

## II. GEOMORPHOLOGY

Weathering - chemical  
- mechanical

### a.) Chemical weathering

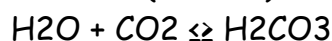
- decomposition of rock
- creates altered rock substances (e.g. granite --chem. w. --> kaoline)

H<sub>2</sub>O is the key medium

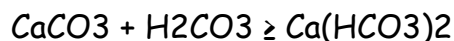
#### 1.) Carbonation-solution

=> takes place on rocks which contain Ca (e.g. limestone, chalk)

=> water (rainfall) combines with CO<sub>2</sub> to form weak carbonic acid



This carbonic acid subsequently reacts with calcium-containing compound (e.g. limestone)



As the PH of the water differs, it is capable of dissolving other rocks containing alcalic-character elements

#### 2.) Hydrolysis

#### 3.) Hydration

=> a process whereby certain minerals absorb water, expand and change

#### 4.) Oxidation

=> takes place when iron elements (/compounds) react with (dissolved oxygen) found in the soil or the atmosphere, e.g.  $2\text{Fe} + \text{O}_2 \Rightarrow 2\text{FeO} + \text{O}_2 \Rightarrow \text{Fe}_2\text{O}_3$

### b.) Mechanical weathering

- rock disintegration
- produces smaller angular fragments (of the same rock)

#### 1.) Freeze-thaw (=frost shattering = ice crystal growth)

=> takes place when water in cracks and joints freezes @<0°C

=> as water freezes, it increases its volume thus exerting pressure (up to 0.21Pa@-22°C

=> especially effective in regions where moisture is plentiful

### 2.) Salt crystallization

=> decomposition of rock by solutions of salt

=> has two main types

>in areas where  $t$  is oscillates around 27°C Na<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>CO<sub>3</sub> expand ~3-times in volume, thus exerting pressure on joint and fissures

>when water evaporates salt crystals may be left behind and, subsequently, when the temperature rises(!) and exerts pressure on the rock; this is common in relatively hot and arid regions (because the salt accumulates {water evaporates}), as well as in polar regions where salts are deposited from the snow flakes

### 3.) Disintegration

=> occurs in hot desert areas where the diurnal temperature tends to rise up to 40°C and nocturnal temperatures are usually little above 0°C

=> rock is a poor contractor of heat, that's why stresses (contraction caused by the temperature fall) occur only in the outer layers

### 4.) Pressure release

=> occurs when the overlying rock(s) is(/are) removed by (e.g.) erosion, this causes causes underlying rock to expand and fracture parallel to the surface

=> the removal of the overlying rock (=pressure release) results into the creation of cracks (or joints) to form at right angle to the unloading surface

*If*

*Overlying pressure is released pseudo-bedding planes will be formed*

*If horizontal pressure is released vertical joint will develop*

### Biological weathering

- leverage of fauna and flora resulting into chemical (e.g. organic acids) and mechanical weathering (e.g. plants' roots disintegrative leverage)
- not a separate type of weathering though a combination of a.) and b.)

Weathering undertakes irreversible changes in a rock

1.) from a solid state to a clastic (fragmental state) /e.g. scree/

2.) -----||----- a pliable state (clay)

## Slopes

A slope = inclined surface or hillslope

= an angle of inclination (slope angle), including  $0^\circ$

Surfaces:

- sub-aerial
- sub-marine
- aggradational
- degradational
- transportational
- mixture of these

### Slope development

1.) Geological structure

⇒ rock type, presence of fissures (faults), angle of dip and the vulcanity determine the strenght of a rock and its vulnerability to weathering

2.) Nature of the regolith

⇒ regolith = superficial, unconsolidated material (found @ the earth's surface), includes soil, scree, weathered bedrock and deposited material

⇒ prone to downslope movement (clay-rich r. is extremely unstable)

3.) Vegetation

⇒ can decrease overland run-off (through interseption and moisture storage)

→ deforested slopes frequently exposed to massive erosion

### Theories of slope evolution

1.) Slope decline (W. M. Davies)

2.) Slope replacemnt (Walther Penck)

3.) Slope retreat (L.C. King)

## Mass movements

- any large-scale movemnt of the earth's surface lacking a moving agent (e.g. a brook)
- we distinguiush
  - fluid movement (e.g. mudflows)
  - dry movement (e.g. rock falls)
  - fast movement (e.g. avalanches)
  - very slow movement (e.g. soil creep)

We can classify the particular process according to certain features:

- water content
- speed of movement
- medium (material) carried
- type of movement (slide, slump, flow, fall...)

It is possible to ascertain so-called "safety factor" of a slope = the total of forces sustaining the slope compared to the forces "trying" to move it. Each force has an effect that acts to sustain the slope (a stick component) or an effect that acts to move the medium down the slope ( a slide component)

Gravity, for instance, encompasses both, a stick and a slide component.

The downslope movement is directly proportional to slope angle and the weight of the medium (slide component of gravity).

Water may get into spaces between particles, hence so-called pore pressure, immensely increasing the ability of the slope to move, is created.

### **Types of the mass movement**

Surface wash - takes place when soil's infiltration capacity has been exceeded, in particular when the ground is frozen or heavily saturated; on the other hand, it might take place also in semi-arid and arid regions where particles' size prevent percolation

Sheetwash - unchanneled flow of the water over the earth's surface, usually divides into areas of higher and lower velocity; is capable of transporting material disengaged by rainsplash

Throughflow - takes place when water moves down through the soil; channelled into natural pipes in soil => has sufficient energy to transport material of considerable volume)

Heave/creep - small-scale movement occurring mostly in winter

Talus creep - slow movement of fragments on a scree slope

Rainsplash erosion - erosive effect of raindrops on the hillslope (because of sharp energy exchange => raindrops encompass relatively high kinetic energy)

Falls - occur on steep slopes (<70°); once rocks are detached (usually by weathering or human activity), they fall under the effect of gravity;

Short fall => relatively straight scree is produced

Long fall => concave scree is produced

Slopes - movement of entire mass of material along a slip plane

⇒ rockslides and landslides

⇒ rotational slides (resulting into formation of series of massive steps [terraces])

- cause: steep slope + weak rock + active undercutting

slipplanes occur

- @ the junction of two layers

- @ a fault line

- where there is a joint

- along a bedding plane

- @ the point beneath the surfaces where the shear stress exceeds shear strength

Rockslides

Landslides - a process whereby material (soil+rocks etc.) moves downslope as a result of shear failure (shear stress > shear strength) @ the boundary of the moving mass

Slumps and flows

- slumps occur on weaker rocks (e.g. clay) and have a rotational movement along a curved slip plane

- flows are more continuous and more likely to contort the mass into a new form

Avalanches - rapid movements of snow, ice, rock and soil down the slope

**Dry avalanche** - newly fallen (fluffy) snow falls off older snow

**Wet avalanche** - partially molten snow moves

Debris avalanche = rapid mass movements of sediments

*Glaciation and periglaciation*

Glaciation (lat. glacies = ice, glacier) = formation of glaciers in certain areas

Periglaciation => periglacial phenomena (gr. περι = around, round, about; lat.

glacies = ice, glacier) = karyogenic phenomena

(gr. κρυος = cold, ice; γιγνομαι = I am being created) => phenomena determined by the phase metamorphosis of water, especially edging the area already covered by glaciers, each glacial period is preceded and followed by periglacial period

### **Periglacial environment**

- characterised by permafrost and freeze-thaw action

=> permafrost (lat. permanere = persist, persevere; frost[engl.] = impermeable, permanently frozen soil; ~20% of the Earth's surface is underlain by permafrost

- we distinguish 3 types of permafrost: continuous, discontinuous and sporadic
- above the permafrost so-called active layer is found; a.l. is extremely mobile, because it thaws out seasonally and hence is involved in mass movements

Periglacial advances (esp. during the glacial phases) and retreats (during the process of so called deglaciation, esp. interglacial periods) manus in manu with glaciation

### **Periglacial processes**

Congelifraction = the process whereby rocks are split up by freeze-thaw weathering

Frost heave = occurs when water freezes in the soil, pushes the surface upwards and churns it up; Ice-lensing = growth of ice crystals in the soil

Solifluction (lat. *solum* = soil; *fluere* = to flow) etymologically more properly called congelifraction (lat. *congelare* = freeze [over]; *fluere* = to flow), in winter soil freezes over and is separated into fragments. In spring the water thaws, but because it cannot infiltrate into soil (due to the impermeable permafrost) it moves along the permafrost carrying soil particles (called peds).

Nivation (lat. *nix* [genitive *nivis*] = snow) also called cryoplanation (lat. *plannum* = plain) or altoplanation (*altus* = high, [tall]) = a freeze-thaw weathering process taking place underneath a snow bank

Fluvial activity - (lat. *fluvius* = river)

Anemal (gr. *ανεμος* = wind) activity

Cambering = a process whereby segments of the rock are dislodged from the main body and start to move (but not fall[!]) downhill

Avalanches (see "mass movements")

### **Process of glaciation**

- accumulation of (newly fallen) snow = alimantation (lat. *alimentum* = boost, aliment)

Snow flakes are compressed into a collection of granular ice pellets called neve(firn), as the pressure keeps increasing neve starts to melt. Molten water fills the gaps in the structure and freeze. Apart from this water vapour may change directly to ice whereby the process of desublimation.

Glacial regime = the balance between ( $\alpha \Rightarrow$  the rate of supply and the amount of ice compared to  $\beta \Rightarrow$  the amount and rate of losses

If  $\alpha > \beta \Rightarrow$  positive g.r.

If  $\alpha < \beta \Rightarrow$  negative g.r.

### Glacial classification

1.) Division according to size

a.) Niche glaciers

b.) Cirque glaciers

c.) Valley glaciers

d.) Piedmont glaciers

e.) Ice caps

f.) Ice sheets

2.) Thermal classification

a.) polar (cold-based) glaciers - ice remains frozen @ the base, hence there is very little water and almost no movement

b.) temperature glaciers warm-based glaciers, water is present in relatively high amount, acts as a lubricant, water percolates thus increasing weathering processes taking place in the bedrock.

### Glacial erosion

- as the glacier moves down the slope it provides for the processes of plucking (occurring especially in jointed rocks or those weakened by freeze-thaw w.) and abration

### Features of the glacial erosion

Aretês - formed by headward recession of two or more cirques

- $\Rightarrow$  cirque (also [in Slovak alike] called by the German word *kar*) = semicircular end of the glaciated valleys; ice may carve deep rock basins called ribbon lakes, adjacent to the ice mass proglacial lakes are formed. Tributary (to the main one) glaciers form so-called hanging valleys.

Crag and tail ree landforms created by a very large resistant object obstructing ice flow.

**DRIFT** - in reference with glacial deposition it stands for all glacial and fluvioglacial deposits left after the ice has molten; including:

Erratics - large boulders foreign to the local geology (i.e. brought from another part of the land)

Morains (from French *moraine*) = glacial accreptions, weathered form the valley sides and carried by a glacier

Drumlins - small oval mounds, formed due to friction between the ice and the underlying geology

Glaciers store huge amounth of water and the changes of state of this water leads into eustatical (global) change in the sea level. Glacier also changes isostatically (locally) the level of land underneath. This may result into the formation of fjords and rias (~riased beaches).



