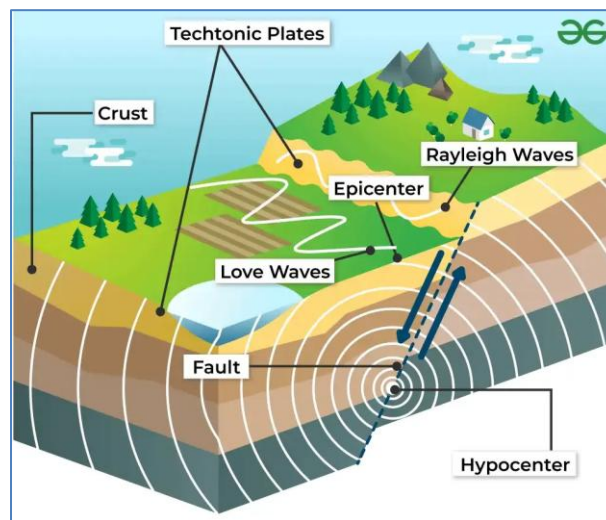


Chapter III

GEOLOGICAL AND ENVIRONMENTAL NATURAL HAZARDS

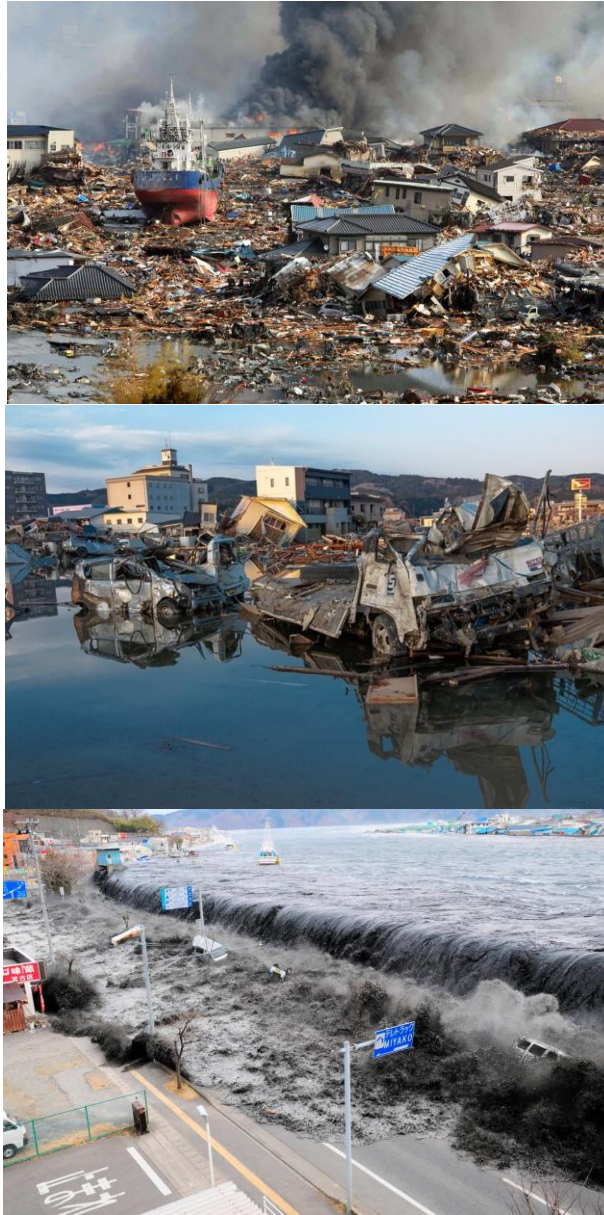
I. EARTHQUAKES

Earthquakes result from the sudden release of accumulated tectonic stress **along faults**. They generate seismic waves that propagate through the Earth's crust, causing ground shaking.



Example 1:

Tōhoku Earthquake (Japan, 2011): A magnitude 9.0 megathrust earthquake triggered a devastating tsunami and the Fukushima nuclear disaster, illustrating cascading hazards.



Tsunami: <https://www.youtube.com/watch?v=4XvFFfgXwnw>

Example 2:

El Asnam Earthquake (Algeria, 1980): Magnitude 7.3 earthquake causing surface rupture and major destruction, demonstrating active tectonics in the Tell Atlas.



Example 3:

Boumerdès Earthquake (Algeria, 2003): Magnitude 6.8 event leading to more than 2,200 fatalities and widespread infrastructure collapse.



II. LANDSLIDES AND SLOPE INSTABILITY

A landslide is the downward and outward movement of rock, soil, or debris on a slope under the influence of gravity.

In geology, landslides are classified as mass movements and occur when the driving forces (mainly gravity) exceed the resisting forces (such as friction and cohesion).

◆ Simple definition:

A landslide is the movement of earth materials down a slope.

◆ **Scientific definition:**

A landslide is a gravity-driven mass movement involving rock, debris, or soil along a slope, occurring along a failure surface when shear stress exceeds shear strength.

◆ **Main characteristics:**

- Occurs on natural or artificial slopes
- Can be slow (creep) or rapid (debris flow, rockfall)
- Triggered by:
 - Heavy rainfall
 - Earthquakes
 - Volcanic activity
 - Human activities (excavation, deforestation)

Example 1:

El Kherba Landslide — Mila, Algeria

- A large landslide occurred in the El Kherba area, which is part of the municipality of Mila in northeastern Algeria (wilaya of Mila).
- This landslide was reactivated by the Mw 4.9 earthquake of 7 August 2020, which struck near Mila and was strong enough to disturb slopes that were already unstable.
- According to geological studies:

- The El Kherba landslide is a very large deep-seated slope failure, extending about 2,170 m long and 1,800 m wide, with an estimated volume of ~26 million m³ of material.
- Damage from the landslide was significant, affecting over 1,000 buildings, including schools, roads, and water infrastructure in the area near Mila city.
- Research in the Bulletin du Service Géologique de l'Algérie confirms that the 07 August 2020 seismic event triggered multiple landslides in the region, with El Kherba one of the most prominent ones among localities like Grarem Gouga, Bou Hatem, and Hemala.

Geological and Risk Context

- The region around Mila is susceptible to landslides, especially where steep slopes, certain soil types (e.g., clayey soils), and groundwater conditions combine. These factors can make slopes prone to failure when shaken by earthquakes or saturated by rainwater.
- Geological hazard maps show landslide-prone zones within the wilaya of Mila, indicating that El Kherba falls within areas where such mass movements are known to occur following seismic or hydrological triggers.

What Triggered It?

The main triggers identified in studies are:

1. Seismic shaking from the 2020 earthquake, which reactivated pre-existing unstable terrain.
2. Local geological conditions and water content that may have weakened slopes over time and contributed to the susceptibility to sliding.



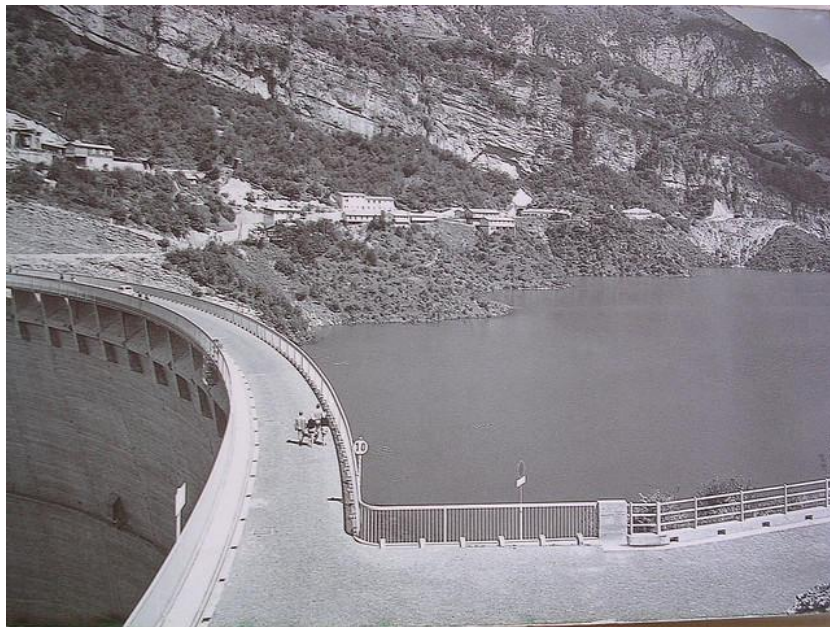
**Example 2:**

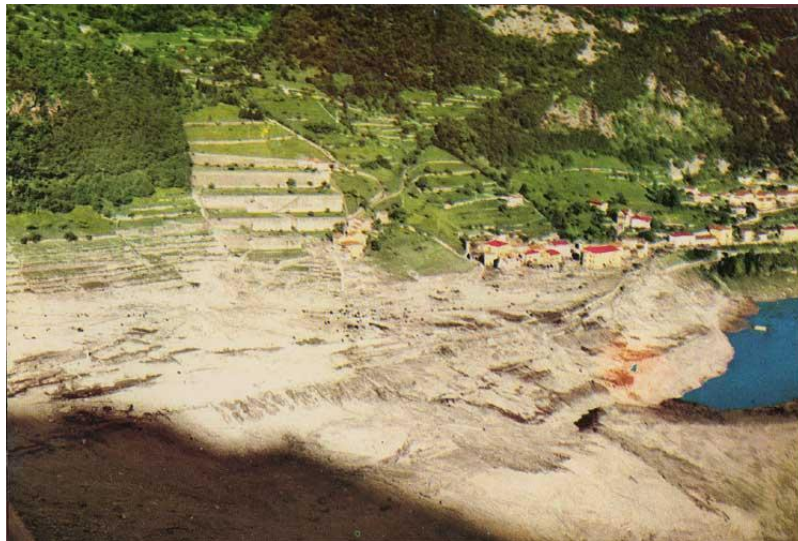
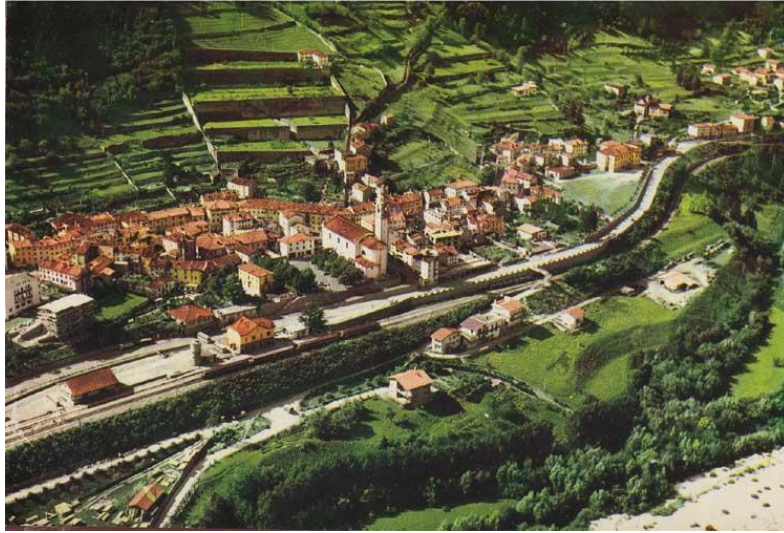
Vajont Landslide (Italy, 1963): Around 260 million m³ of rock collapsed into a reservoir, producing a catastrophic wave that killed about 2,000 people.





The collapse of the mountain filled in almost half of the reservoir in minutes





Example 3:

Himalayan Landslides (India/Nepal): Monsoon-triggered slope failures frequently block roads and rivers, causing secondary flooding. The Himalayas are highly vulnerable to landslides, but governments have failed to prepare for the hazard and develop early warning systems vital to preventing loss of human lives and property.

The devastating Himalayan landslide that hit Sindhupalchowk district in Nepal on August 2 has wiped out an entire village and affected two others, killing at least 156 people and blocking the Sunkoshi river with possibility of flash floods threatening downstream areas in Nepal and India.





III. DEVASTATING FLOODS

Floods result from intense rainfall exceeding the infiltration capacity of soils.

Example 1 – Bab El Oued Floods (Algiers, 2001): Torrential rainfall caused over 700 deaths due to uncontrolled urbanization and insufficient drainage.

Example 2 – Pakistan Floods (2010): Exceptional monsoon rains submerged vast areas, affecting millions of people and causing long-term economic losses.

Example 3 – Central European Floods (Germany/Belgium, 2021): Extreme rainfall events linked to climatic variability caused severe infrastructure damage.

IV. GROUND COLLAPSE (SUBSIDENCE AND SINKHOLES)

Ground collapse may occur due to karst dissolution, mining activities, or groundwater overexploitation.

Example 1 – Florida Sinkholes (USA): Numerous collapses in limestone terrains due to dissolution processes and groundwater fluctuations.

Example 2 – Mexico City Subsidence: Excessive groundwater extraction has caused long-term land subsidence exceeding several meters.

Example 3 – Mining Subsidence (Northern France): Abandoned underground mines have caused surface deformation and structural damage.

V. CLAY SHRINK–SWELL HAZARD

Expansive clay soils undergo volumetric changes depending on moisture conditions.

Example 1 – Southern France Shrink–Swell Crisis: Recurrent droughts have caused widespread foundation cracking in residential buildings.

Example 2 – Texas Expansive Clays (USA): Seasonal moisture variation leads to severe damage to roads and housing.

Example 3 – Northern Algeria Clayey Formations: Seasonal wetting and drying cause ground cracking and structural deformation.

VI. MUDFLOWS AND DEBRIS FLOWS

Mudflows are rapid flows of water-saturated fine sediments, often triggered by heavy rainfall.

Example 1 – Vargas Tragedy (Venezuela, 1999): Intense rainfall triggered massive debris flows causing thousands of fatalities.

Example 2 – Wildfire-Triggered Mudflows (California, USA): Post-fire landscapes become highly susceptible to debris flows.

Example 3 – Mountainous Areas of Mila (Algeria): Intense rainfall events mobilize fine sediments and generate localized mudflows.

VII. ENVIRONMENTAL POLLUTION (WATER, SOIL, AIR)

Pollution interacts with geological systems and may amplify environmental hazards.

Example 1 – Aral Sea Environmental Crisis: Diversion of rivers caused severe ecological degradation and soil salinization.

Example 2 – Industrial Groundwater Pollution (Annaba, Algeria): Heavy metals contamination affects aquifers near industrial zones.

Example 3 – Air Pollution in Urban Megacities: High particulate matter concentrations intensify health risks and climate effects.

GENERAL CONCLUSION

Each geological and environmental hazard presents unique mechanisms, but all share a common characteristic: they become disasters when combined with human vulnerability. Case studies from Algeria and worldwide highlight the importance of scientific assessment, hazard mapping, and sustainable land-use planning.