Methods of geology

Geologists use a number of fields, laboratory, and numerical modeling methods to decipher Earth history and to understand the processes that occur on and inside the Earth. In typical geological investigations, geologists use primary information related to [petrology](https://en.wikipedia.org/wiki/Petrology) (the study of rocks), stratigraphy (the study of sedimentary layers), and structural geology (the study of positions of rock units and their deformation). In many cases, geologists also study modern soils, [rivers](https://en.wikipedia.org/wiki/River), [landscapes](https://en.wikipedia.org/wiki/Landscape), and [glaciers](https://en.wikipedia.org/wiki/Glacier); investigate past and current life and [biogeochemical](https://en.wikipedia.org/wiki/Biogeochemistry) pathways, and use [geophysical methods](https://en.wikipedia.org/wiki/Geophysics) to investigate the subsurface. Sub-specialities of geology may distinguish **endogenous** and **exogenous** geology.

### Field methods

Geological [field work](https://en.wikipedia.org/wiki/Field_work) varies depending on the task at hand. Typical fieldwork could consist of:

[Geological mapping](https://en.wikipedia.org/wiki/Geological_map):

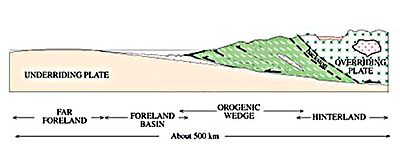
* + Structural mapping: identifying the locations of major rock units and the faults and folds that led to their placement there.
  + Stratigraphic mapping: pinpointing the locations of [sedimentary facies](https://en.wikipedia.org/wiki/Sedimentary_facies) ([lithofacies](https://en.wikipedia.org/wiki/Lithology) and [biofacies](https://en.wikipedia.org/wiki/Biofacies" \o "Biofacies)) or the mapping of [isopachs](https://en.wikipedia.org/wiki/Isopach" \o "Isopach) of equal thickness of sedimentary rock
  + Surficial mapping: recording the locations of soils and surficial deposits
* Surveying of topographic features
  + compilation of [topographic maps](https://en.wikipedia.org/wiki/Topographic_map)
  + Work to understand change across landscapes, including:
    - Patterns of [erosion](https://en.wikipedia.org/wiki/Erosion) and [deposition](https://en.wikipedia.org/wiki/Deposition_(geology))
    - River-channel change through [migration](https://en.wikipedia.org/wiki/Meander) and [avulsion](https://en.wikipedia.org/wiki/Avulsion_(river))
    - Hillslope processes
* Subsurface mapping through [geophysical methods](https://en.wikipedia.org/wiki/Geophysical_survey)
  + These methods include:
    - Shallow [seismic](https://en.wikipedia.org/wiki/Seismology) surveys
    - [Ground-penetrating radar](https://en.wikipedia.org/wiki/Ground-penetrating_radar)
    - [Aeromagnetic surveys](https://en.wikipedia.org/wiki/Aeromagnetic_survey)
    - [Electrical resistivity tomography](https://en.wikipedia.org/wiki/Electrical_resistivity_tomography)
  + They aid in:
    - [Hydrocarbon exploration](https://en.wikipedia.org/wiki/Exploration_geophysics)
    - Finding [groundwater](https://en.wikipedia.org/wiki/Groundwater)
    - [Locating buried archaeological artifacts](https://en.wikipedia.org/wiki/Archaeological_geophysics)
* High-resolution stratigraphy
  + Measuring and describing [stratigraphic sections](https://en.wikipedia.org/wiki/Stratigraphic_section) on the surface
  + [Well drilling](https://en.wikipedia.org/wiki/Well_drilling) and [logging](https://en.wikipedia.org/wiki/Well_logging)
* [Biogeochemistry](https://en.wikipedia.org/wiki/Biogeochemistry) and [geomicrobiology](https://en.wikipedia.org/wiki/Geomicrobiology)
  + Collecting samples to:
    - determine [biochemical pathways](https://en.wikipedia.org/wiki/Biochemical_pathway)
    - identify new [species](https://en.wikipedia.org/wiki/Species_(biology)) of organisms
    - identify new [chemical compounds](https://en.wikipedia.org/wiki/Chemical_compound)
  + and to use these discoveries to:
    - understand early life on Earth and how it functioned and metabolized
    - find important compounds for use in pharmaceuticals
* [Paleontology](https://en.wikipedia.org/wiki/Paleontology): excavation of [fossil](https://en.wikipedia.org/wiki/Fossil) material
  + For research into past life and [evolution](https://en.wikipedia.org/wiki/Evolution)
  + For [museums](https://en.wikipedia.org/wiki/Museum) and education
* Collection of samples for [geochronology](https://en.wikipedia.org/wiki/Geochronology) and [thermochronology](https://en.wikipedia.org/wiki/Thermochronology)
* [Glaciology](https://en.wikipedia.org/wiki/Glaciology): measurement of characteristics of glaciers and their motion

### Petrology

In addition to identifying rocks in the field ([lithology](https://en.wikipedia.org/wiki/Lithology)), petrologists identify rock samples in the laboratory. Two of the primary methods for identifying rocks in the laboratory are through [optical microscopy](https://en.wikipedia.org/wiki/Optical_microscopy) and by using an [electron microprobe](https://en.wikipedia.org/wiki/Electron_microprobe). In an [optical mineralogy](https://en.wikipedia.org/wiki/Optical_mineralogy) analysis, petrologists analyze [thin sections](https://en.wikipedia.org/wiki/Thin_section) of rock samples using a [petrographic microscope](https://en.wikipedia.org/wiki/Petrographic_microscope), where the minerals can be identified through their different properties in plane-polarized and cross-polarized light, including their [birefringence](https://en.wikipedia.org/wiki/Birefringence), [pleochroism](https://en.wikipedia.org/wiki/Pleochroism), [twinning](https://en.wikipedia.org/wiki/Crystal_twinning), and interference properties with a [conoscopic lens](https://en.wikipedia.org/wiki/Conoscopy" \o "Conoscopy). In the electron microprobe, individual locations are analyzed for their exact chemical compositions and variation in composition within individual crystals. [Stable](https://en.wikipedia.org/wiki/Stable_isotope)and [radioactive isotope](https://en.wikipedia.org/wiki/Radioactive_isotope)studies provide insight into the [geochemical](https://en.wikipedia.org/wiki/Geochemistry) evolution of rock units.

Petrologists can also use [fluid inclusion](https://en.wikipedia.org/wiki/Fluid_inclusions) dataand perform high temperature and pressure physical experiments to understand the temperatures and pressures at which different mineral phases appear, and how they change through igneous[]](https://en.wikipedia.org/wiki/Geology#cite_note-35) and metamorphic processes. This research can be extrapolated to the field to understand metamorphic processes and the conditions of crystallization of igneous rocks. This work can also help to explain processes that occur within the Earth, such as [subduction](https://en.wikipedia.org/wiki/Subduction) and [magma chamber](https://en.wikipedia.org/wiki/Magma_chamber) evolution.

### tructural geology

[](https://en.wikipedia.org/wiki/File:Orogenic_wedge.jpg)

A diagram of an orogenic wedge. The wedge grows through faulting in the interior and along the main basal fault, called the [décollement](https://en.wikipedia.org/wiki/Decollement). It builds its shape into a [critical taper](https://en.wikipedia.org/wiki/Critical_taper), in which the angles within the wedge remain the same as failures inside the material balance failures along the décollement. It is analogous to a bulldozer pushing a pile of dirt, where the bulldozer is the overriding plate.

Structural geologists use microscopic analysis of oriented thin sections of geological samples to observe the [fabric](https://en.wikipedia.org/wiki/Fabric_(geology)) within the rocks, which gives information about strain within the crystalline structure of the rocks. They also plot and combine measurements of geological structures to better understand the orientations of faults and folds to reconstruct the history of rock deformation in the area. In addition, they perform [analog](https://en.wikipedia.org/wiki/Analogue_modelling_(geology)" \o "Analogue modelling (geology)) and numerical experiments of rock deformation in large and small settings.

The analysis of structures is often accomplished by plotting the orientations of various features onto [stereonets](https://en.wikipedia.org/wiki/Stereographic_projection" \o "Stereographic projection). A stereonet is a stereographic projection of a sphere onto a plane, in which planes are projected as lines and lines are projected as points. These can be used to find the locations of fold axes, relationships between faults, and relationships between other geological structures.

Among the most well-known experiments in structural geology are those involving [orogenic wedges](https://en.wikipedia.org/wiki/Accretionary_wedge), which are zones in which [mountains](https://en.wikipedia.org/wiki/Mountain) are built along [convergent](https://en.wikipedia.org/wiki/Convergent_boundary) tectonic plate boundaries. In the analog versions of these experiments, horizontal layers of sand are pulled along a lower surface into a back stop, which results in realistic-looking patterns of faulting and the growth of a [critically tapered](https://en.wikipedia.org/wiki/Critical_taper) (all angles remain the same) orogenic wedge.[]](https://en.wikipedia.org/wiki/Geology#cite_note-39) Numerical models work in the same way as these analog models, though they are often more sophisticated and can include patterns of erosion and uplift in the mountain belt. This helps to show the relationship between erosion and the shape of a mountain range. These studies can also give useful information about pathways for metamorphism through pressure, temperature, space, and time.

### Stratigraphy

[](https://en.wikipedia.org/wiki/File:Ritagli_di_Lecca,_Fondachelli_Fantina.JPG)

Different colors show the different minerals composing the mount Ritagli di Lecca seen from [Fondachelli-Fantina](https://en.wikipedia.org/wiki/Fondachelli-Fantina" \o "Fondachelli-Fantina), Sicily

In the laboratory, stratigraphers analyze samples of stratigraphic sections that can be returned from the field, such as those from [drill cores](https://en.wikipedia.org/wiki/Drill_core). Stratigraphers also analyze data from geophysical surveys that show the locations of stratigraphic units in the subsurface. Geophysical data and [well logs](https://en.wikipedia.org/wiki/Well_log) can be combined to produce a better view of the subsurface, and stratigraphers often use computer programs to do this in three dimensions. Stratigraphers can then use these data to reconstruct ancient processes occurring on the surface of the Earth, interpret past environments, and locate areas for water, coal, and hydrocarbon extraction.

In the laboratory, [biostratigraphers](https://en.wikipedia.org/wiki/Biostratigraphy) analyze rock samples from outcrop and drill cores for the fossils found in them. These fossils help scientists to date the core and to understand the [depositional environment](https://en.wikipedia.org/wiki/Sedimentary_depositional_environment) in which the rock units formed. Geochronologists precisely date rocks within the stratigraphic section to provide better absolute bounds on the timing and rates of deposition. Magnetic stratigraphers look for signs of magnetic reversals in igneous rock units within the drill cores. Other scientists perform stable-isotope studies on the rocks to gain information about past climate.