

Answer Key: Geology II Exam

1st Year LMD – 2nd Semester (2025-2026)

I. Multiple Choice Questions

Correct answers are indicated by the plus sign (+).

1. The luster of minerals:

- Corresponds to planes of weakness in the crystal structure.
- Corresponds to their resistance to being scratched.
- + Is the appearance of their surface when it reflects light.

2. The Catazone:

- Is the intermediate zone between diagenesis and metamorphism.
- + Corresponds to intense metamorphism.
- Temperature and pressure are high, but there are few constraints.
- + Is often characterized by the foliation of minerals.

3. Sandstones are rocks that are:

- Magmatic.
- + Detrital sedimentary.
- + Exogenous.

4. The Friedrich Mohs scale:

- is a rock density scale.
- + is a mineral hardness scale.
- comprises twelve (12) classes.

5. Contact metamorphism:

- + Is accompanied by the orientation of the rock.
- + Occurs within the country rock at the contact zone with intrusive bodies.
- Is produced by a meteorite impact on the planet's surface.

6. The various principles of stratigraphy allow for:

- + Relative dating of geological events and bodies.
- Dating events in years.
- + Reconstructing the geological history of a given region.

7. Endogenous rocks (of internal origin) can refer to rocks that are:

- + Metamorphic.
- Sedimentary.

- + Plutonic.

8. A volcanic rock corresponds to a rock that is:

- + Effusive.
- + Extrusive.
- + A rock resulting from the crystallization of liquid or magma at the surface.

9. An angular unconformity of strata corresponds to:

- A succession of horizontal layers.
- Roche moutonnées with angular extremities.
- + The superposition of two layers with different dips on either side of the unconformity surface.

10. The concept of isostasy is:

- The primary driver of tectonic plate drift.
- + The state of equilibrium of the rigid lithosphere resting on the asthenosphere.
- + A permanent equilibrium between the Earth's crust and the asthenosphere.

II.

The Seven Principles of Stratigraphy (3.5 pts)

1. The principle of horizontal continuity.
2. The principle of superposition.
3. The principle of original horizontality.
4. The principle of uniformitarianism (actualism).
5. The principle of faunal (paleontological) succession.
6. The principle of cross-cutting relationships.
7. The principle of inclusions.

III.

Determining the Age of a Rock (R) Using Geochronological Dating (2 pts)

Given that the amount of the parent element at time $t = 0$ is 10 g, the amount of the parent element at the current time t is 5 g, and the radioactive decay constant $\lambda = 6,931 \times 10^{-7} \text{ yr}^{-1}$

$$\frac{N_t}{N_0} = \frac{5}{10} = 0,5$$

Where t is the time required for half of the rock to decay:

$$t = \frac{0,693}{\lambda} = \frac{0,6931}{6,931 \cdot 10^{-7}}$$

$$= \frac{0,6931 \cdot 10^7}{6,931} = 10^6 = 1000000 \text{ years}$$

IV. Water is an important agent of rock erosion in various forms, acting both **mechanically and chemically**.

1. Mechanical Action (0.25 pts)

- **Hydroclasty:** Fragmentation caused by variations in the water content of rocks or minerals through alternating phenomena of drying (desiccation) and wetting (humectation) (0.25 pts).
- **Marine Erosion:** The sea, through the repeated impact of waves, fragments and displaces coastal rocks (0.25 pts).
- **Frost Wedging (Cryoclasty):** When it freezes, water changes volume and causes the rock to shatter.

Note: Cryoclasty is an example of erosion by thermoclasty: the rock shatters due to the alternating freeze-thaw cycles of infiltrating water. When water freezes, it occupies more volume and exerts enough force to shatter a rock. The fragments released by freezing are called **gelifragments** (0.25 pts).

- **Glaciers:** Glaciers, moving under their own weight, wear down the bedrock (substratum) and displace the materials they break apart (moraines).
 - Glacial movements, which are primarily gravitational, exert significant stress on the bedrock, mainly caused by rock blocks trapped at the base of the ice layer and forced to move along with the glacier's flow.
 - These blocks "scrape" the valley bedrock, smoothing landforms and carving **glacial striations**, eventually generating **glacial valley** morphologies over the long term.
 - During periods of **deglaciation**, ice blocks previously anchored to the ocean floor can move with tidal currents, carving **iceberg wallows/scours** into the seabed.
 - There are three types of glacial erosion processes: abrasion, plucking, and fluvio-glacial erosion.
 1. **Abrasion (Mechanical):** The result of friction from debris-laden ice scraping against rocks. This produces:
 - **Striations or glacial striae:** Small furrows (millimeter-sized) parallel to the direction of ice flow.
 - **Polishing:** The smoothing of rock due to glacial friction, resulting in the formation of **roches moutonnées (sheepbacks)**.
 2. **Plucking / Quarrying (Mechanical Erosion):** The second type of glacial erosion process. The glacier tears away pieces of rock that become incorporated into the ground moraine. Plucking gives roches moutonnées an asymmetrical shape: they are polished on the upstream side (where the glacier is compressed against the rock) and jagged on the downstream side of obstacles (where the glacier detaches from the rock and meltwater refreezes, tearing rock pieces away).
 3. **Fluvio-glacial Erosion:** The third erosive factor. In temperate glaciers, this is driven by subglacial water, which is sometimes under high pressure. A specific

case is **glacio-karstic erosion**, where ablation on a limestone substrate is partially driven by chemical dissolution processes (*1 pt*).

- The **splash effect** (the impact of falling raindrops on the soil), **soil creep**, and **solifluction** (the downslope movement of muddy materials softened by an increase in liquid water content) (*0.25 pts*).
- **Runoff Waters:** The action of runoff depends primarily on the **quantity** of water precipitated within a **minimum timeframe**. Consequently, storm rains are responsible for significant continental erosion.
- **Runoff Processes:** * **On Homogeneous Terrain** (rocks of the same nature), several phenomena occur:
 - **Gully erosion (Ravinement):** Occurs in clay, marl, or shale terrains. After heavy rain, water exploits existing soil fissures and gradually widens them. The effects can be catastrophic, creating **badlands** topography.
 - **Lapiez (Karren):** Appear in limestone terrains where runoff water attacks the limestone by wearing it down and dissolving it.
 - **On Heterogeneous Terrain** (rocks of different types), runoff waters wash away the **finest, loosest, or most soluble** materials, leaving behind only the resistant or insoluble parts. This leads to the appearance of **fairy chimneys / hoodoos** (natural rock columns with strange, evocative shapes that inspire many legends), **granite chaos** (boulder fields or corestones left behind as a landform after weathering along joint networks during the cooling of a deep granitic intrusion), or **ruiniform landscapes** (*0.25 pts*).
- **Watercourses:** After running off, rainwater collects into well-defined channels and flows toward larger streams and rivers.
 - When watercourses are temporary (dry for part of the year), they are called **torrents or wadis (oueds)** (in arid regions like Algeria).
 - When they are permanent (water is always present), they are called **streams or rivers**.
 - Watercourses act simultaneously as agents of **erosion, transport, and deposition**, depending on current velocity and the size of the transported particles (*0.25 pts*).
- **Groundwater:** Groundwater originates primarily from the **infiltration** of precipitation. Once underground, it can form nearly static **aquifers (water tables)** that feed **springs and wells**, or it can circulate and carve through rocks.
 - Regions where underground water circulation is more significant than surface runoff develop a unique topography called **karst morphology** (characterized by caves and underground gallery networks).
 - Groundwater can move as actual subterranean rivers. Water circulation is made possible—particularly in limestone—by the dissolution of rock by water charged with **carbon dioxide**.
 - Erosion caused by groundwater activity is called **karst erosion**. This action leads to the formation of extensive networks of galleries and caves.
 - The water exiting these caves at springs contains calcium carbonate, which precipitates to form **tuffs or travertines** (*0.25 pts*).

2. Chemical Action (0.5 pts)

The chemical decomposition of rocks gives rise to weathering features.

- **Dissolution:** A major process, particularly of limestone by more or less acidic rain, creating what is known as **karst**. Dissolution is a form of **weathering** that mainly affects limestone massifs, resulting in karst landscapes. Water, loaded with organic acids and **carbon dioxide**, infiltrates through cracks and shapes carbonate rocks. It forms a "weathering complex," releasing the chemical elements of the rock as **ions dissolved in water**.
- Unlike **siliceous sandstone**, limestones are highly vulnerable to dissolution. Other rocks and minerals are also soluble:
 - **Silica:** Relatively low solubility.
 - **Carbonates:** Solubility increases with water acidity.
 - **Gypsum:** Solubility increases with water temperature.
 - **Sulfates.**
 - **Sodium and Potassium Chlorides:** Extremely high solubility.
- Chemical weathering alters rock minerals through **hydration, oxidation, redox reactions, and hydrolysis**.
- **In Intertropical Zones:** The weathering of **feldspathic** rocks by leaching leads to the formation of **laterites**. These red or brown rocks are composed of **aluminum and iron hydroxides**, forming a hard crust (duricrust) on the surface of plateaus in hot, humid regions.
- **Hydrolysis:** The process of **breaking chemical bonds** within minerals. It gives rise to **oxides** (such as **limonite**) or clays, ultimately forming **soil**.

V. Definitions of Terms

- **Thermoclasty (Thermal Shattering):** Erosion linked to temperature fluctuations. In regions with high thermal amplitude (continental climates, polar regions, deserts, high mountains, etc.), repeated thermal shocks from day/night cycles fracture and eventually shatter certain rocks on both microscopic and macroscopic scales.
- **Weathering (Alteration):** The processes responsible for transforming healthy rock (known as the "parent rock") into its decomposition products. There are different weathering processes:
 - *Physical or mechanical weathering:* (e.g., temperature fluctuations, impacts).
 - *Chemical weathering:* This process is intensified by high temperatures and humidity, particularly in tropical climates (resulting in phenomena such as dissolution and hydrolysis).
 - *Biological weathering:* (e.g., tree roots fracturing rocks, burrowing animals).
- **Isostasy:** The state of equilibrium of the rigid lithosphere resting on the asthenosphere. According to the principle of isostasy (recalling that the lithosphere "floats" on the asthenosphere), the removal of a layer of material from the surface of a continent triggers a rebalancing of mass, causing the continental lithosphere as a whole to uplift.

- **Karstification:** The widening of fissures primarily in limestone rocks (calcium carbonate), leading to the formation of underground cavities (caves). This creates what is known as a "karst landscape."
- **Schistosity:** A structural feature of metamorphic rocks where the rock splits into thin layers (folia) of identical mineralogical composition. While it can appear during diagenesis (due to lithostatic pressure), it is most often linked to tectonic stresses. Schistosity usually develops perpendicular or oblique to the applied forces.

VI. Classification of Minerals (1 pt)

Matching the following minerals to their mineralogical classes/families:

Mineral	Mineralogical Class
1. Hematite (Fe O ₃)	Oxide
2. Chalcopyrite (CuFe S ₂)	Sulfide
3. Gypsum (CaSO ₄ H ₂ O)	Sulfate
4. Calcite (CaCO ₃)	Carbonate