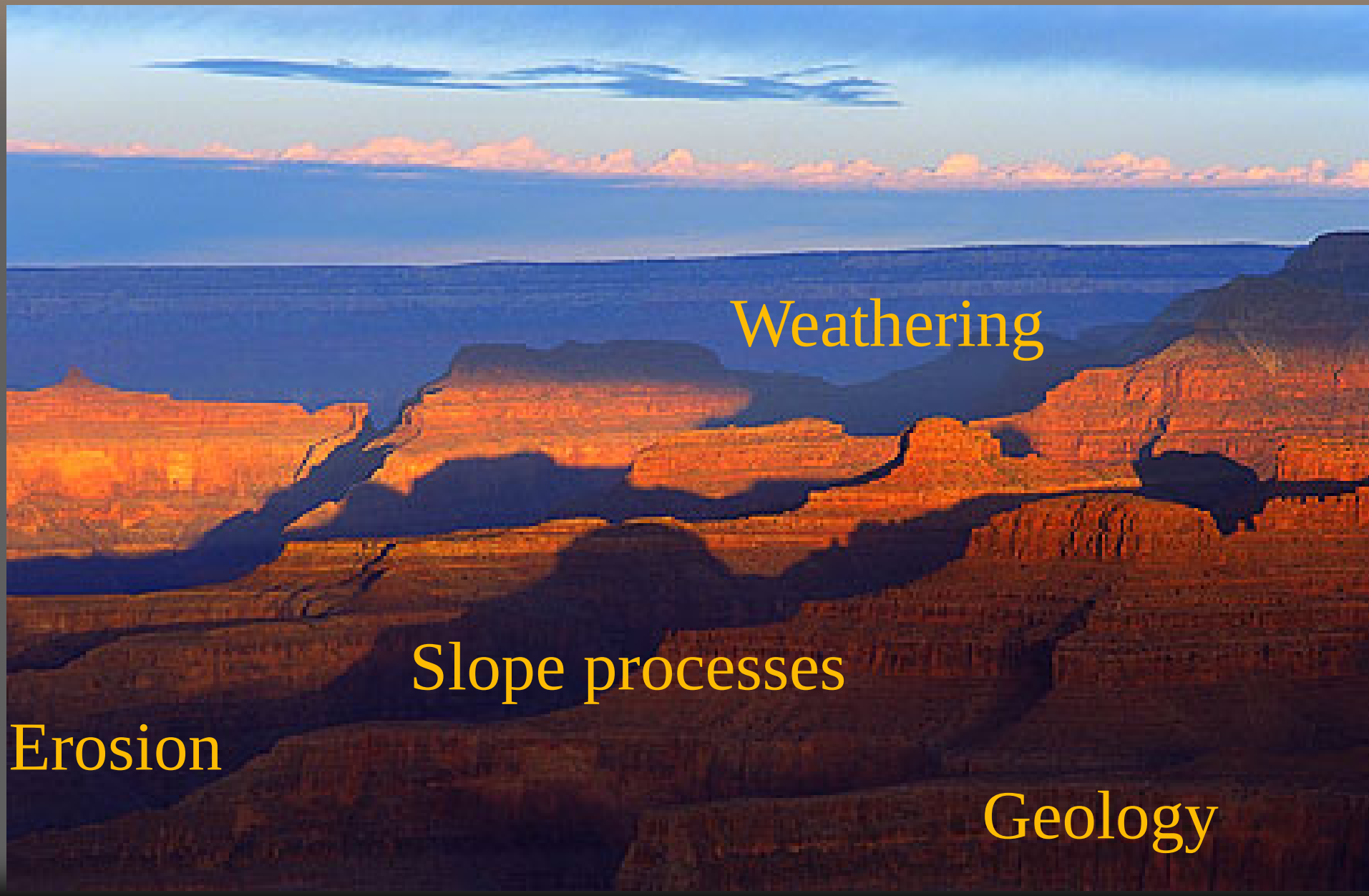
Weathering and Erosion



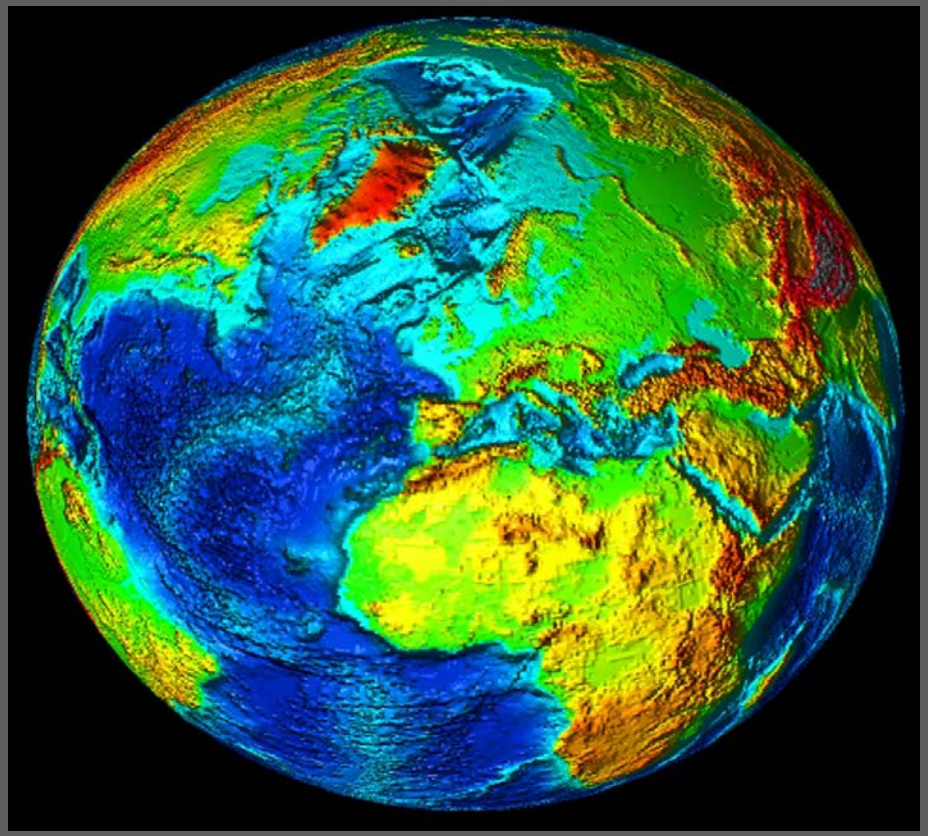
The beginning or end of the conservation story?

Introduction



Our Planet: The basic principles

- Atmospheric (meteorology)
  - Weather vs climate
  - Latitude
  - Altitude
  - Ocean currents
- Hydrologic (water)
  - Oceans/rivers/lakes/sub-terrestrial
  - Hydrological cycle
- Lithospheric (geology)
  - Soils
  - plate tectonics
  - rocks
- Biospheric (biogeography)
  - ecology
  - ecosystems

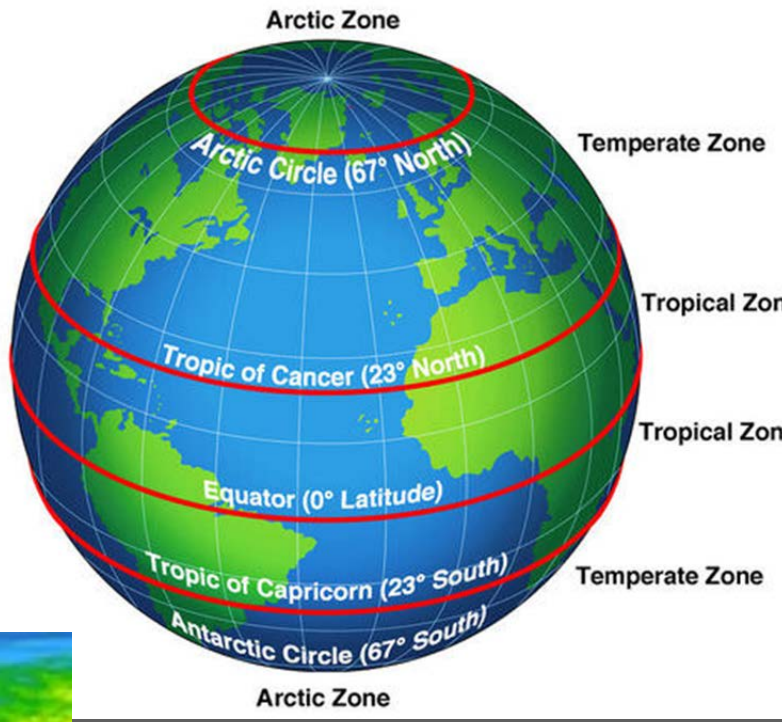


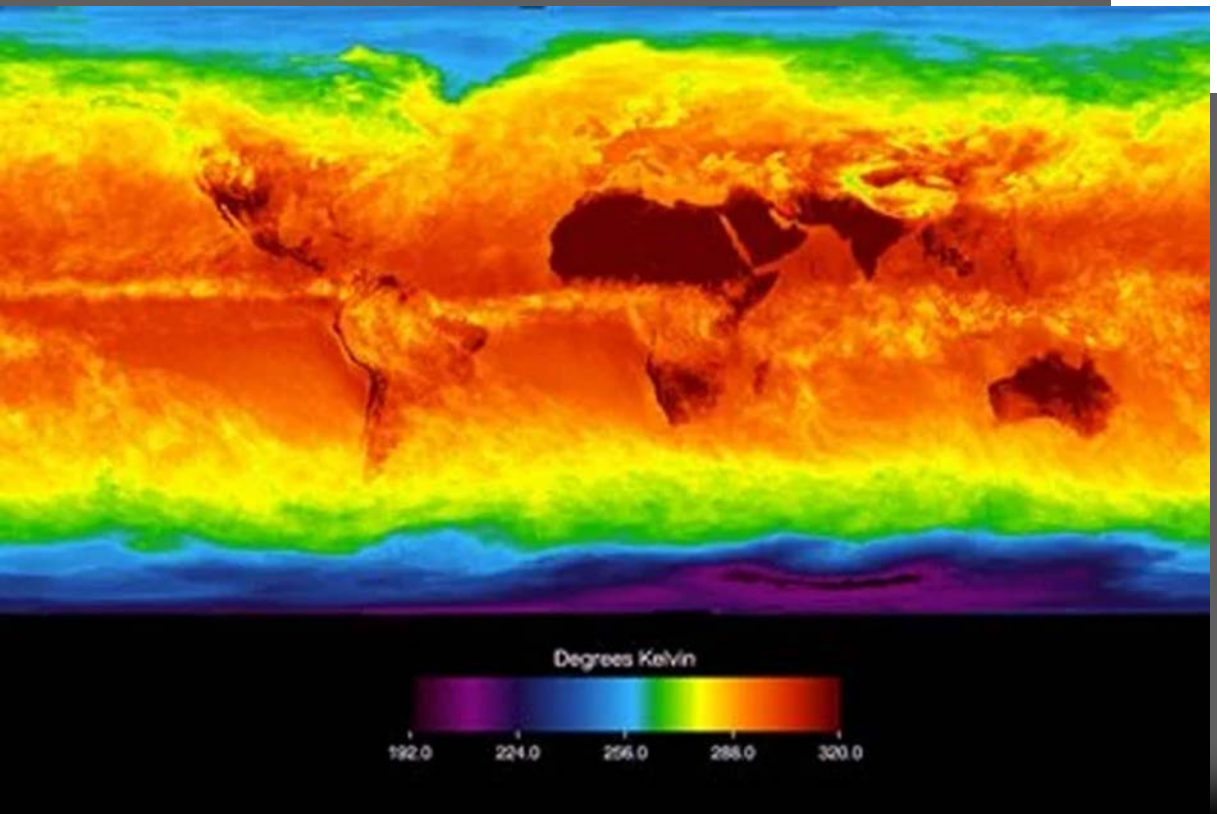
Weather vs climate

- BBC Weather forecast
- https://www.bbc.co.uk/iplayer/episode/m000rynk/weather-for-the-week-ahead-03022021

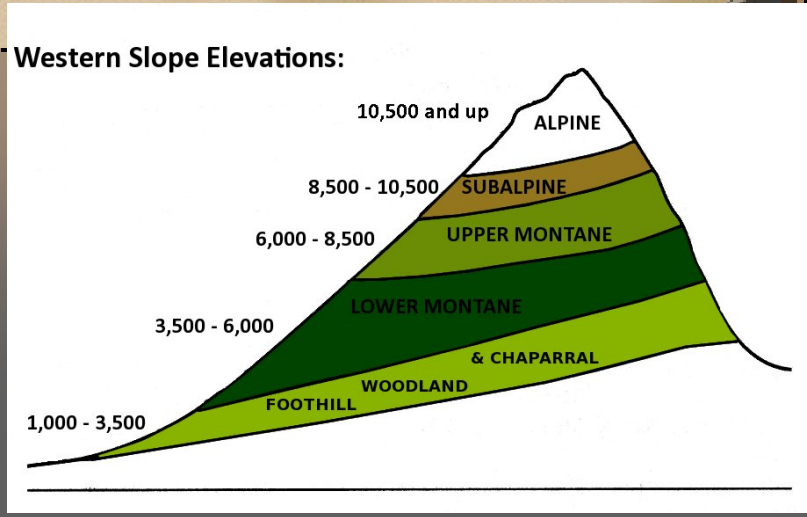


Latitude


Arctic Zone
Arctic Circle (67° North)
Temperate Zone
Tropical Zon
Tropic of Cancer (23° North)
Tropical Zon
Equator (0° Latitude)
Tropic of Capricorn (23° South)
Temperate Zone
Antarctic Circle (67° South)
Arctic Zone

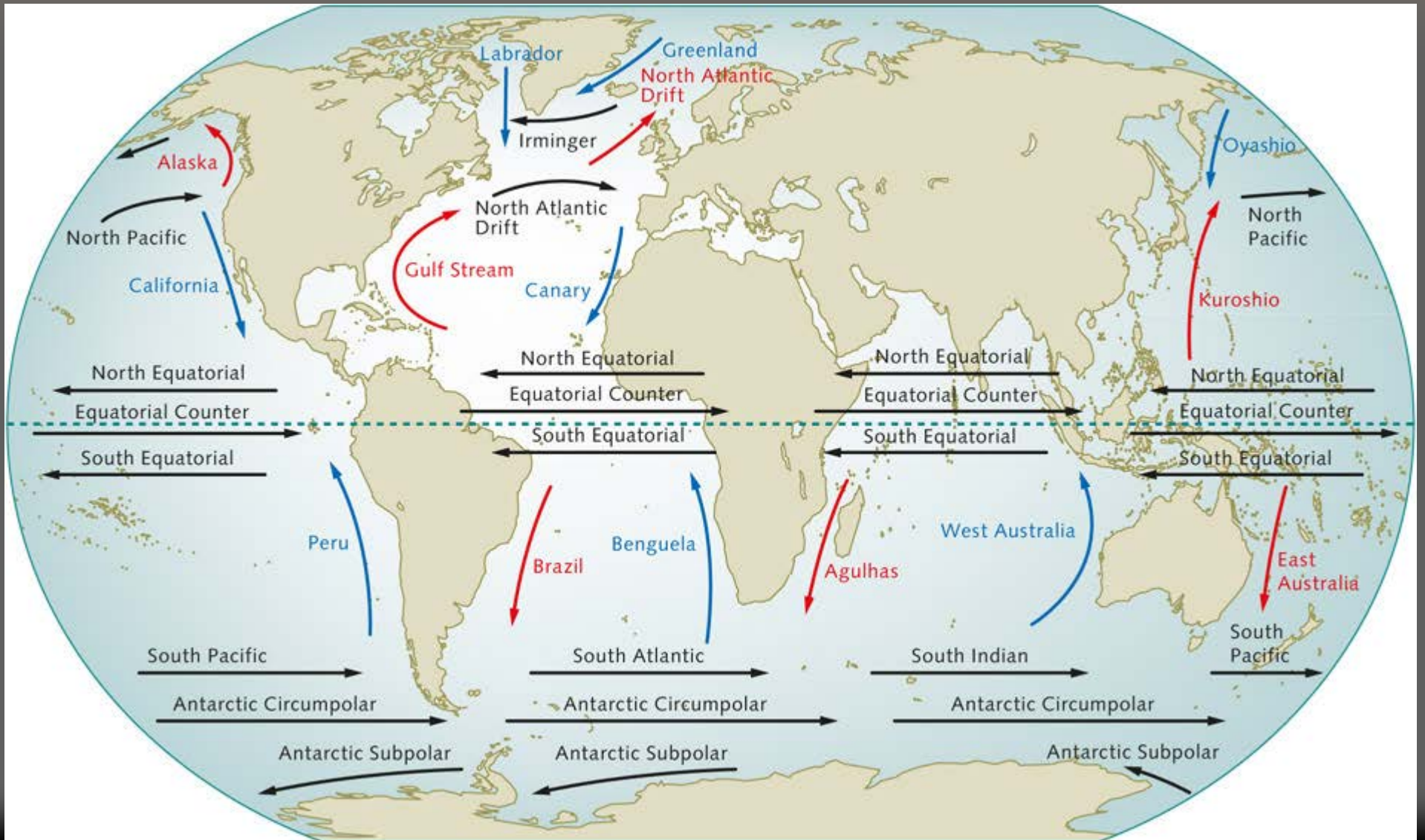

Degrees Kelvin
192.0
224.0
256.0
288.0
320.0

Altitude

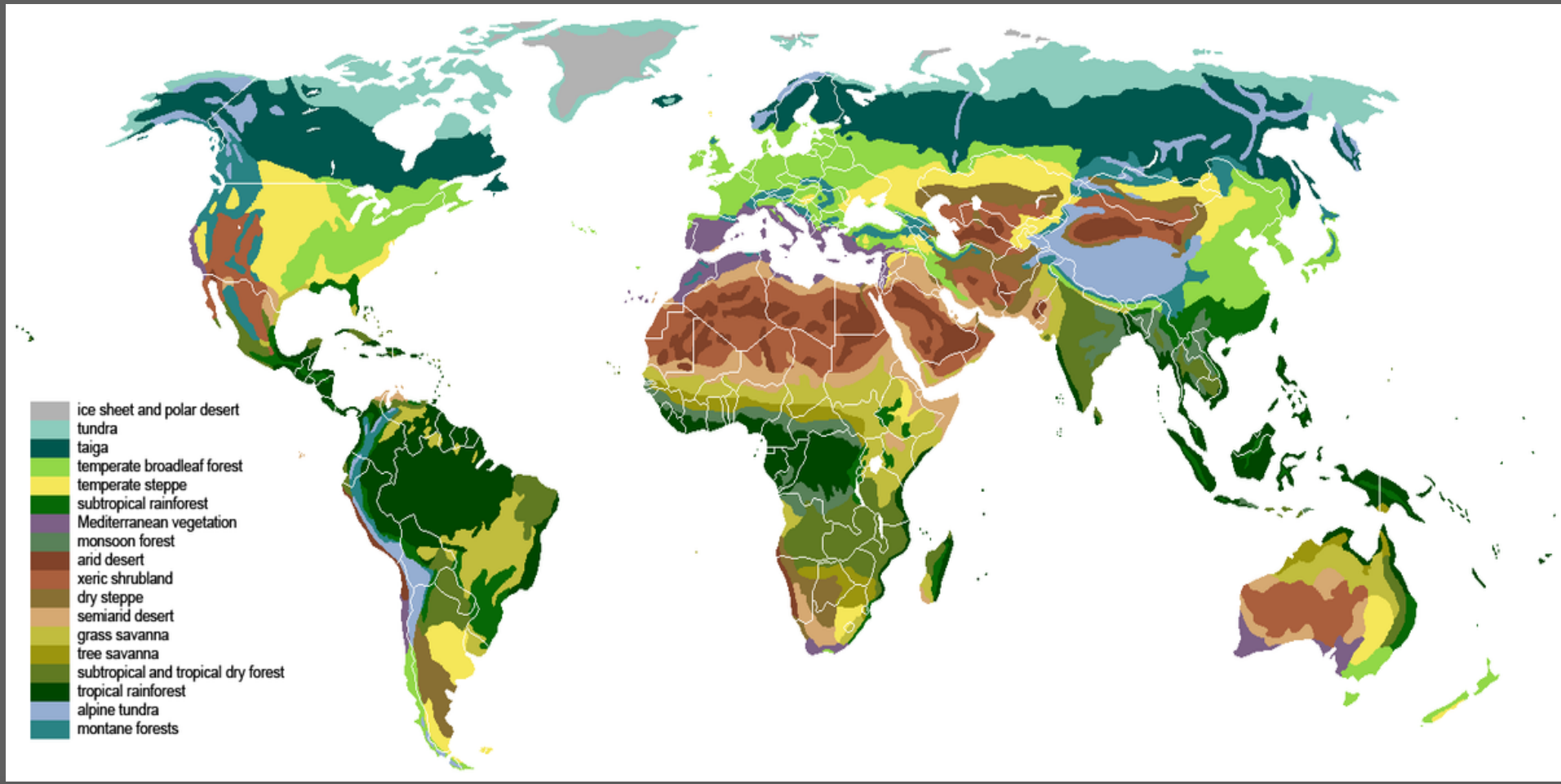

Western Slope Elevations:
10,500 and up
ALPINE
8,500 - 10,500
SUBALPINE
6,000 - 8,500
UPPER MONTANE
3,500 - 6,000
LOWER MONTANE
& CHAPARRAL
WOODLAND
FOOTHILL
1,000 - 3,500



Ocean currents



Complexity within order



Oceans/rivers/lakes/sub-terrestrial





Oceans/rivers/lakes/sub-terrestrial

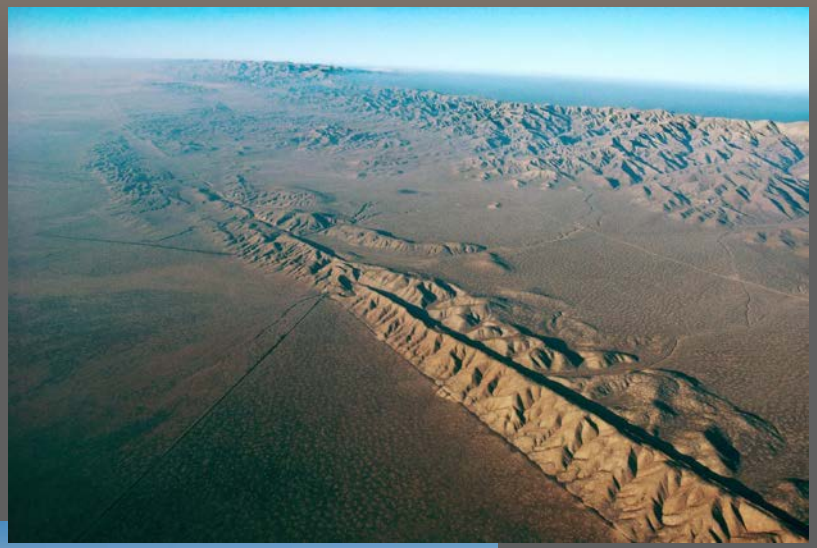






Rocks, Soils and plate tectonics

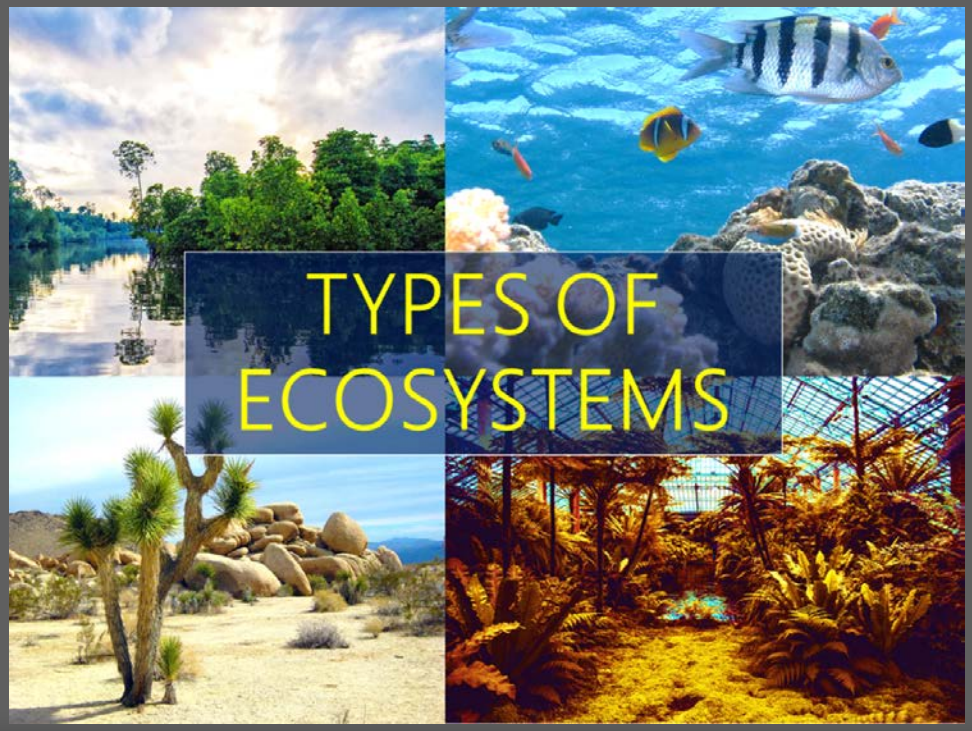




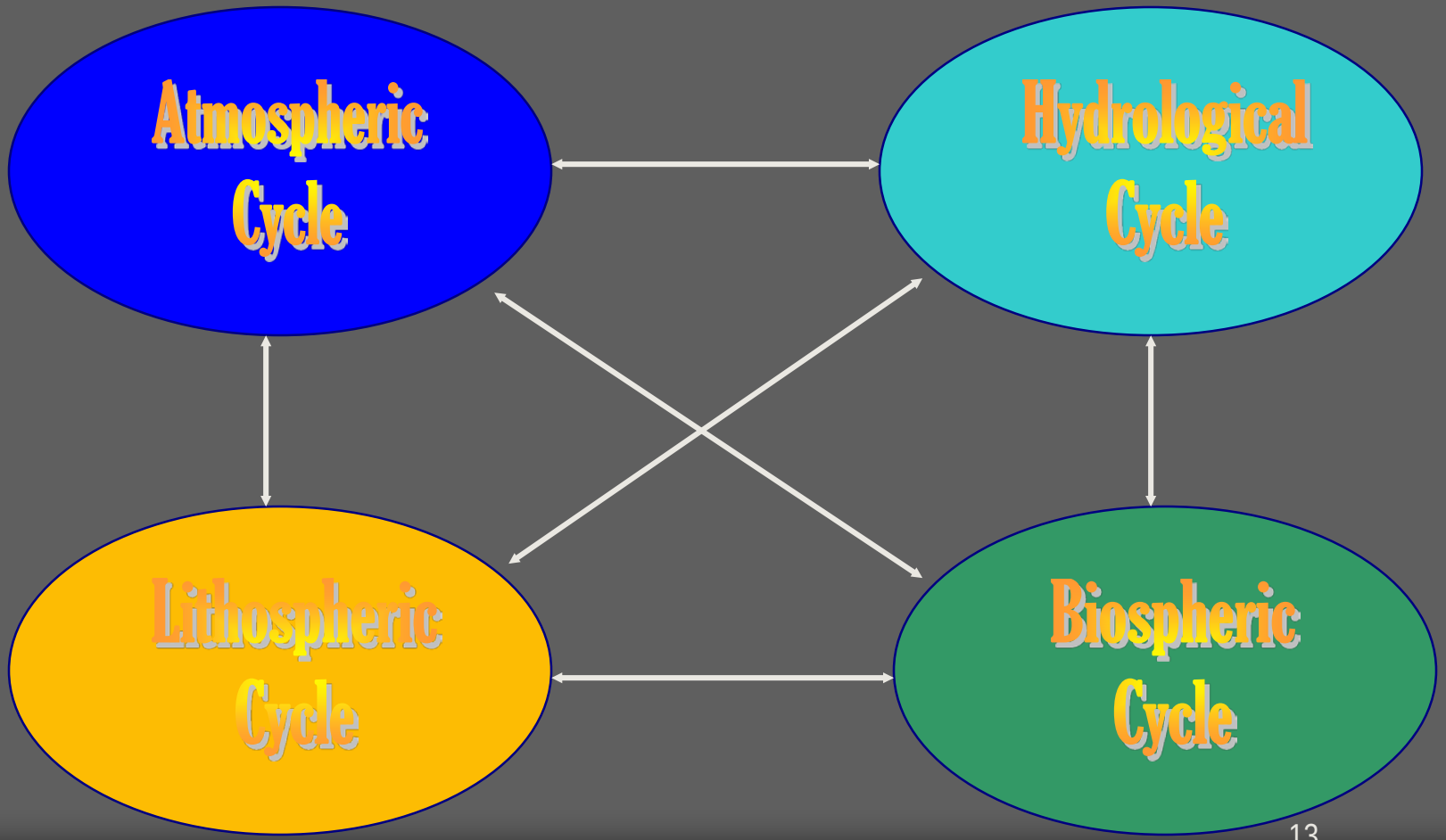




Ecology and ecosystems



Interaction of these principles which creates the habitats we conserve



Anthropogenic



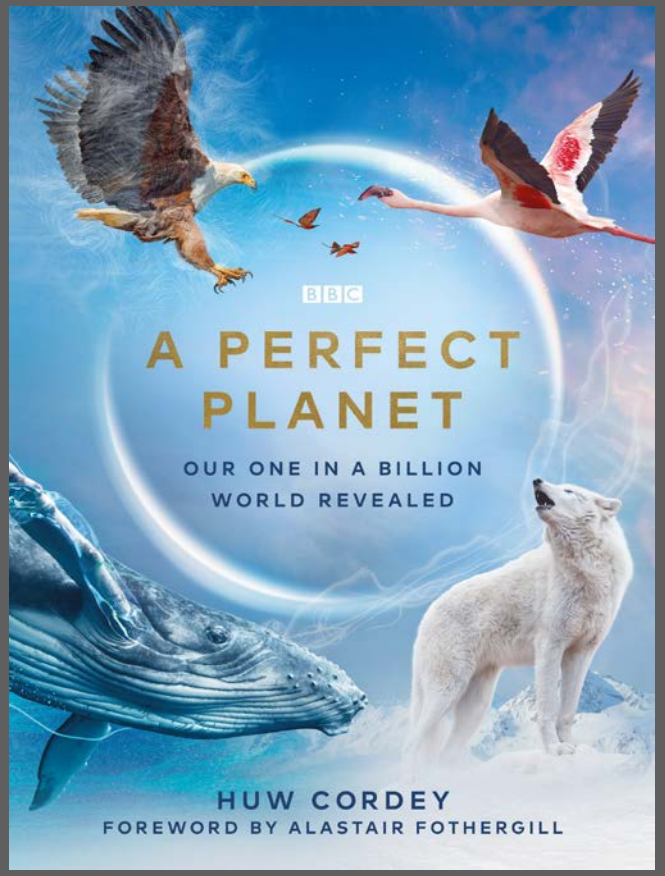






A Perfect Planet. Humans

- https://clickv.ie/w/2hpp
- Go through the link and note how an understanding of the physical landscape is important to conservation.
- Present and discuss.



What is Geology

- **Definition**
  - *"the study of the origin, structure and composition of the earth."* (Collins, 2004: 348)

- **Rock Types**
  - Igneous
  - Sedimentary
  - Metamorphic

- **Rock Description**
  - **Table**





Granite

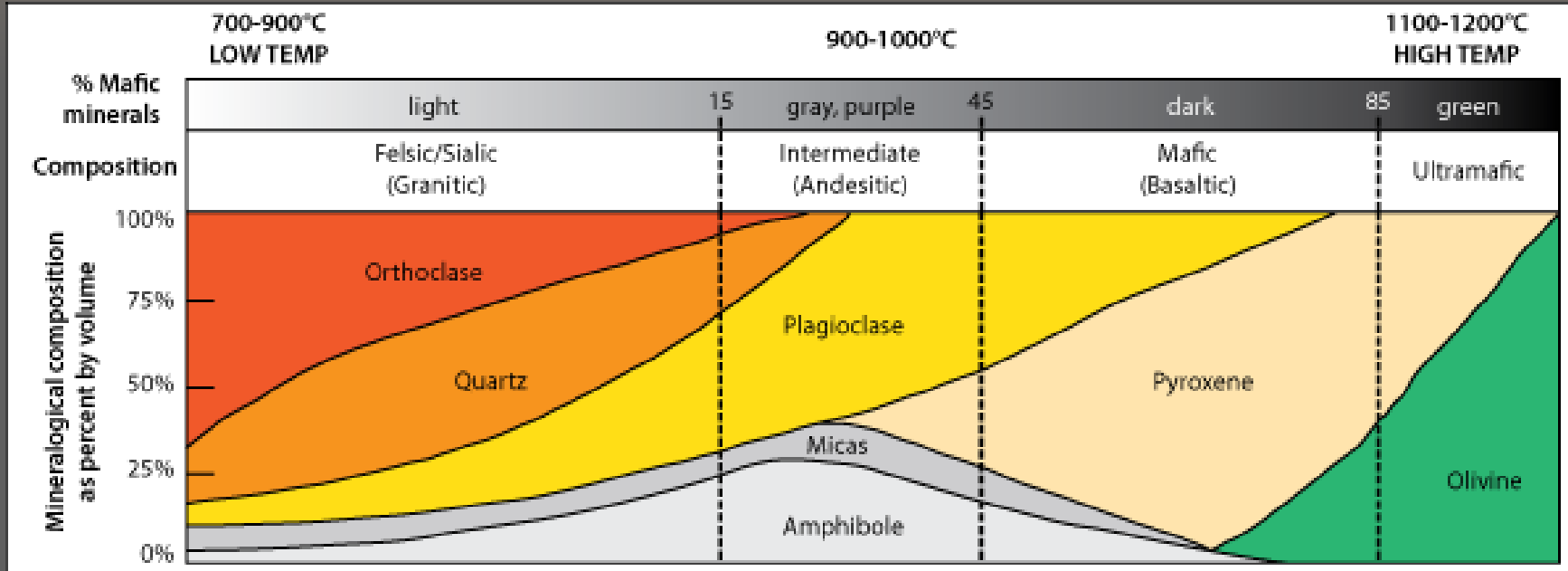


Mauna Loa, Hawaii

Igneous rock:

Intrusive or extrusive

Igneous rock identification



Texture	Rock names			
Coarse-grained	Granite	Diorite	Gabbro	Peridotite
Fine-grained	Rhyolite	Andesite	Basalt	Uncommon (rarely encountered)
Pyroclastic	Rhyolite Tuff	Andesite Tuff	Basalt Tuff	
Glassy	Obsidian			
Vesicular	Pumice (like meringue)		Scoria	

The various environments that create sedimentary rocks



Swamp
Floodplain
Glacier
Sand dunes
Salt flats
Playa lake
Alluvial fans



Glacial deposits



Estuary
Barrier island
Reef
Beach
Lake
Delta
Lagoon
Spit

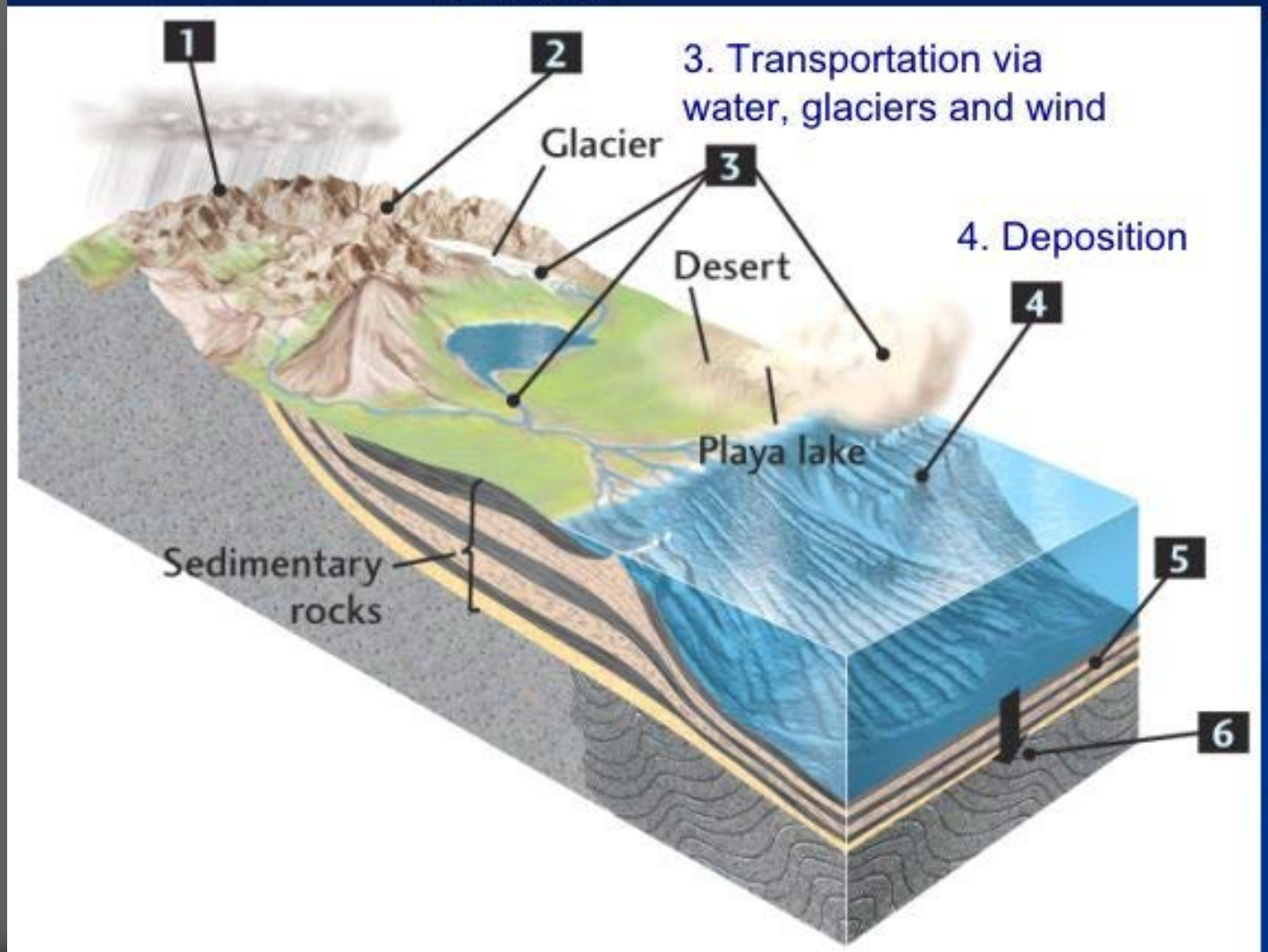


Stream
Deep-sea fans
Turbidity current

Sediment stages

1. Weathering

2. Erosion



5. Burial and compaction

6. Diagenesis


Sandstone
Cross bedding
Why Vegetation?


Pueblo
Oxidation

Shale

'sedimentary my dear Watson'



Shale, near Berlin

Formation

When river's velocity decreases to a level that even fine particles - muds, clay, and silt - are deposited. These sediments are so small that there are very few air spaces between them to prevent the particles from touching. Therefore, just pressure and the evaporation of the water are enough to change these particles into a rock called shale.

Fossils

In some locations, shale rock is sought out for the possibility of fossils that they may contain due to the ability of the sediments to get close to one another, eliminating gaps between the particles, and thus preventing oxygen from reaching the dead organism and rotting it before the sediments can harden into shale.

Fossils

Important indicators of environmental change. Therefore is vital to contemporary comparability

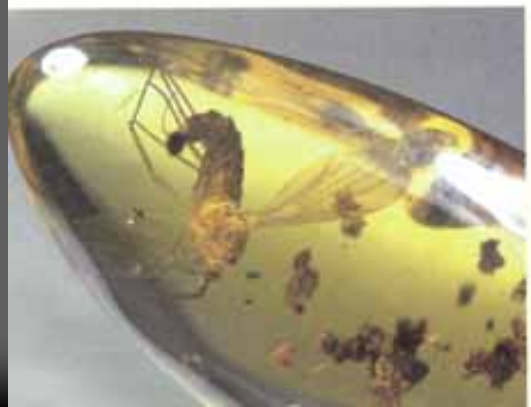




ammonite

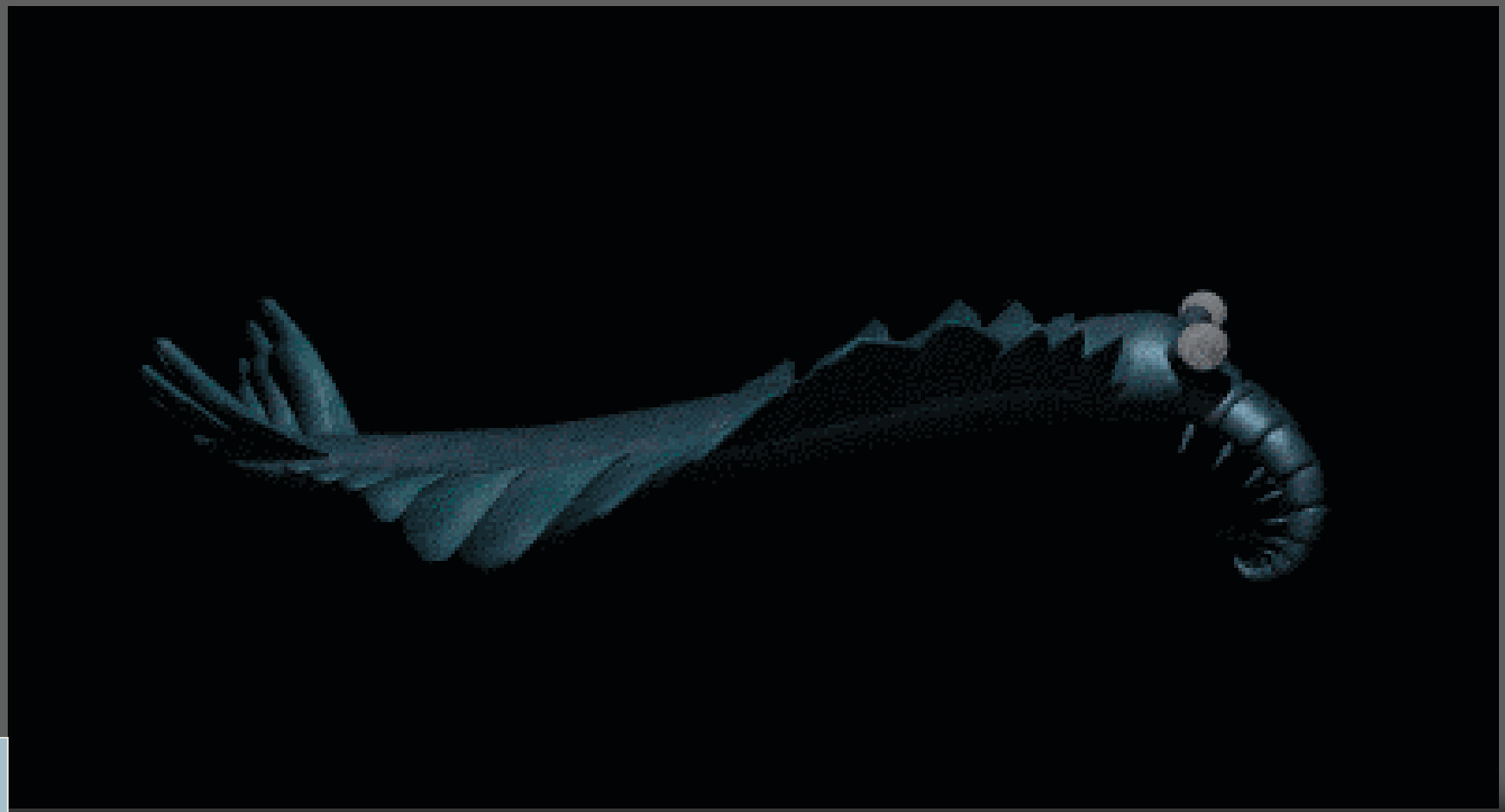








Some animals lived over such a short interval of time (index fossils) that one can tell the geologic interval with it alone. **Hallucigenia** is only found in the early Cambrian: 505 million years ago--from the **Burgess Shale** in the Canadian Rockies.

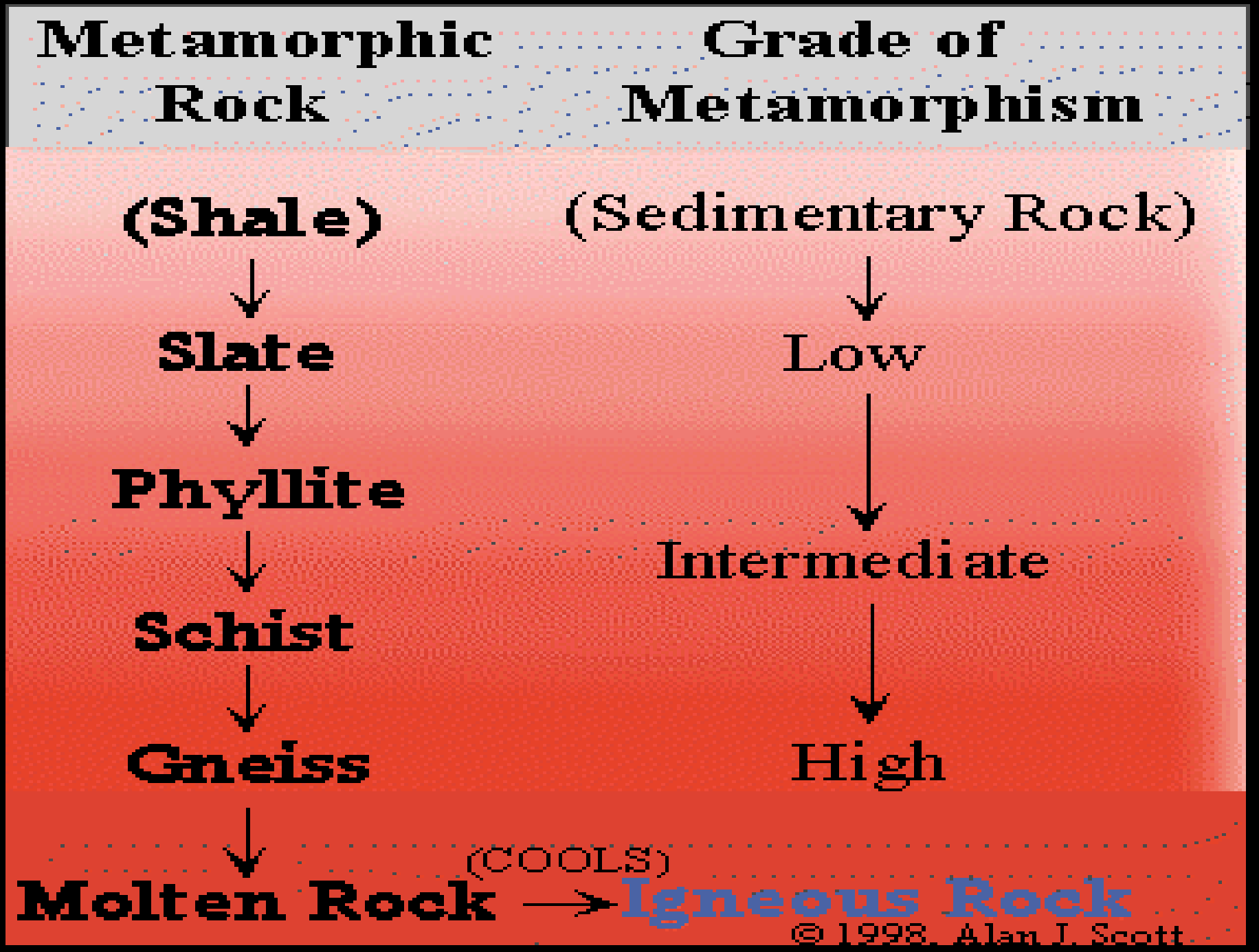


Metamorphic rocks

Rock Name	Texture	Grain Size	Comments	Parent Rock
Slate	Foliated	Very fine	Excellent rock cleavage, smooth dull surfaces	Shale, mudstone, or siltstone
Phyllite	Foliated	Fine	Breaks along wavey surfaces, glossy sheen	Slate
Schist	Foliated	Medium to Coarse	Micas dominate, scaly foliation	Phyllite
Gneiss	Foliated	Medium to Coarse	Compositional banding due to segregation of minerals	Schist, granite, or volcanic rocks
Marble	Nonfoliated	Medium to coarse	Interlocking calcite or dolomite grains	Limestone, dolostone
Quartzite	Nonfoliated	Medium to coarse	Fused quartz grains, massive, very hard	Quartz sandstone
Anthracite	Nonfoliated	Fine	Shiny black organic rock that may exhibit conchoidal fracture	Bituminous coal

Increasing Metamorphism

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Metamorphic Rock
Grade of Metamorphism
(Shale)
Slate
Phyllite
Schist
Gneiss
Molten Rock
(COOLS)
Igneous Rock
(Sedimentary Rock)
Low
Intermediate
High
© 1998 Alan J. Scott

Metamorphic example



Slate



Phyllite

Increase in heat

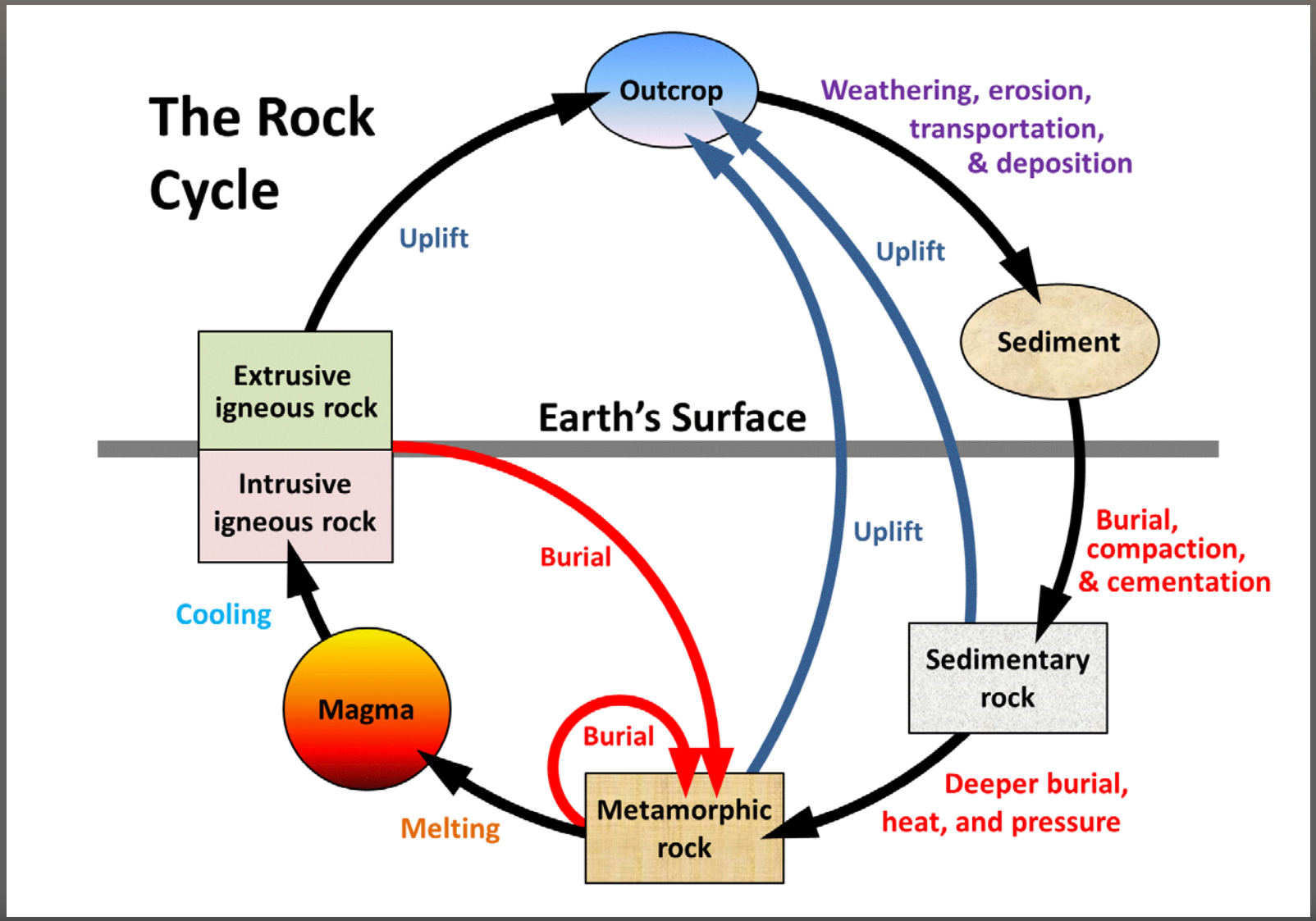
Gneiss



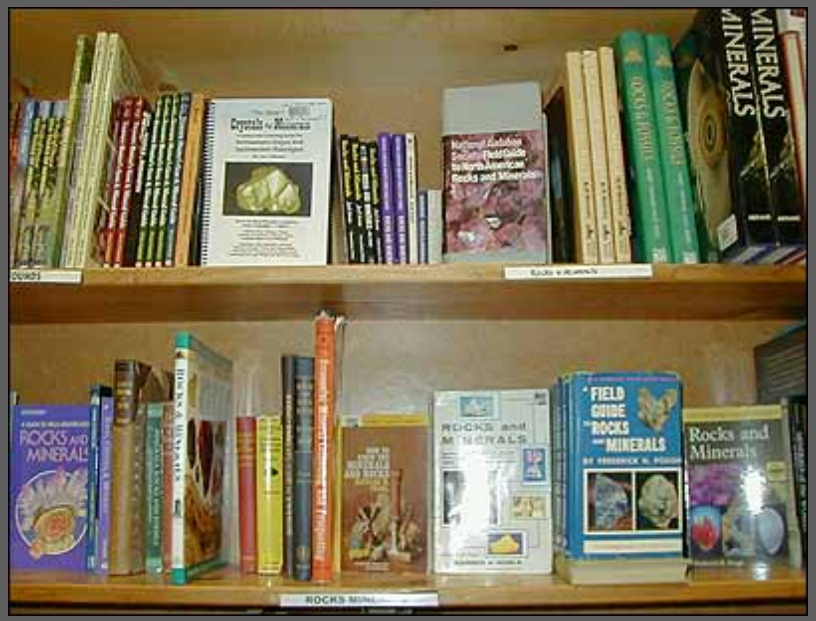
Schist



Rock Cycle


The Rock Cycle
Outcrop
Weathering, erosion, transportation, & deposition
Uplift
Uplift
Sediment
Extrusive igneous rock
Earth's Surface
Intrusive igneous rock
Burial
Uplift
Burial, compaction, & cementation
Cooling
Sedimentary rock
Magma
Burial
Metamorphic rock
Deeper burial, heat, and pressure
Melting

Minerals



- Minerals are made of elements or in itself is an element (e.g gold)
  - Gold
  - Diamond
  - Calcite
  - Mica
  - Ouartz
  - Feldspars

  } Granite
  - Rock variations based on the mix of minerals

Definitions

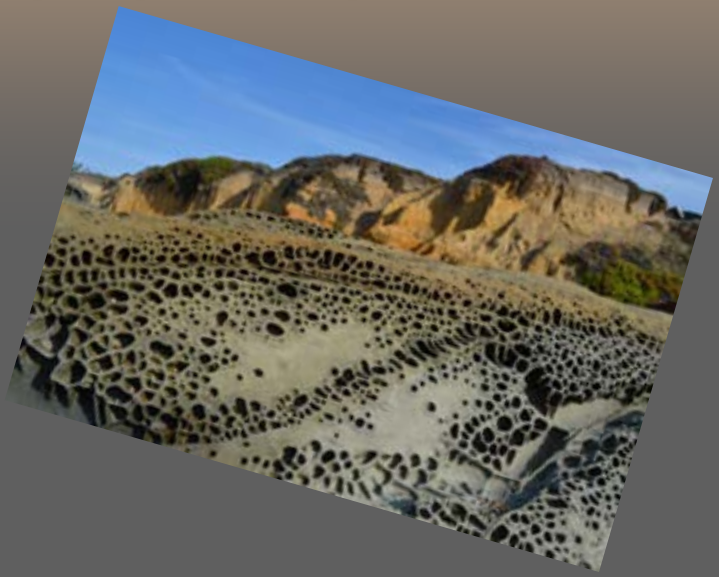
- Weathering: disintegration or alteration of rock in its natural or original position (in situ) at or near the Earth's surface through physical, chemical, and biological processes induced or modified by wind, water, and climate *(Encyclopaedia Britannica, 2019:2).*



Physical weathering is the weakening and subsequent disintegration of rock by physical forces (into their basic components e.g. sand). These physical forces include temperature fluctuation, abrasion, frost action (freezing and thawing), and salt crystal growth.

Chemical weathering is the weakening and subsequent disintegration of rock by chemical reactions (therefore they change their composition). These reactions include oxidation, hydrolysis, and carbonation. These processes either form or destroy minerals, thus altering the nature of the rock's mineral composition. Temperature and, especially, moisture are critical for chemical weathering; chemical weathering of rock minerals generally occurs more quickly in hot, humid climatic regions *(Plant and Soil Sciences, 2015:3).*

How is erosion different to weathering?





- Erosion is the process by which soil and rock particles are worn away and **moved** elsewhere by wind, water or ice. Weathering involves no moving agent of transport *(The Geological Society, 2019:23).*

Weathering

1. Physical, 2. Chemical, 3. Biological

1. **Physical**

- Freeze thaw
- Aeolian (wind)
- Salt Crystallisation
- Pressure release
  - -Sheeting
  - -Exfoliation domes
- Thermal Expansion
  - -Exfoliation
- Raindrop impact

Precipitation



Temperature

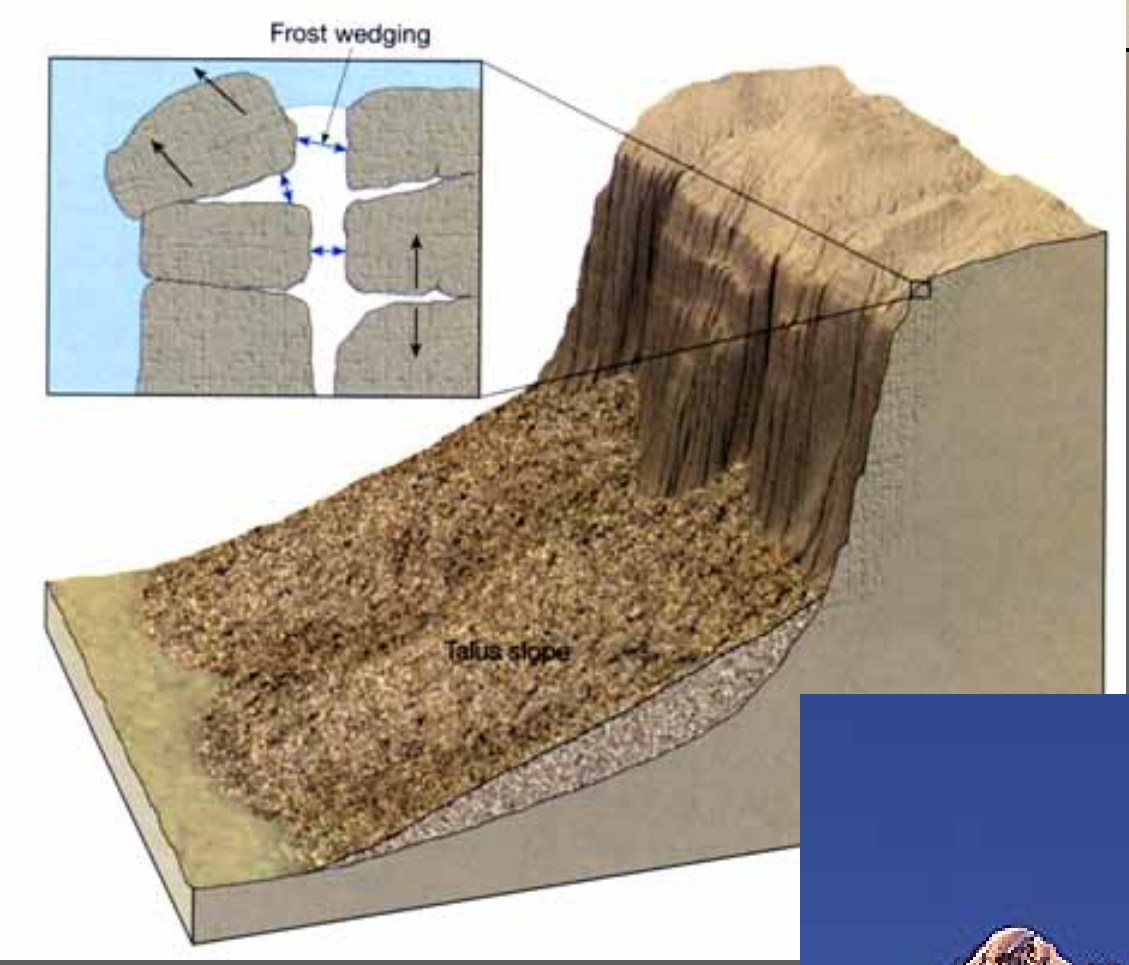


Flora and fauna activities



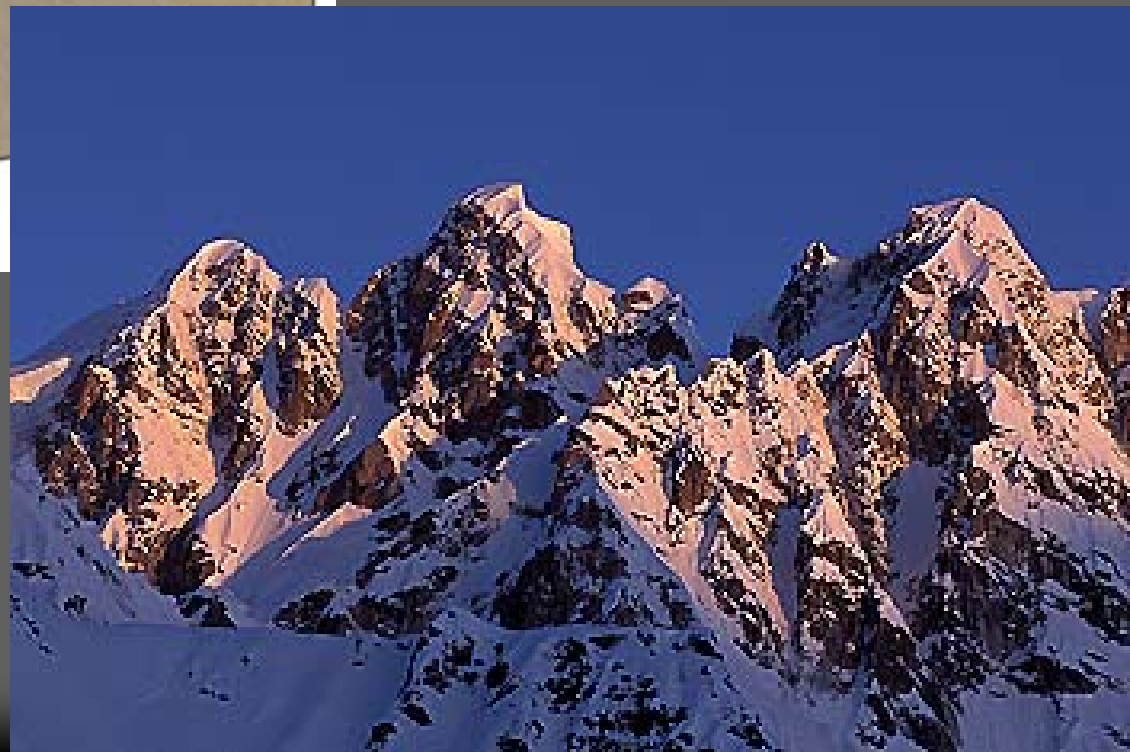
Types of Weathering

Lithology Type



Freeze Thaw

- 9% increase
- Talus or scree slopes
- Pyramidal peaks
- Harsh Habitat



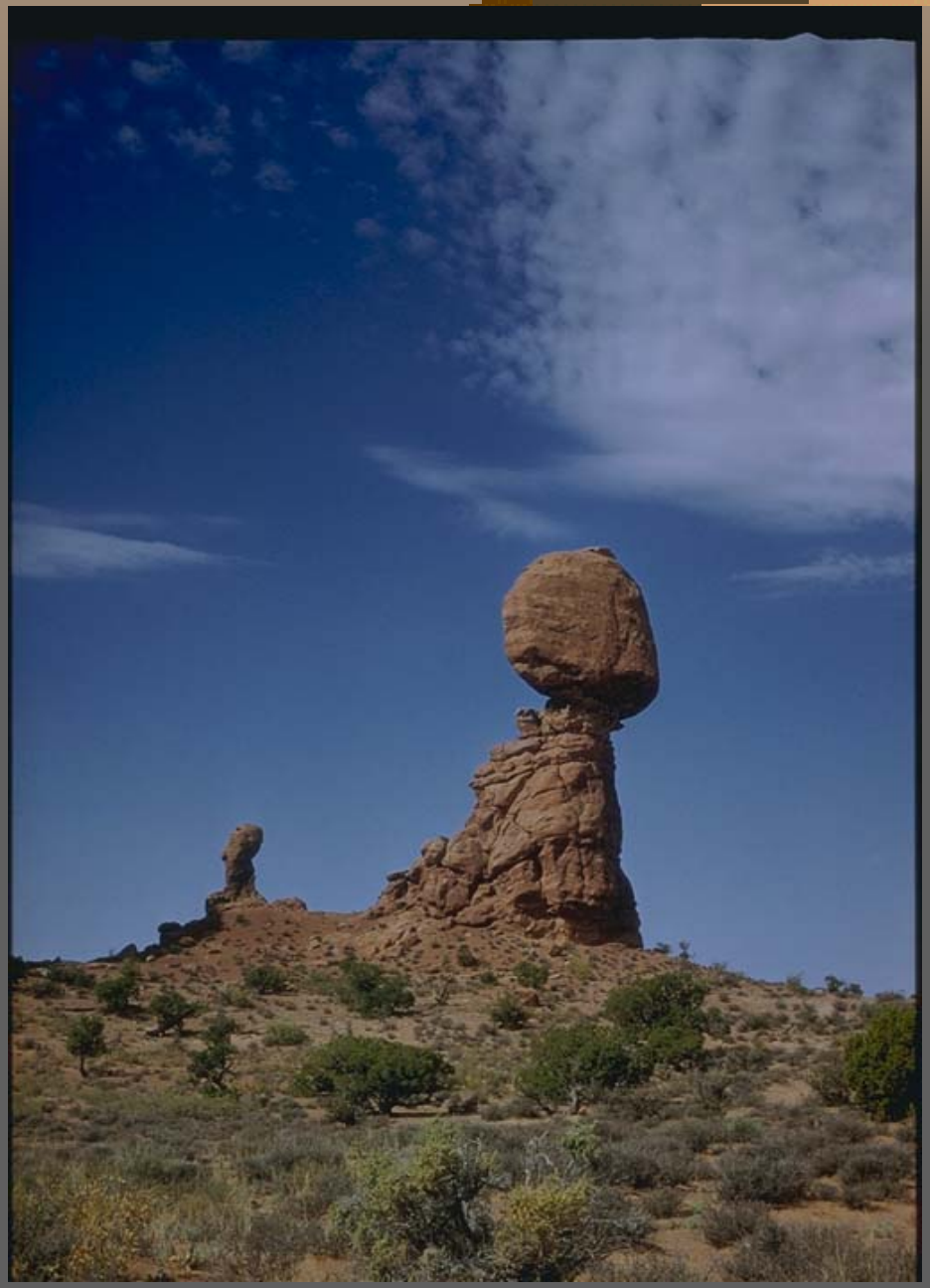
Arches National Park, Moab, Utah

Arches and Bridges Delicate Arch, The rock in this arch was once a part of an ancient fin. An alcove formed in the fin. Erosional forces continued until this free-standing arch perched at the edge of a slick-rock bowl is all that remains of the fin. Differences in the rock's resistance to erosion make the arch appear to resemble a dragon sniffing a flower. Note the resistant cap rock that is still in place.



Balancing Rock, Moab, Utah

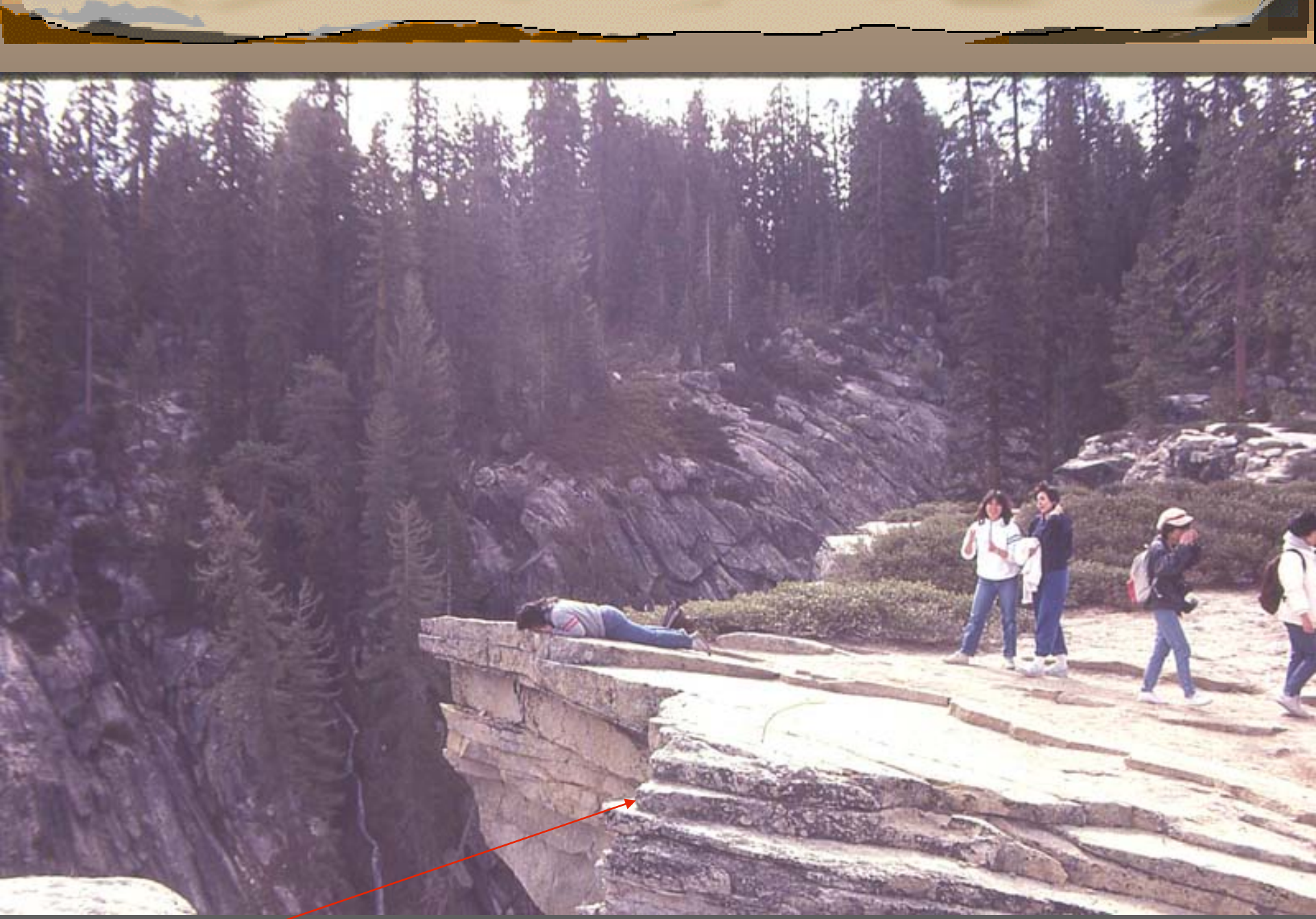
Arches and Bridges Balancing Rock, Arches National Park, Moab, Utah Over time the shape and size of the arches change, and the forces that created an arch finally destroy it, leaving goblin-like columns. In this case a layer of more resistant rock caps the formation. Earthquakes can cause balanced rocks to topple, so the existence of balanced rocks suggest tectonic stability.





These rocks have been blasted by wind and sand causing them to become rounded.

WIND ABRASION


Sheeting



This is a picture of the Half Dome. The rock is peeling away from the mountain in layers just like an onion. This is exfoliation.



Exfoliation domes, Yosemite



Expansion cracks

Summary Youtube

Summary of mechanical weathering 7mins

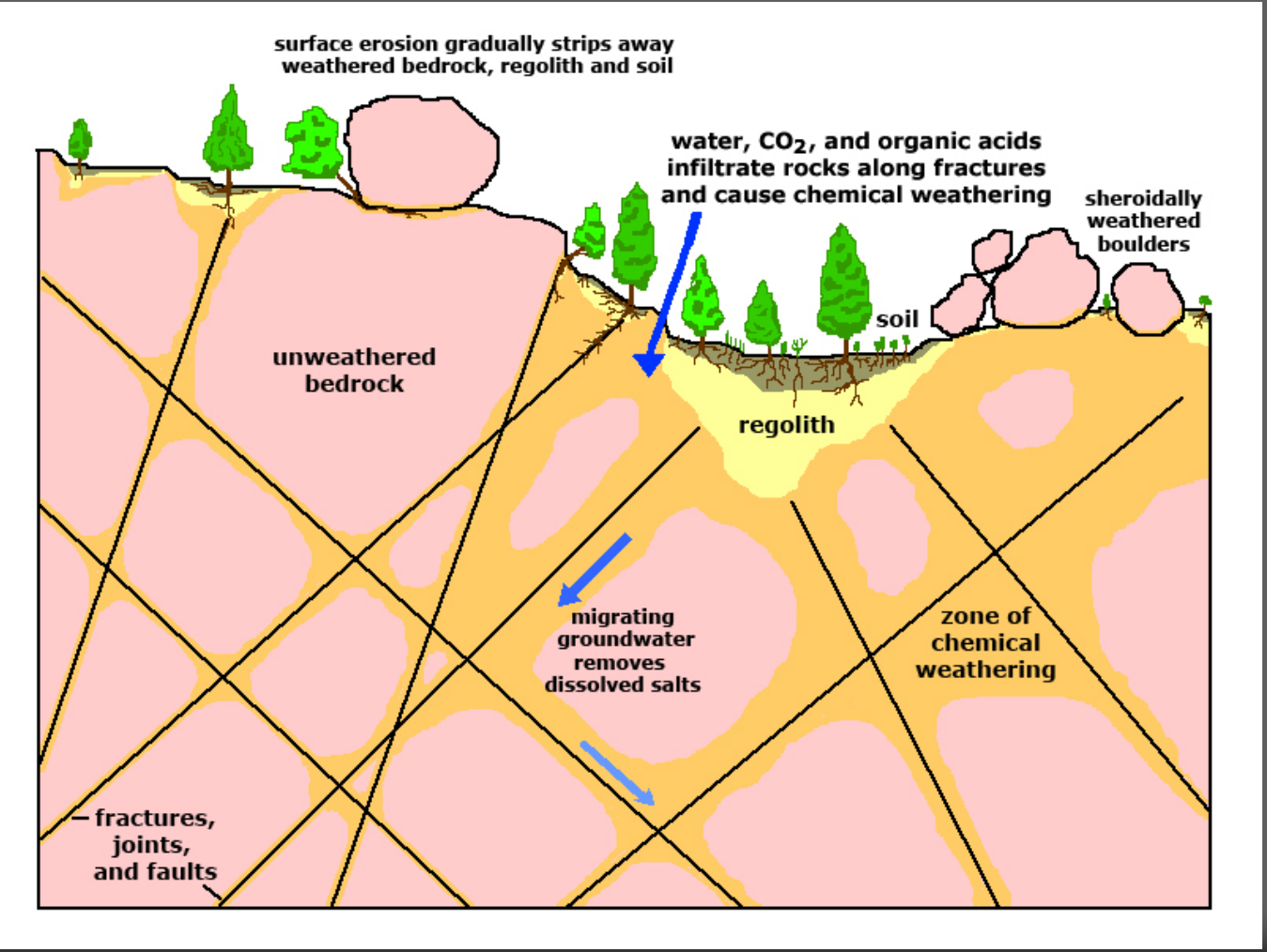
2. Chemical

Basics

- Selective mineral attack
- Pronounced in regions with fluctuating water table
- Pronounced at base of slopes (wetter & warmer)

Chemical weathering is discriminate

- Enhanced weathering: in joints, organic matter, hydrology and even air pressure (barometric changes push and pull air from the ground) etc.



Chemical Processes

- Oxidation = rusting
  - Combination of oxygen in aerated soils aerobic
  - Opposite Waterlogged soils reduction anaerobic (gleying (Grey))
- Hydration- rocks that can absorb water e.g. Gypsum
- Hydrolysis
  - Hydrogen reacts with minerals in the rock (cation exchange) e.g. kaolinisation
- Carbonation – carbonic acid e.g limestone pavements Malham (Yorkshire dales)
- Formulae



This rock is red because of the oxidation of iron in the sediment when the rock was being formed.

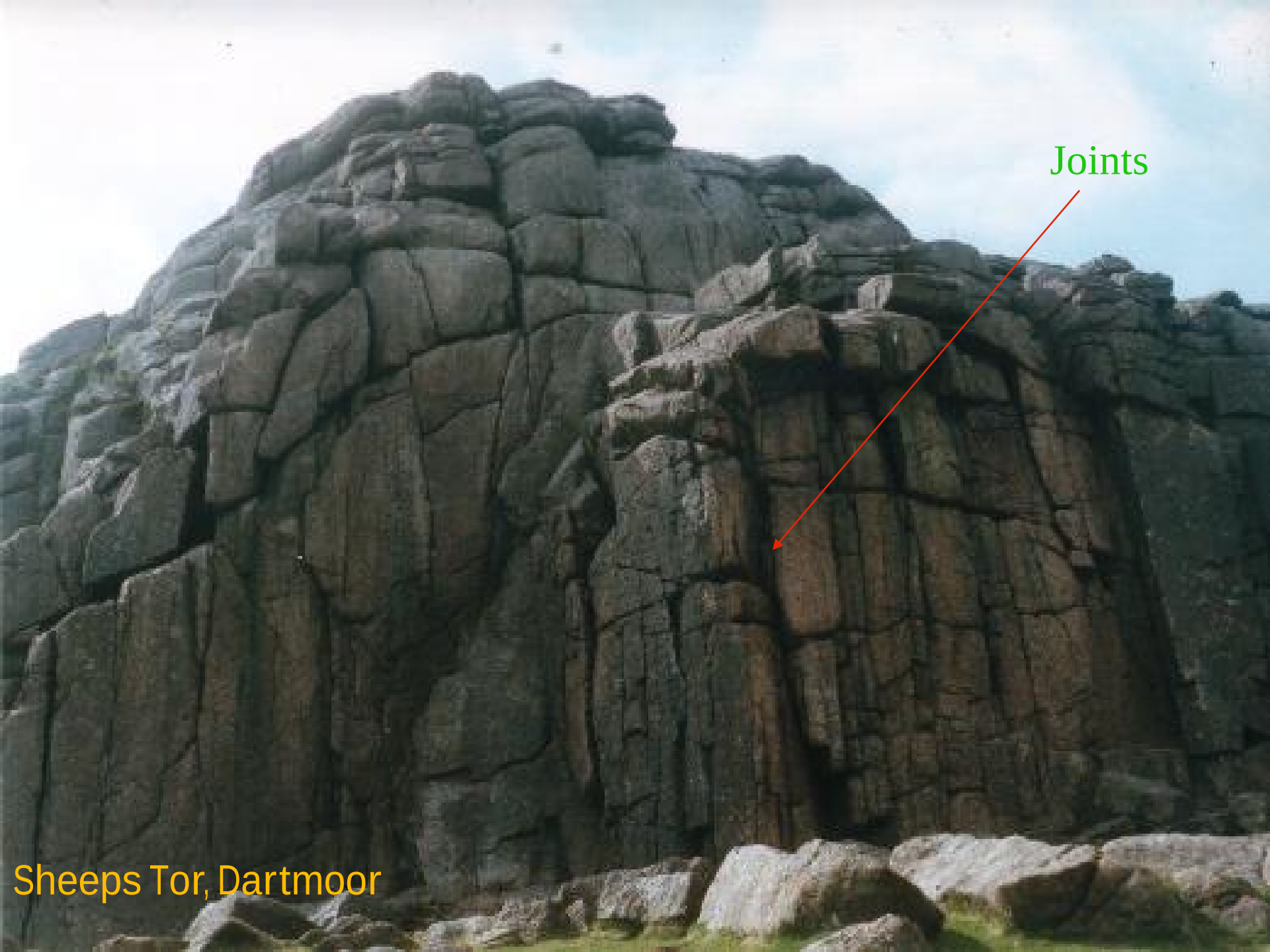
Gleying





Fallen block of contorted gypsum, with enterolithic veins. Soft Cockle Member, Purbeck Formation. Beach at Worbarrow Tout, Dorset.

Ian West (c) September 2002.



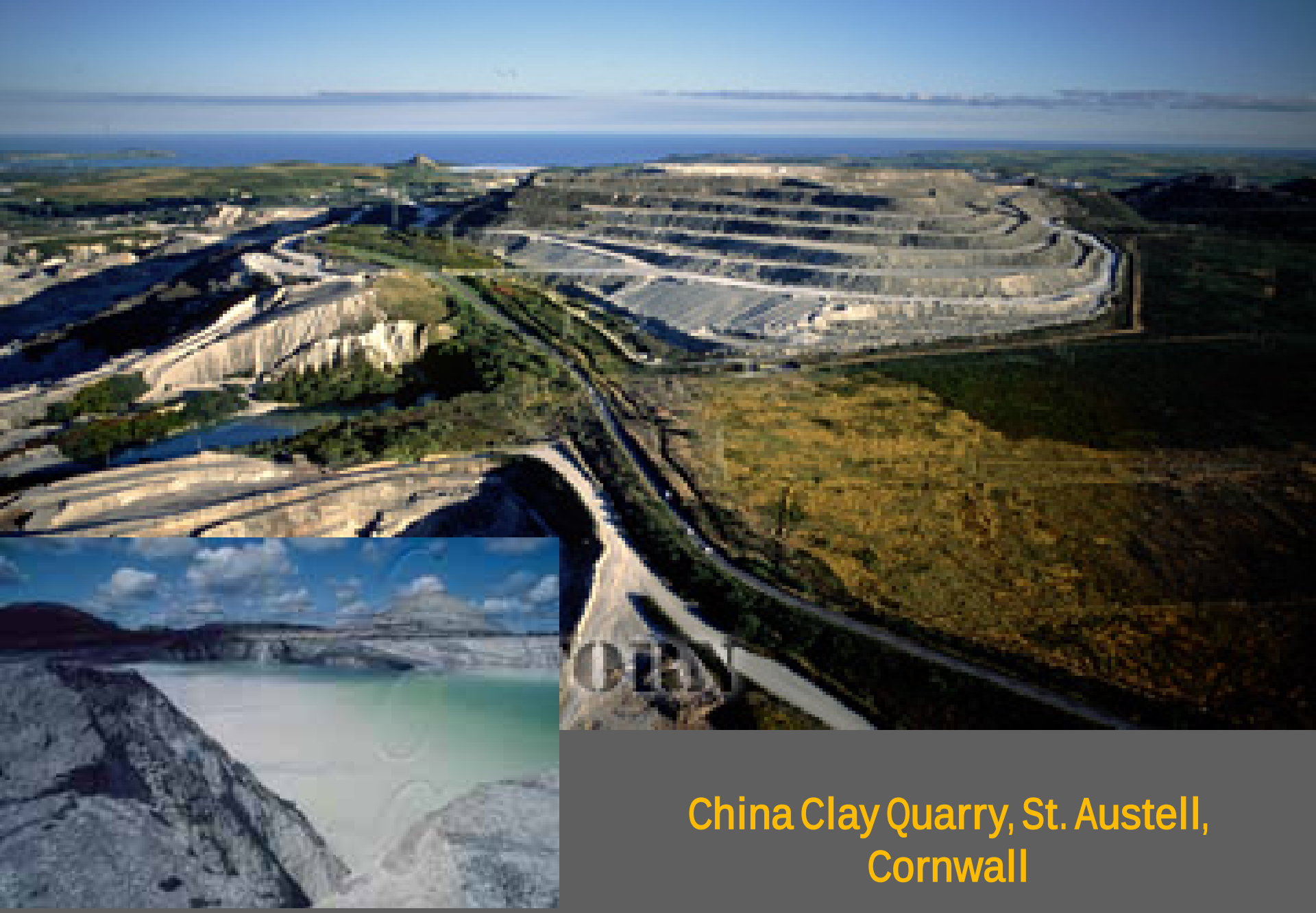
Sheeps Tor, Dartmoor



China clay quarry, Cornwall



China clay extraction



China Clay Quarry, St. Austell, Cornwall

Eden Project, Cornwall

- Environmental impact
- Tourism
- Conservation
- Discuss



Limestone

- Chemical weathering limestone and conservation

HABITAT CREATION AND SURVEY WORK PLANNED

The typical aspect of calcareous grasslands in Bavaria is highly asthetic and appreciated.

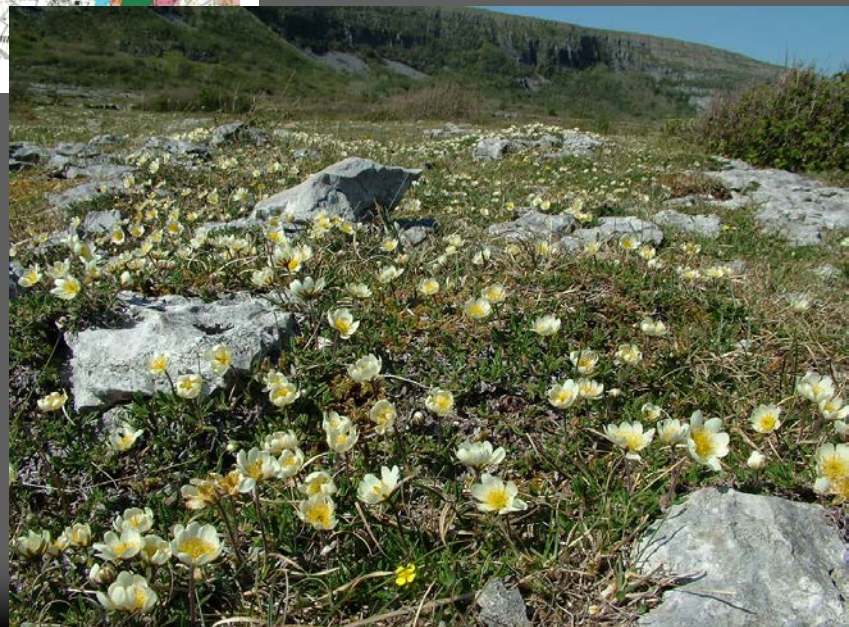


Mapping of target and indicator species and the development of a habitat management concept is the basis for further environmental education projects (such as green class rooms).



The location of the Lengfurt plant and its quarries by the river Main gives possibility to recreate both the horizontal and vertical structure of the typical calcareous cliff with patchwork of grasslands and shrubs.







Limestone Pavements
Karst scenery at Great Asby Scar







Smooth clints and grassy grikes



Dark red helleborine

The Limestone Pavement Action group

- The Limestone Pavement Action group (LPAG) is working to help deliver the UK Biodiversity Action Plan for limestone pavement.

- LPAG works to reduce the threats to limestone pavement from extraction, poor management and overgrazing; and to increase knowledge about this very special habitat.

- Limestone pavement is protected by law in the UK and it is an offence to damage or remove pavement from areas covered by Limestone Pavement Orders.

Seminar

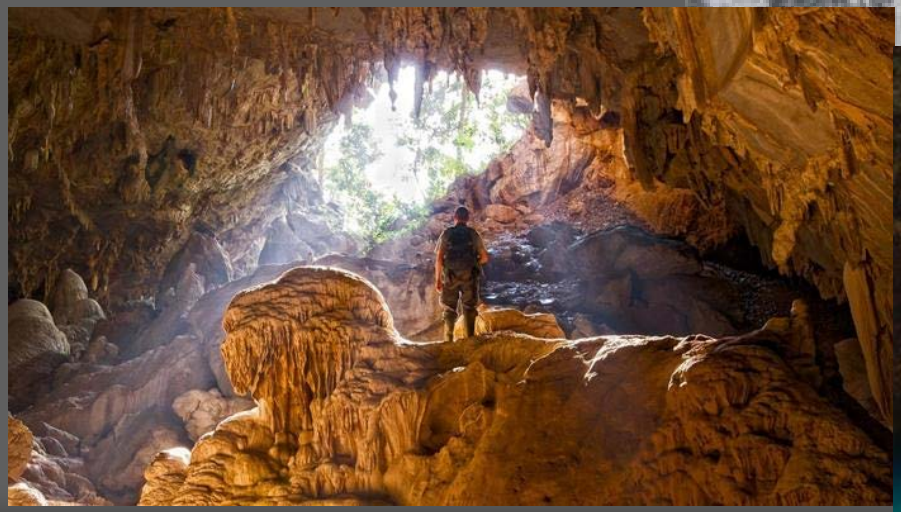


- Research information and report back on:
- Limestone Pavement
  1. Formation
  2. Status and habitats/Indicator and target species
  3. Law, governance, LPAG and News
  4. Locations in the world. Find conservation information on one example outside Europe
  5. Research papers: Principal points

Summary

Chemical weathering overview YouTube 6mins







Biological chemical weathering

- Humic acid- decomp of veg. – more organic life and carbon dioxide which = carbonation
- Lichen- Can extract iron from rocks and concentrate at the surface
- Acid rain





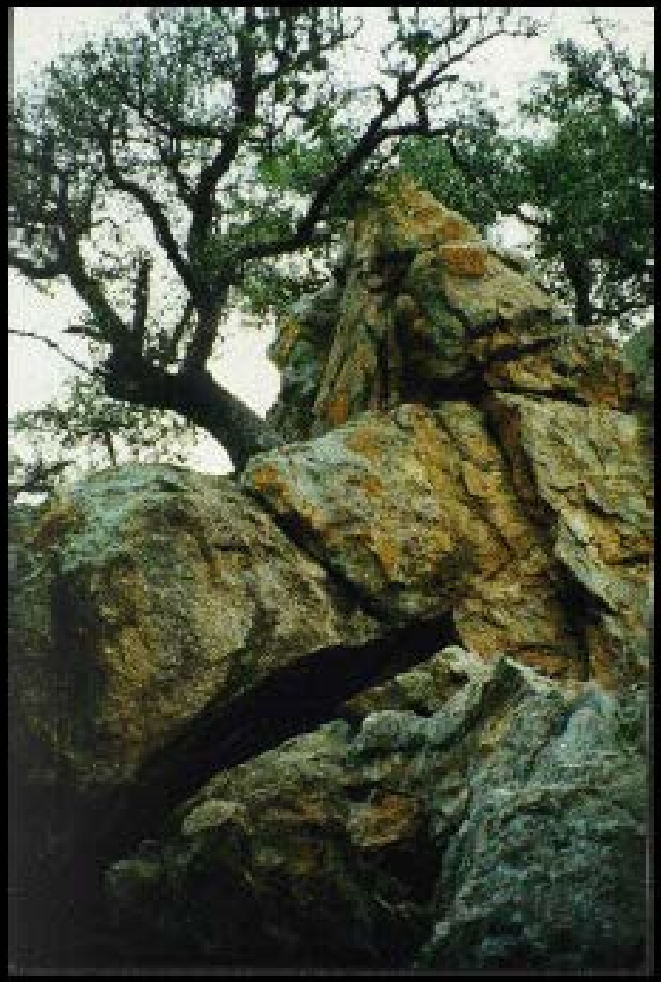
1908 to 1969

Acid rain has eaten away this limestone statue.

Acid Rain

3. Biological

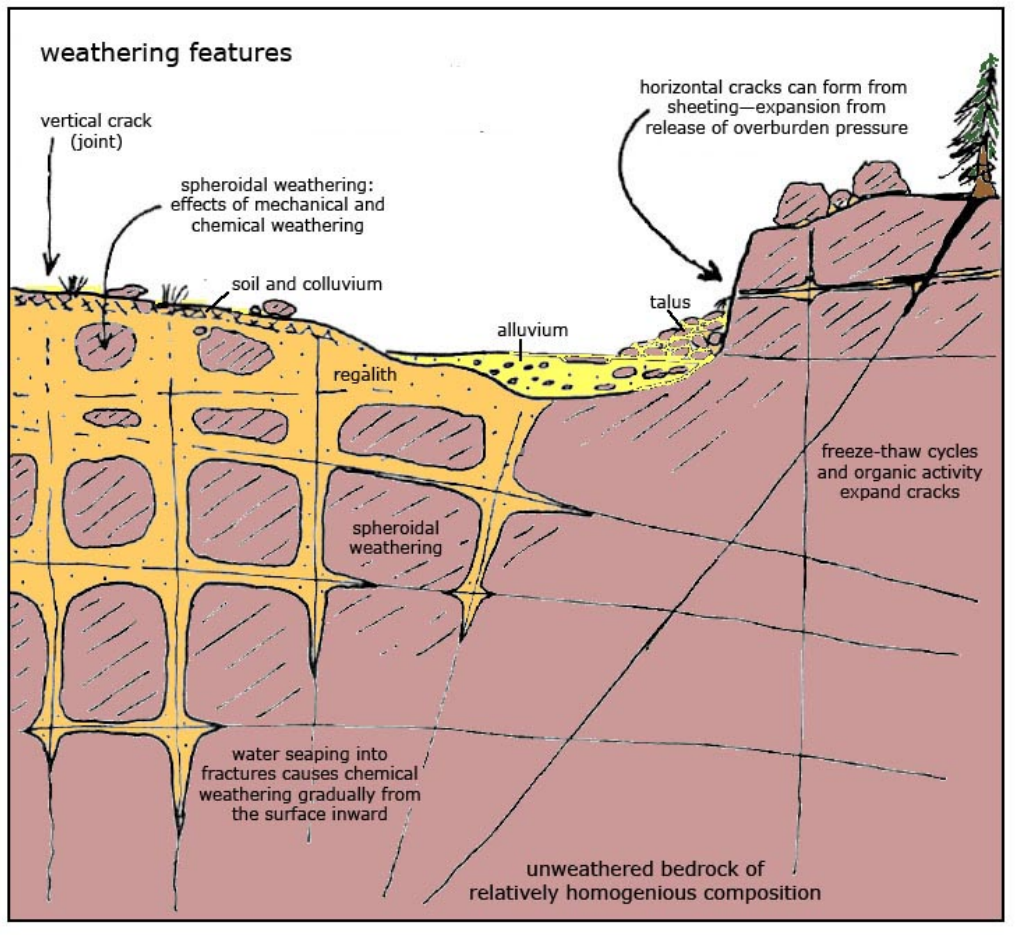
- Tree roots
- Burrowing animals



Root Pry

The tree is growing in the rock and soon the rock will break apart because of the tree roots.

The types of weathering work in a complexed form at a given location



Differential weathering

Different rocks are > < susceptible to weathering



Bryce Canyon



Sierra Nevada































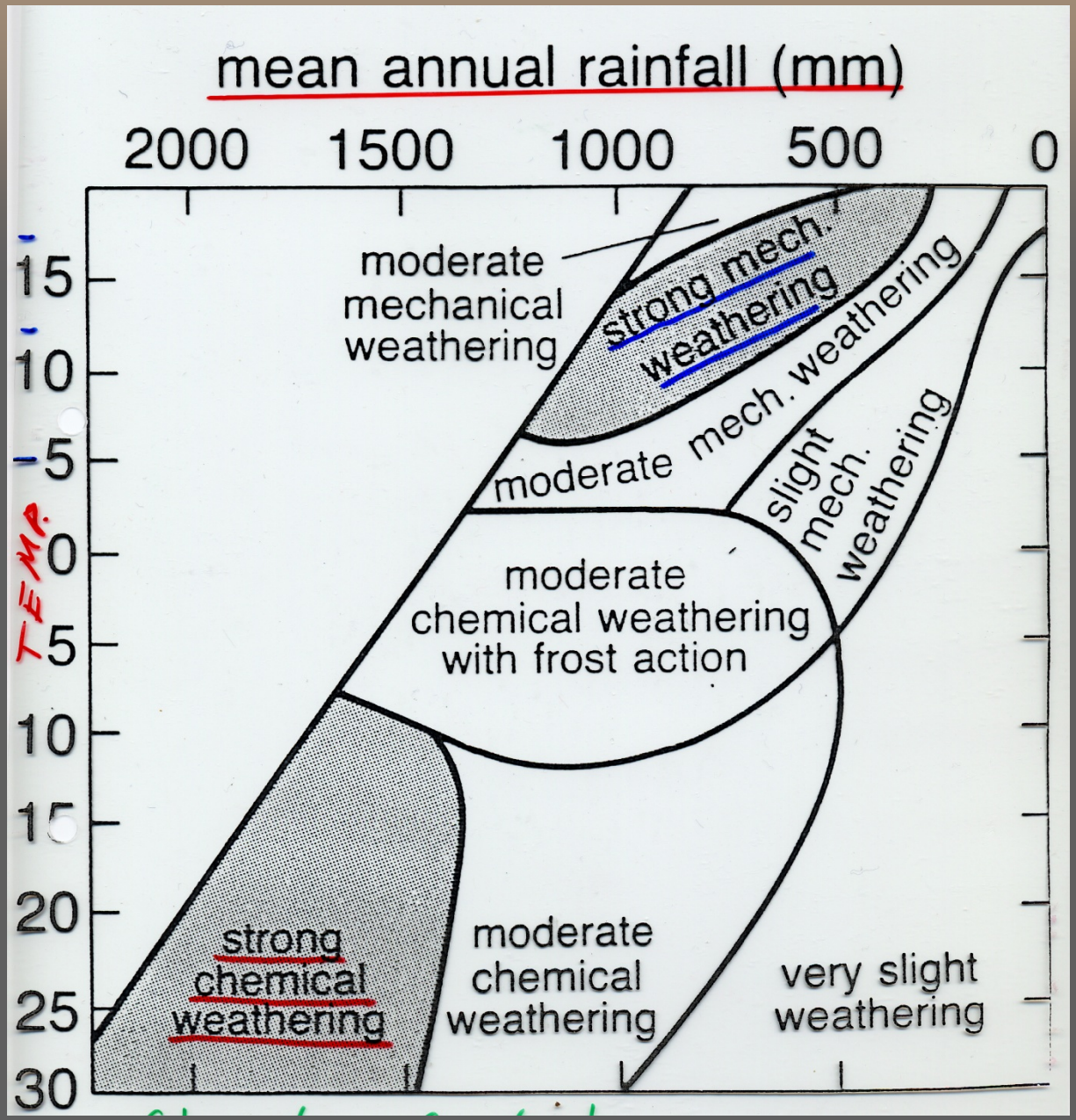




Climate control on weathering

- Exercise
  - Handout





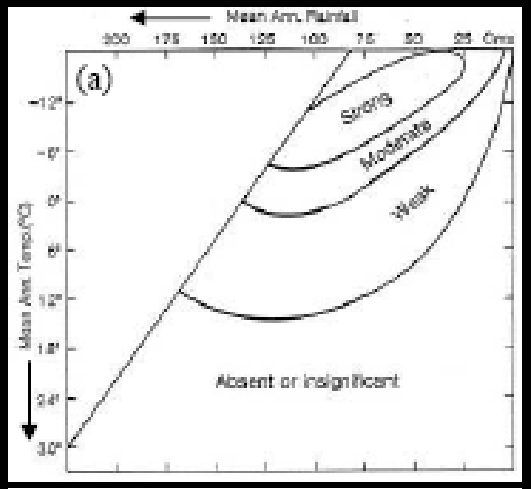
Climatic Control on rates of weathering

(Peltier, 1987: 232)

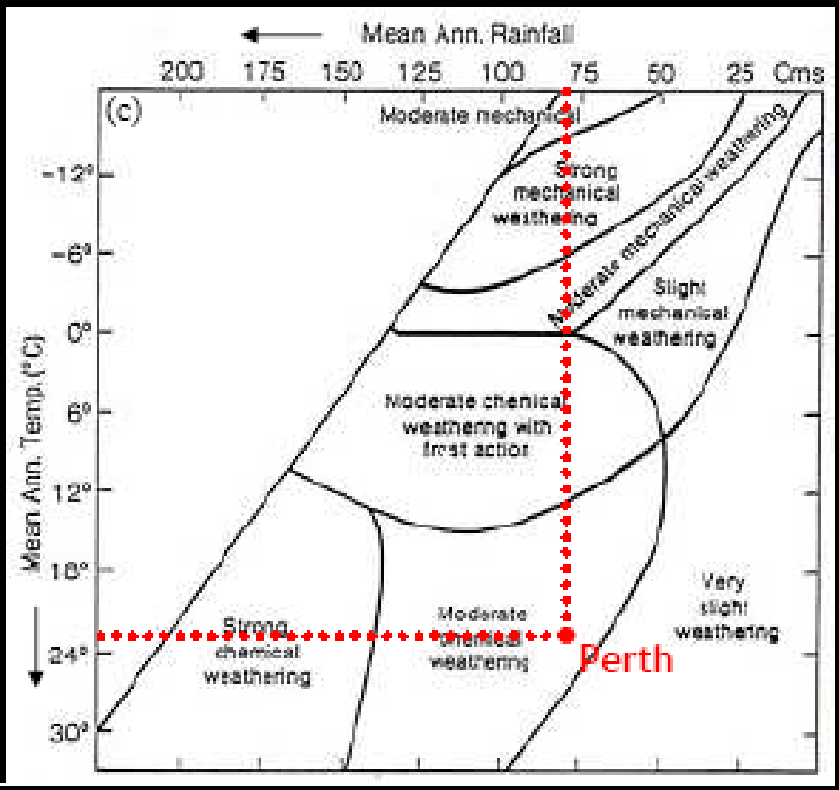
More on weathering: The Peltier Model

Mechanical weathering

Chemical weathering



Combined chemical & mechanical weathering



Darling Ranges, Perth (average annual rainfall ~80 cm, average annual temperature ~22˚) ends up in the slight-to-moderate chemical weathering region. **But we know from boreholes and exposed faces that the weathering zone is much more extensive so how do we explain this??**

Weathering of rock is a complex process and depends on many factors including:

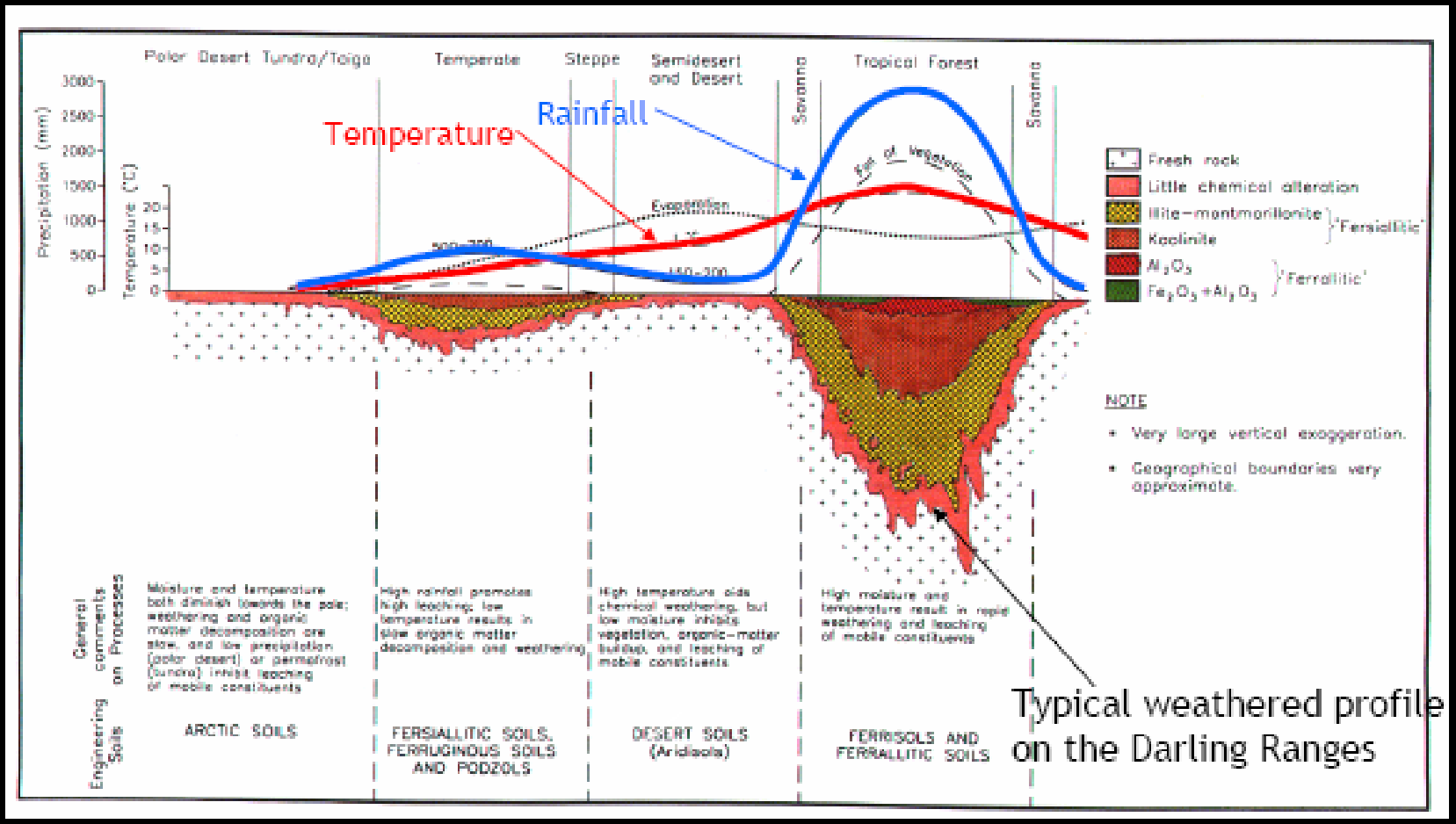
- Climate - wind, rain, frost & temperature
- Topography (e.g. waterlogged valleys are subjected to deeper weathering than plateaus)
- Rock structure (e.g. presence of faults, joints etc dictate rock fracturing due to freeze-thaw cycles)
- Rock types (e.g. dominance of various minerals dictate resilience to weathering)

Looking at climate... Also TIME is a major factor!

- Mechanical weathering (due to freeze-thaw & heat-cool cycles) obviously depends on climate
- Chemical weathering is also strongly climate dependent as this form of weathering dominates in regions of relatively high humidity and rainfall

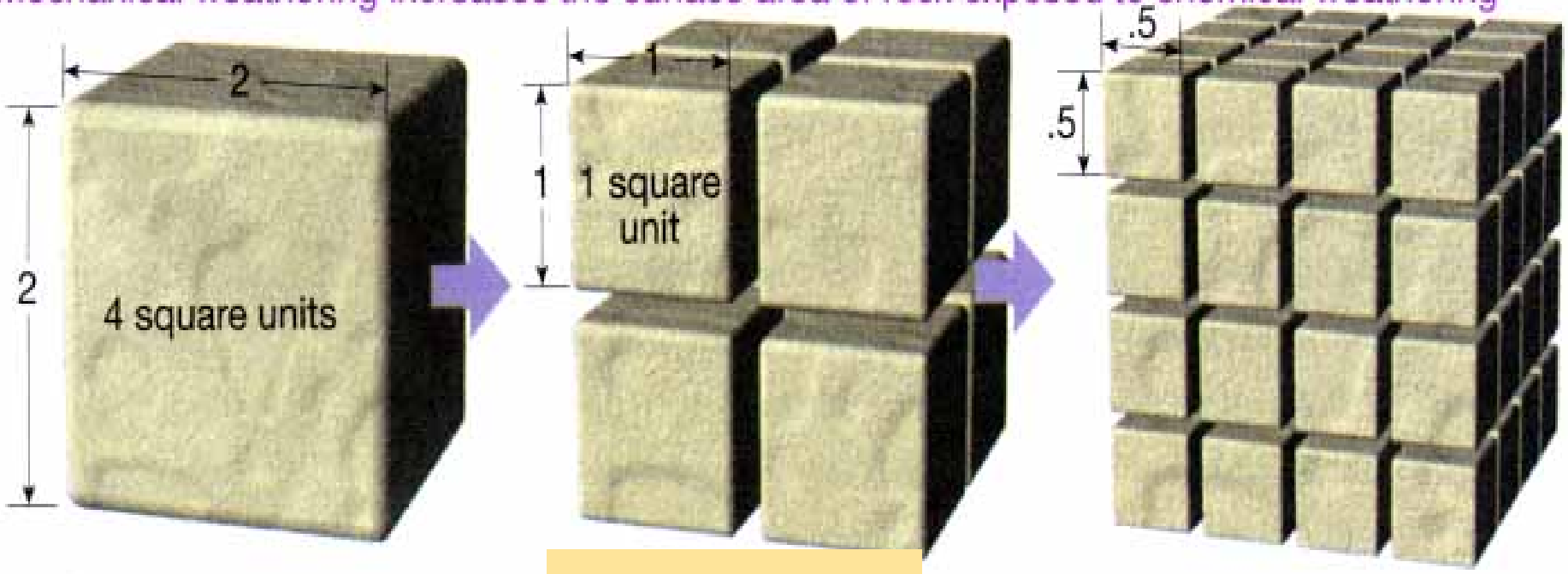
More on weathering

- Weathering takes time, a lot of time
- Soils observed nowadays results from weathering taking place millions of years ago
- At that time, Perth Climate was hotter and wetter



Physical weathering increases surface area for chemical weathering to work on. Weathering is often in combination

Mechanical weathering increases the surface area of rock exposed to chemical weathering



4 square units ×
6 sides ×
1 cube =

24 square units

How many square units? Move for answer

How many square units?

From rock to soil

Weathering: physical fragmentation and chemical decay of rock

Mass movement: down slope movement by gravity

Erosion: dislodging, dissolution, or removal by wind, water, or ice

Transportation: movement or transport of sediment

Deposition: laying down of sediment to form soil

Extent of weathering reduces with depth



Bonnington, WA

SOIL
e.g. Laterite

ROCK
e.g. Granite

Weathering of granite and possible soil formation

Existing rock minerals	Probable debris minerals	Possible resulting soils
Quartz	Quartz	Sand
Muscovite	Muscovite	Micaceous sand
Biotite mica	Chlorite or vermiculite + Mg carbonate solution	Clay (dark)
Orthoclase feldspar	Illite or kaolinite + K carbonate solution	Clay light
Plagioclase feldspar	Montmorillonite + Na or Ca carbonate solution	Lime mud/clay or marl

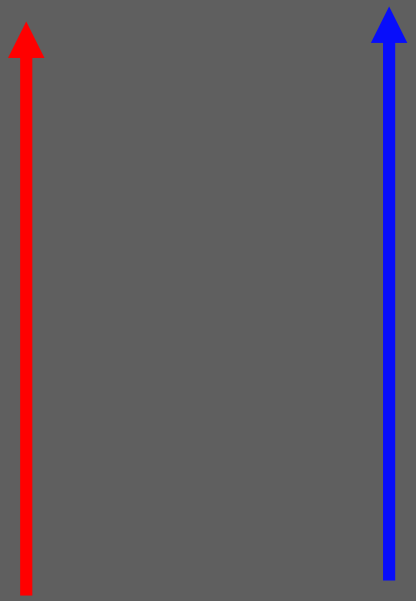
Mechanical weathering: minerals emerge from weathering process unchanged. Resulting soil comprised of larger fractions e.g. sand & gravels.

Chemical weathering: minerals altered during weathering process. Results in clay soils (small fractions).

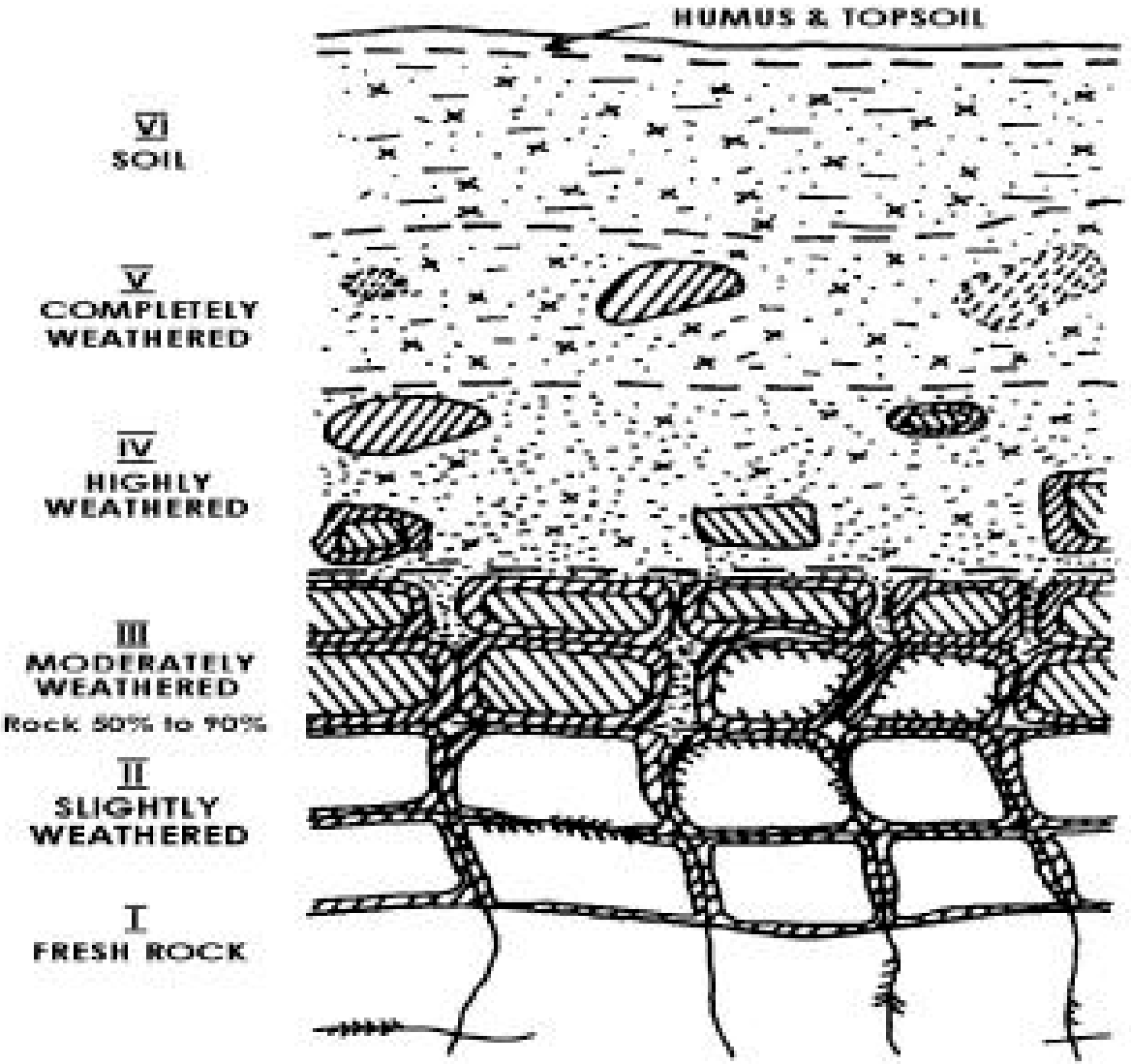
Weathering Profile and some geotechnical Properties (Smithson, et al, 2004 & Dearman, 1974)

Deformability Porosity

HIGH 60%



LOW 0.2%

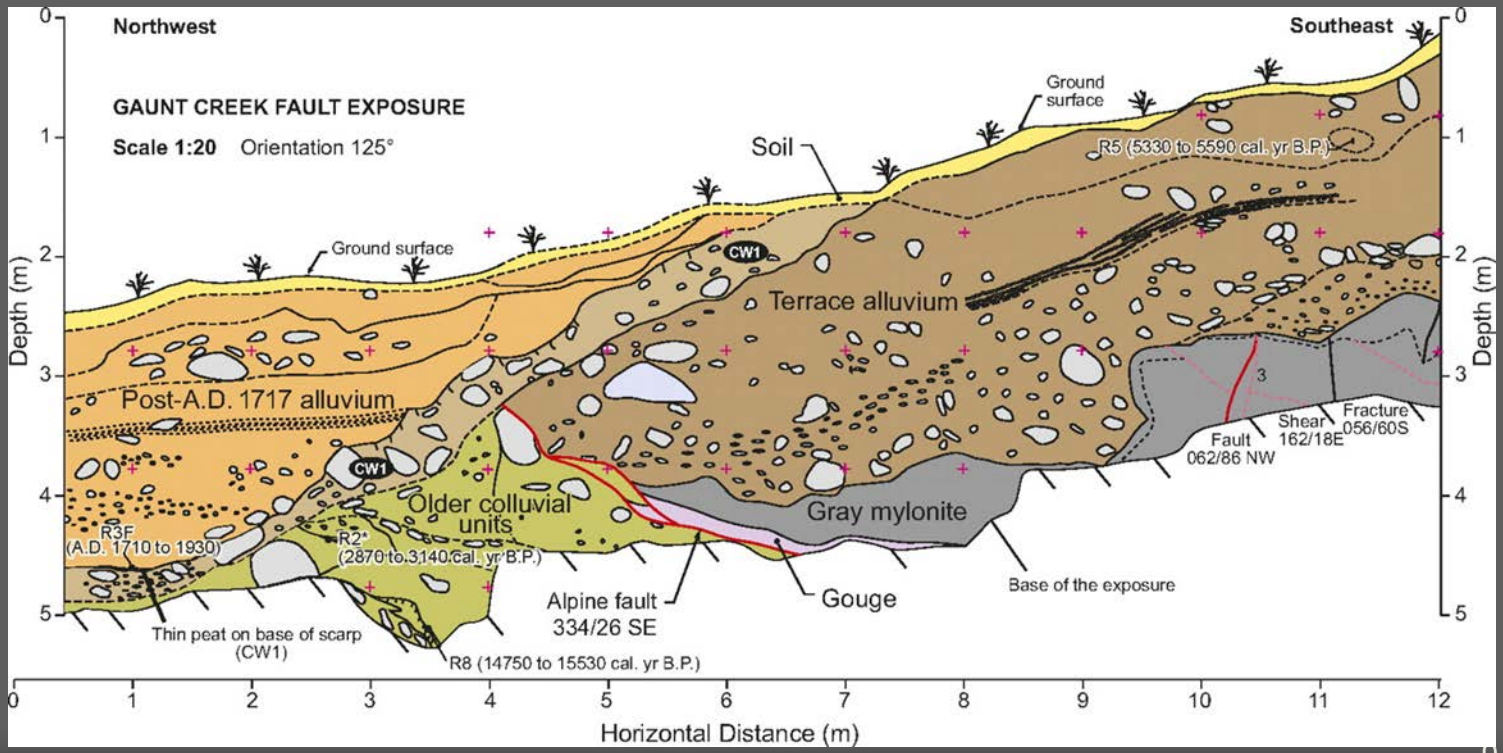




University of Nevada, House et. al (2015) Northern McCullough Mtn area.

Complexity

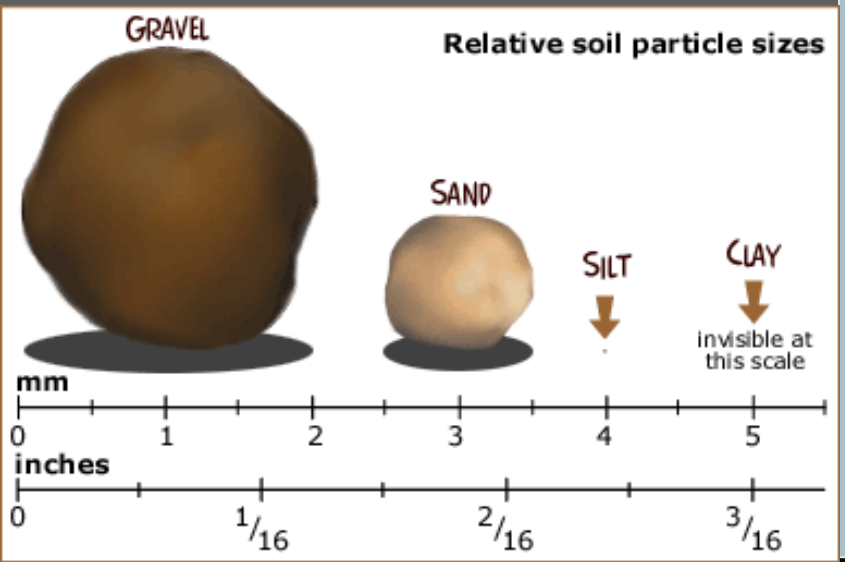
- **The journey of sediments can take a long time!** The migration of sediments from upland regions to the ocean basins can take a very long time. Sediments can be eroded and re deposited many times along the journey. Locations are often a complex mix of past processes e.g.



Sediment classification

- Phi scale is a Clastic size indicator
- Wentworth in 1922





Phi Units*	Size	Wentworth Size Class	Sediment/Rock Name
-8	256 mm	Boulders	Sediment: GRAVEL Rock RUDITES: (conglomerates, breccias)
-6	64 mm	Cobbles	
-2	4 mm	Pebbles	
-1	2 mm	Granules	
0	1 mm	Very Coarse Sand	Sediment: SAND Rocks: SANDSTONES (arenites, wackes)
1	1/2 mm	Coarse Sand	
2	1/4 mm	Medium Sand	
3	1/8 mm	Fine Sand	
4	1/16 mm	Very Fine Sand	
8	1/256 mm	Silt	Sediment: MUD Rocks: LUTITES (mudrocks)
		Clay	

* Udden-Wentworth Scale

Soils Definition

The unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants.

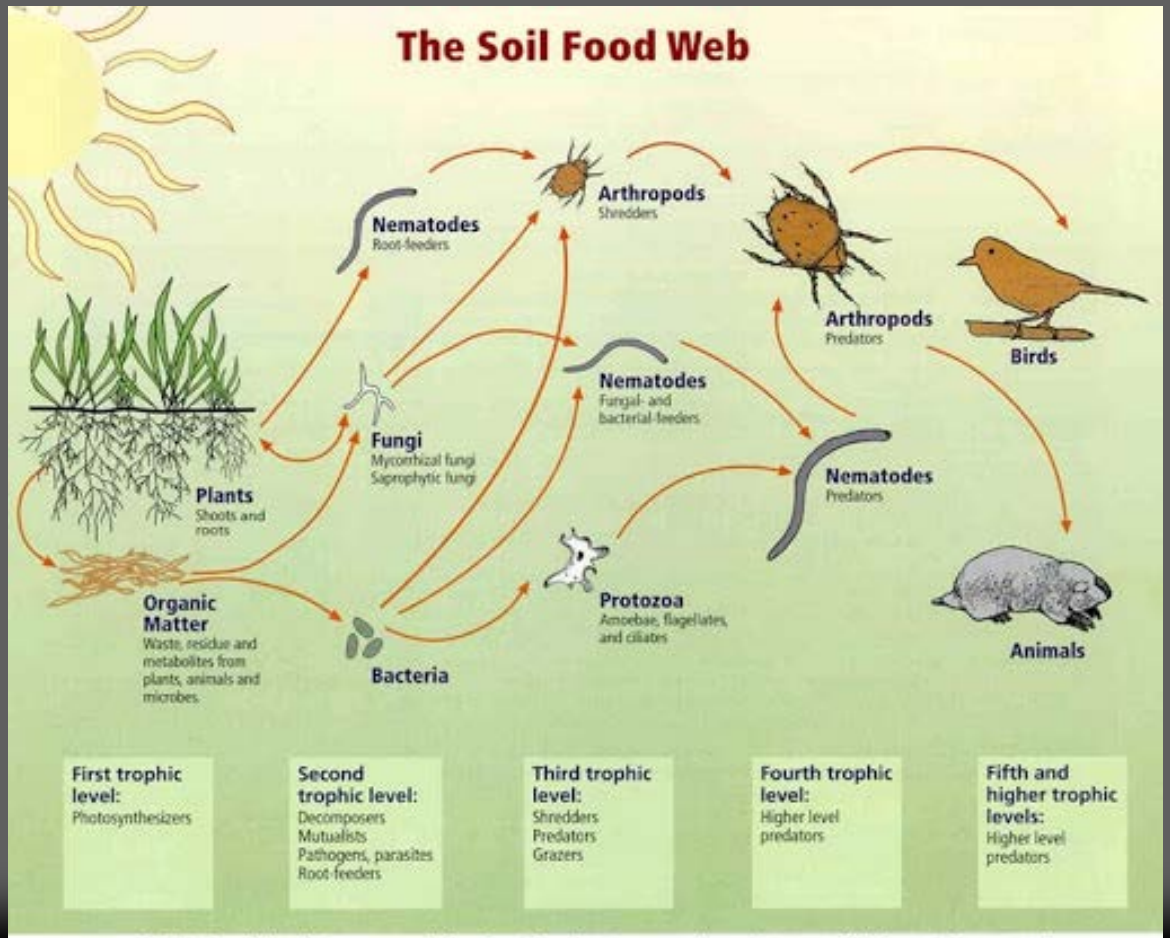
"The unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time." (USDA, 2017:1).





Soils Definition

*"Soil is an essential component of "**Land**" and "**Eco-systems**" that both are broader concepts encompassing vegetation, water and climate in the case of land, and in addition to those three aspects, also social and economic considerations in the case of ecosystems*" (UN, 2017:2).



Soil terms

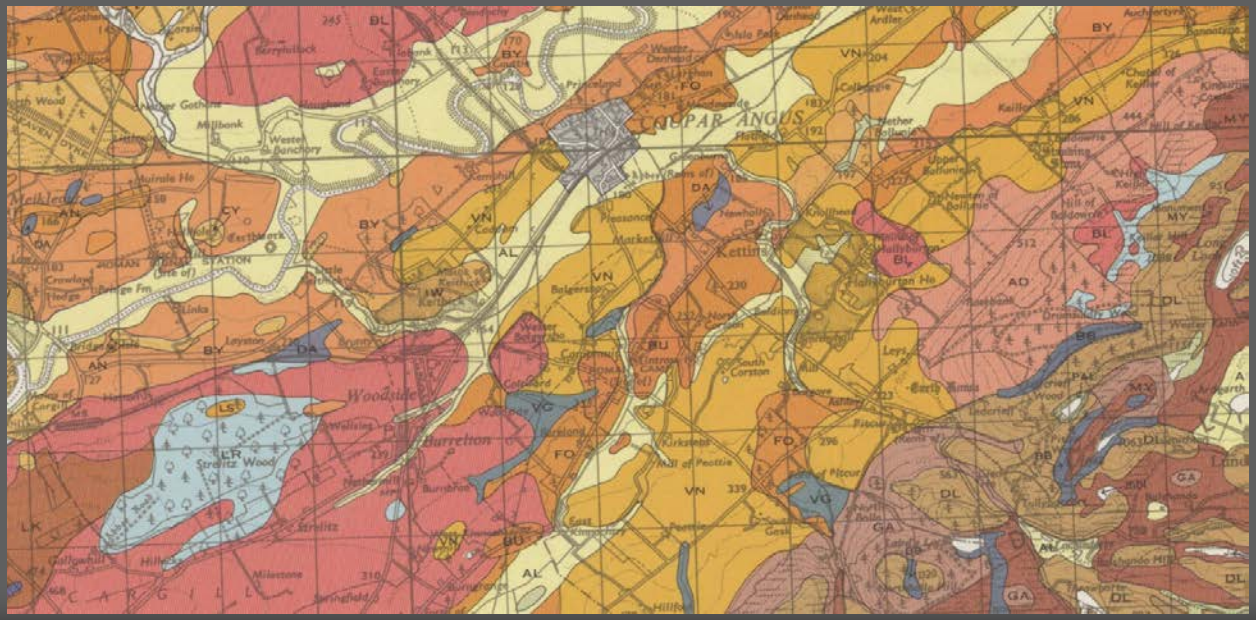
Soil survey

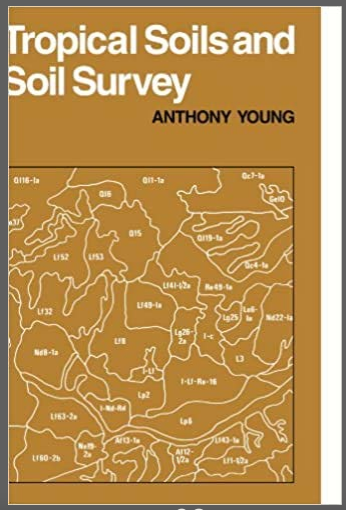
is a systematic study of the **soil of an area** including classification and mapping of the properties and the distribution of various soil units.

Soil Maps and Databases

are the main **information products** generated by soil surveys, in the early days of soil science they were in paper format, but with rapidly developing technology they are now produced in advanced GIS environments.

Cranfield soil Institute GIS





Soil terms

Soil Assessment

in the context of land evaluation, soil assessment focuses on the matching of the specific soil requirements of the land use versus the properties of the soil. Most of soil assessments have been made for **agricultural land uses and cropping systems**, but the same principles could be applied for other applications e.g. conservation.

Soil degradation

is defined as a **change in the soil health status** resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries. Soil conservation is important!





Terms cont'd

Soil Improvement

concerns in the first place the **appropriate management of problem soils**. It also involves the improvement of degraded soils in terms of soil protection, mitigation, and rehabilitation. E.g. Biochar

Soil Biodiversity

can be defined as the **variation in soil life**, from genes to communities, and the variation in soil habitats, from micro-aggregates to entire landscapes. Mycelium





Terms cont'd

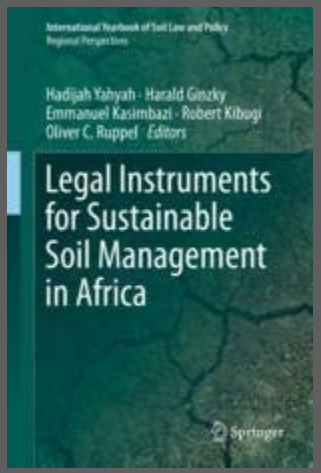
Soil Management

The soil sustains most living organisms, being the ultimate source of their mineral nutrients. Good **management of soils assures that mineral elements do not become deficient or toxic to plants**, and that appropriate mineral elements enter the food chain.

Soil Governance and Policy

concerns **policies and strategies** and the processes of **decision-making by nation states and local governments** on how the soil is utilised. Globally, governance of the soil has been focused on agriculture due to increased food insecurity in the most populated regions on earth (Soil Science Society of America, 2017:5).



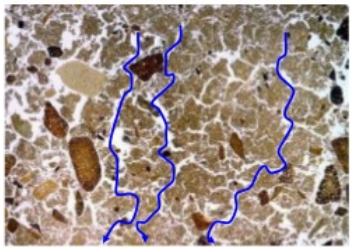


Describing soils

- **Regolith** is the name for a layer of loose rock debris resting on bedrock, constituting the surface of most land. Regolith can become **soil** with the introduction of **organic residues** and ongoing weathering.

Leaching

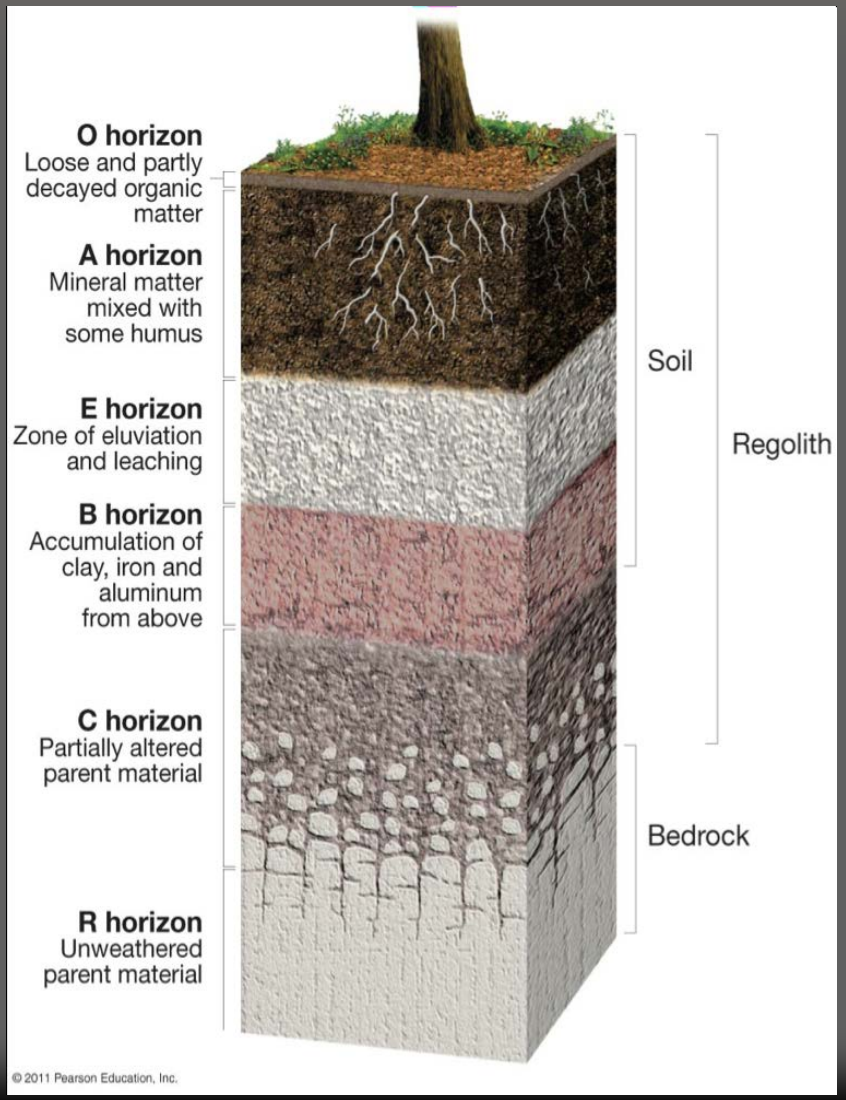
Wherever rainfall exceeds evaporation and there is free downward movement of water through the soil pore system, soluble minerals are leached or removed from the soil profile.



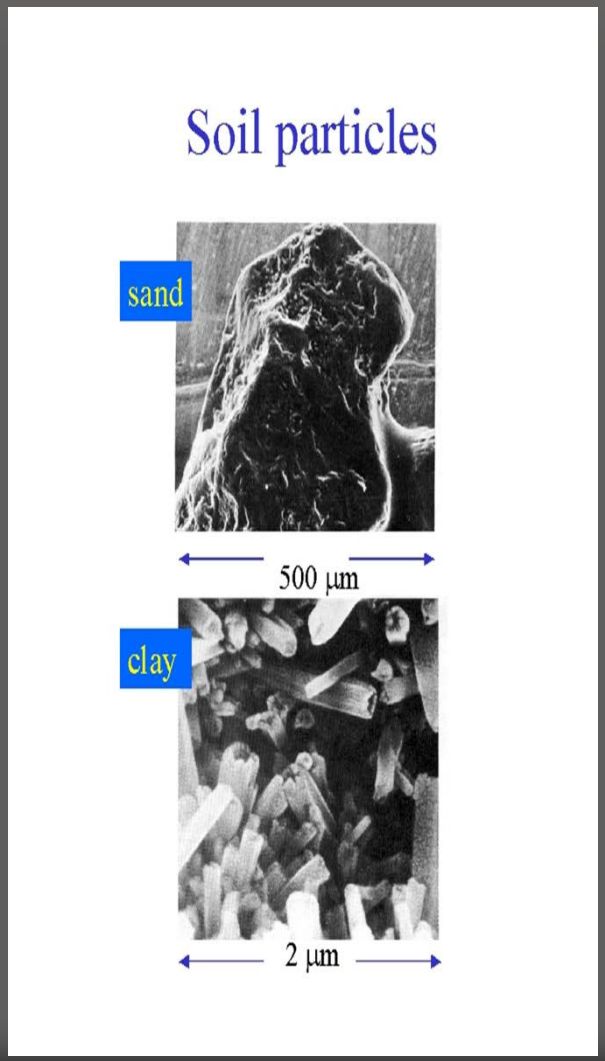
A soil with small soil peds or crumbs and high porosity leading to free drainage and active leaching

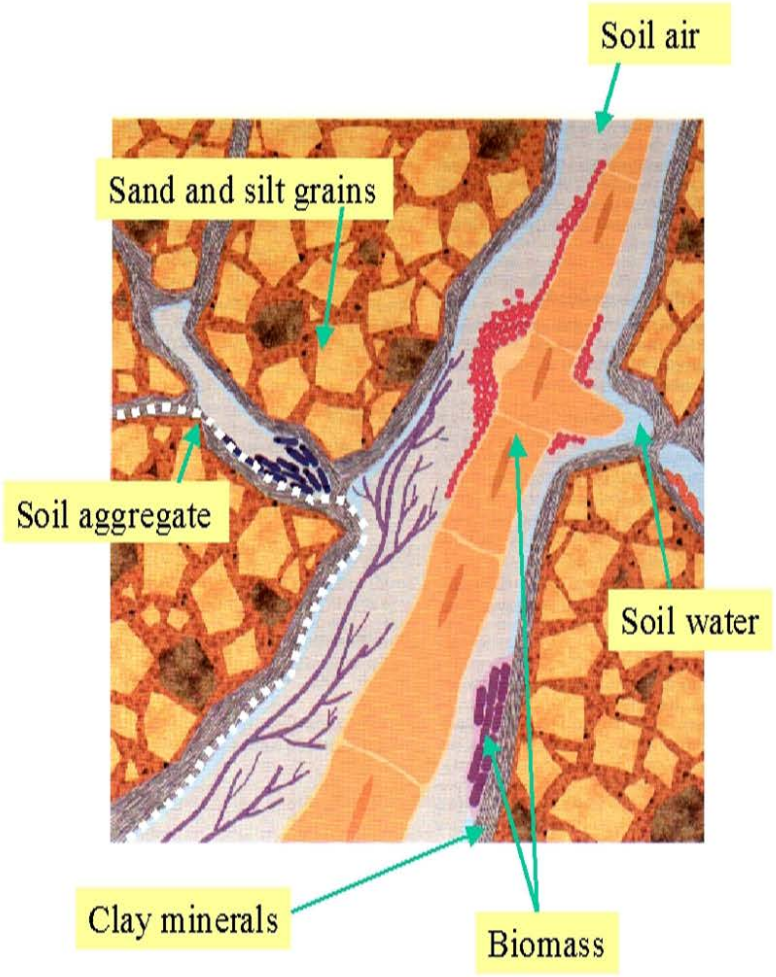
Continual leaching tends to impoverish the upper mineral horizons by removal of basic cations (cations are ions having a a positive electrical charge e.g. Ca^{2+}).

Leaching is most active in sandy soils with high porosity and is least in fine-textured soils such as clays which have restricted pore spaces.

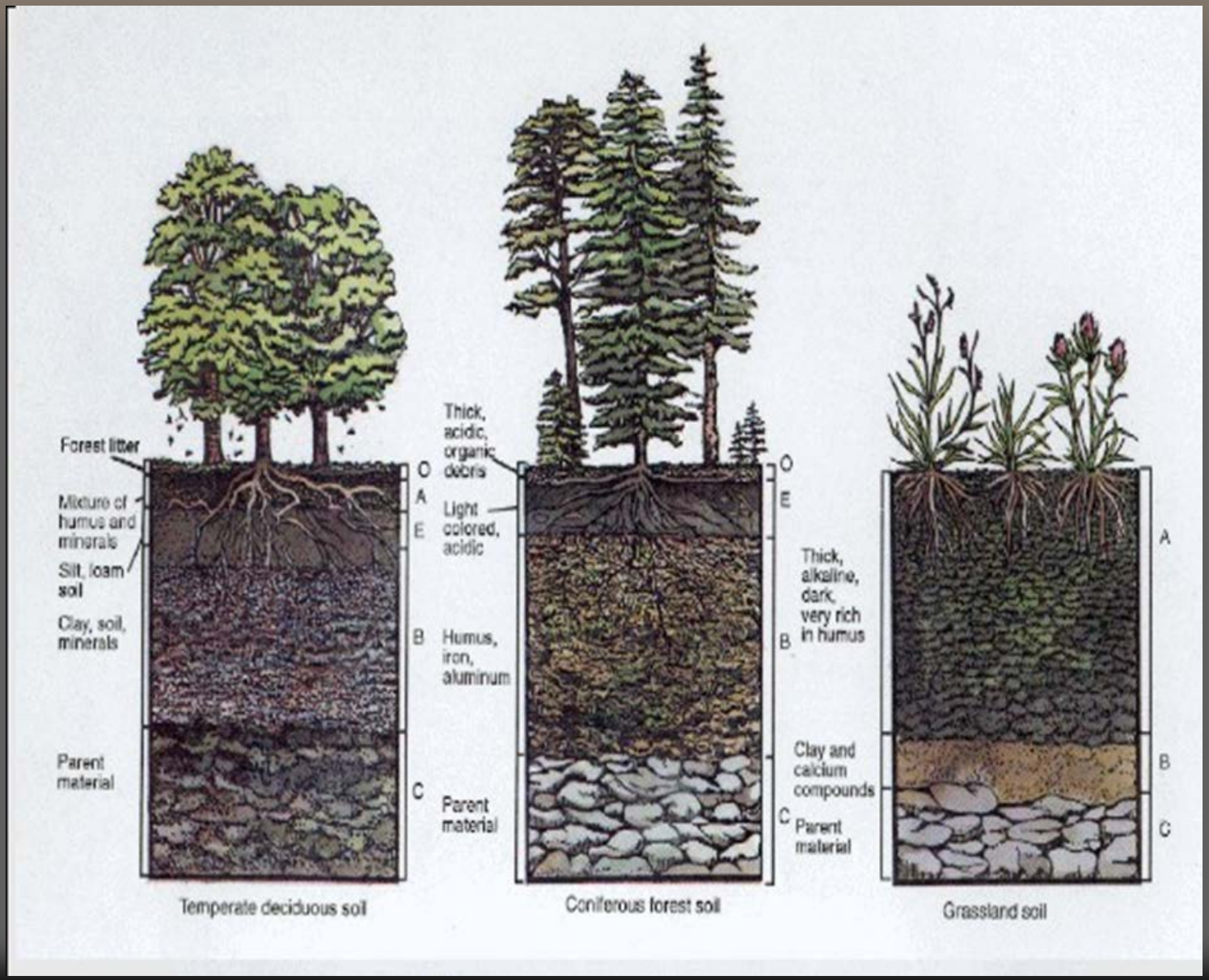


Soils: Some principles





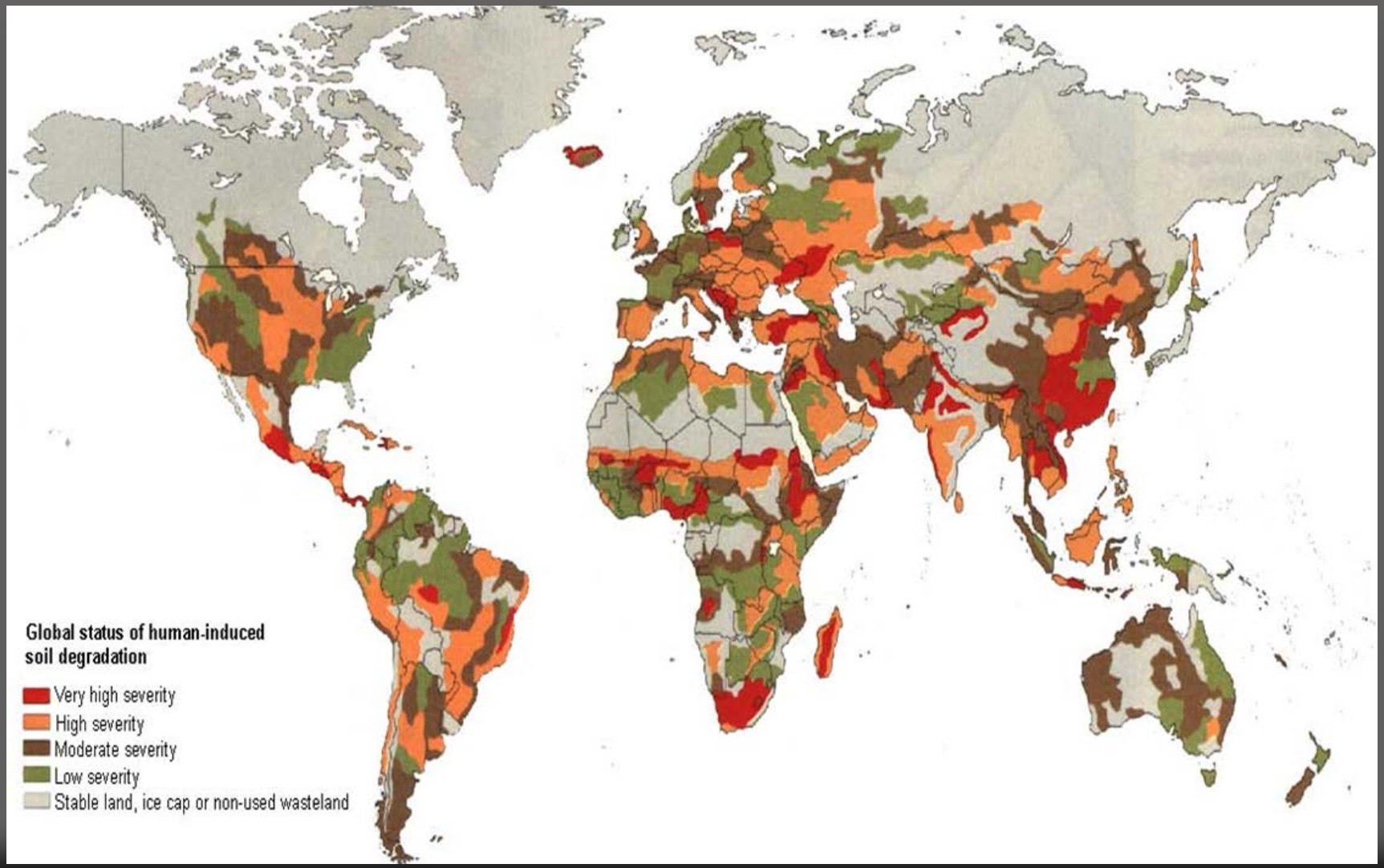
Soils of the world



Soils of the world continued



Soil degradation



Ecosystem Services of Soil

- The ecosystem Service (ES) approach is increasingly used to incorporate ecological sustainability into political decision-making (GrêtRegamey et al., 2015).

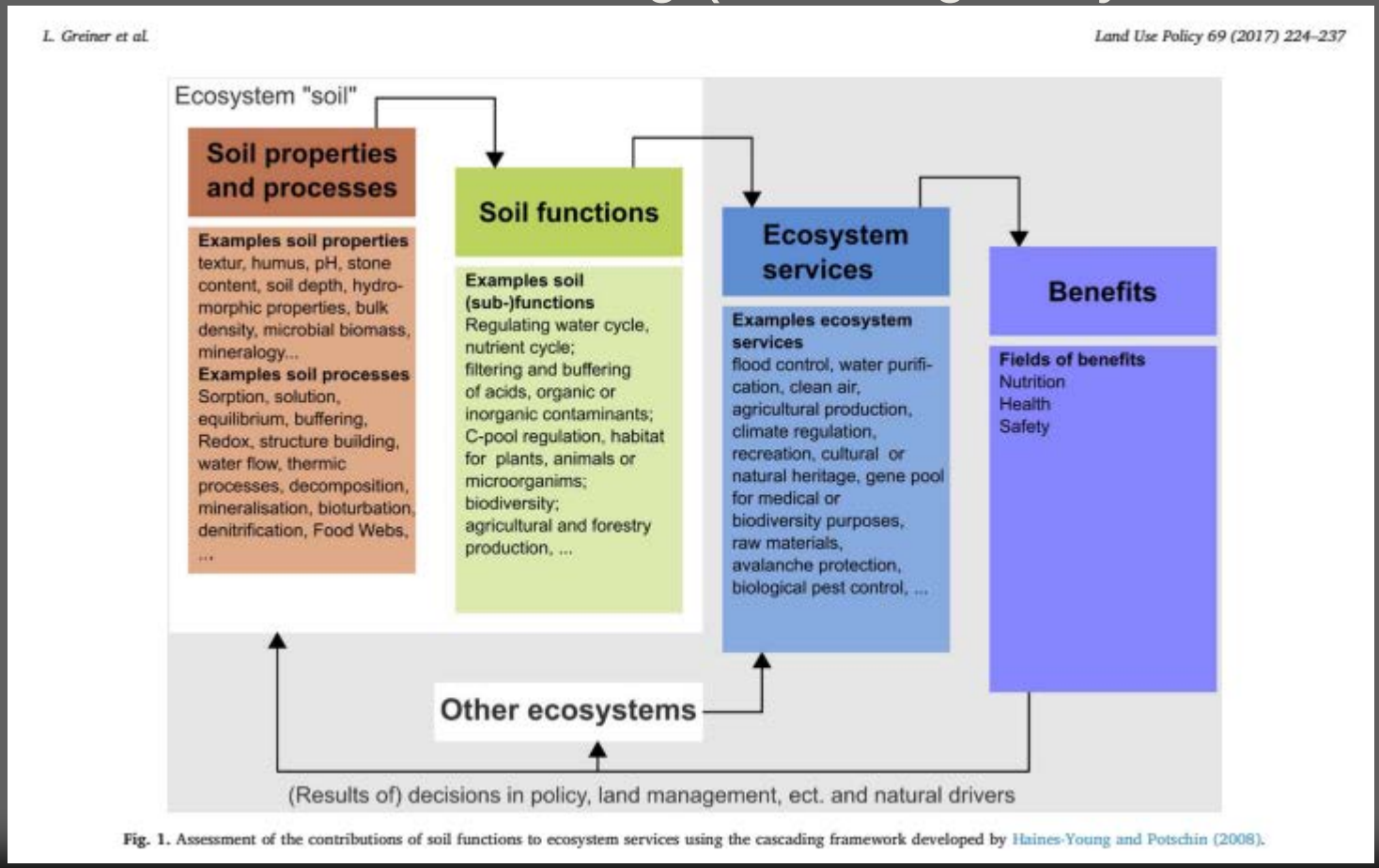


Fig. 1. Assessment of the contributions of soil functions to ecosystem services using the cascading framework developed by Haines-Young and Potschin (2008).

Why an understanding of soils is vital to conservation

- Seminar
- Individually: find an example of how an understanding of soil is important to conservation.
- Individually: Briefly present your example to the rest of the class
- Class/group: From all the examples identify why soils and their processes are important to conservation.
- Class/group: create a PowerPoint slide highlighting your findings

Some examples from exercise

- https://www.ceh.ac.uk/sites/default/files/files/SOILS_4ppA4Leaflet_Final_ForWeb.pdf
- https://www.wyeuskfoundation.org/too-much-soil-entering-rivers
- https://www.woodlandtrust.org.uk/publications/2013/02/pontbren-project-sustainable-uplands-management/
- https://www.nrcs.usda.gov/wps/portal/nrcs/detail/nj/technical/cp/?cid=nrcs141p2_018675
- http://www.ocscd.org/3-reasons-soil-conservation-important/
- https://www.sciencedaily.com/releases/2021/02/210215160227.htm
- htthttps://www.ceh.ac.uk/case-studies/case-study-why-should-we-conserve-and-manage-our-
- soilsps://www.fwi.co.uk/arable/land-preparation/soils/compaction-and-erosion-a-serious-threat-to-uk-farm-soils

Video

- Documentary in which gardening expert Chris Beardshaw delves into the micro-world of soil to reveal what it is, how it works and why we couldn't survive without it. 58 mins

A quick overview of Erosion

- Is the removal of surface material from the Earth's crust, primarily soil and rock debris, and the transportation of the eroded materials by natural agencies from the point of removal.

- The broadest application of the term erosion embraces the general wearing down and moulding of all landforms on the Earth's surface, including the weathering of rock in its original position, the transport of weathered material, and erosion caused by wind action, fluvial processes, marine processes, and glacial processes. This broad definition is **more correctly** called denudation, or degradation, and includes mass-movement processes (Encyclopaedia Britannica, 2017:45).







Erosion

There are many kinds of Erosion.

Here are a few:

- Wave Action
- Running Water
- Landslides
- Avalanche
- Glaciers
- Slump
- Creep
- Rock Fall
- Mud Flow



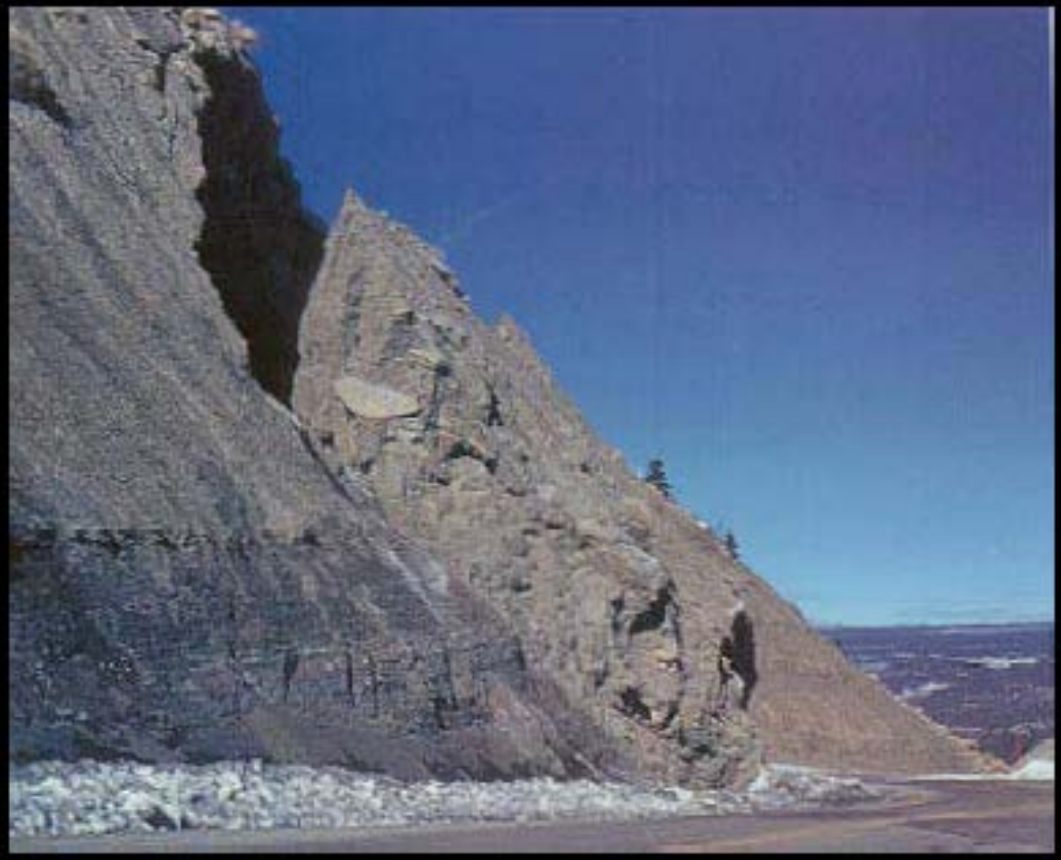
Wave action is when waves hit the rocks and pieces of rock break off.



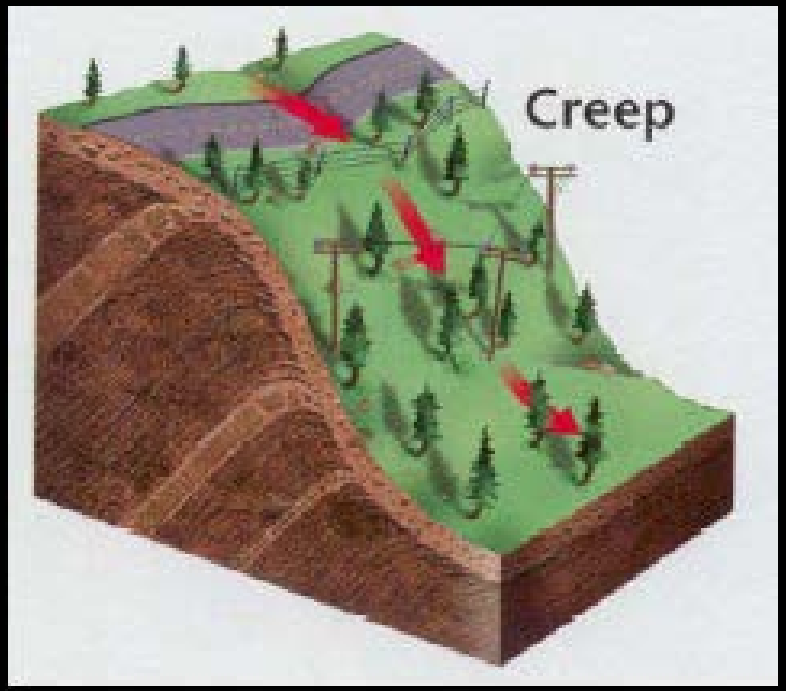
In this picture the running water eroded the sides of this canyon and created the V-shaped valleys.



This is a picture of a landslide.
A type of mass wasting.



In this picture the land has slumped into the road below.



This is a diagram of creep. The hillside slowly slips over many years from temperature or water.



This is a picture of an avalanche. It is similar to a landslide with ice and snow instead of rock.



This is a picture of a glacier which carves out a U-shaped valley where it flows dragging rocks and boulders along the way.



Weathering affects a lot of things in our world but there are some things that we can do to help prevent damage caused by weathering.

What are some of these actions??