

Introduction to Geology



- Geology: the science of Earth's materials, structures, and history



- It connects landscapes, resources, hazards, and climate change



- We depend on geology for water, energy, and safer communities



- Journey: minerals → rocks → plate tectonics → deep time → reading the landscape



Minerals



Rocks



Plate Tectonics



Deep Time

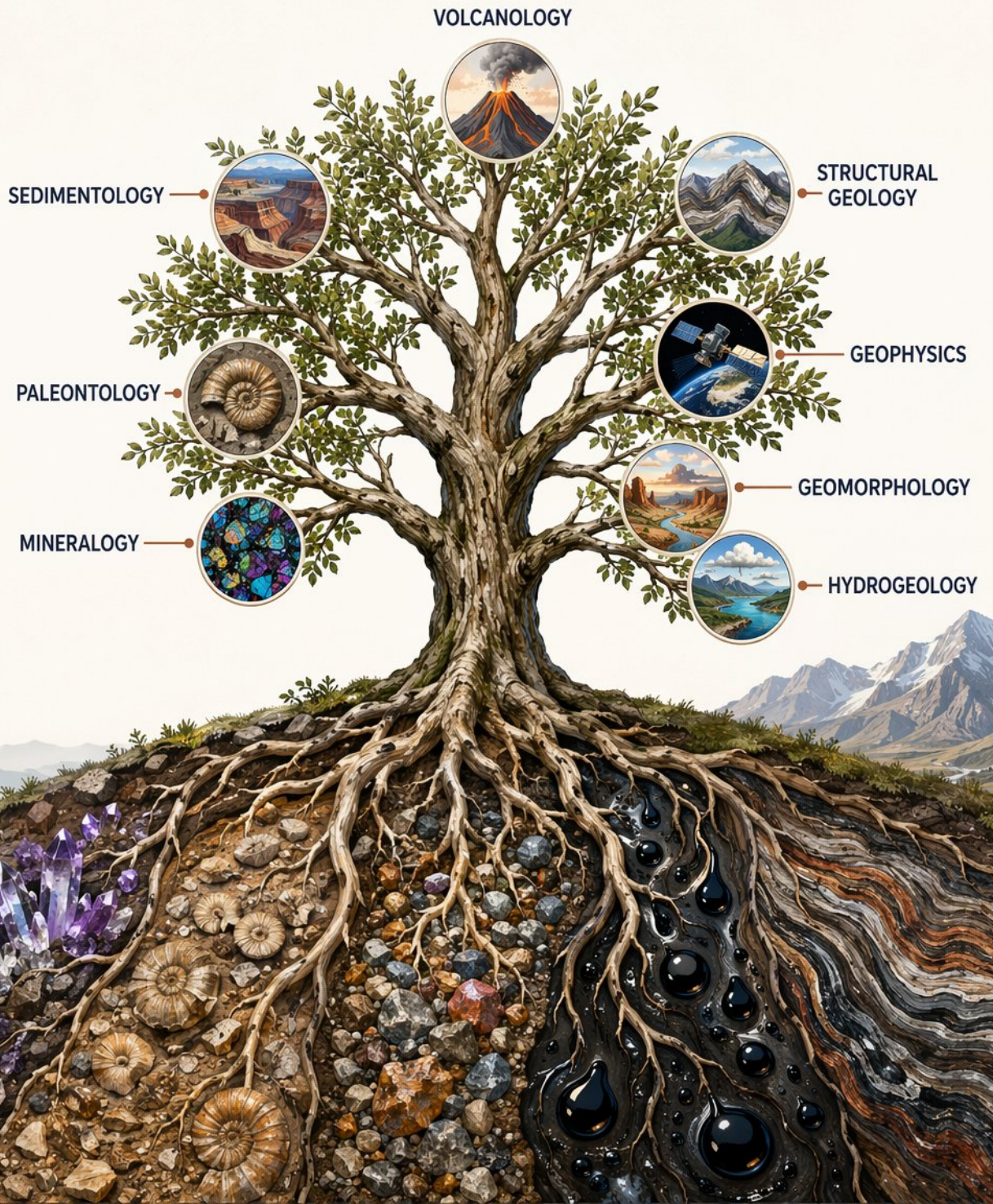


Reading the Landscape



What Is Geology and Why Does It Matter?

Presenter: [Your Name]





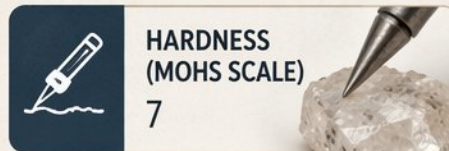
Minerals: Earth's Building Blocks

- A mineral is a naturally occurring, inorganic solid with a fixed chemical recipe and orderly atomic structure.
- Identify minerals by color, streak, hardness (Mohs scale), luster, and cleavage.
- Quartz, feldspar, and mica are the most common rock-forming minerals.
- Quartz is glassy and hard; feldspar is blocky and often pink or white; mica peels into thin sheets.

QUARTZ



STREAK
White



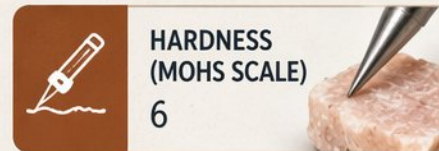
HARDNESS (MOHS SCALE)
7

LUSTER: Glassy | **CLEAVAGE:** None

FELDSPAR



STREAK
White



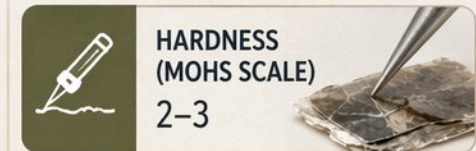
HARDNESS (MOHS SCALE)
6

LUSTER: Vitreous | **CLEAVAGE:** Two cleavages at $\sim 90^\circ$

MICA



STREAK
White



HARDNESS (MOHS SCALE)
2-3

LUSTER: Pearly to Silky | **CLEAVAGE:** One perfect cleavage

The Rock Cycle and the Three Rock Families

- **Igneous:** cooled from magma or lava (e.g., granite)
- **Sedimentary:** compacted layers of sediment (e.g., sandstone)
- **Metamorphic:** transformed by heat and pressure (e.g., marble)
- Any rock can transform into another type over time



Peeling Back the Layers: Earth's Internal Structure

- Earth's layered structure: crust, mantle, outer core, and inner core
- **Crust:** thin, rocky outer layer; oceanic (basalt) and continental (granite)
- **Mantle:** thick, semi-solid layer that flows slowly over time
- **Core:** liquid outer core (iron-nickel) and solid inner core
- Lithosphere (rigid) vs. asthenosphere (weak, flowing layer beneath)

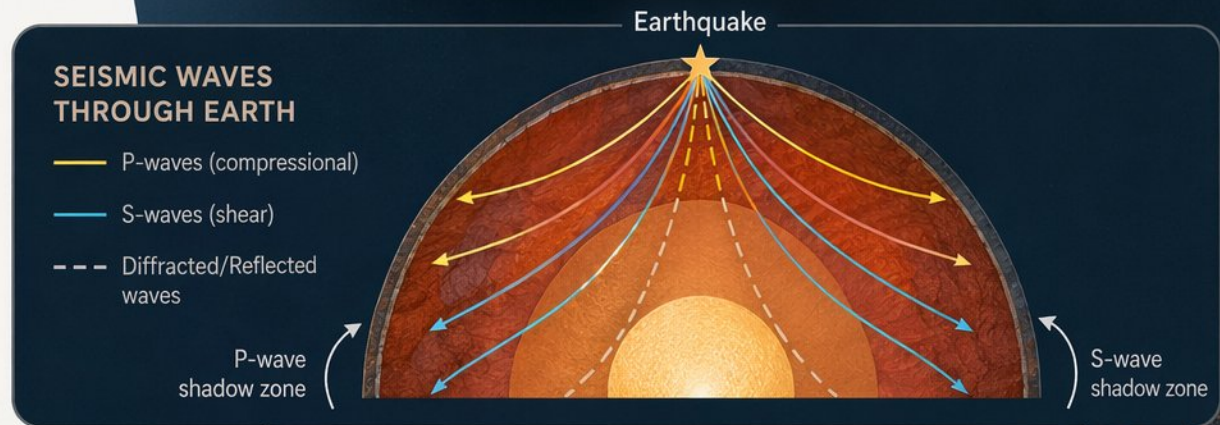
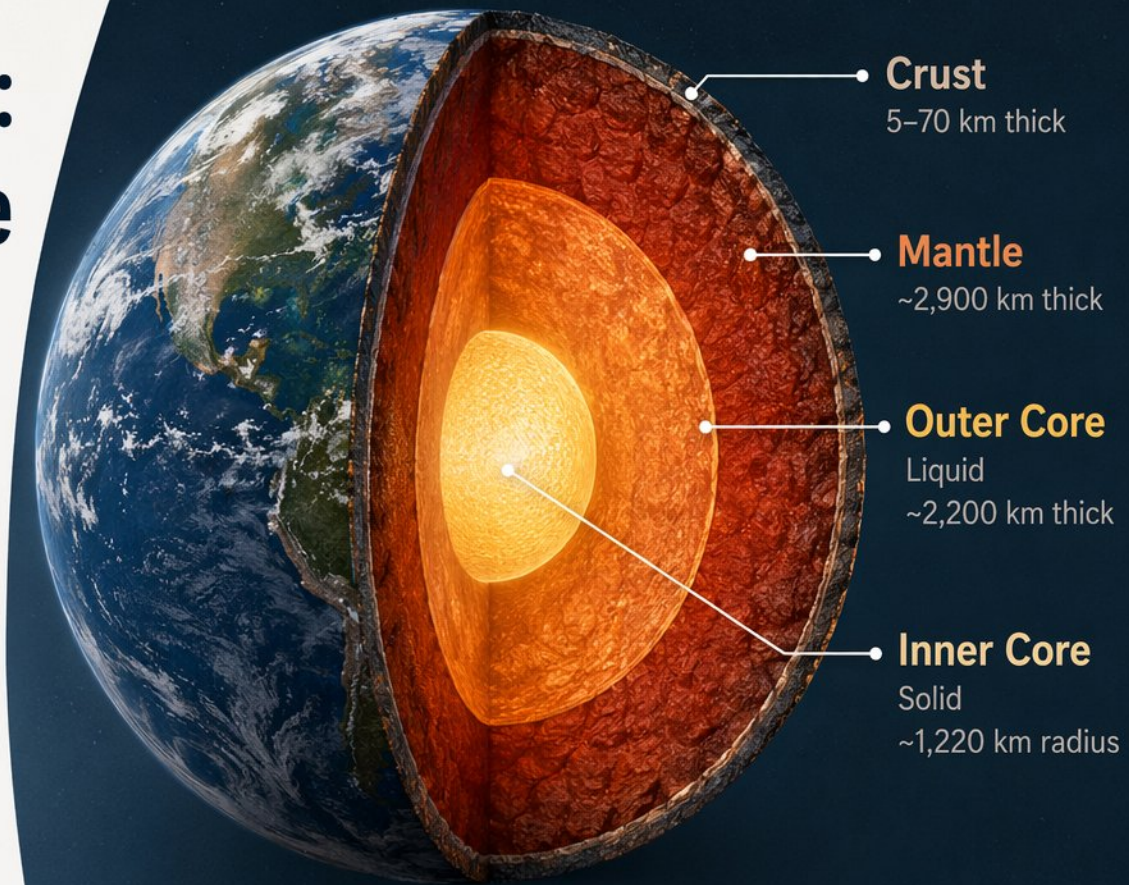
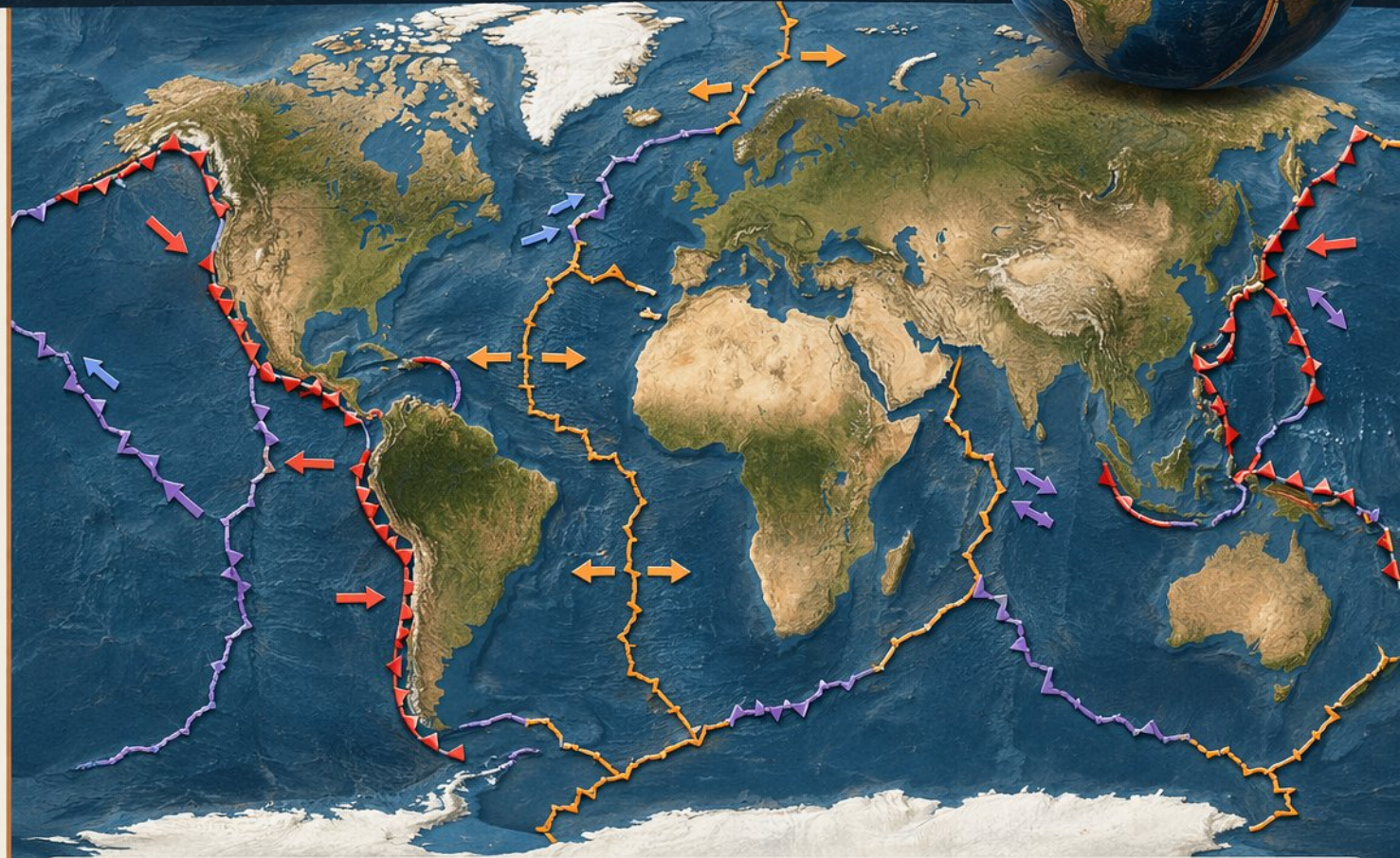


Plate Tectonics:

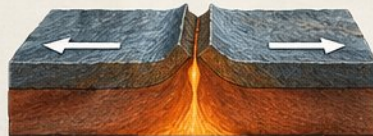
The Engine of a Dynamic Planet



- From Wegener's continental drift to the modern theory of moving continents
- Divergent: plates pull apart; Convergent: plates collide; Transform: plates slide past
- Mantle convection drives plate movement: hot material rises, cool material sinks
- The puzzle of fitting coastlines and matching fossils across oceans



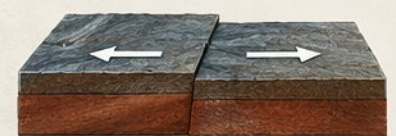
 **DIVERGENT**
Plates pull apart



 **CONVERGENT**
Plates collide



 **TRANSFORM**
Plates slide past

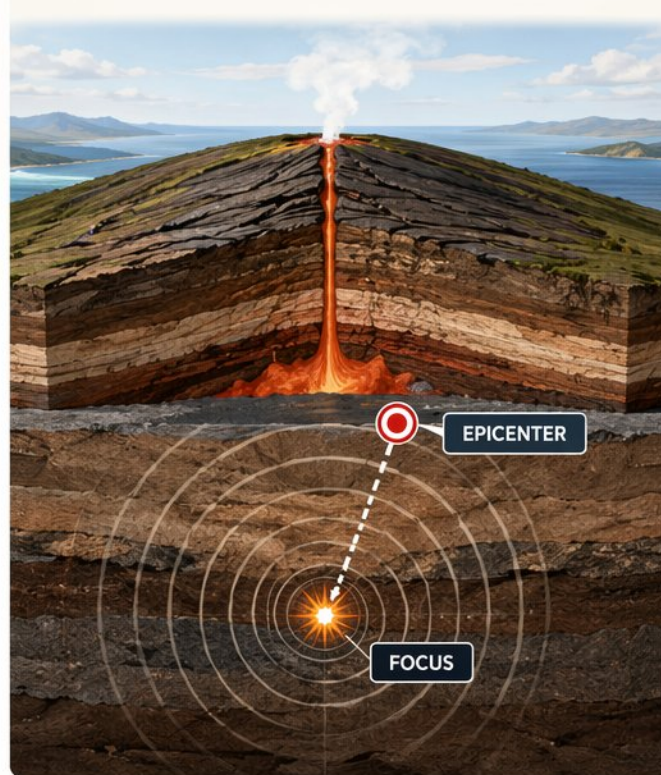


Where Plates Meet: Earthquakes and Volcanoes

- Most earthquakes and volcanoes happen along plate boundaries, especially the Ring of Fire
- Earthquake basics: focus, epicenter, seismic waves, Richter and moment magnitude scales
- Shield volcanoes: broad, gentle slopes from fluid lava flows
- Stratovolcanoes: steep, explosive cones common in the Pacific Ring of Fire

SHIELD VOLCANO

Broad, gentle slopes from fluid lava flows



STRATOVOLCANO

Steep, explosive cones common in the Pacific Ring of Fire



Focus

Underground point where an earthquake starts



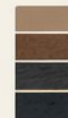
Epicenter

Point on the surface directly above the focus



Seismic Waves

Energy that travels outward from the focus



Earth Layers

Rocks of different types and ages

The Ring of Fire: Earth's Most Active Zone



A 40,000-km horseshoe of volcanoes, quakes, and trenches around the Pacific



Home to roughly 75% of active volcanoes and 90% of earthquakes



Pacific Plate subduction triggers melting, fueling explosive stratovolcanoes



Deep ocean trenches mark where one plate dives beneath another



This belt shapes the Ring's violent earthquakes and tsunamis



VOLCANIC ARC

Chain of volcanoes formed by subduction zones

SUBDUCTION ZONE

One tectonic plate dives beneath another

OCEAN TRENCH

Deepest parts of the ocean at plate boundaries

LAVA FLOW

Magma reaches the surface, building land and islands

Surface Processes: Weathering, Erosion, and Deposition

- **Physical weathering** breaks rocks via freeze-thaw cycles and abrasion
- **Chemical weathering** dissolves or alters minerals through oxidation and acids
- Water, wind, ice, and gravity transport weathered material as **erosion**
- **Deposition** builds deltas, sand dunes, and glacial moraines from settled sediment



From Sediment to Stone: How Sedimentary Rocks Form



- Compaction and cementation turn loose sediment into solid rock



- Sandstone, shale, and limestone each reveal ancient environments



- Fossils preserved in sedimentary rocks open a window into past life



- The rock cycle continuously recycles all three rock families



Decoding Earth's History: Geologic Time and Fossils



Earth formed 4.6 billion years ago; a cosmic calendar compresses deep time into one year.



The geologic time scale divides history into eons, eras, periods, and epochs.



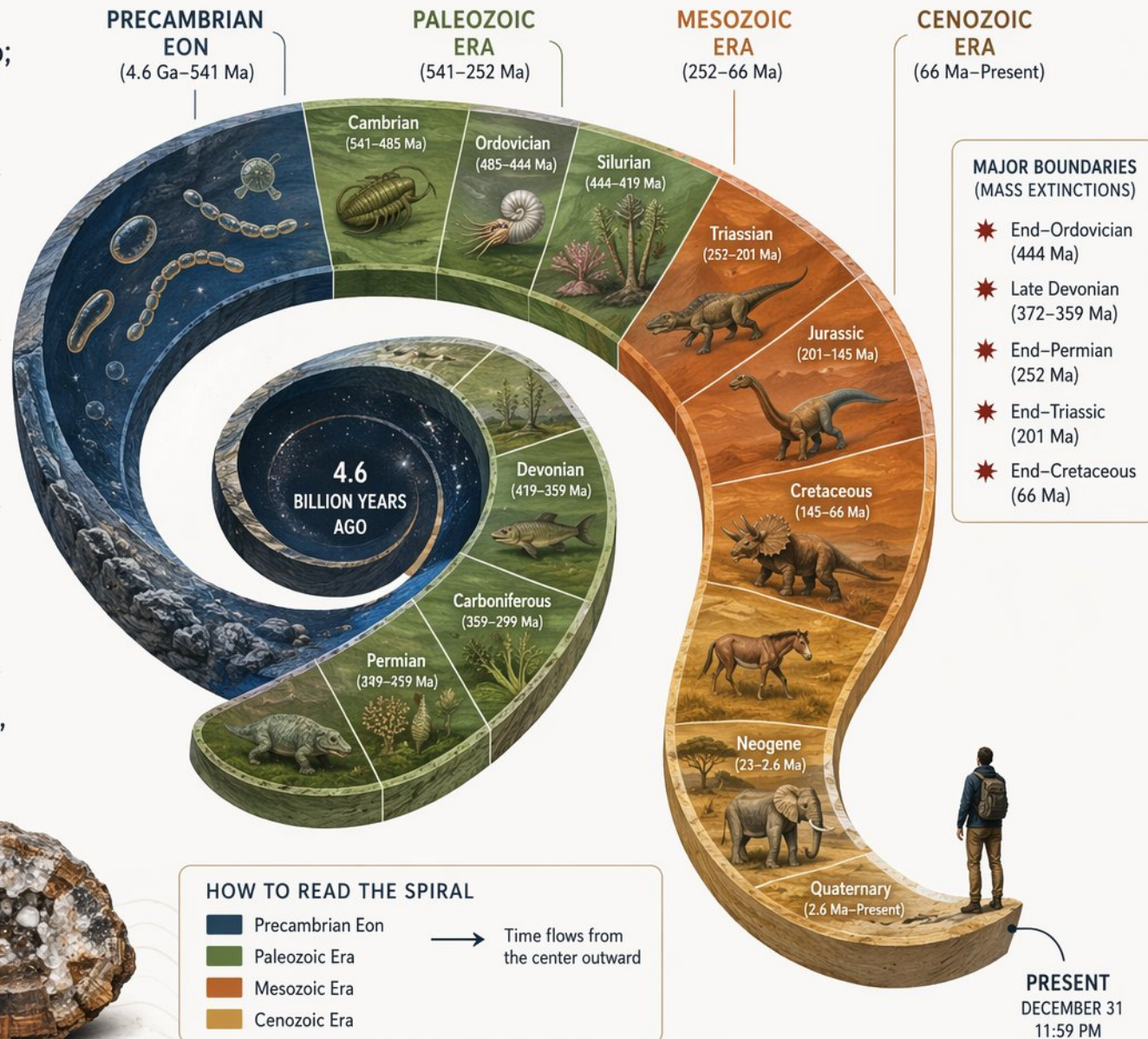
Major boundaries mark mass extinctions and the rise of new life forms.



Fossils form as molds, casts, or through mineral replacement (permineralization).



Sedimentary rocks preserve fossils, revealing past environments and evolution.



Major Chapters in Earth's Story



PRECAMBRIAN



- **Precambrian:** nearly 88% of Earth's history, from formation to first complex life



PALEOZOIC ERA



- **Paleozoic Era:** explosion of marine life, first land plants, assembly of Pangea



MESOZOIC ERA



- **Mesozoic Era:** Age of Dinosaurs, ended by mass extinction 66 million years ago



CENOZOIC ERA



- **Cenozoic Era:** Age of Mammals, rise of humans and the ice ages

How Geologists Read the Landscape



- Use landforms, rock types, and structures to interpret Earth's history



- Topographic maps: contour lines show elevation, slope, and relief

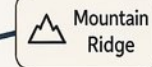
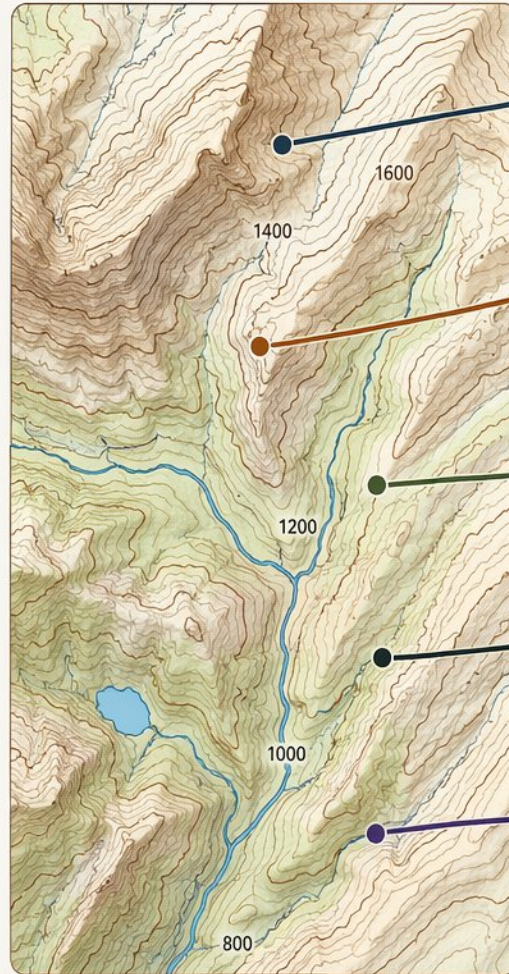


- Geologic maps: colors and symbols identify rock units and ages



- Faults and folds reveal past tectonic forces and deformation

TOPOGRAPHIC MAP



Mountain Ridge



Valley



Layered Rock Unit

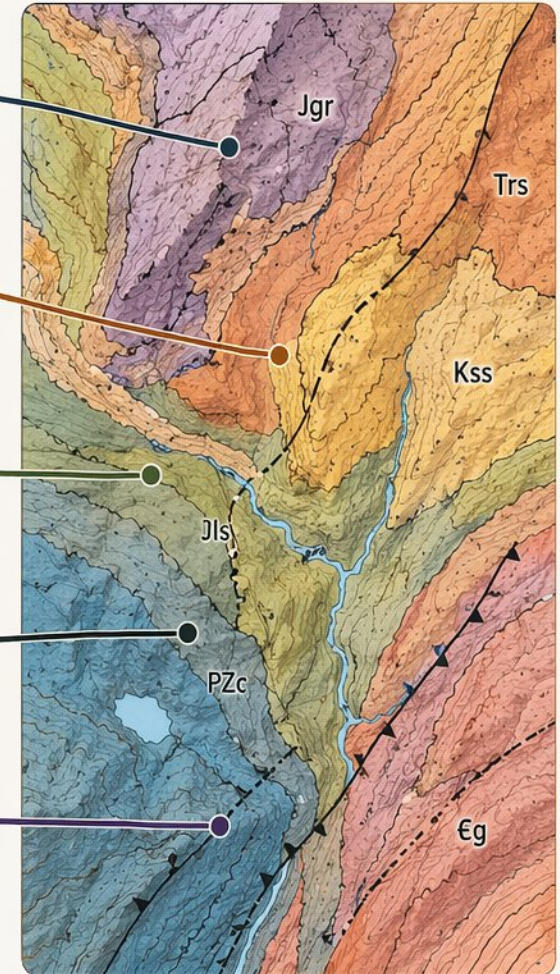
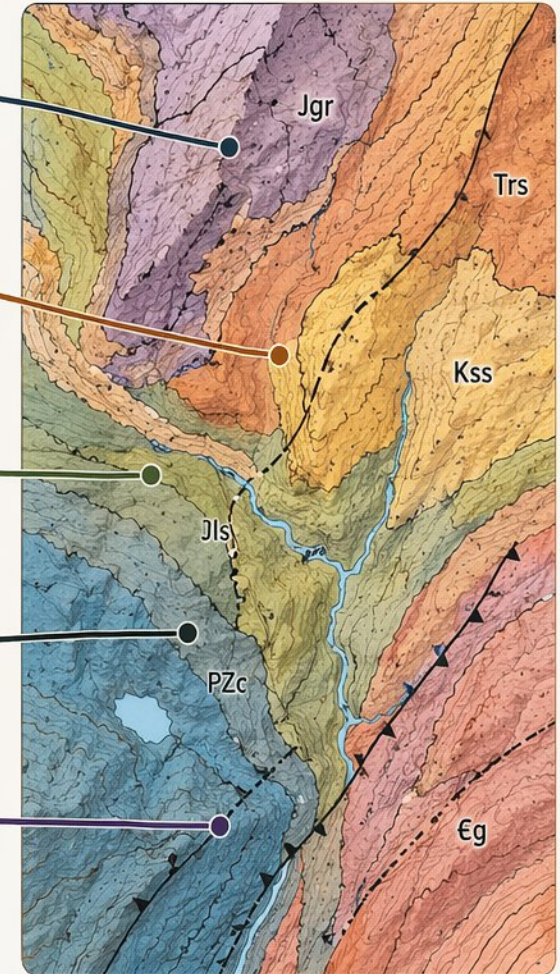


Fault Zone



Folded Layers

GEOLOGIC MAP



A Geologist's Toolkit:

From Hand Lens to Satellites



- **Field tools:**

hand lens, rock hammer,
compass, and notebook



- **Lab tools:**

microscopes, X-ray diffraction,
and mass spectrometers



- **Remote sensing:**

satellite imagery, LiDAR,
and drone surveys



- **Scales:**

from grain-by-grain close-ups
to continent-wide views



Geology in the News: Climate, Resources, and Hazards



- Sea level controls phosphate, driving a carbon burial thermostat over 60 million years



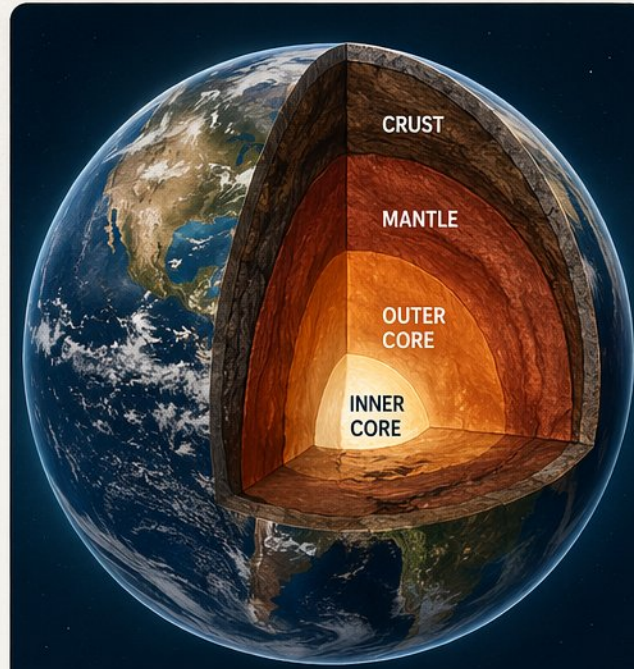
- Silicate weathering removes CO₂; organic carbon weathering can release it back



- Metamorphic sulfur and carbon emissions linked to ancient climate swings and mass extinctions



- Earth's systems are deeply interconnected—geology helps us decode past and present change

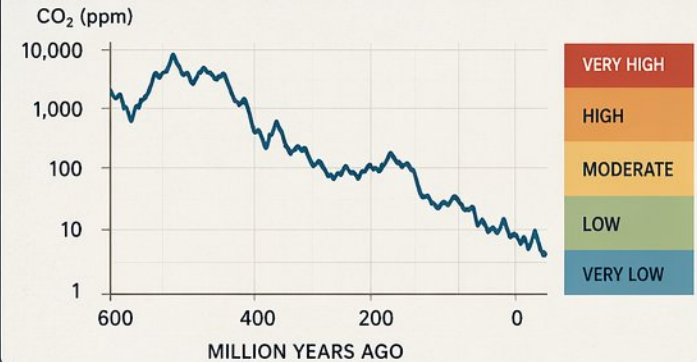


EARTH SYSTEMS, CONNECTED

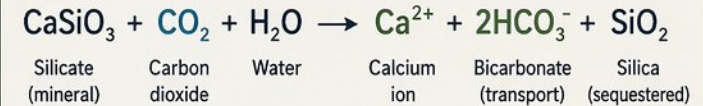


Understanding past Earth processes helps us anticipate future change.

CO₂ OVER GEOLOGIC TIME (MILLION YEARS AGO)

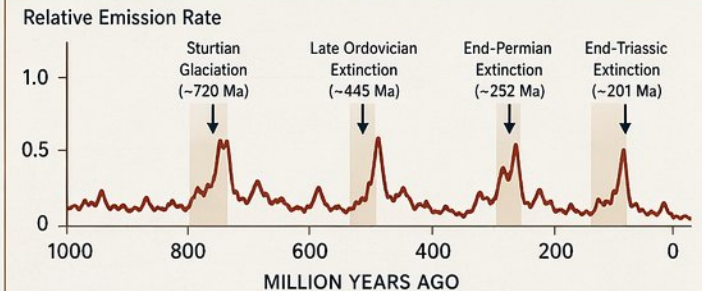


SILICATE WEATHERING (CARBON REMOVAL)



Removes CO₂ from the atmosphere over geologic time

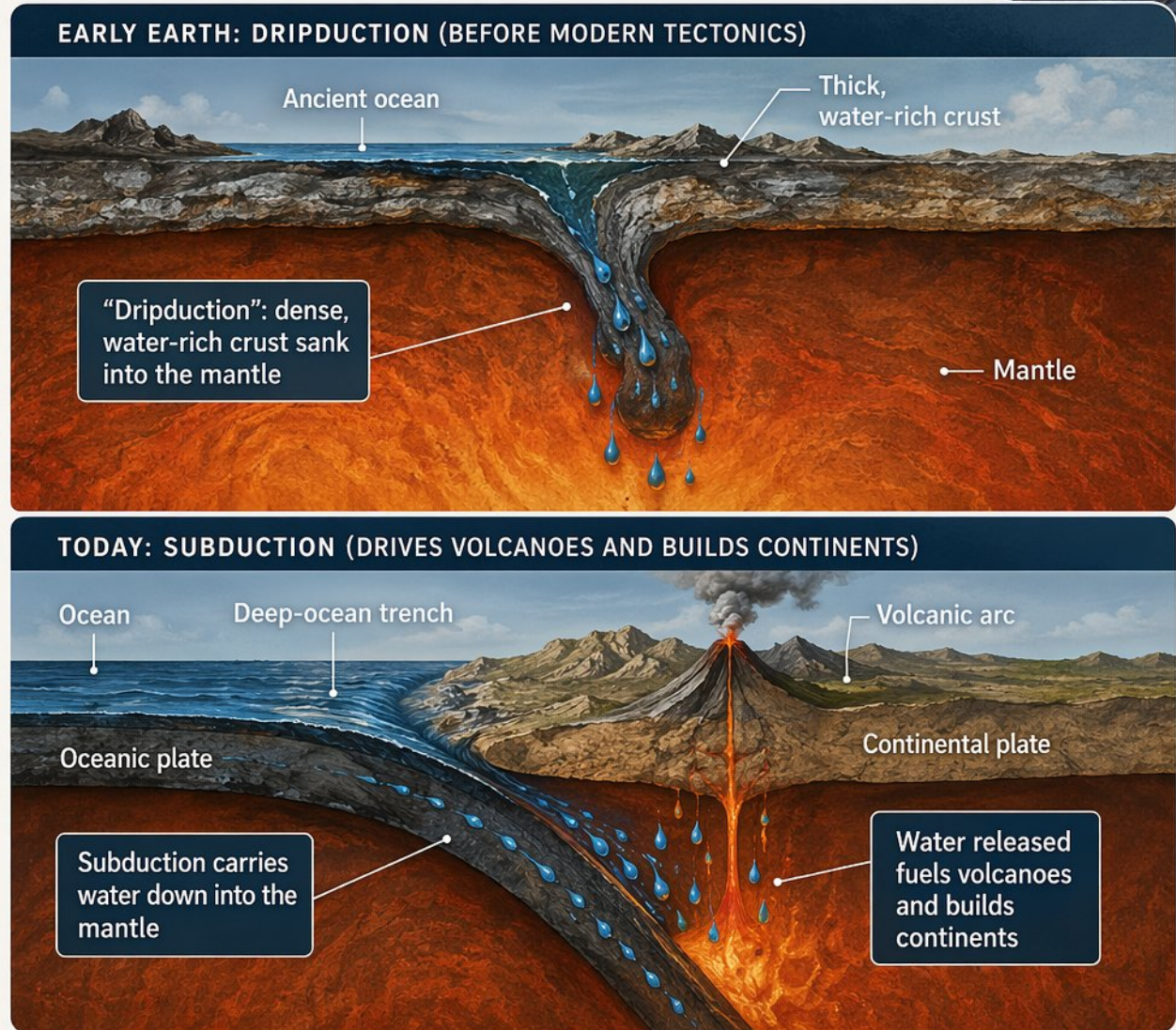
METAMORPHIC GAS EMISSIONS OVER TIME



Metamorphic sulfur and carbon emissions can influence climate and are linked to mass extinctions.

Water and Earth: A Deep Connection

- Ancient 3.1-billion-year-old rocks show water cycling deep into the mantle
- ‘Dripduction’: dense, water-rich crust sank into the mantle before modern tectonics
- Today, subduction carries water down, fueling volcanoes and building continents
- Recycled water influences volcanic eruptions, continental growth, and life’s ingredients



Water moves deep within Earth—shaping our planet from its earliest days to today.

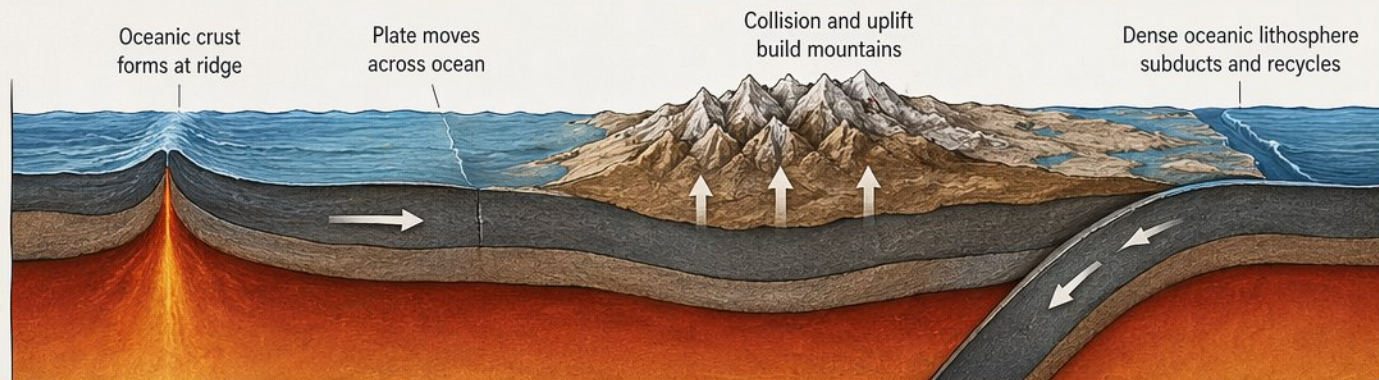
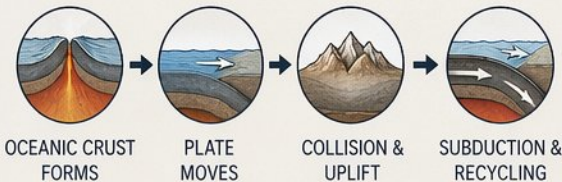
Building Mountains: The Roof of the World

- Indian plate subducting beneath Asia built the Tibetan Plateau
- West and central Tibet have distinct exhumation histories
- Indian slab underthrusting drove uplift 45–20 million years ago
- The plateau shapes global climate and feeds Asia's largest rivers



THE TECTONIC CONVEYOR BELT

Tectonic plates move, collide, and recycle—driving mountain building and shaping our planet.



Geology's Role in Resources and Energy



- Iron, copper, and rare-earth elements power modern technology



- Fossil fuels, geothermal energy, and critical minerals for renewables



- Ancient atmospheric oxygen preserved in iron-ore deposits



- Resource formation links photosynthetic life and mineral deposits



- Metamorphic gas emissions influenced ancient climate and extinctions



Copper



Geothermal Energy



Iron Ore



Renewable Energy



Rare-Earth Oxides



Earth's Dynamic History

Putting It All Together: Geology in Your World



- Journey recap: minerals, rocks, plate tectonics, deep time, and surface processes



- Geology powers daily life: ground, water, and energy



- Earth science tackles climate, hazards, and resource challenges



Stay Curious: Resources and Citizen Science



- Beginner-friendly guides: USGS, NPS geology pages, and Geological Society of America



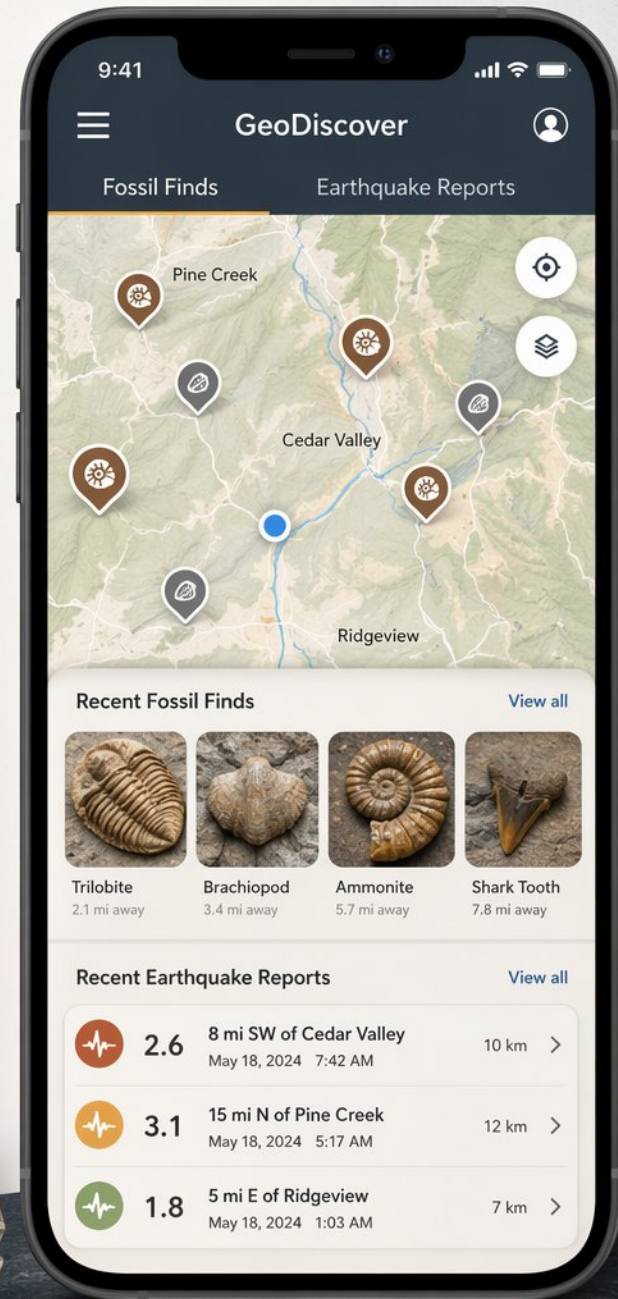
- Field guide apps for identifying local rocks, minerals, and fossils



- Contribute to earthquake monitoring and landscape change projects



- Join fossil finds and help map your local geology



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