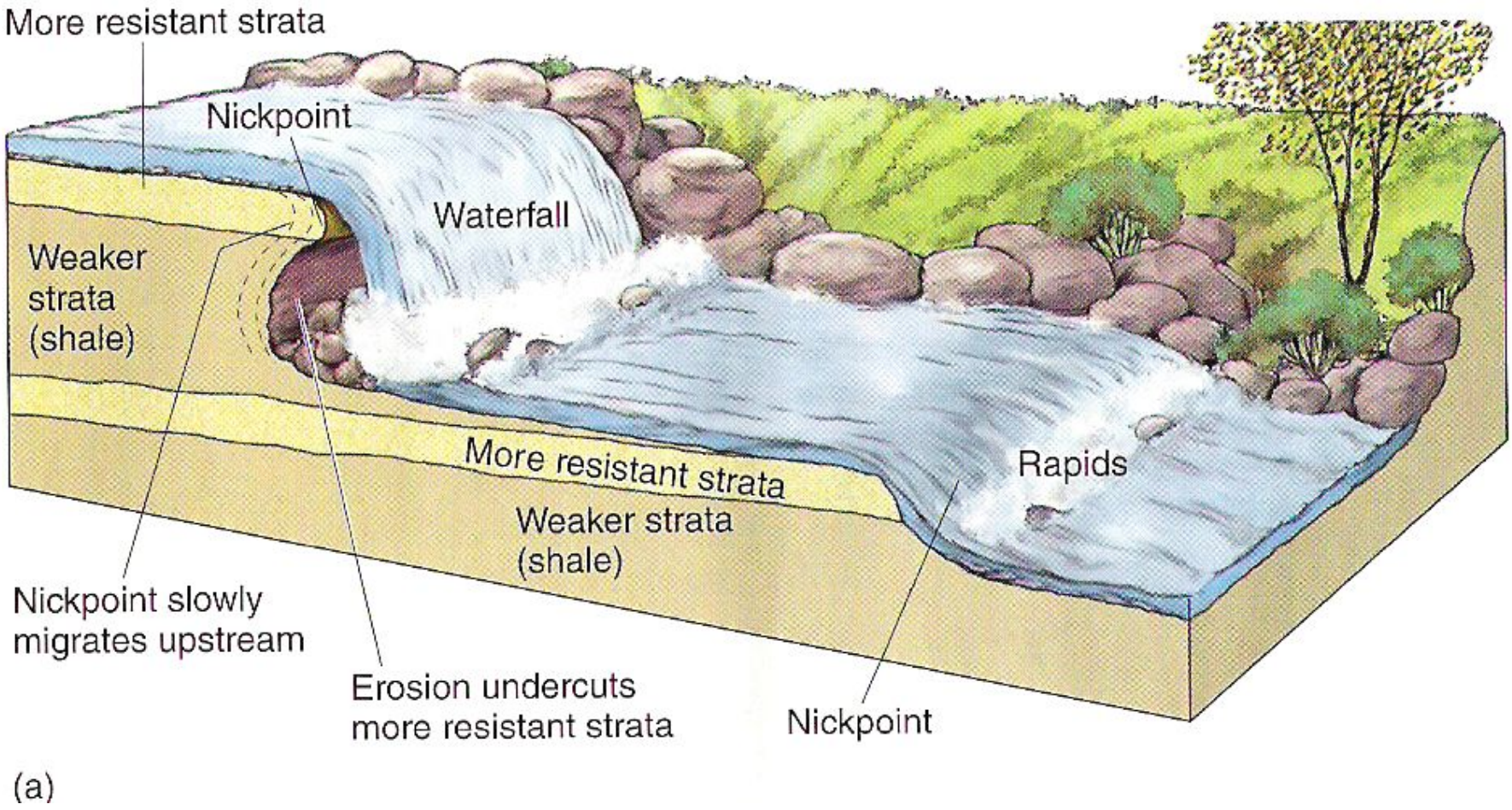

Head
Steeper gradient
Longitudinal stream profile
Gentler gradient
Mouth
Elevation
River length


Stream
Local base level
Lake
Absolute base
(Sea level)
Base level
Sea level

Base level

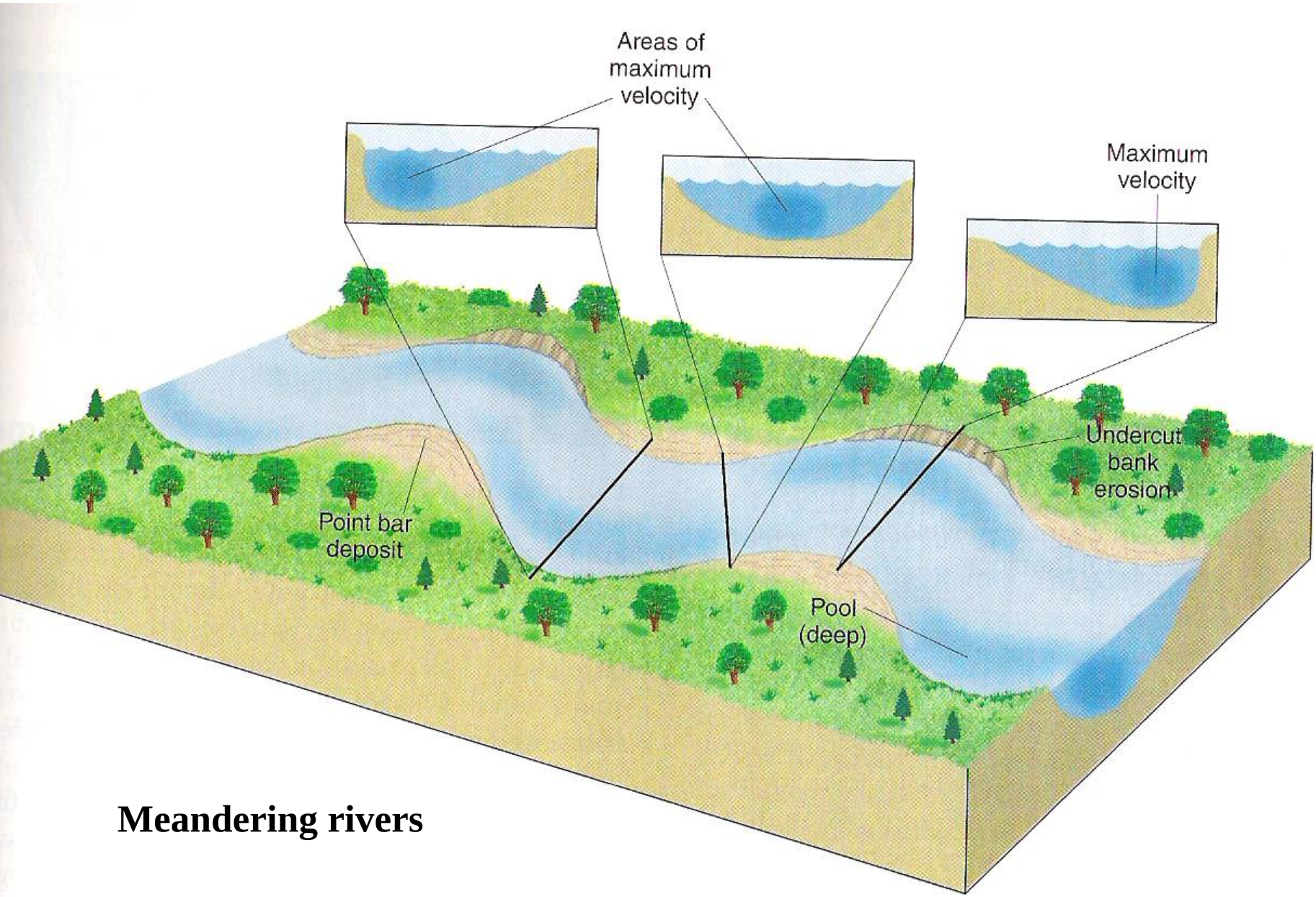

Narrow
V-shaped valley
A.
Site of erosion
Site of deposition
B.


Site of erosion
Site of deposition
B.
Floodplain
well developed
C.

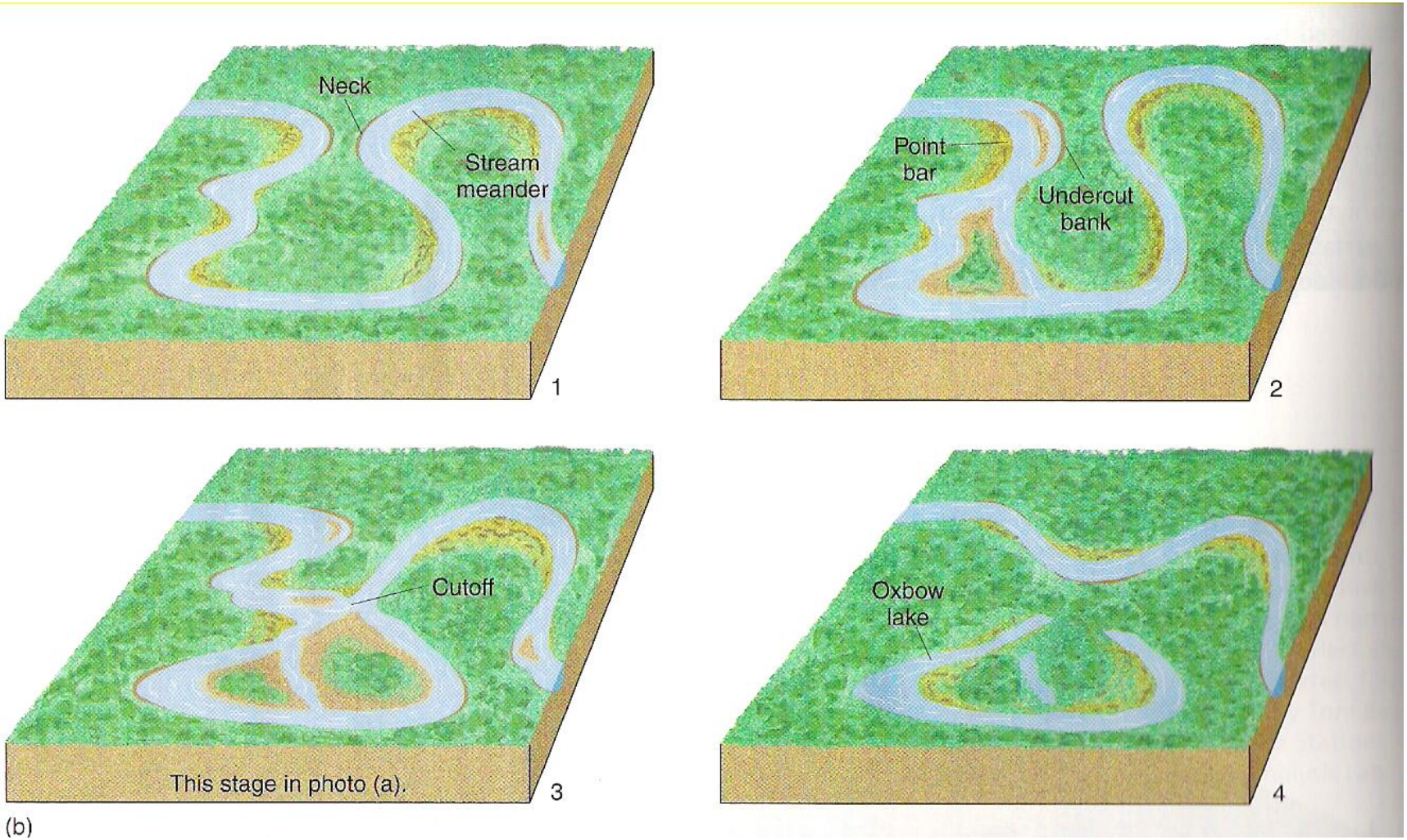

More resistant strata
Nickpoint
Waterfall
Weaker strata (shale)
More resistant strata
Weaker strata (shale)
Rapids
Nickpoint slowly migrates upstream
Erosion undercuts more resistant strata
Nickpoint

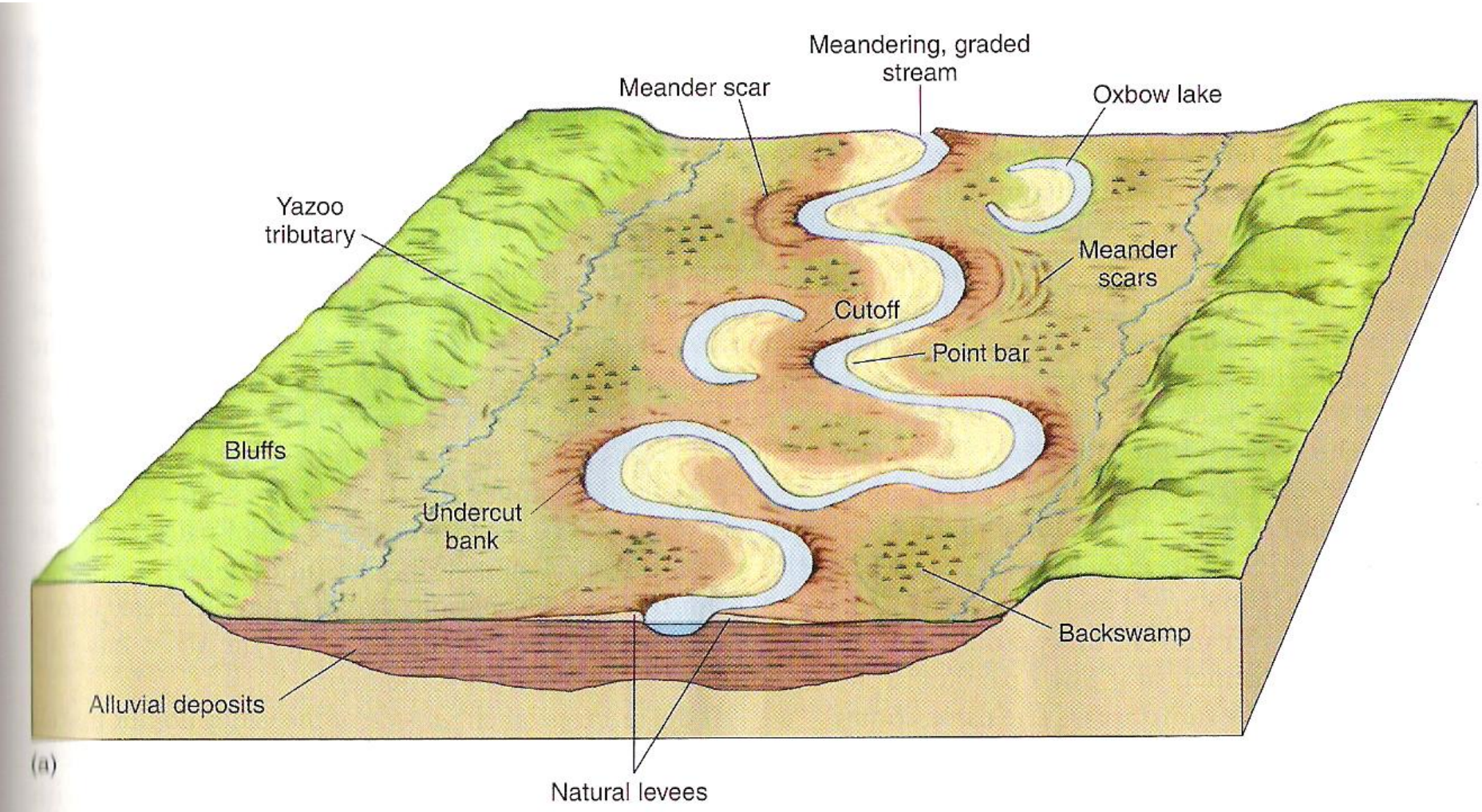
(a)


Niagara, USA



Meandering rivers


Neck
Stream meander
1
Point bar
Undercut bank
2
Cutoff
This stage in photo (a).
3
Oxbow lake
4
(b)


Meandering, graded stream
Meander scar
Oxbow lake
Yazoo tributary
Meander scars
Cutoff
Point bar
Bluffs
Undercut bank
Backswamp
Alluvial deposits
Natural levees

(a)

Meandering Mississipi, USA

Braided river


River plain
www.wallpaper.net.au

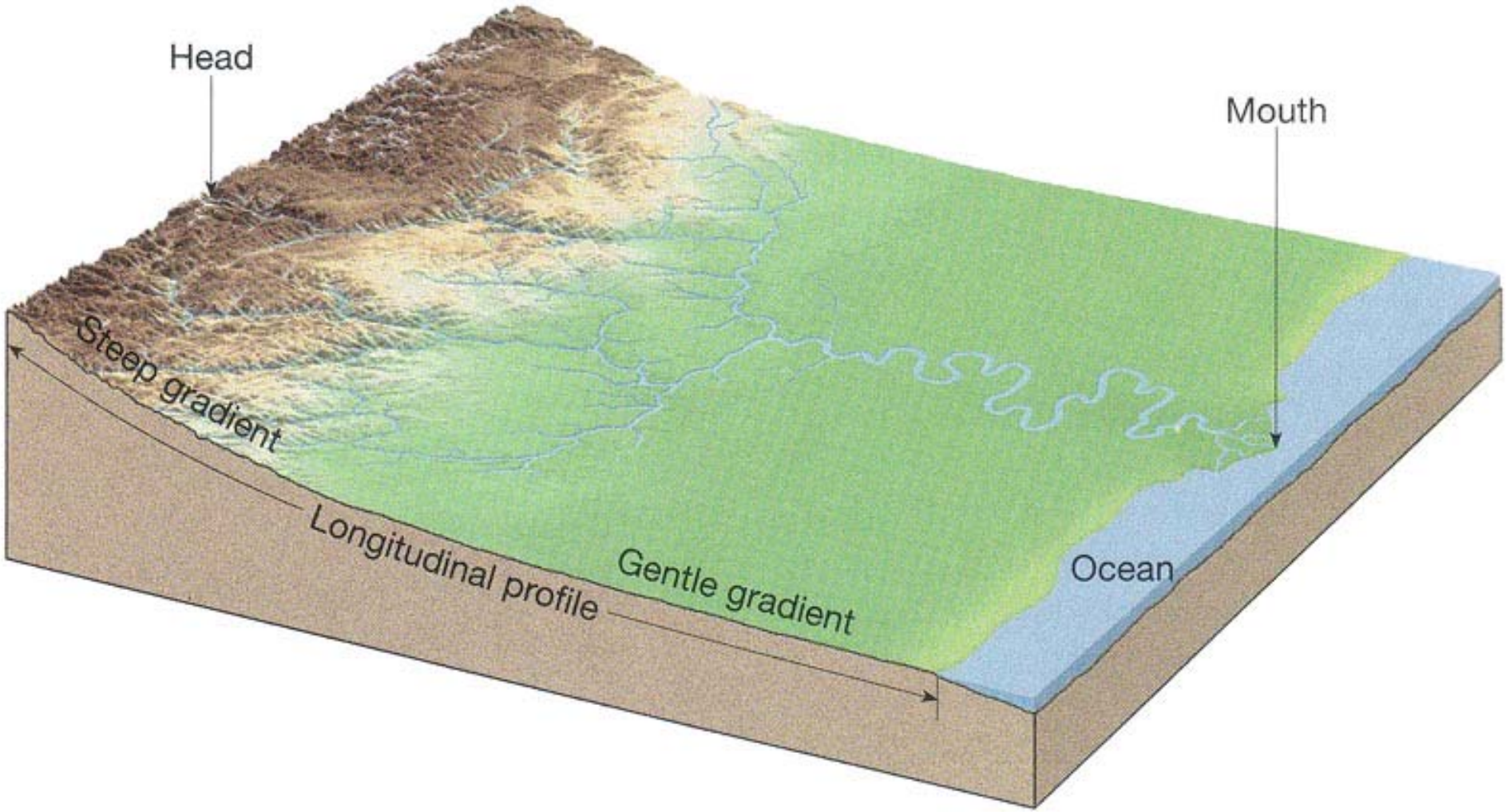

Estuary

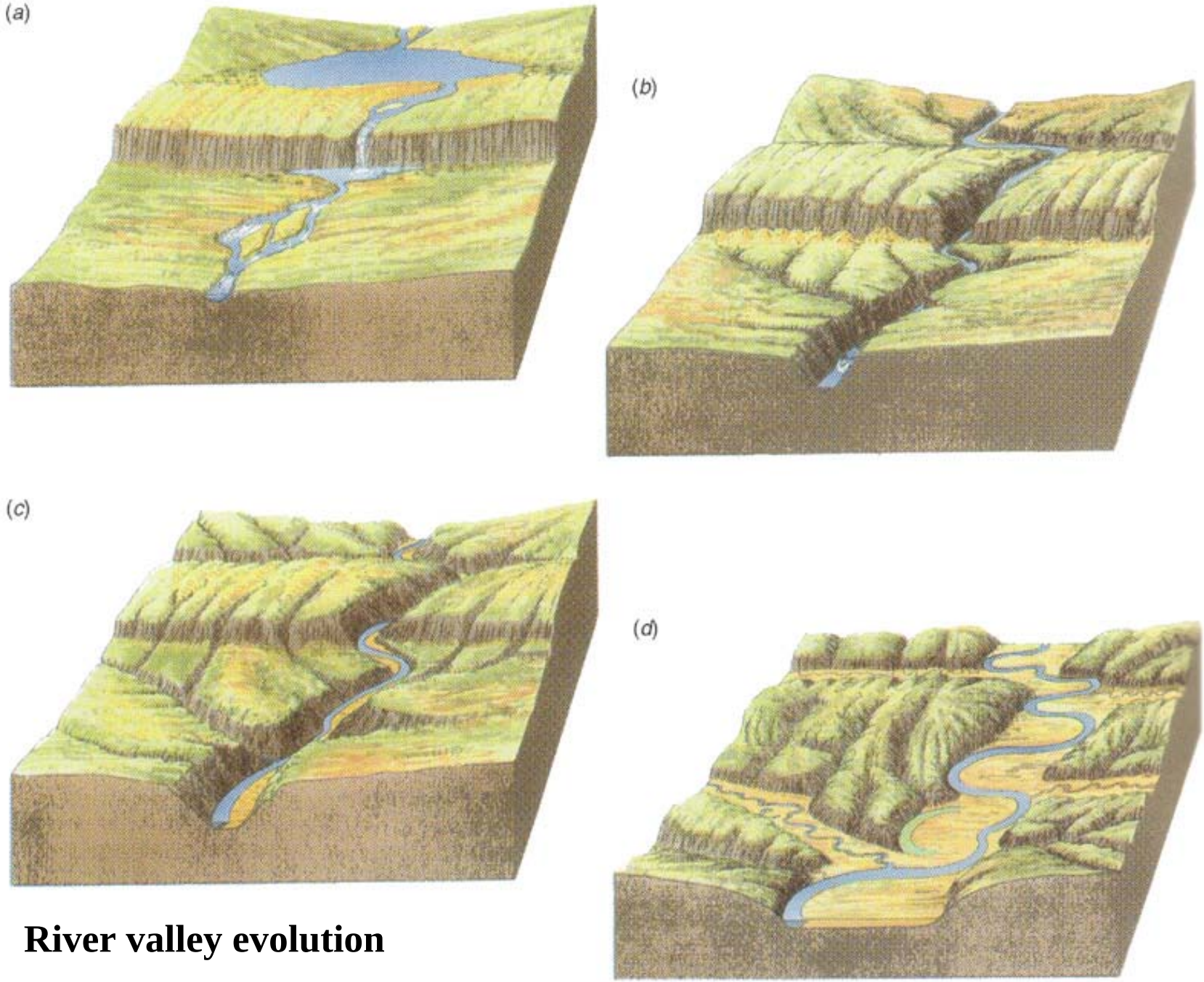

Nile delta, Egypt


N
W
E
S
Image © 2005 MDA EarthSat
© 2005 Google
Ganges-Brahmaputra delta, Bangladesh
Pointer lat 22.682997° lon 91.848903° elev 26 m
Streaming 100%
Eye alt 270.56

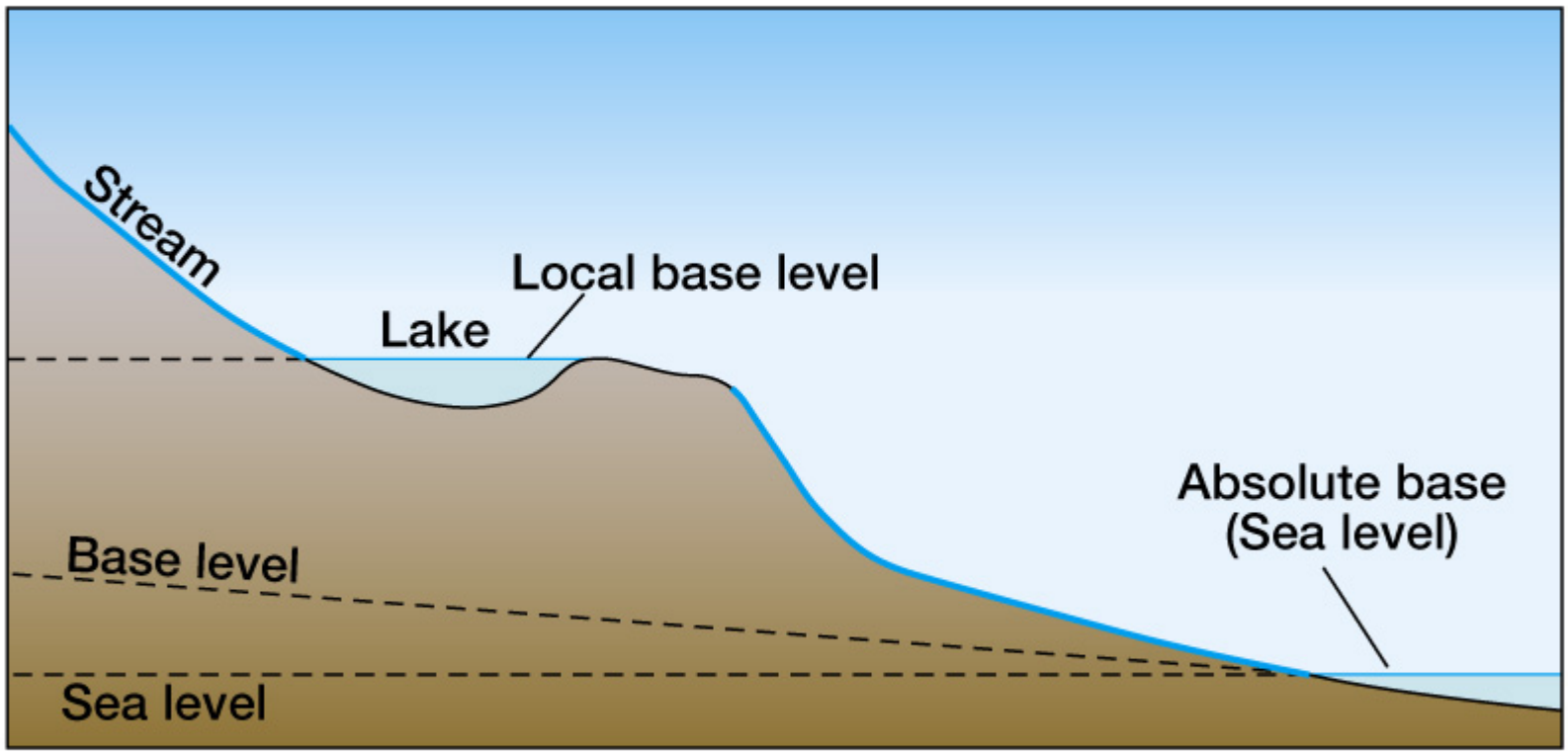

Amazonas delta, Brasil


Colville
Makenenzie
Yukon
Copper
Columbia
Colorado
Mississippi
Appalachicola
Magdalena
Orinoco
Amazon
Sao Francisco
Parana
Lena
Ob
Amur
Dnepr
Po
Rhone
Ebro
Volga
Huang Ho
Yangtze
Nile
Tigris Euphrates
Ganges Bramaputra
Indus
Red
Irrawaddy
Mekong
Senegal
Niger
Tana
Congo
Zambeze
Orange
Mahakam
Fly
Purari
Ord
Burdekin
Shoalhaven
Murray
Solid Sediment
Discharge
10^6 Tons
2000
1000
500
250
125
not given

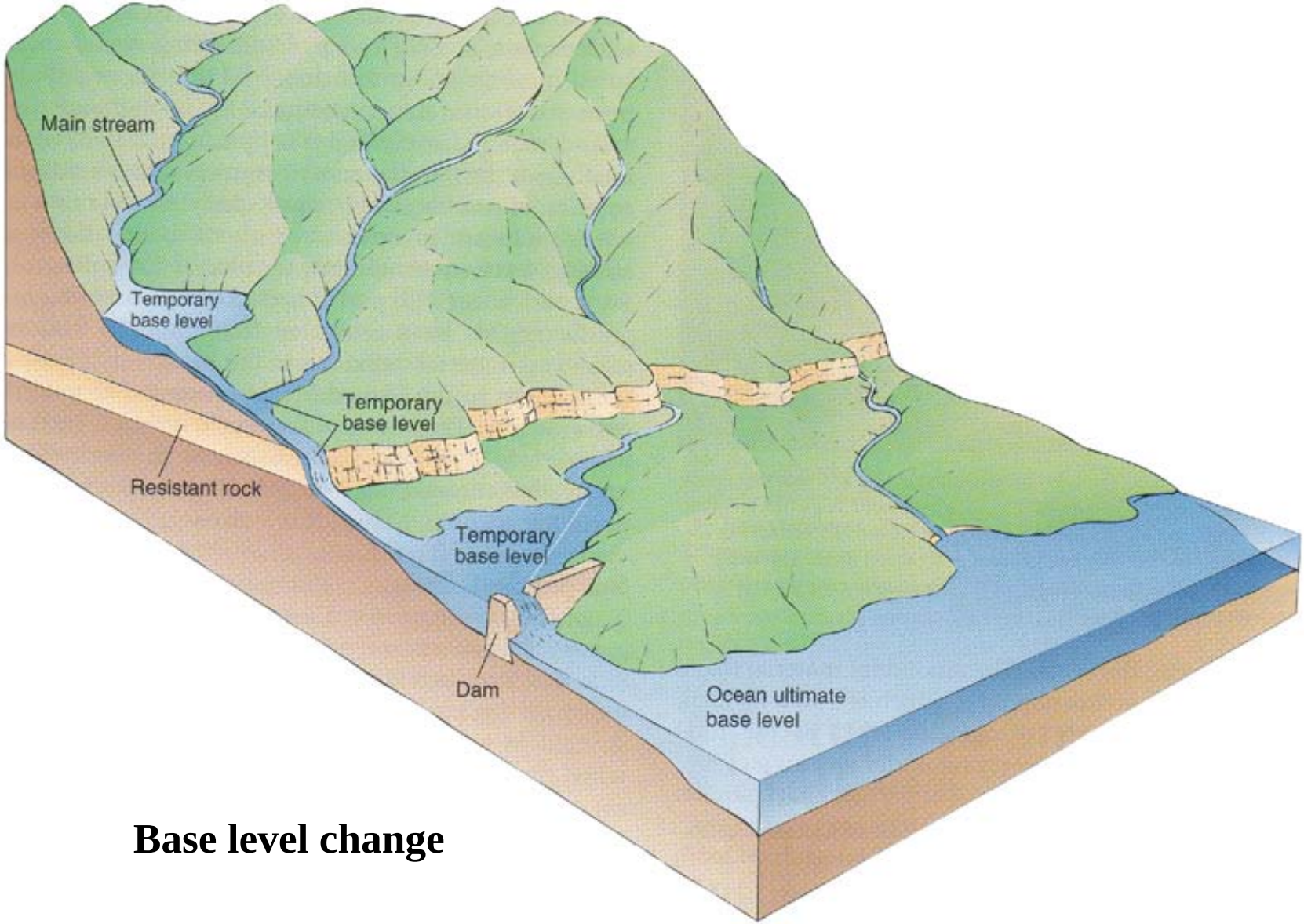

Head
Mouth
Steep gradient
Longitudinal profile
Gentle gradient
Ocean



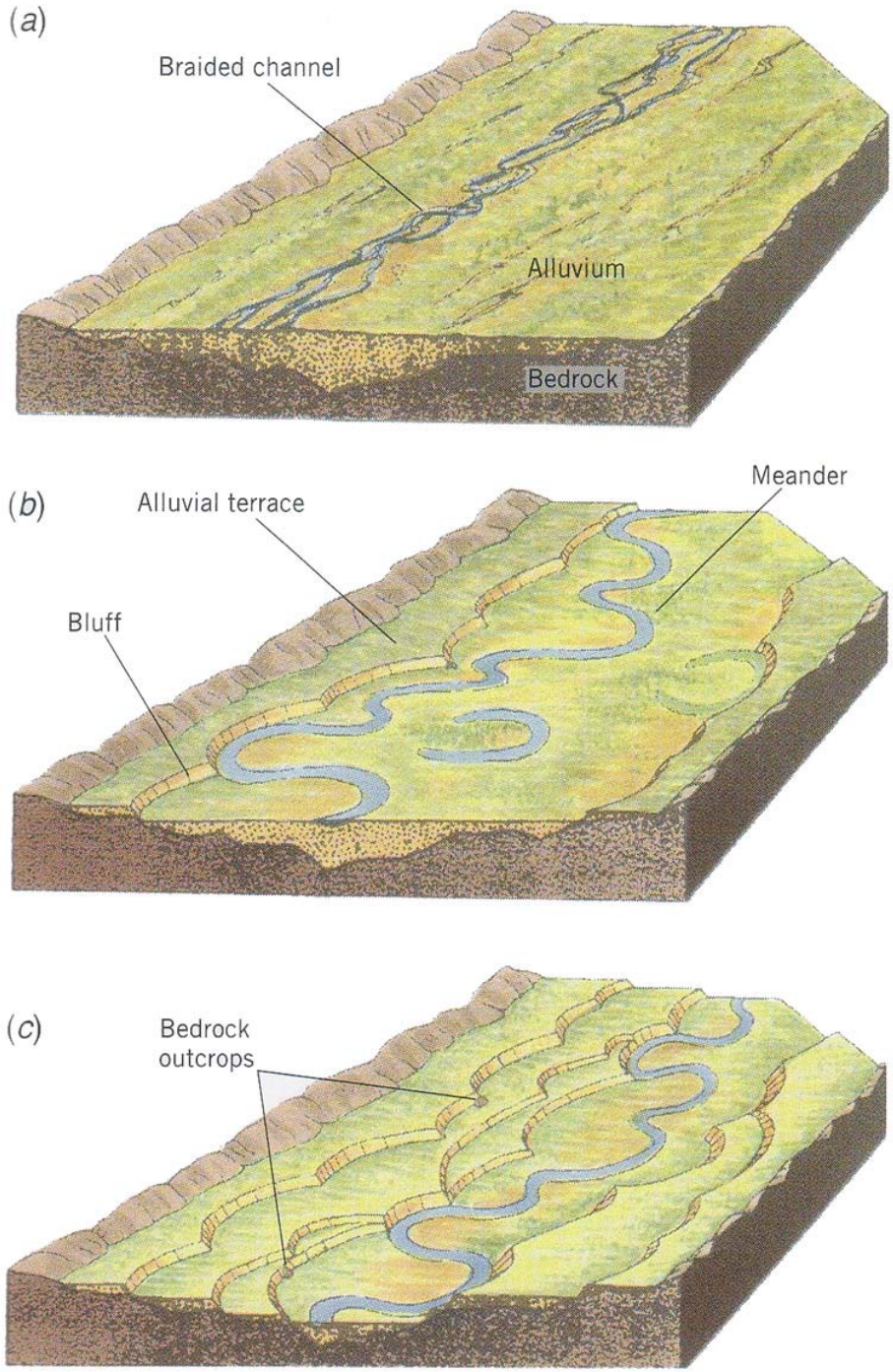
River valley evolution


Stream
Local base level
Lake
Absolute base
(Sea level)
Base level
Sea level

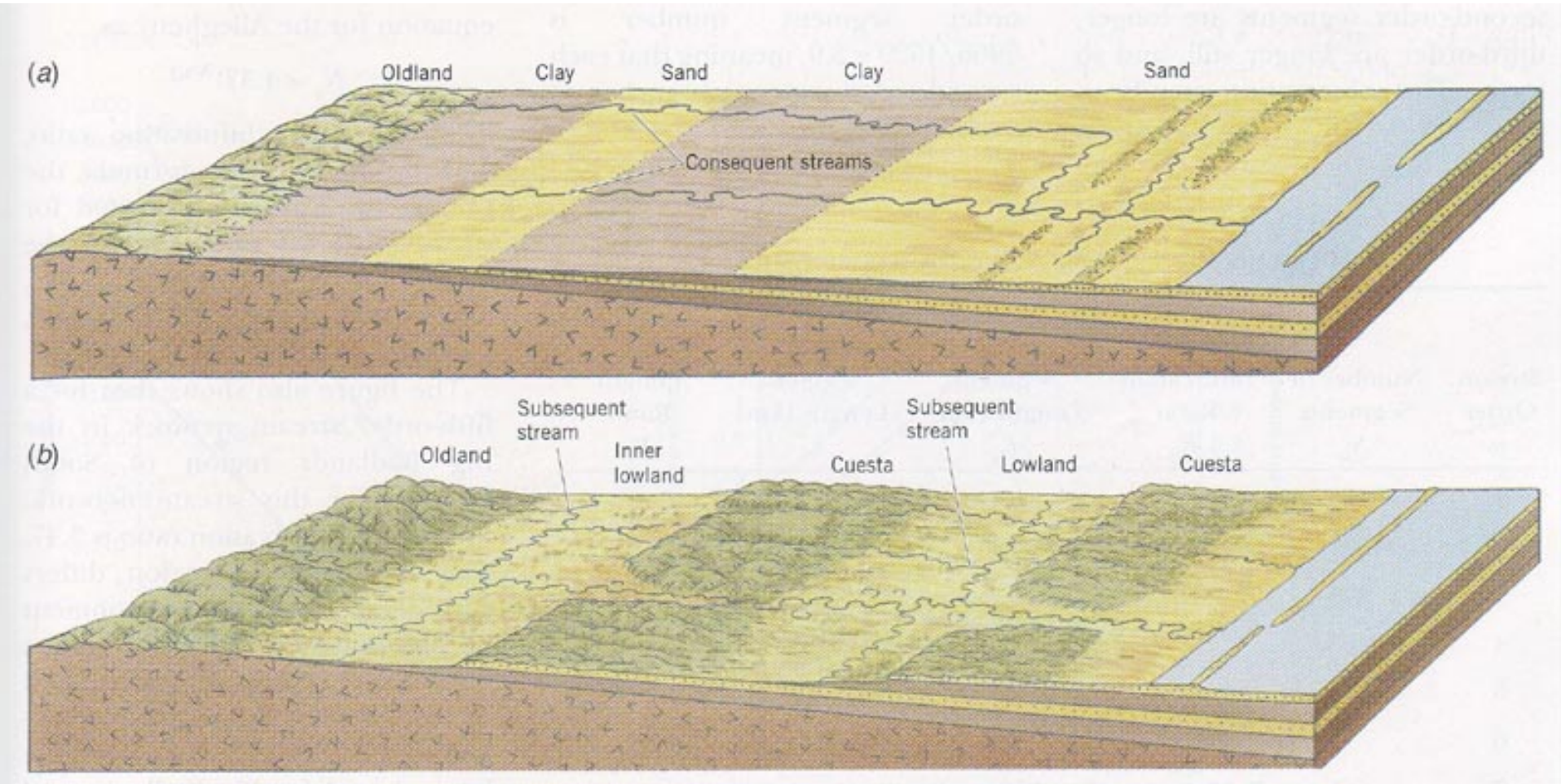
Base level



Base level change



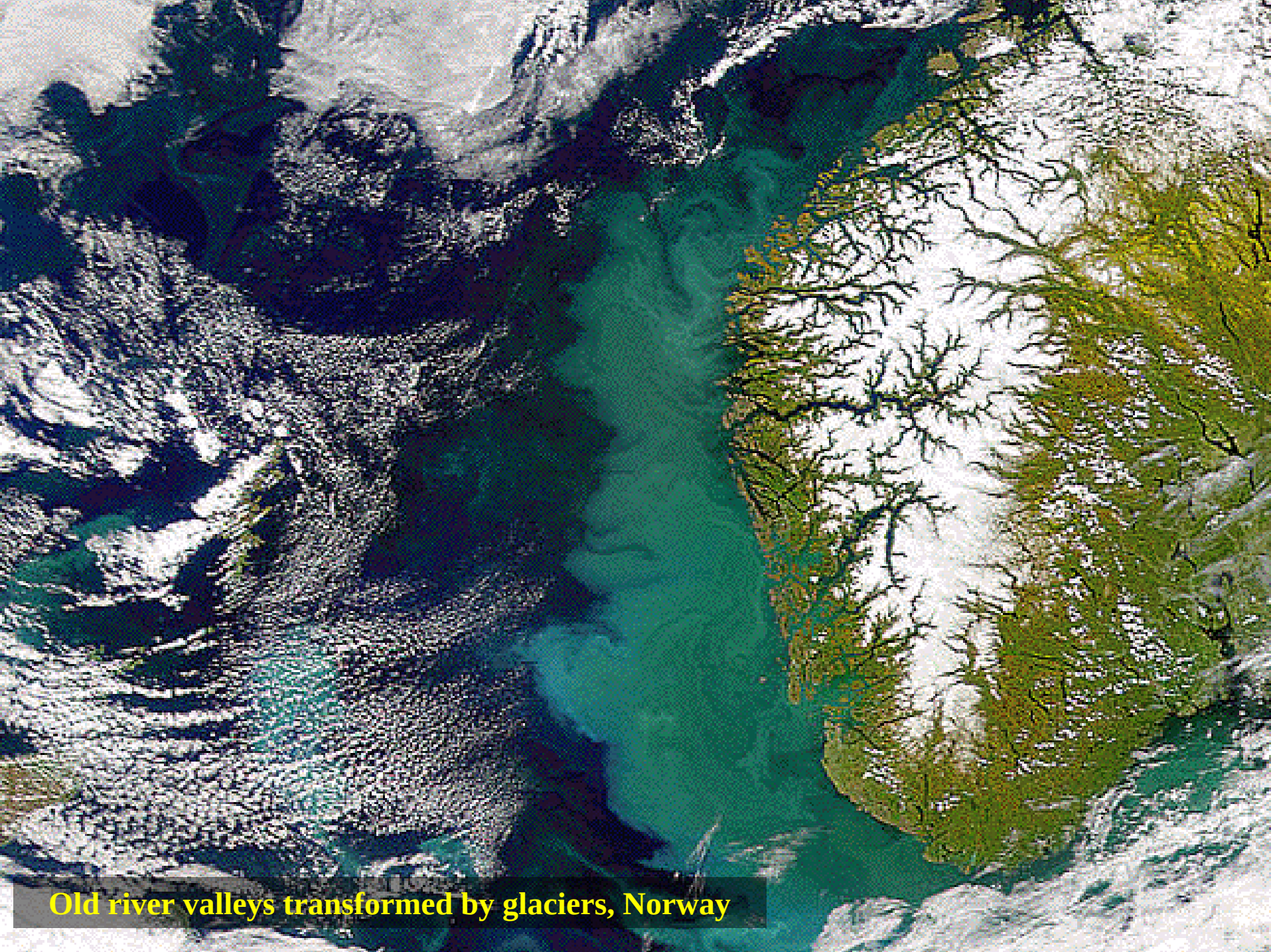
Formation of river terraces



Effects of erosion over time

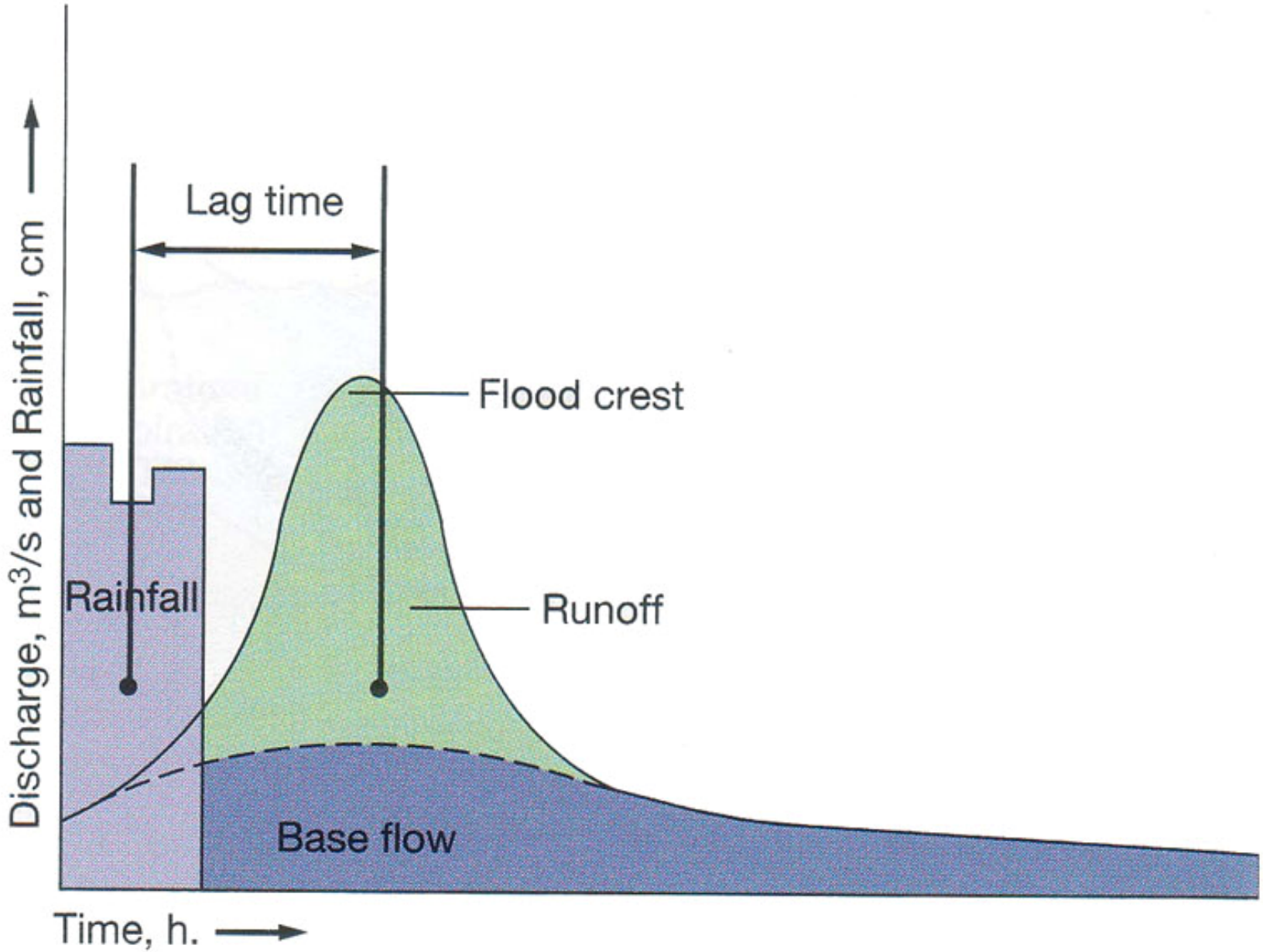

Rhine valley, Germany

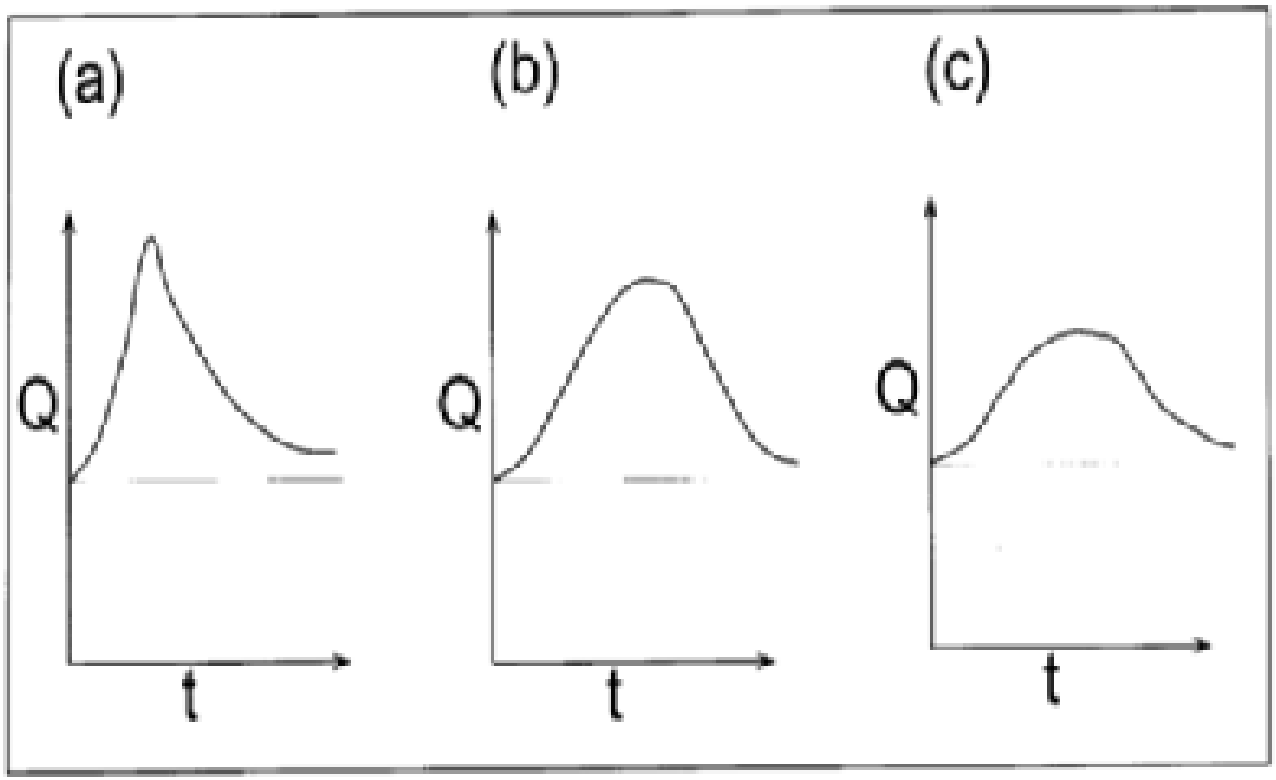

Grand Canyon, USA



Old river valleys transformed by glaciers, Norway

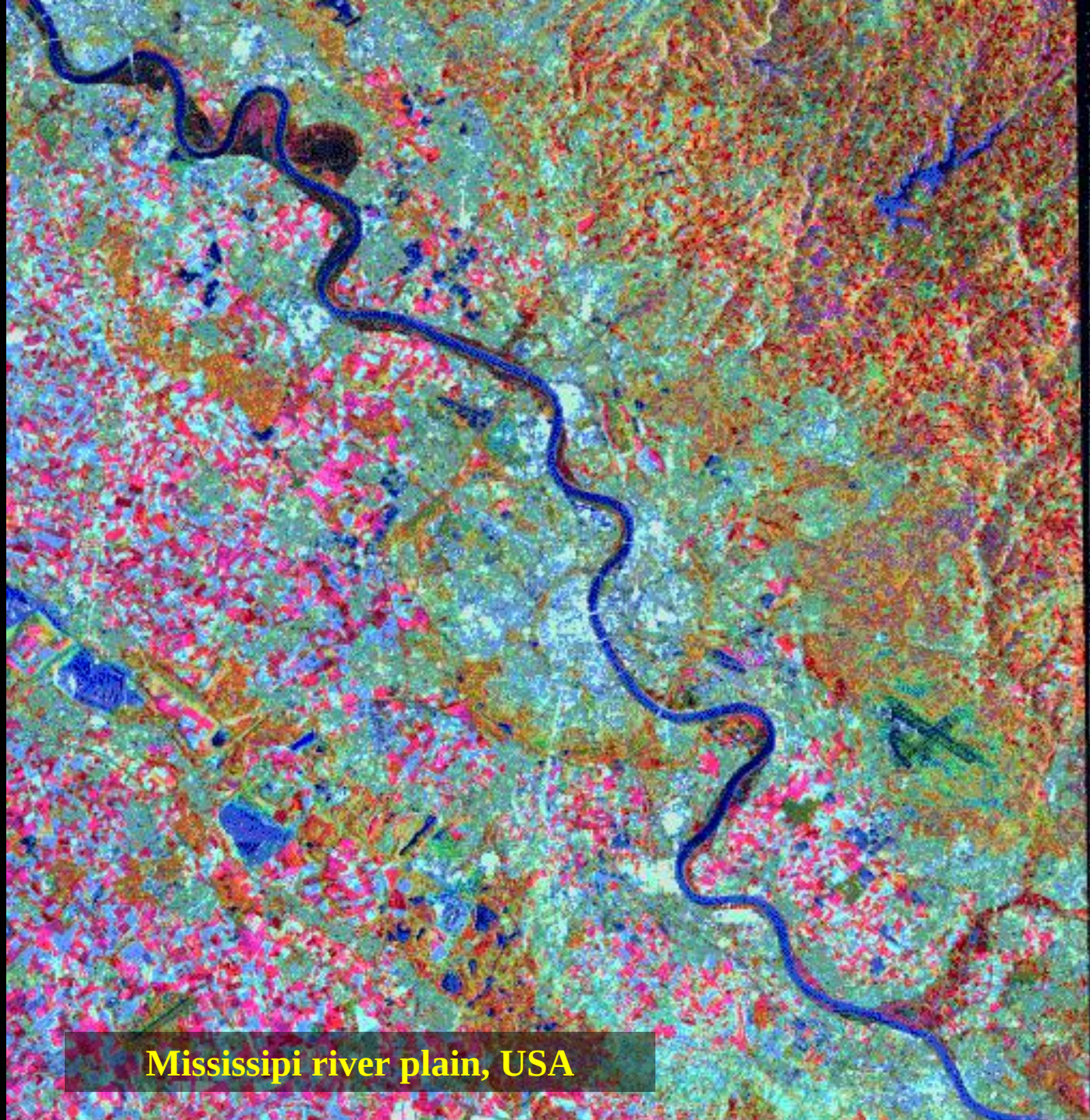

CABINET
3471

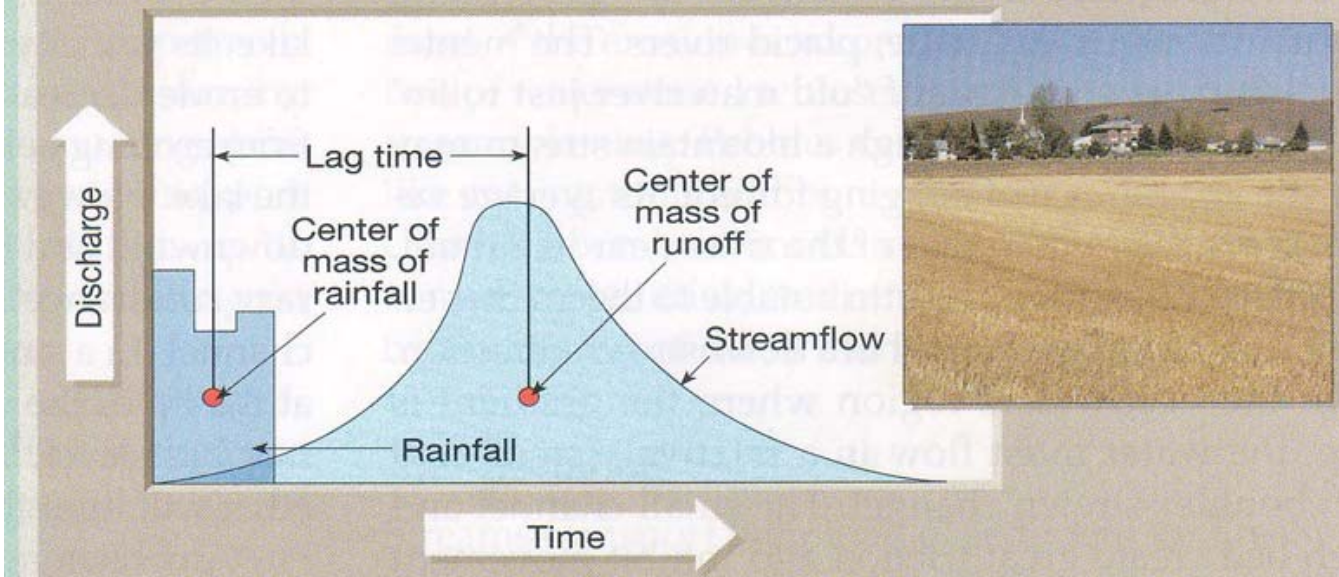

Discharge, m3/s and Rainfall, cm
Lag time
Flood crest
Rainfall
Runoff
Base flow
Time, h.



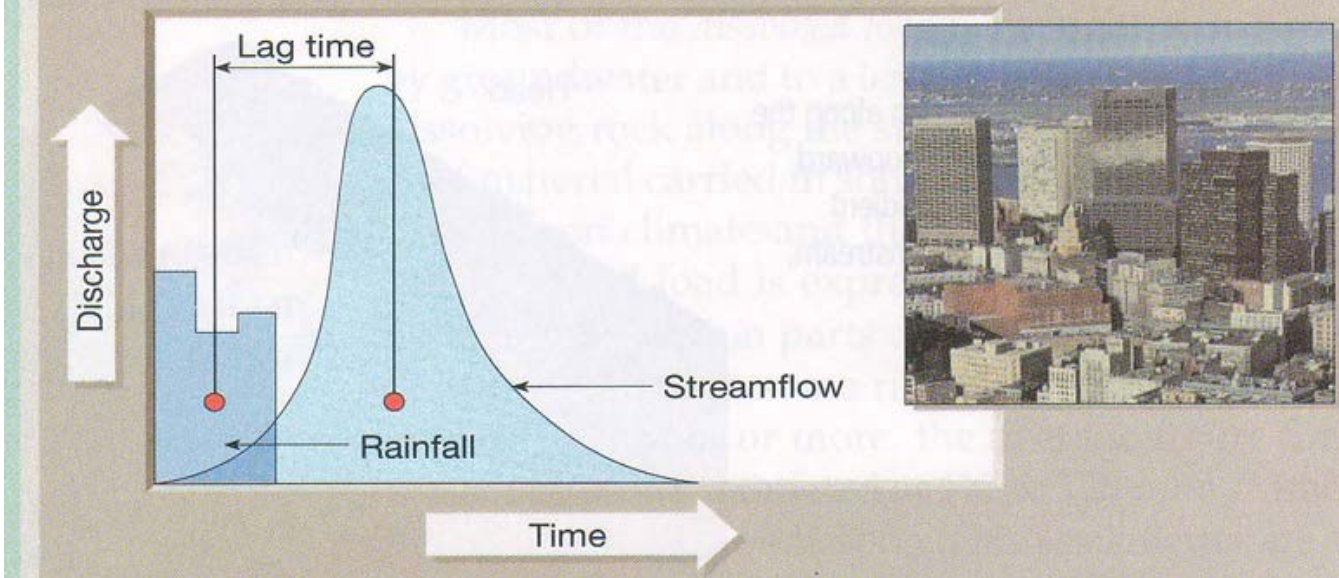
Typical hydrograph shapes for (a) an upland stream, (b) a piedmont river (middle reaches) and (c) a lowland river


OSLO CITY
LINDEX
CUBUS
MENY
BIK BOK
TANUM
Allers


Mississipi river plain, USA



Typical lag time between rainfall and runoff



Lag time between rainfall and runoff after urbanization

River flooding Mississipi, USA

River flooding Mississipi, USA

Rhine valley, Germany: Economic significance

Canal, Amsterdam

Canal, Amsterdam


Lake Superior
SOO CANALS
Lake Michigan
Lake Huron
Lake Ontario
Lake Erie
Chicago
ILLINOIS AND MICHIGAN
La Salle
Detroit
Toledo
Cleveland
OHIO AND PENNSYLVANIA
OHIO AND ERIE
Erie
Lockport
Buffalo
WELLAND CANAL
GENESEE VALLEY
OSWEGO
Rome
BLACK RIVER
CHAMPLAIN
ERIE
CHENANGO
CHEMUNG
Albany
Northampton
Worcester
Lowell
MIDDLESEX
Boston
BLACKSTONE
Providence
NEW HAVEN AND NORTHAMPTON
CUMBERLAND AND OXFORD
Portland
DELAWARE AND HUDSON
MORRIS
New York
DELAWARE AND RARITAN
SCHUYLKILL
Philadelphia
SUSQUEHANNA AND TIDEWATER
CHESAPEAKE AND DELAWARE
CHESAPEAKE AND OHIO
Washington
Cumberland
Pittsburgh
Alleghany Portage R.R.
PENNSYLVANIA STATE CANAL SYSTEM
WALHONDING AND MOHICAN
SANDY AND BEAVER
Ft. Wayne
MIAMI
Columbus
MUSKINGUM
HOCKING
OHIO AND ERIE
Portsmouth
WABASH AND ERIE
Terre Haute
WHITE-WATER
Cincinnati
Ohio
Louisville
OHIO FALLS
Evansville
JAMES RIVER AND KANAWHA
Richmond
Buchanan
Norfolk
DISMAL SWAMP
ALBEMARLE AND CHESAPEAKE
CANAL ERA, 1825-1860
km 0 100 200
mi 0 100 200

River transport, USA

Construction of new canal, Germany