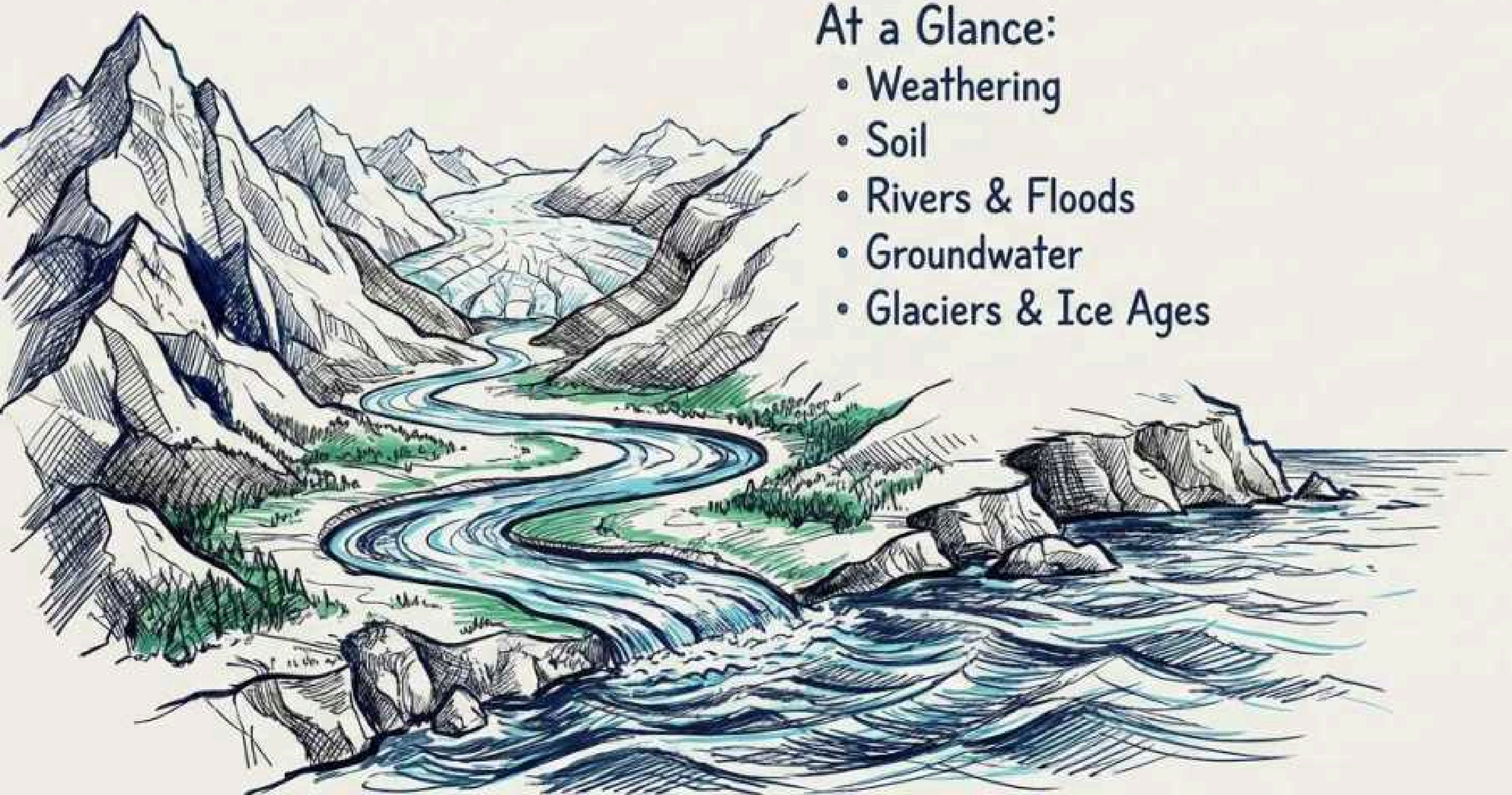
¶ 5.1

Lecture 5: Weathering, Rivers, Groundwater, and Ice

The forces that wear the Earth down.



At a Glance:

- Weathering
- Soil
- Rivers & Floods
- Groundwater
- Glaciers & Ice Ages

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¶ 5.2

The Journey: We follow rock as it weathers into soil, travels down rivers, seeps into the ground, and is carried by ice.

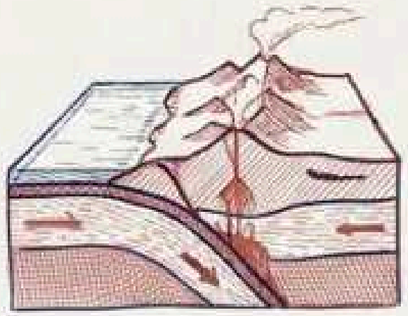
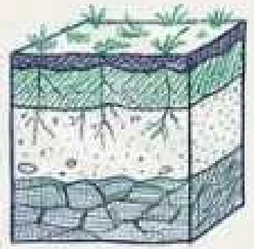


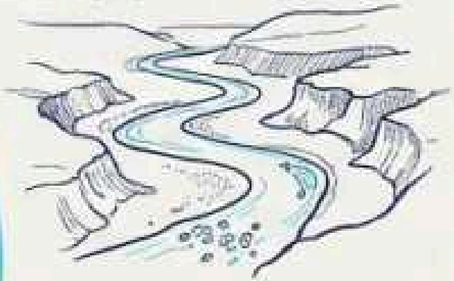
Plate Tectonics: Building the Land Up.

Surface Forces: Wearing It Down

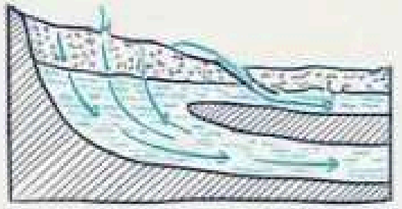
1. Soil



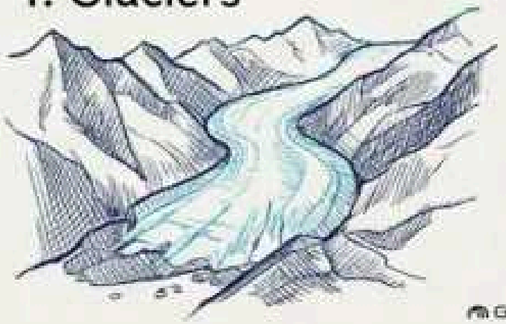
2. Rivers



3. Groundwater



4. Glaciers



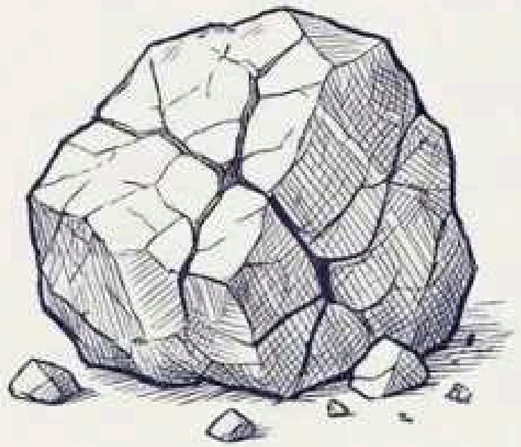
The same few processes, running for long enough, carve every landscape you have ever seen.

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¶ 5.3

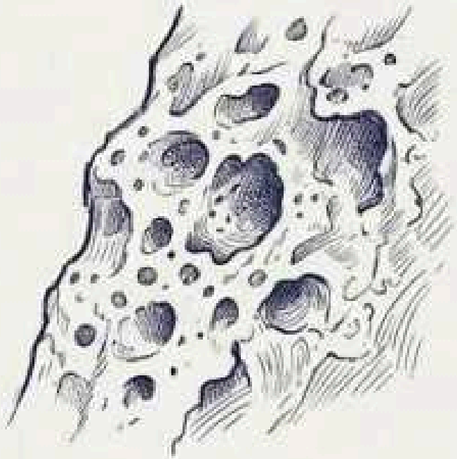
Step 1: Weathering
(Breakdown in place)

A. Physical



Changes size / breaks into pieces

B. Chemical



Changes the minerals themselves

Step 2: Erosion
(Removal & Transport)

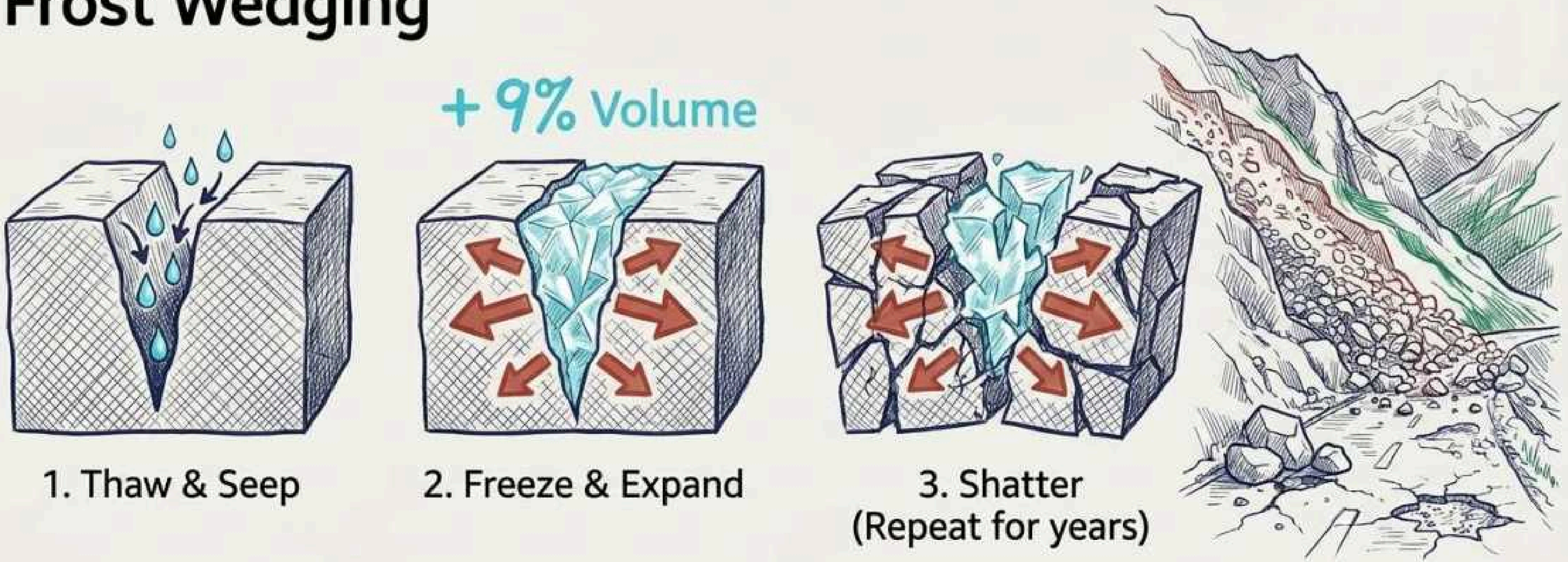


Core Principle: Weathering prepares the material. Erosion carries it away.

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Physical Weathering: Frost Wedging

¶ 5.4



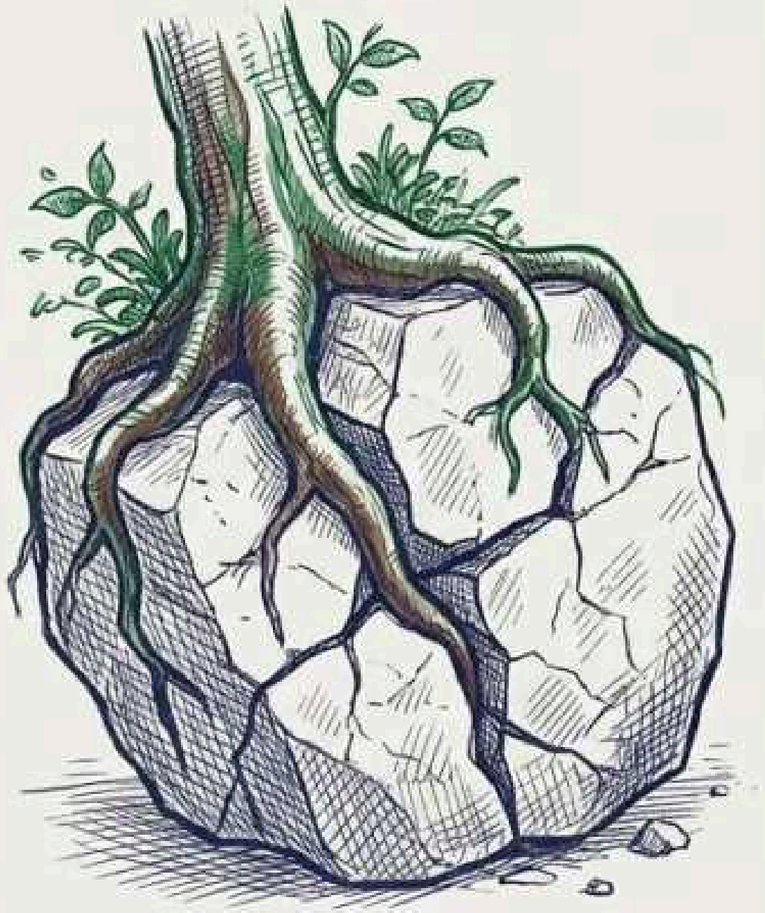
This process is why roads break up in winter, and why mountain slopes are covered with shattered rock.

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Other Physical Processes

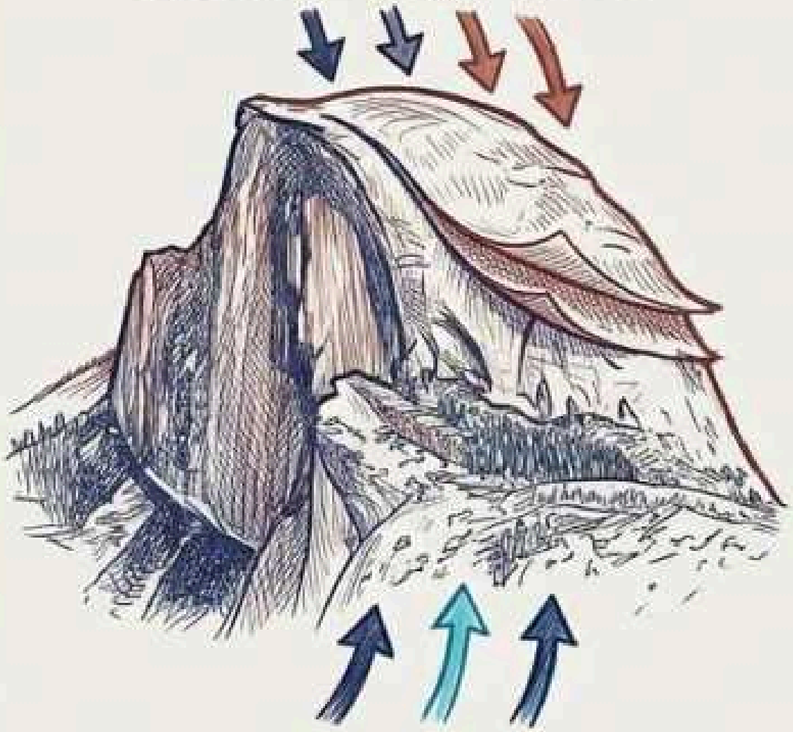
¶ 5.5

Plant Roots



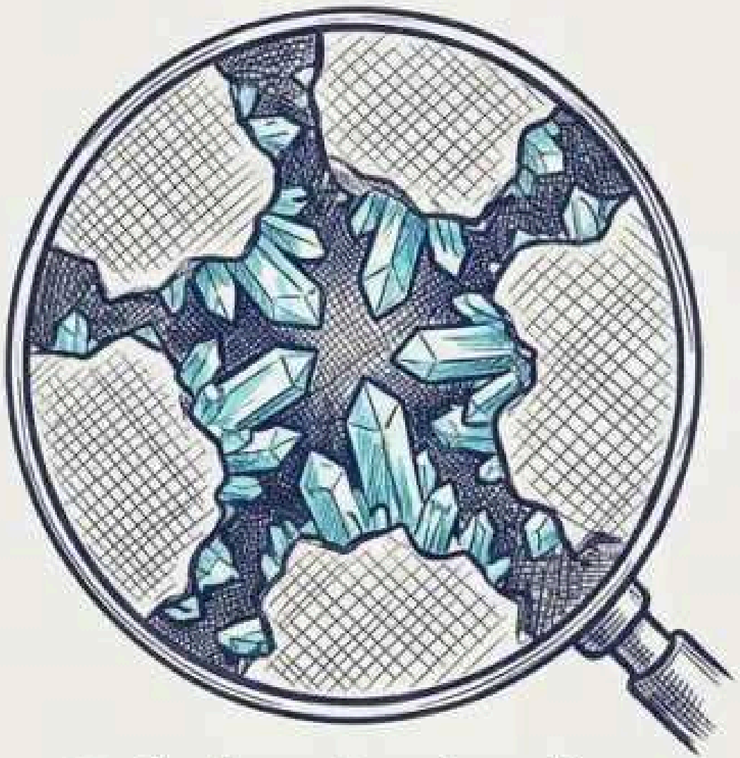
Exfoliation

Erosion strips cover



Deep pressure release

Salt Wedging



Daily heating/cooling causes salt crystals to grow and fracture rock.

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¶ 5.6

Rain + CO_2 (from air) → Carbonic Acid (Weak)



Feldspar + Acid → Clay

Crucial Driver: Water is required.

Heat speeds reactions = fastest weathering occurs in warm, wet climates.

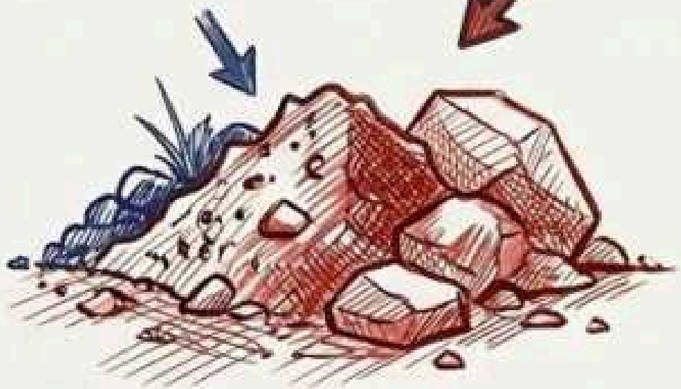
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Chemical Weathering: Mineral Sorting

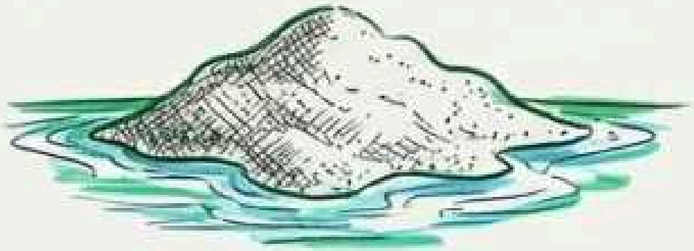
¶ 5.7



Iron + O_2 + H_2O → Rust



Feldspar → Clay & Dissolved Ions (Weak Minerals)



Quartz → Survives! (Highly Resistant)



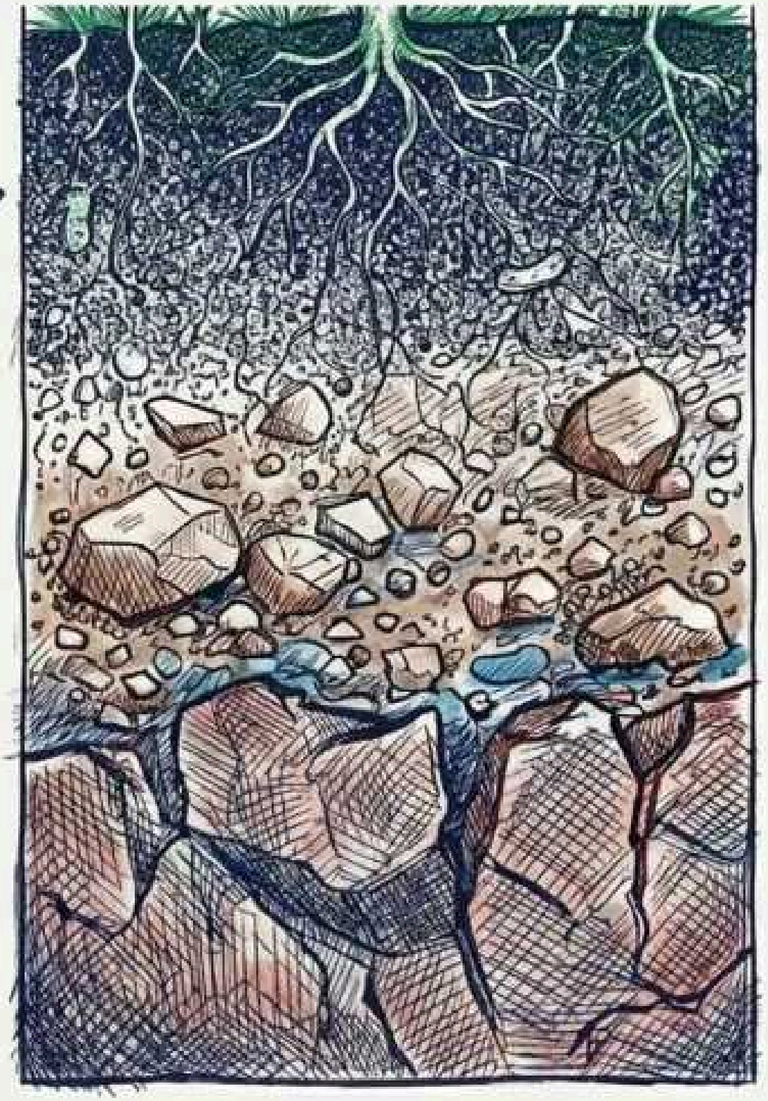
Becomes beach sand

Weathering sorts minerals based on resistance.

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The Value of Soil

¶ 5.8



The Reality

Soil feeds the world, but farm fields lose it much faster than nature makes it.

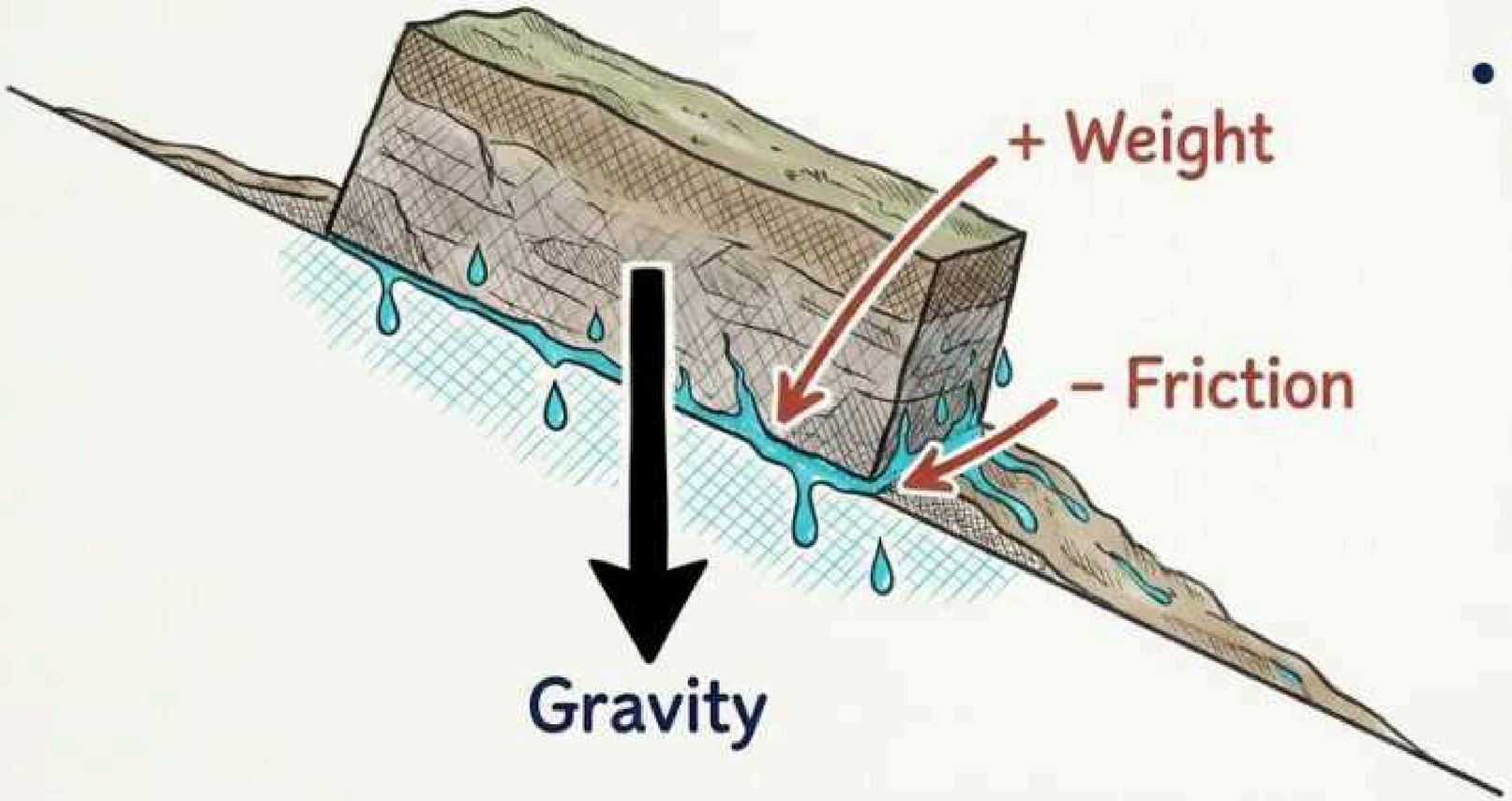
The Takeaway

Soil conservation is one of the most practical and vital applications of Earth science.

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¶ 5.9

Gravity & Mass Wasting



- Triggers for Mass Wasting:
  - Heavy rain on a steep slope
  - Earthquakes
  - Road cuts and artificial grading

From slow soil creep to sudden landslides—this is exactly why hazard maps matter.

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River Transport Mechanics

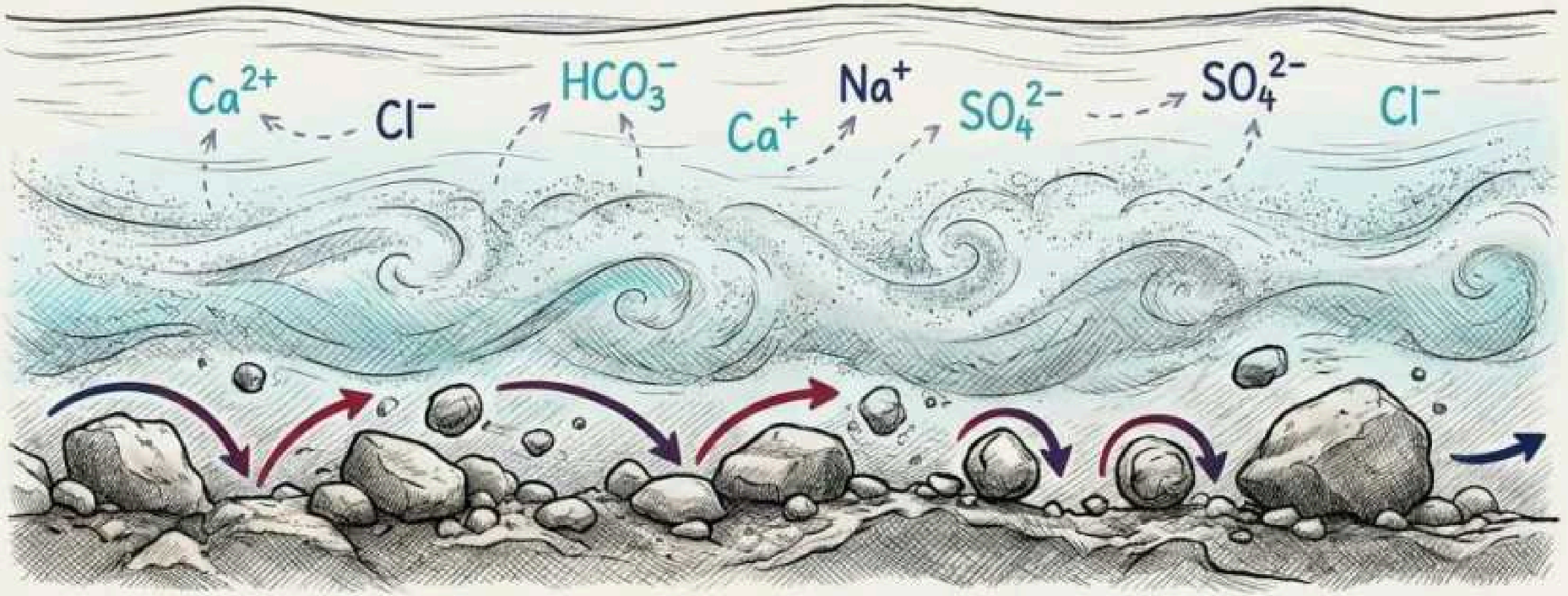
¶ 5.10

The Conveyor Belt to the Sea

Dissolved Load
(Chemical ions)

Suspended Load
(Fine silt & clay)

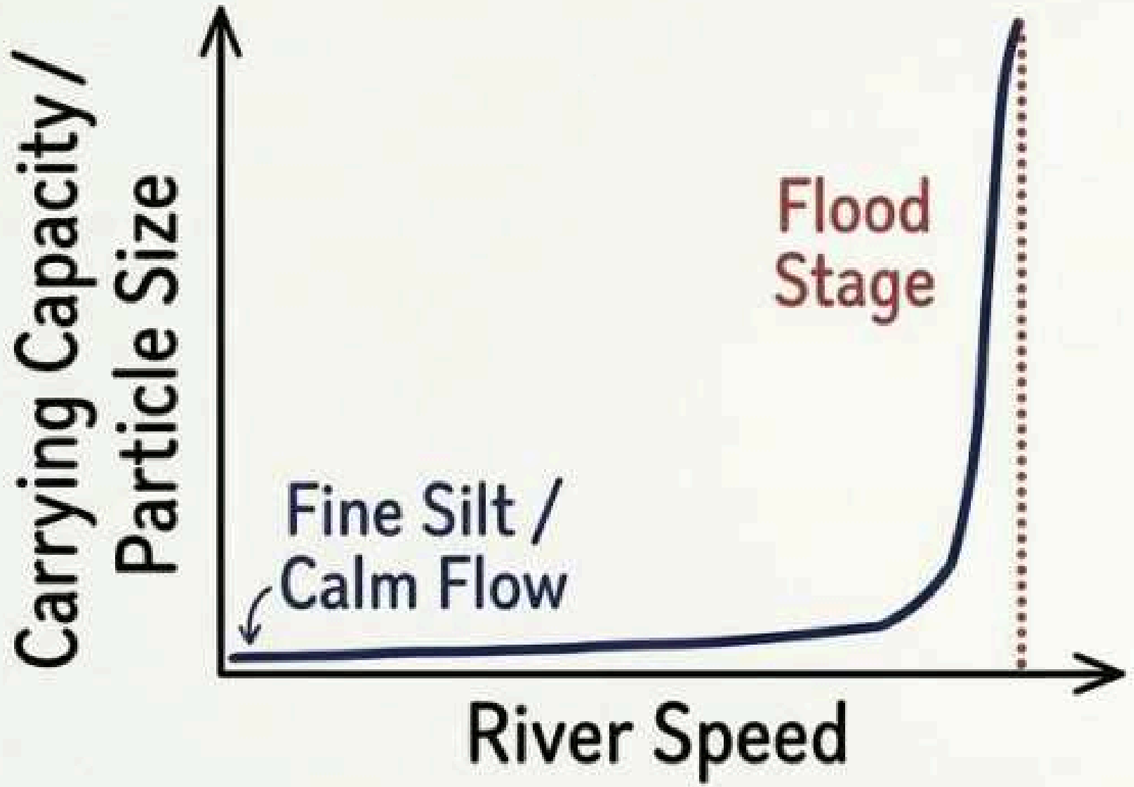
Bedload
(Coarse fragments)



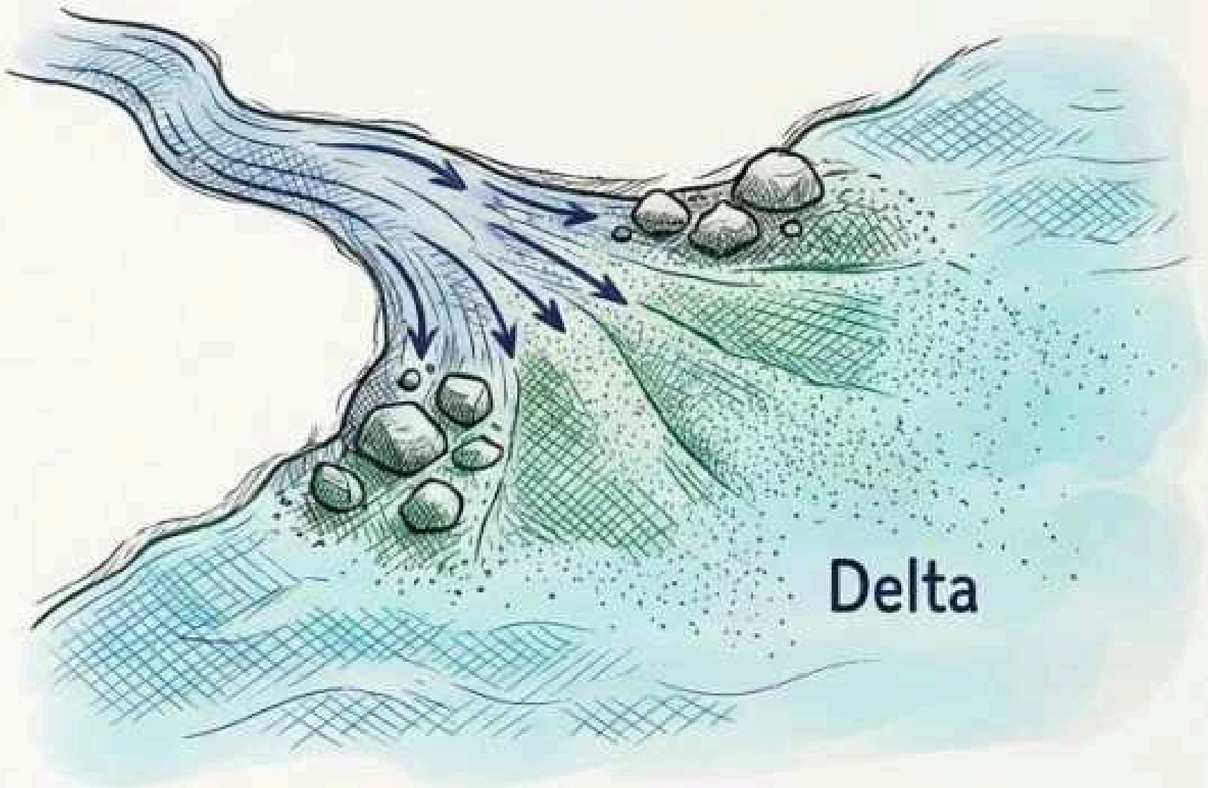
Statistic: Rivers move ≈ **20 Billion Tons** of sediment to the oceans every year. Most **erosion** on Earth is done by **running water**.

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¶ 5.11



A flood does more work in in a few days than years of normal flow.



When a river slows, speed drops to zero. It drops its load in order, from coarse to fine.

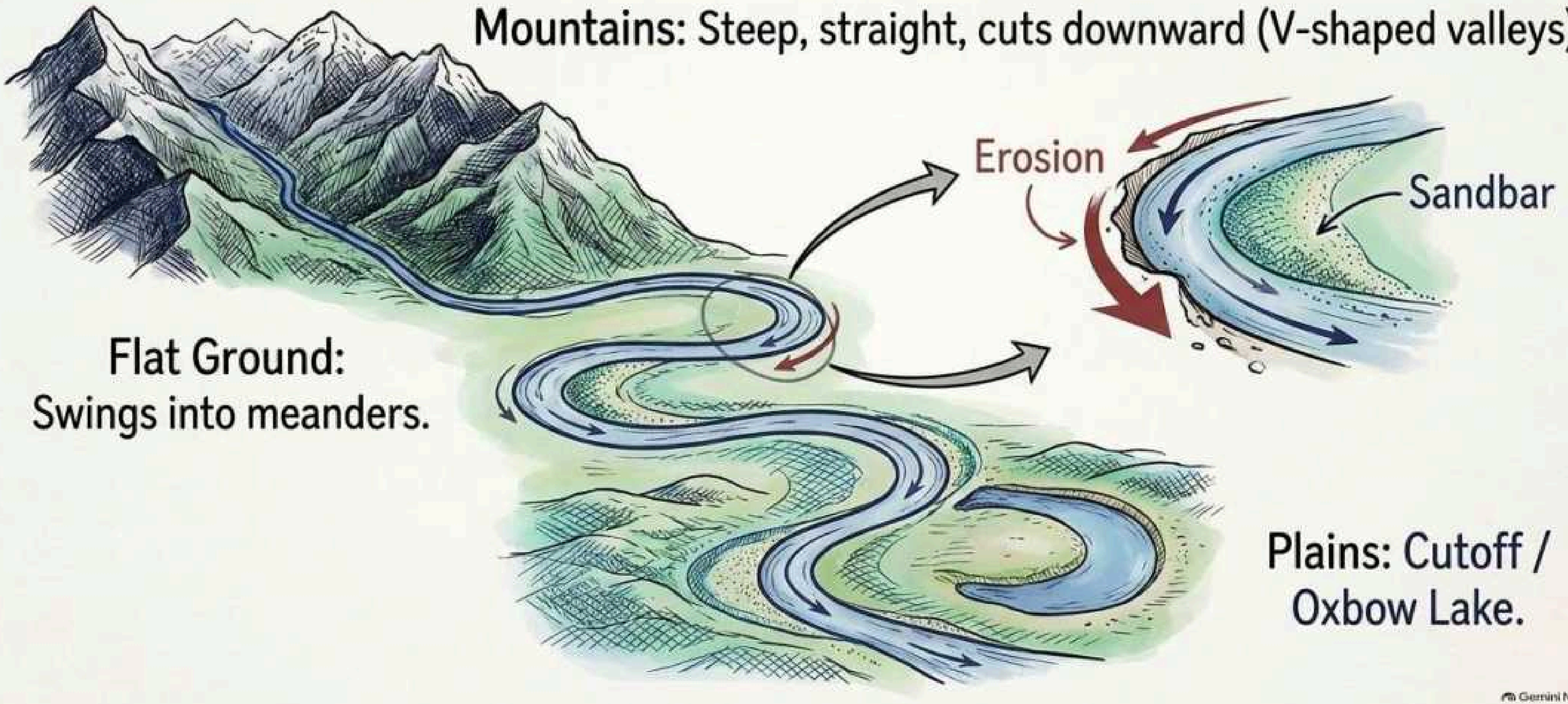
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River Anatomy Over Time

¶ 5.12

A river's shape changes along its length based on slope

Mountains: Steep, straight, cuts downward (V-shaped valleys).



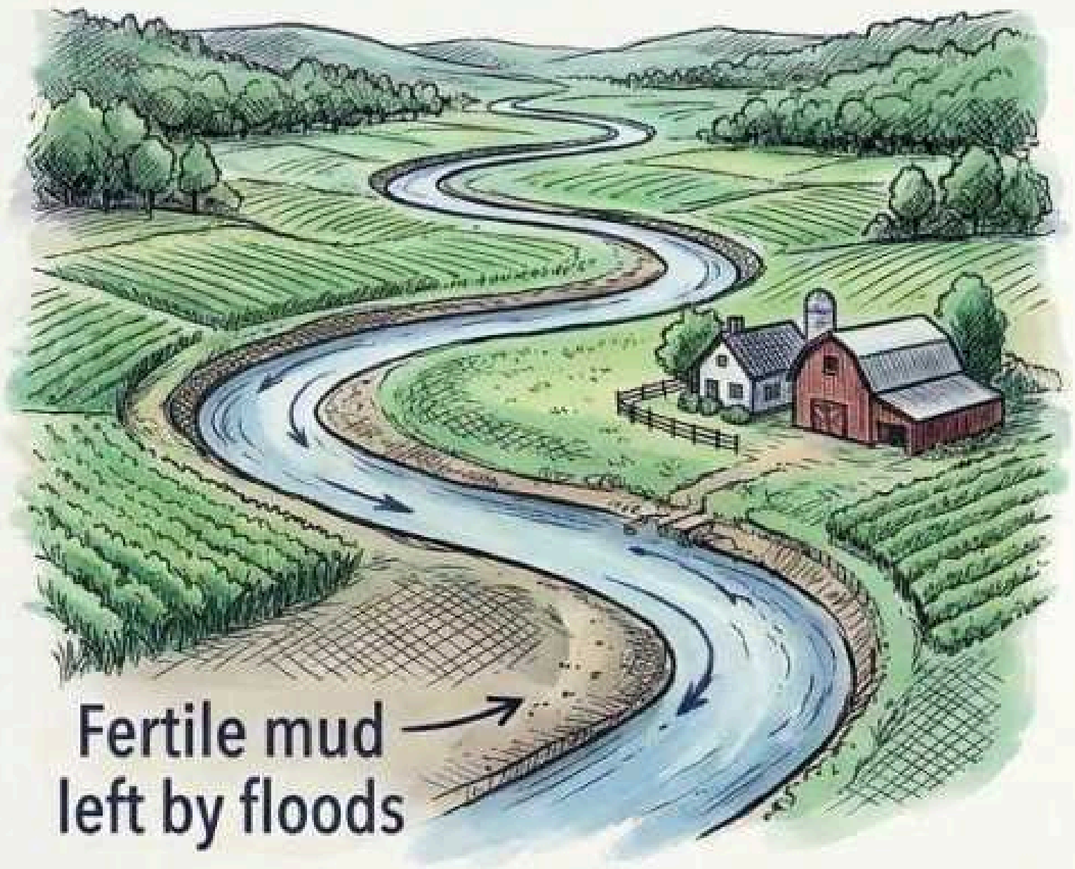
Flat Ground:
Swings into meanders.

Plains: Cutoff / Oxbow Lake.

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Floodplains & Probability

¶ 5.13



The Myth: "A 100-Year Flood happens once a century."

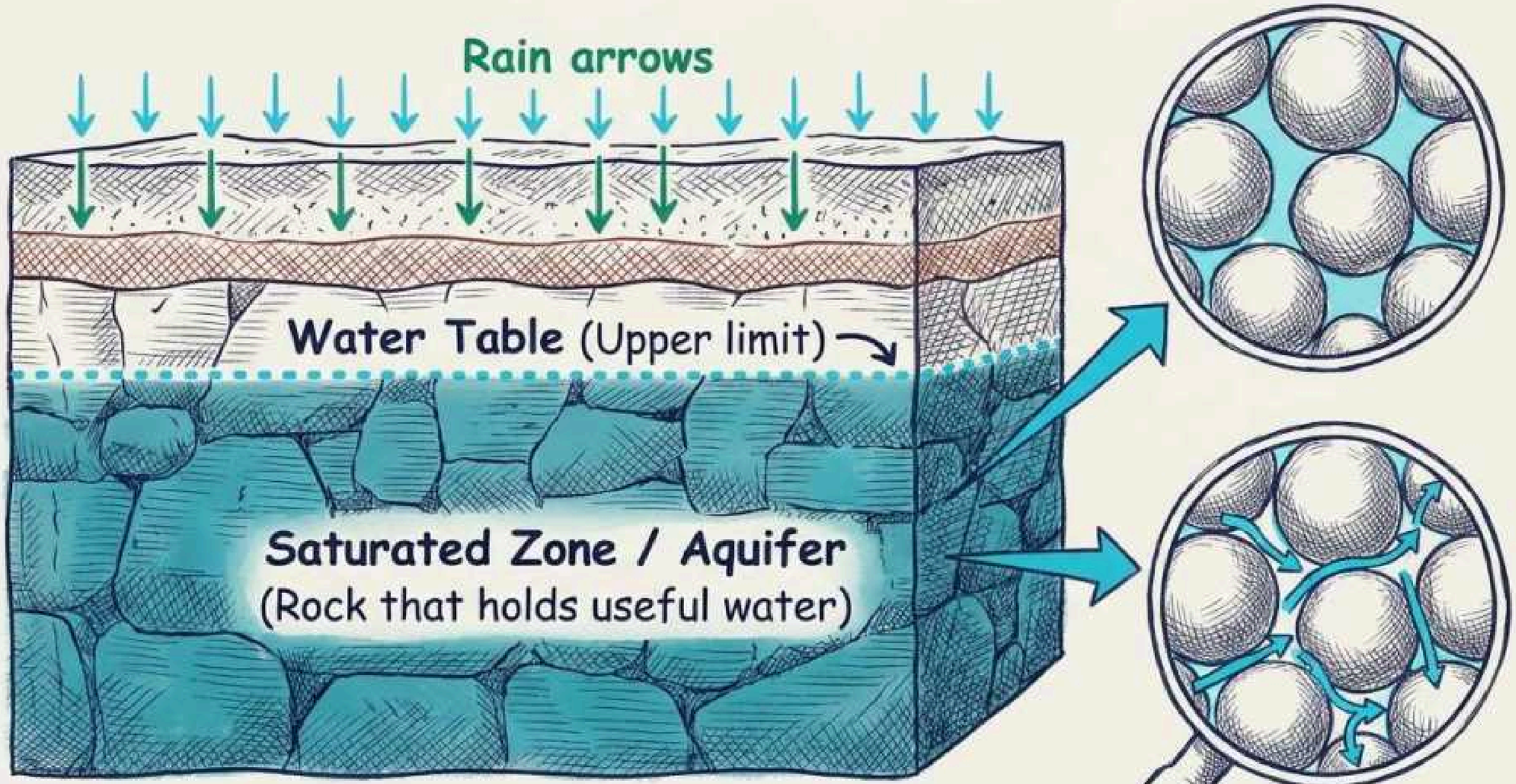
The Reality: P = 1% chance of flood in ANY given year.

Can a 100-year flood happen two years in a row? YES.

People farm and build on floodplains because the soil is fertile, then are surprised when the probability catches up.

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Groundwater Basics



Porosity

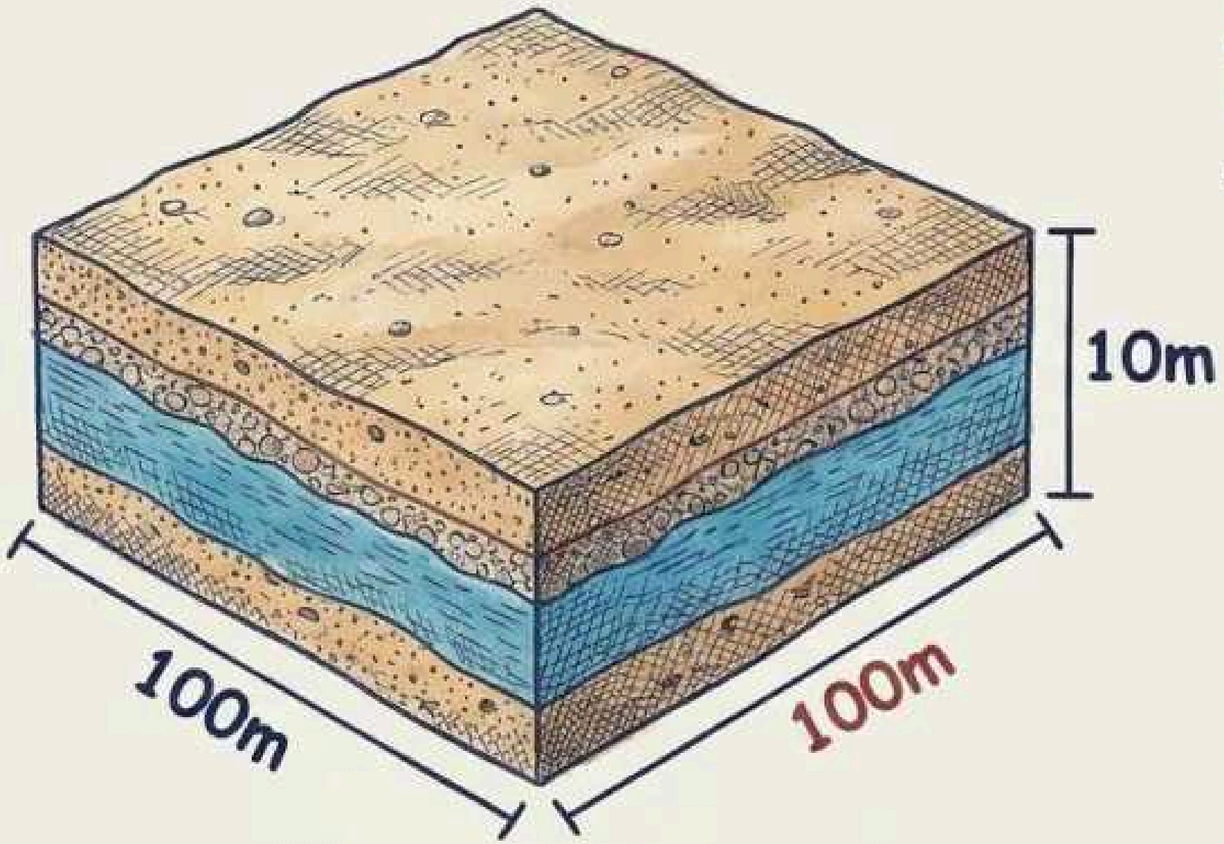
% of open space.

Permeability

How well the spaces connect.

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The Aquifer Equation



$$\text{Total Volume} = L \times W \times H$$

$$\text{Total Volume} = 100\text{m} \times 100\text{m} \times 10\text{m}$$
$$= 100{,}000\ \text{m}^3$$

$$\text{Porosity} = 25\%$$

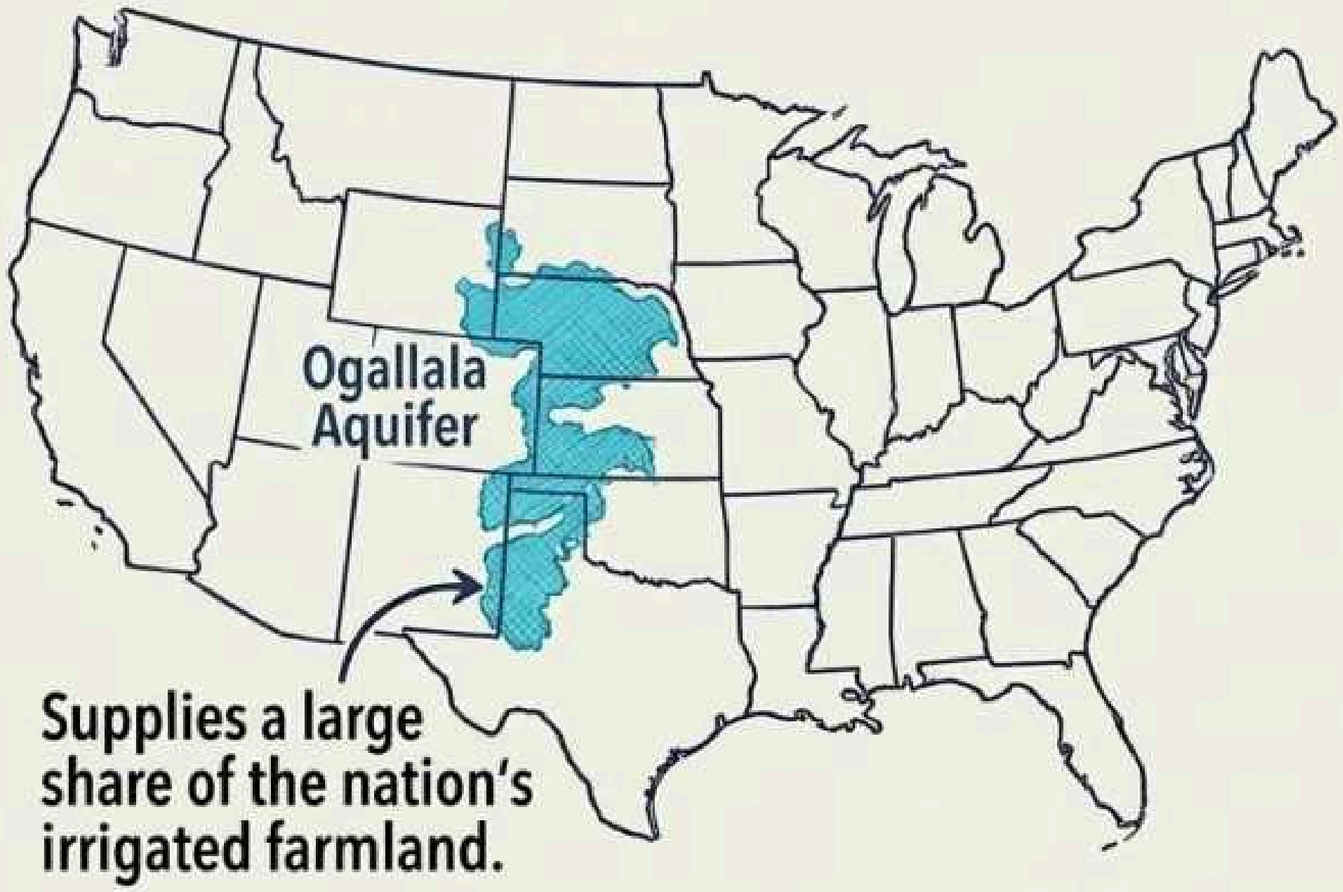
$$\text{Water Held} = 100{,}000\ \text{m}^3 \times 0.25$$
$$= 25{,}000\ \text{m}^3$$

(25 Million Liters)

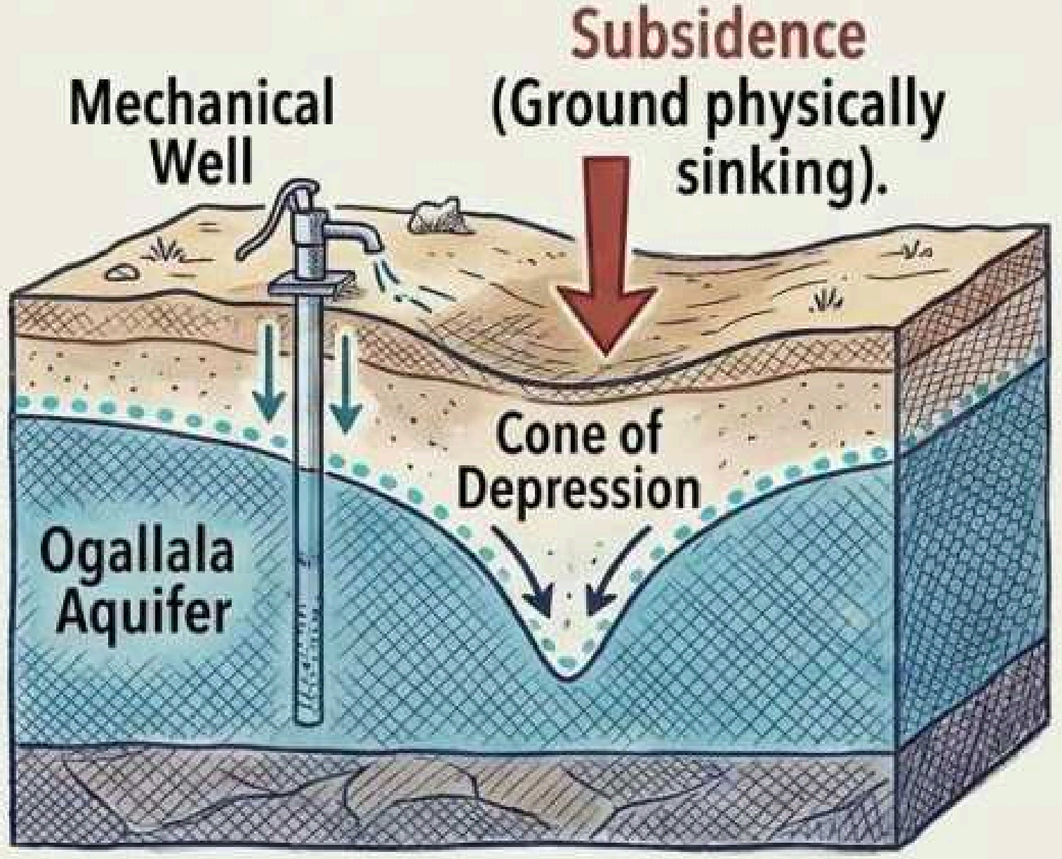
Crucial Warning: Groundwater moves incredibly slowly (often only meters per year). Therefore, a polluted aquifer stays polluted for generations.

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Depleting the Reserves



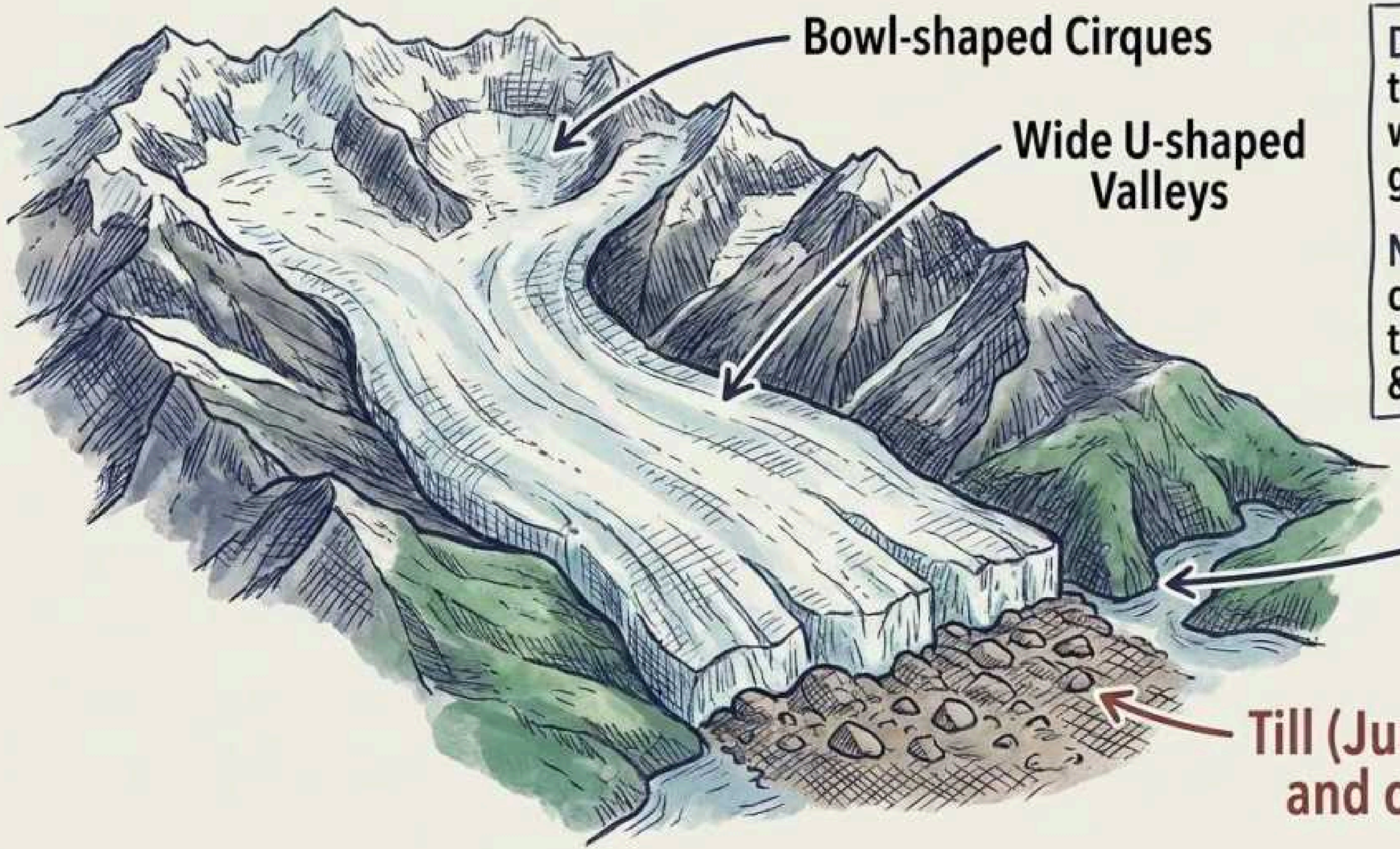
Supplies a large share of the nation's irrigated farmland.



Groundwater can be used faster than rain replaces it. Pumping draws the water down and causes the land to sink.

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Glacial Carving



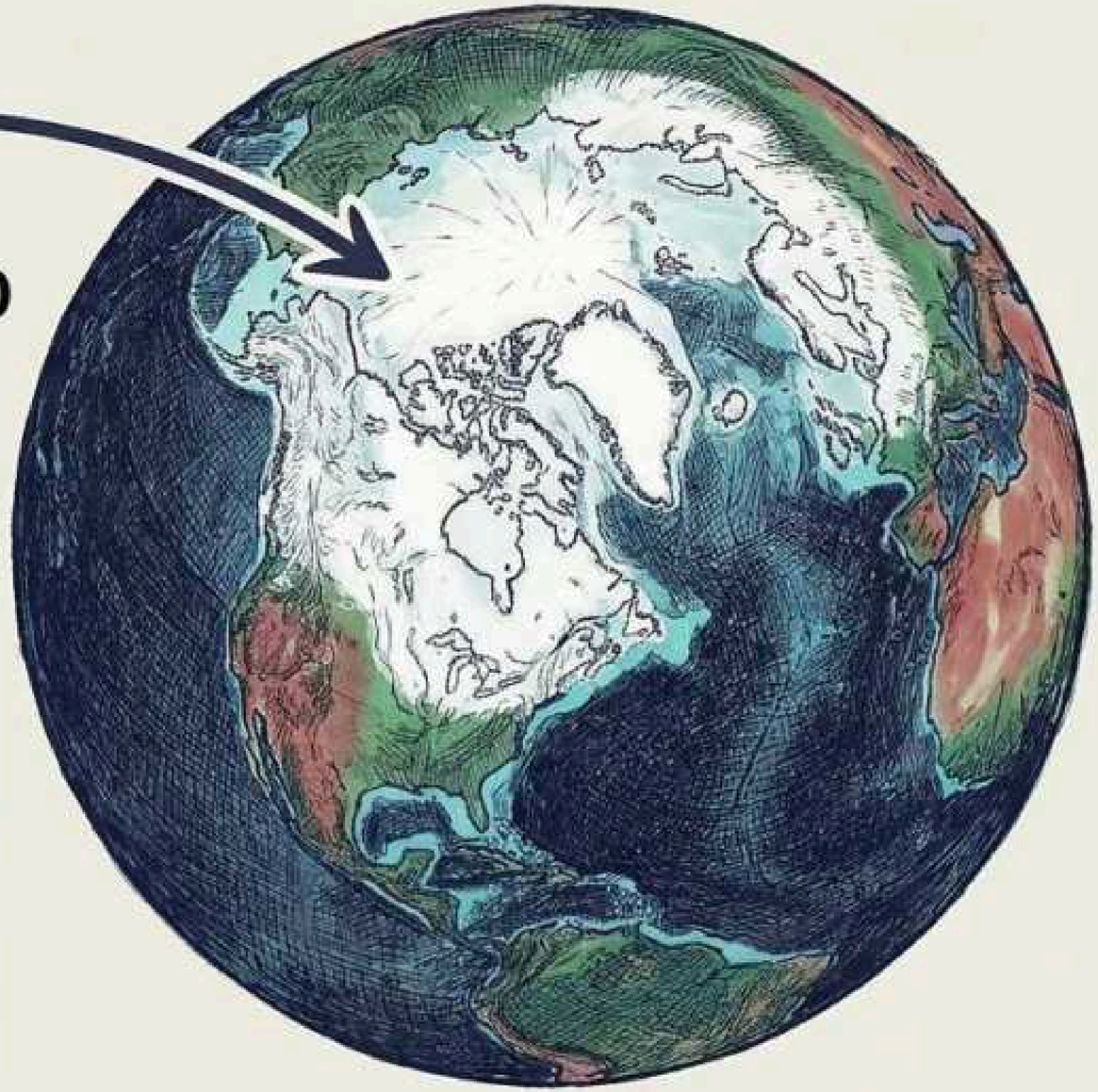
Definition: A mass of ice that flows under its own weight, plucking and grinding rock.

Note: Ice currently covers ~10% of land today (mostly Antarctica & Greenland).

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The Ice Ages

Last Glacial Maximum: 20,000 Years Ago



The Driver

Driven by slow, predictable changes in the Earth's orbit.

The Legacy

These ice sheets created the Great Lakes, the Norwegian fjords, and the rock-strewn fields of New England.

The Impact

Because so much water was locked in ice, global sea level stood ≈ 120 meters lower than today.

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Ice as Water Storage

+ 65 Meters: Potential sea level rise if all land ice melts.

(Not happening soon, but shows the sheer volume stored).





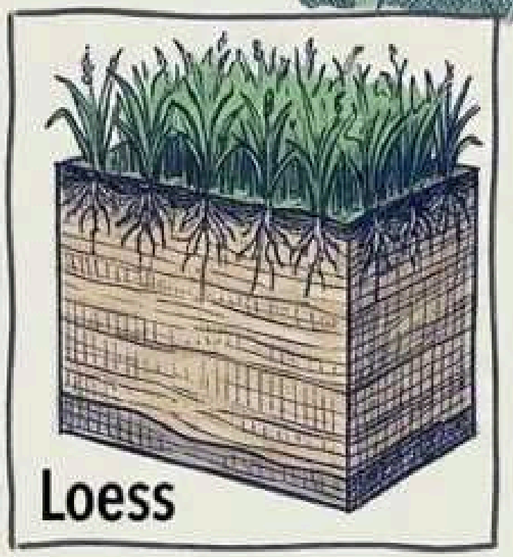
Glaciers supply critical river water for hundreds of millions of people.

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Wind Forces & Global Connections

Sahara dust crosses the ocean to fertilize the Amazon with phosphorus.

Sahara



Wind-blown silt builds some of the richest farmland on Earth (e.g., the Loess Plateau of China, which is hundreds of meters thick).

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The Synthesis Question

¶ 5.21

The Setup

Limestone

Quartz Sandstone

After 10,000 years of rain and frost, which will be more worn down?

Limestone (Carbonic Acid dissolution).

The Journey



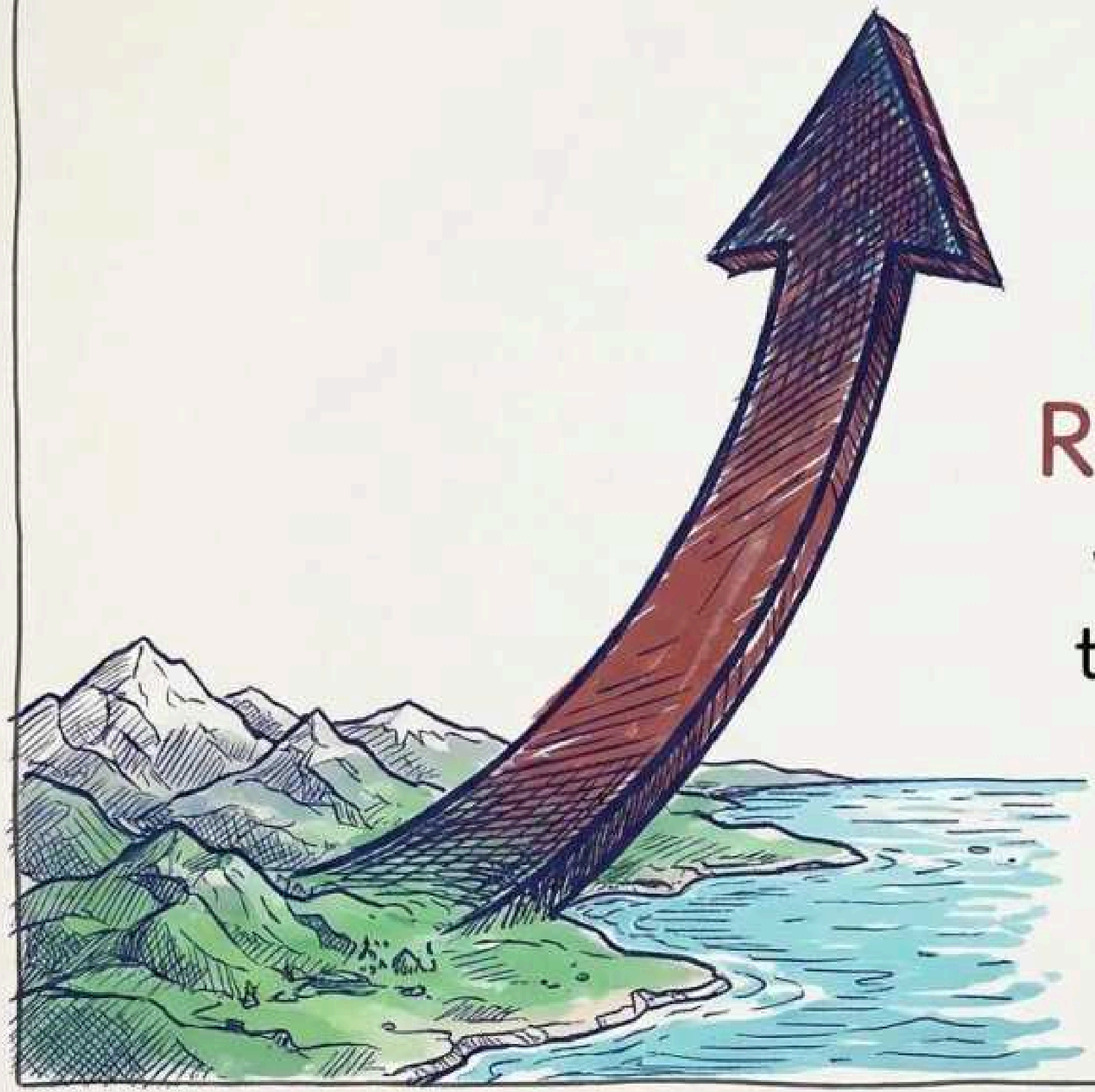
Weathering (Breakdown)

Erosion (Transport begins)

River Load (Conveyor belt to sea)

Ocean (Final deposition)

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Up Next — Lecture 6:
Rising above the ground.

We will study the atmosphere, the oceans, and the climate they produce together.

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