

# INVITATION TO STRUCTURAL GEOLOGY

Earth's rocks are like pages from an ancient book, telling a dramatic story of our planet's past. This story isn't still; it describes fierce battles among massive forces, ongoing changes, and major shifts that have shaped Earth's structure. Before exploring structural geology, it's key to understand its role in decoding these geological stories on Earth and other planets.

Think of Earth's crust as a giant, active puzzle. Structural geology looks at how these pieces bend, break, and move, constantly changing the planet. Like detectives, geologists examine twisted layers, jagged cracks, and displaced rocks to uncover billions of years of tectonic history. This field shows how tiny grains reveal enormous forces and how mountain ranges expose deep stresses that drive Earth's evolution.

Consider Maurits Cornelis Escher's mesmerizing metamorphosis, in which a fish seamlessly transforms into a bird (Fig1-1).



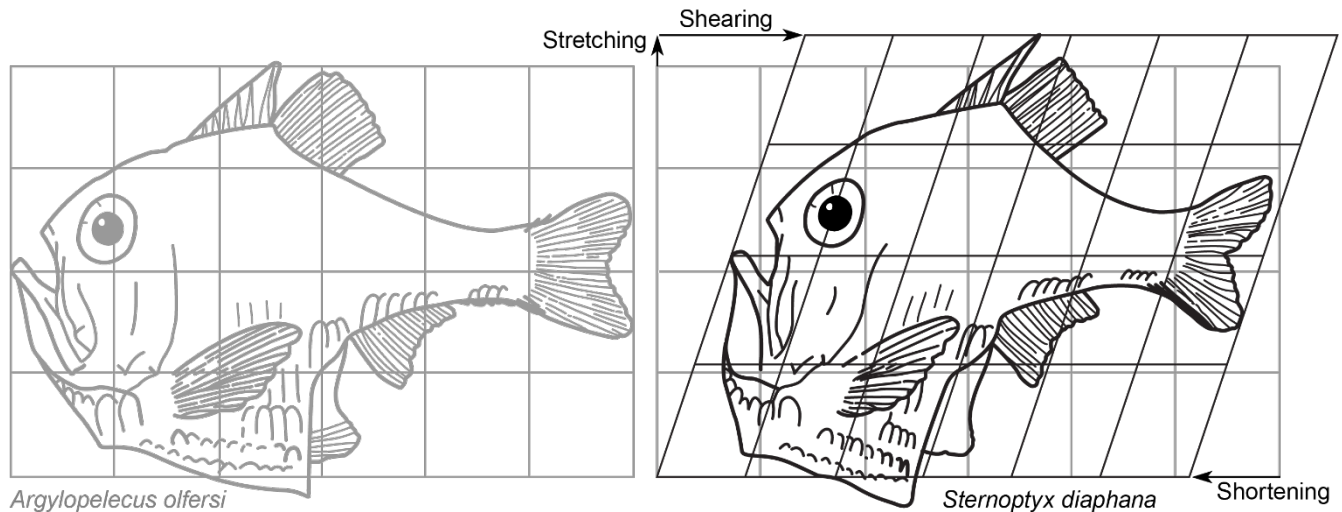
Maurits Cornelis Escher, Lucht en water I

"Sky & Water I" facsimile from <https://mcescher.com/product/facsimile-sky&water I>

His artwork vividly captures deformation, a crucial process that structural geologists strive to understand in Earth's crust. The transformation reflects the movement of each point within the shape: the fish's tail follows the red trajectory, while its mouth moves along the yellow (Fig1-1). While not every minor

change needs tracking, added detail enhances our grasp of the final form, like the flying goose's shape. Escher's vertical shift relates to a key geological challenge: we can only directly observe rocks formed and deformed within the top 20-30 kilometers of Earth. But deeper processes, such as those inside the fish's shape, influence structures near the surface that we see. Using advanced tools to explore these hidden features makes geophysical studies essential for uncovering Earth's unseen dynamics. Combining surface data with deep insights gives a clearer, more complete picture of structural geology.

In the spirit of exploring across disciplines, biologist D'Arcy Wentworth Thompson emphasized how physical laws strongly influence biological forms. (Fig1-2).



Deformation of a biological example: Transformation of *Argyropelecus olfersi* into *Sternoptyx diaphana* (after D'Arcy Thompson, *On Growth and Form*, 1917)

His groundbreaking research reveals that even the most complex species changes often follow simple, elegant mathematical patterns. This idea, based on the belief that physical laws shape natural processes, is especially relevant to geological deformation. Just as biological forms evolve within physical limits, rocks and landscapes change under tectonic forces, often in predictable ways. Structural geologists work to uncover these patterns and understand the rules driving Earth's ever-changing surface.

D'Arcy Thompson's knack for revealing the hidden order in everything, from "organic to inorganic, animate and inanimate things..." adds real value to structural geology. His insights inspire scientists to see the beauty and simplicity behind complex geological patterns, which careful study can uncover. By fostering teamwork across disciplines and encouraging fresh ideas, Thompson's approach pushes the boundaries of science, making structural geology more engaging and dynamic.

## Physical and mathematical background

Geologists study how rock formations originate and evolve at the crucial point where Earth's past and future meet. Their work involves close observation, precise descriptions, careful measurements, and deep analysis. They track rocks from their formation to their current state and even forecast how they might change. Along the way, they uncover the shifting shapes, patterns, and internal structures of geological features, showing how forms like fish and goose, though different, are connected through a deeper, transformational history, as illustrated in figure 1-1.

Understanding geological deformation involves exploring four key interconnected aspects.

- 1 - **Geometry**: the three-dimensional shapes and spatial arrangements of geological structures at every scale, from microscopic minerals to mountain ranges.

- 2 - **Kinematics**: the documentation of movement, position shifts, and slow-motion processes of these structures within geological contexts over time.
- 3 - **Dynamics**: the forces and physical mechanisms that drive Earth's motions and sculpt its landscapes.
- 4 - **Rheology**: the study of how rocks and other geological materials flow and deform under stress.

Structural geologists approach their work with disciplined curiosity. They start by examining geological shapes and then recreate these structures in labs that mimic Earth's internal conditions. Building on this, they develop models to simulate complex processes, deepening our understanding of how Earth behaves. This rigorous and creative method helps predict and prevent natural disasters, safeguarding lives and communities. It also supports the sustainable development of resources and infrastructure vital to society. In the end, structural geology translates the silent language of rocks into practical knowledge that helps us build a safer, more resilient future.

### Geometric analysis

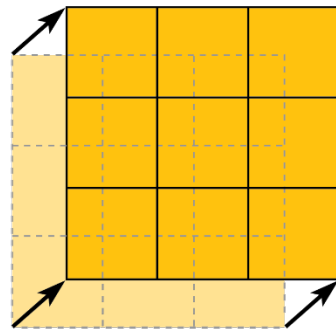
Geometric analysis provides a straightforward and impactful view of Earth's shapes and structures. By looking at visible features like exposed rocks, drill samples, satellite images, and geophysical data, we turn complex geology into simple, visual forms. Folds, faults, and layers are shown as basic planes and lines, highlighting the core layout of the crust. This approach helps create clear cross-sections and shows how Earth's layers bend, break, and change over time. Whether finding water, minerals, energy sources, or assessing earthquake and landslide risks, the geometric method is crucial for modern geoscience, enhancing our understanding of the ever-moving ground beneath us.

### Kinematic analysis

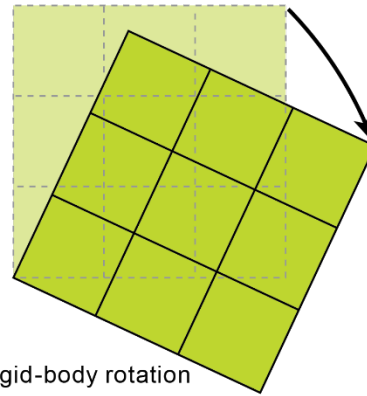
Kinematics is the mathematical study of motion, showing how objects move and change position over time without considering the forces involved. It includes both the relative movement of points within a deforming object, like a fish's mouth opening in **Fig1-1**, and the coordinated motion of the entire organism, such as a fish shifting between different states. Four key deformation agents play a vital role in Earth's structural history (**Fig1-3**).

- 1) **Translation**, the grand mover, transports entire rock masses across the landscape, setting the broad geometry of deformation.
- 2) **Rotation**, the subtle choreographer, twists rock blocks and weaves complex patterns of stress adjustment.
- 3) **Dilation**, the silent sculptor, expands or contracts volumes, thereby altering porosity and density.
- 4) **Distortion**, the dramatic artist, warps shapes to reveal the intensity and distribution of strain.

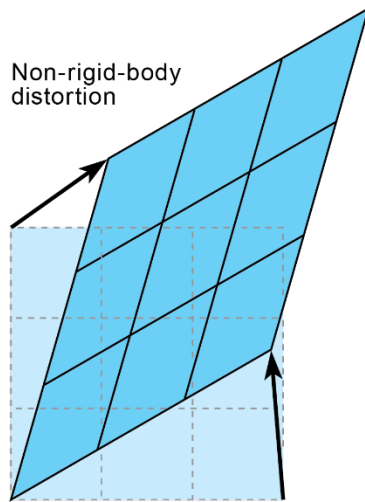
### Within-plane relative movements between points of a squared structure



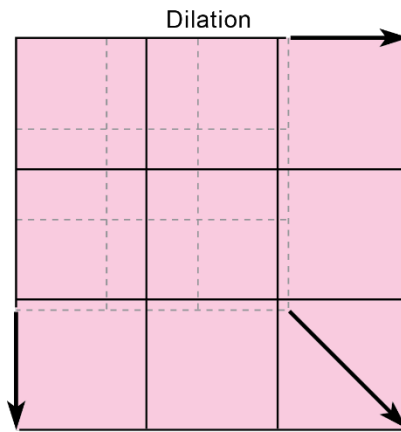
Rigid-body translation



Rigid-body rotation



Non-rigid-body distortion



Dilation

Rigid-body deformation occurs when translation and rotation happen together, maintaining the shape and size of an object. In contrast, non-rigid deformation changes both shape and volume through distortion or dilation. In nature, these deformations often combine, manifesting as slip (movement along a plane) or flow (movement throughout the object). Ultimately, the deformation's dynamics are understood by linking these motions to the forces and rates that cause them.

### Dynamic analysis

These transformations are not random; they are driven by forces that influence rock movement and stresses that determine the direction and strength of structural changes. Using stationary observations, mathematical tools connect these invisible forces to their observable effects.

### Rheology

Specialized instruments study how Earth materials behave physically and how they flow under stress, a field known as **rheology**. Rheology investigates the relationships between stress, strain, and strain rate to explain how materials respond under different conditions. In rocks, many factors affect their behavior, shaping the formation and evolution of geological structures under Earth's forces.

### **Forces; Power-and-Challenge**

The Earth shows the marks of massive forces, as if shaped by mythic figures like Herakles and Kratos enforcing Zeus's will. Geologists act as detectives of deep time, uncovering hidden powers, studying their effects, and interpreting how ancient stresses have distorted rocks over millions of years.

**Structural geology** explores how geological structures reveal tectonic processes across all scales, from microscopic to regional. Its close connection with tectonics helps scientists trace the Earth's movements and deformations over time.

**Tectonics** reveals the powerful forces shaping Earth's surface, showing how continents collide, oceans form, and mountain ranges rise from ancient landmasses.

Geologists observe that seemingly rigid rocks deform into folds or fracture along faults through fieldwork, mapping, and cross-sections. These formations result from three main types of force directions.

**Compression:** squeezing and shortening.

**Extension:** stretching and pulling apart.

**Shear:** sliding one part past another.

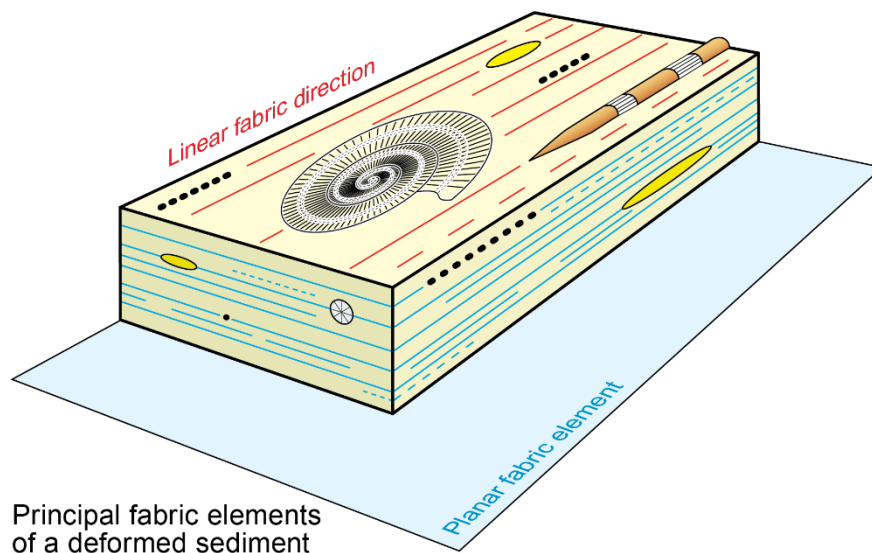
## Structures, rock make-up

Discover the world of geological structures. Structural geology reveals how rocks form, arrange themselves, and serve as clues to Earth's dynamic past. The fabric of a rock shows the geometric layout of features, from tiny minerals to vast regional formations. Texture, a key part of fabric, examines how crystalline axes are oriented and interact, helping us understand the rock's physical and chemical history. Typically, rock fabrics fall into two main categories.

- **Primary fabrics** develop during a rock's initial formation. Features such as cross-bedding or graded bedding in sandstones indicate ancient local environmental conditions.

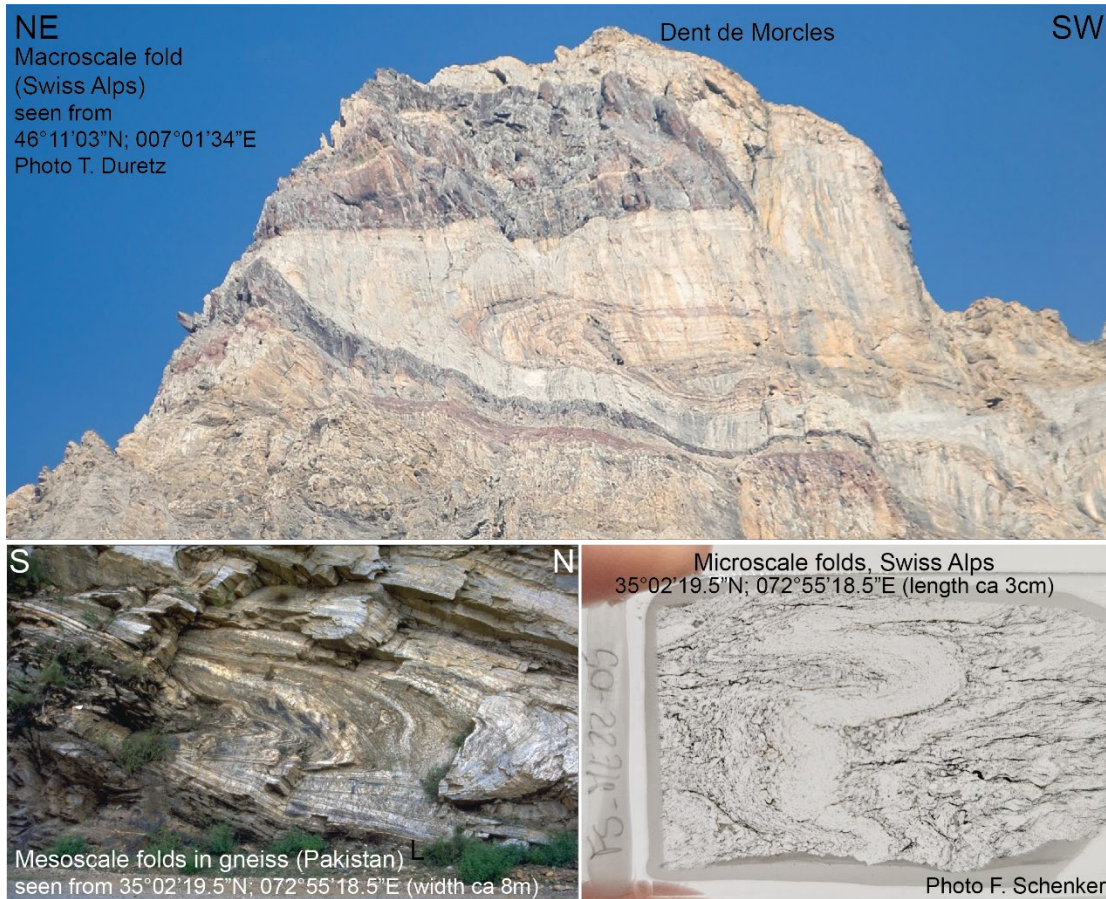
- **Secondary fabrics** form later as rocks deform, responding to various forces and local environmental conditions that influence this deformation.

To understand these geological stories, geologists solve geometric problems by studying natural structures in the field and microstructures in the lab. Like other features, planes (flat or curved) and lines define geological shapes (Fig1-4).



Geological structures are three-dimensional features within rocks that reveal if and how deformation occurred. Their size ranges from tiny atomic scales ( $10^{-6}$  m) to massive planetary features ( $10^6$  m). To handle this wide span, geologists classify structures by size, making observation and study more straightforward.

- **Macrostructures** are the largest features, usually over 100 meters long. Since they extend across multiple outcrops, geologists need to combine observations from various sites to understand their full shape.
- **Mesostructures** ( $10^{-2}$  to  $10^2$  meters) are visible in outcrops and rock samples. They are central to field studies, revealing deformation history and geological evolution.
- **Microstructures** smaller than  $10^{-2}$  meters need optical or electron microscopes. Despite their tiny size, they reveal detailed information about mineral makeup, deformation processes, and the formation conditions of rocks.



A key challenge in structural geology is visualizing how rock bodies extend underground, especially in deformed areas. By examining the orientation of surface fabrics, geologists can infer the hidden shapes of subsurface structures. When combined with detailed mapping, this skill is crucial for locating resources like oil, groundwater, and minerals. **Block diagrams** are particularly useful, turning scattered surface data into clear, three-dimensional models.

By examining primary and secondary structures, geologists piece together Earth's dynamic history and assist in responsible resource exploration and land-use planning. Every rocky landscape, no matter how simple, contains a layered story, waiting to be understood by those capable of perceiving its forms in three dimensions.

### Strain, the essence of deformation structures

Strain analysis measures how an object's shape and volume change by comparing its current dimensions to the original ones.

**Linear strain** quantifies how much a line lengthens or shortens relative to its original length.

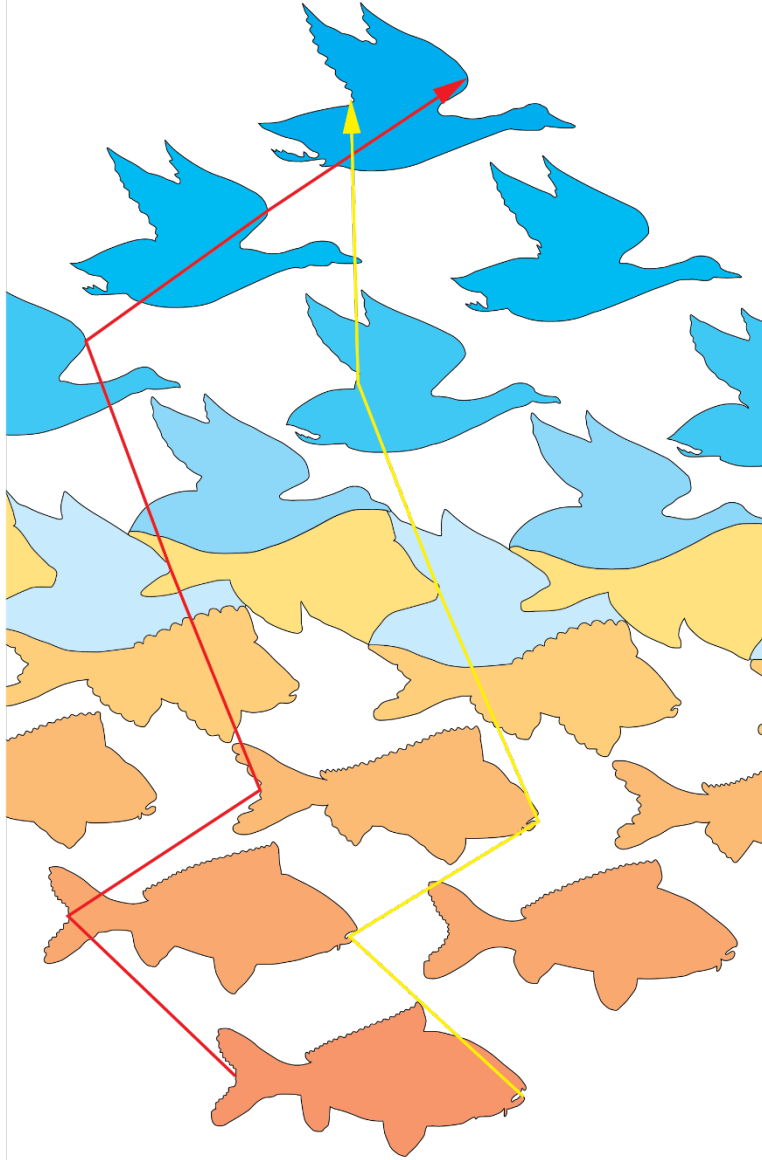
**Volume strain** quantifies changes in volume compared to the original volume.

**Shear strain** is the shear displacement relative to the object's thickness.

### Time, the cosmic watchman

Consider Escher's fascinating illustration of the seamless transformation from fish to bird (Fig1-6).

inspired by *Lucht en water I*, Maurits Cornelis Escher (1938)

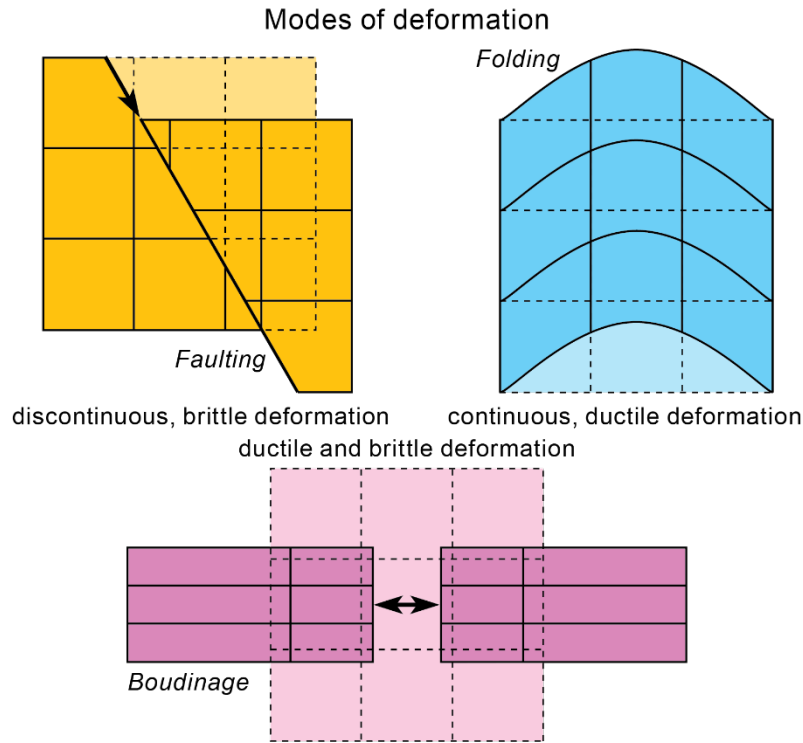


This vivid transformation shows how every tiny movement of the tail or mouth follows a continuous journey of evolution, where form develops through motion. The process is flexible; movements can be slow or sudden, sometimes skipped or reversed, but the overall shape and final form stay consistent. The path, shown by the red and yellow vectors in figures 1-1 and 1-6, seems simple but carries deep artistic and conceptual meaning. It captures both gradual change and sharp, quick shifts.

Geological changes happen over very different time scales, from hundreds of thousands to millions of years ( $10^{13}$  to  $10^{14}$  seconds, about 30 million years). During these long periods, slow deformation can be observed step by step, as shown by the nearly parallel paths of the red tail vector and the yellow mouth vector (Fig1-6). However, the significance of vector movement becomes clear when we compare these

slow processes to rapid events like crack propagation during earthquakes, which occur in less than a tenth of a second. These high-speed events can cause sudden jumps in the deformation pattern, leading to a quick shift of the tail vector forward and the mouth vector backward, causing them to cross paths.

The sudden, dramatic shifts caused by earthquakes have always captivated people, revealing the immense power of tectonic forces and their visible impact on Earth's surface. This process, known as brittle deformation, results in sharp breaks with localized displacement along narrow planes that fracture the surrounding rock, emphasizing the discontinuous nature of this phenomenon (Fig1-7).



Although subtle to us, slow ground movements are closely tracked by geodesists using highly precise tools. Small shifts in reference triangles over time clearly show this gradual movement. Major changes are visible in landscapes, especially in mountain ranges formed from ancient seas' sediments that now tilt steeply, revealing long-term, flow-like behavior. This underscores the unseen forces constantly shaping the Earth.

Folds, common geological features, show that flat layers can bend without cracking. Think of pushing a sheet of paper from both ends on a table: it buckles smoothly instead of tearing. Folds are categorized as **antiforms** (upward curves) and **synforms** (downward curves). By following these folded layers, geologists demonstrate how rocks can deform together without breaking (Fig1-8).



Marble stele, originally flat and vertical, has visibly bent due to constrained vertical expansion due to humidity and temperature variations (hence counteracting vertical compression), over just 150 years (since 1875, Photo 2025).

This natural deformation occurred on a human timescale, highlighting how even durable materials like this Carrara marble can respond to long-term stress and environmental conditions.

Similar cases reported by Siegemund et al. 2008  
*Environmental Geology*, **56** (3-4), 473-494  
 doi: 10.1007/s00254-008-1307-z

Location:  
 Cemetery "Wolfgottesacker"  
 Old Quarter, northwestern section  
 Basel, Switzerland

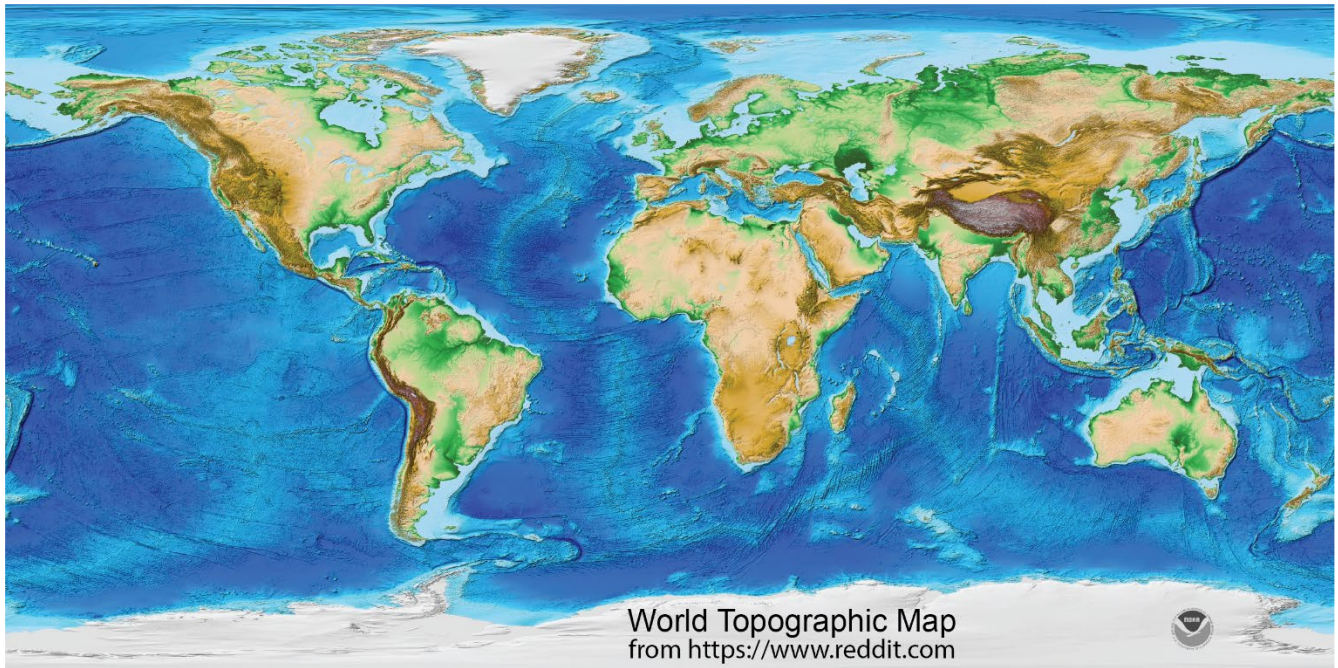
@ 47°32'26"N; 007°36'34"E

**Boudinage structures** form when extensional forces act on planar layers, creating evenly spaced fractures or necked segments that look like stretched, viscous material. These patterns result from a mix of ductile stretching and brittle failure, revealing the complex interaction between flow and fracture during deformation (Fig1-7).

The difference between rapid and slow deformation mainly hinges on strain and its buildup over time. An example outside geology is turning a fish into a bird (Fig1-6). Despite their different forms, the rate of change (strain rate) decides the kind of transformation. In geology, this idea is vital: strain rate determines if rocks deform slowly or break quickly, making it essential for studying rock behavior.

### Topography, sculpture of modern deformation

Earth's internal movements create powerful forces that fuel tectonic activity. Because directly observing these processes is challenging, geologists study surface features to understand what's happening beneath. Landforms offer key clues to reconstruct a region's tectonic past and show how Earth's dynamic interior shapes its surface. For example, river terraces formed by erosion and deposition reveal subtle changes caused by ongoing tectonic activity (Fig1-9).



**Landforms** are unique landscape features, and geomorphology, the study of their origins and development, explains the physical, chemical, and biological processes behind their creation.

Earth's surface shape today results from millions of years of active tectonic movements. **Mountain ranges** like the Alps, between Africa and Europe, and the Himalayas, between India and Asia, are formed by crustal shortening during plate convergence. Meanwhile, large rift zones such as those in Africa and the Rhine Graben in Europe reveal ongoing internal Earth dynamics. When tectonic plates pull apart, they create surface depressions and new ocean basins, forming oceanic lithosphere. The Afar and Red Sea rift systems, which began around 25 million years ago in the Early Miocene, led to the formation of thin ocean crust with magnetic signs dating back to the Pliocene-Pleistocene, about 1.5 million years ago. Exploring Earth's topography makes the natural forces shaping our environment clearer and deepens our understanding of Earth's dynamic geological history.

### **Processes and physical parameters**

Modern science, including Earth Sciences, still echoes Aristotle's idea that knowledge grows through experience and repetition. Today's structural geology showcases this with three main experimental methods: deformation experiments, analog models, and numerical simulations.

#### *Deformation experiments*

Rock mechanics studies how rocks react to stress in laboratory tests, revealing essential properties unseen through simple observation. These tests show two main behaviors: fracture and flow, both vital for understanding geological processes (Fig1-7).

**Fracture** occurs when a material loses cohesion and splits.

**Flow** is a deformation in which materials change shape while maintaining cohesion.

**Ductility** is a material's capacity to deform without fracturing.

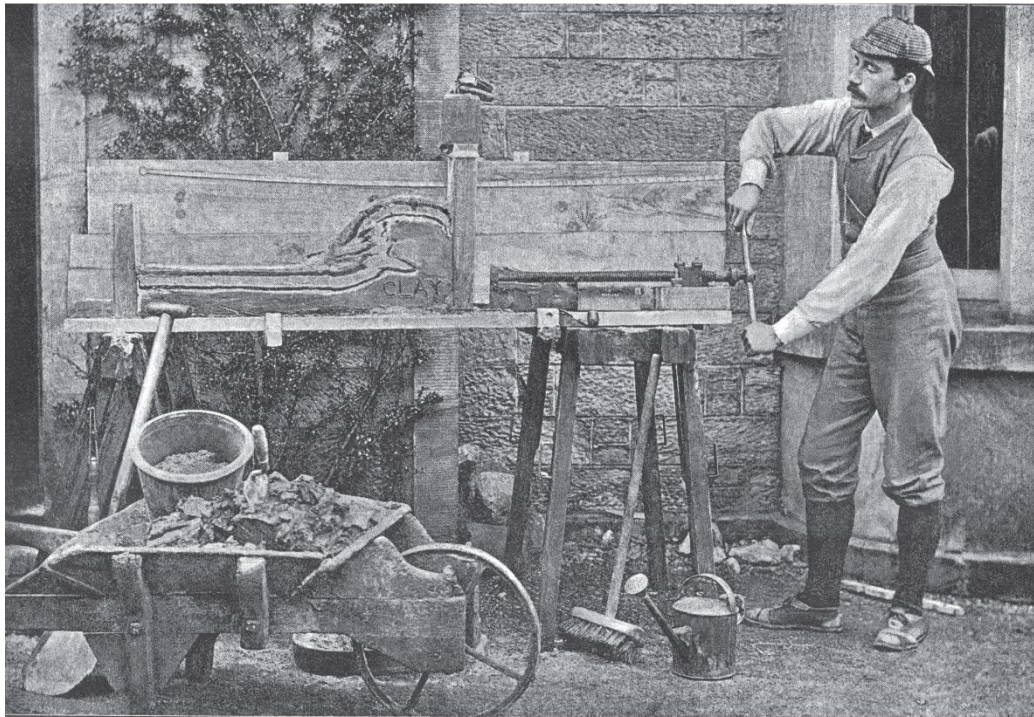
Fracture and flow control how geological materials deform over time. The Earth's crust, the top layer filled with evidence of rock movement, is key to plate tectonics, which studies how lithospheric plates shift.

## Models

In the early 1500s, Leonardo da Vinci's curiosity inspired him to investigate bird flight, thinking that studying nature might unveil the secrets of human flight. His sketches and conceptual models laid the foundation for aerodynamic understanding. However, none of his designs flew, highlighting an important lesson: merely copying nature isn't sufficient. True progress requires a deep understanding, meticulous testing, and precise engineering. This principle still influences how we convert nature into practical knowledge today, particularly through analog and numerical models.

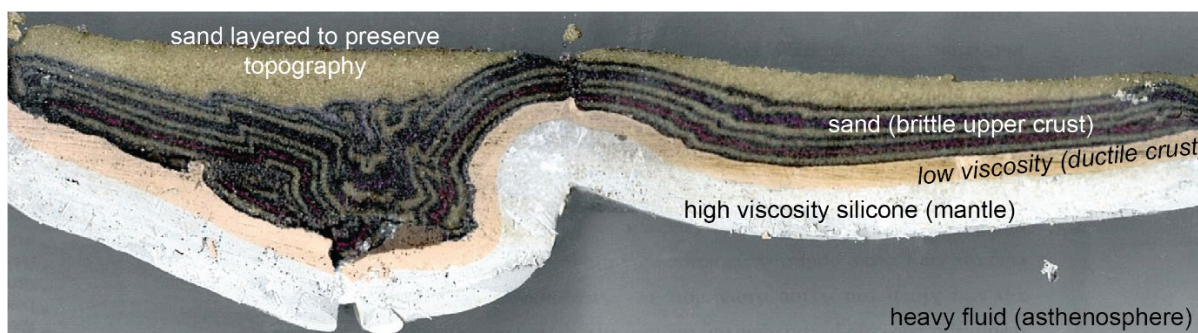
### **Analog models**

Analog modeling uses physical, scaled-down models to represent geological structures, making complex processes easier to visualize and understand. This hands-on approach started with pioneers like Sir James Hall in 1815, who recreated the folding of layered sedimentary rocks, and Henry Mowbray Cadell in 1887, who modeled mountain formation (Fig1-10).



A pioneering geologist modeler  
Cadell H.M. 1889 *Transactions of the Royal Society of Edinburgh* **35** 337–357

Today, small-scale geological models use materials like sand, glass beads, or silicone putty to mimic rock, along with heavy fluid for the asthenosphere (Fig1-11).



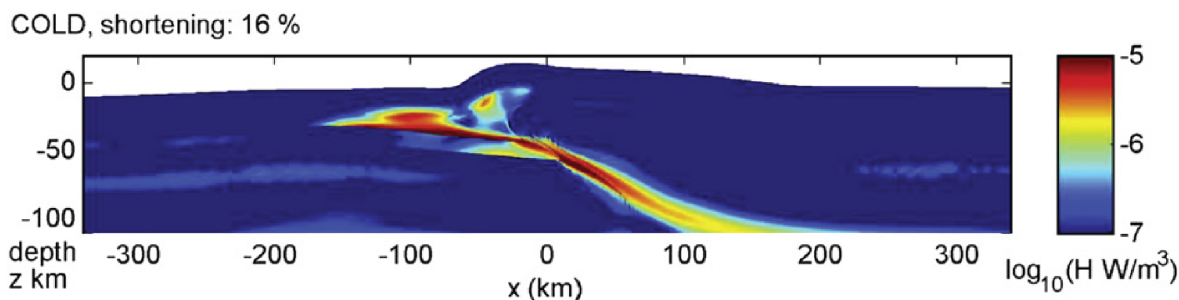
Analogue model of lithosphere of a mountain belt (initial length, 40 cm, 25% shortening)  
(from Sokoutis et al. 2005 *Tectonophysics* **406**(1-2) 1-15)

These models, kept in glass or Plexiglas tanks, use the principle of similarity: each dimension, like density, viscosity, and scale, is precisely adjusted to mirror real-world conditions. Using carefully calibrated materials, they replicate the shape, movement, and behavior of actual geological systems without complex equations. In laboratory timeframes that are easy to manage, scientists can watch processes such as mountain building or fault slipping. Time-lapse photography cuts hours or days into seconds, while sensors inside track pressures and strains, exposing the forces involved.

The results can resemble real structures quite closely, sometimes almost indistinguishably. However, similarity alone doesn't guarantee accuracy. These models simplify Earth's evolution, emphasizing key mechanisms over every detail. They omit chemical reactions, temperature variations, and the full range of rock properties. Not all physical parameters scale correctly, and accelerated tests only capture brief moments compared to the millions of years rocks experience. As a result, researchers must carefully interpret long-term trends from short-term models, always considering their limitations.

### Numerical models

Computer models are essential for testing and refining ideas about tectonic processes. They turn geological phenomena into numerical data by capturing material properties and the physical laws that describe how rocks deform under stress. With multiple variables interacting at once, these models help researchers mimic the complexity of real-world systems (Fig1-12).



Numerical model of thrusting with viscous heating  
(from Burg & Schmalholz 2008 *Earth and Planetary Science Letters* **274**(1-2) 189-203)

Unlike laboratory experiments, numerical models can simulate vast regions and cover millions of years. Researchers can tweak parameters like viscosity, temperature, or boundary forces to see how each affects the results. This hands-on approach helps identify the key factors at play. As computers improve, these virtual labs become even more powerful, handling complex processes more efficiently and accurately. By combining mathematical precision with detailed measurements, computer modeling broadens what can be tested, measured, and understood. However, limitations persist. High-resolution 3D simulations often require supercomputers and can take days or weeks to complete. Plus, because natural systems are

complex and not fully understood, each model carries inherent uncertainties, serving as informed approximations rather than exact replicas of Earth's behavior.

## Mathematical tools

### *Suggested for future studies and jobs:*

L. Kantorovich: Mathematics for natural scientists (768 p. Springer Cham, doi: 10.1007/978-3-030-91222-2)

In structural geology, the following methods are fundamental.

### Euclidean geometry

Structural geologists depend on Euclidean geometry to study planes, angles, and spatial relationships, which are vital for their interpretations. This geometric system, developed around 300 BC, involves points, lines, and circles. Its lasting visual impact is evident in the intricate tilework of Granada's Alhambra Palace from the late 15th century and in M.C. Escher's later artwork, where he examined patterns and symmetry with great precision (Fig1-1). Geologists use Euclidean geometry and spatial reasoning to interpret 2D maps and cross-sections, as well as to visualize and project complex 3D structures. These geometric principles are also key in calculating strain and stress tensors, which are essential for understanding the forces and deformations that shape the Earth's crust.

### Trigonometry

Trigonometry plays a key role in structural analysis. While Hipparchus, a Greek mathematician from the second century BC, is often credited as its inventor, the incredible pyramids of ancient Egypt show that early architects already had a deep understanding of right triangles' sides and angles.

Why focus on triangles? Because any complex shape can be broken down into polygons, which can then be divided into triangles. This makes triangles the essential building blocks for measurement and calculation. For structural geologists, understanding plane **trigonometry** is key: **triangulation** allows them to measure, compare, and model irregular rock formations and deformed layers as geometric shapes. This idea is fundamental to many important applications.

**Geodesy:** The science of measuring and representing the Earth's surface, in which triangulation determines distances, elevations, and positions over large regions.

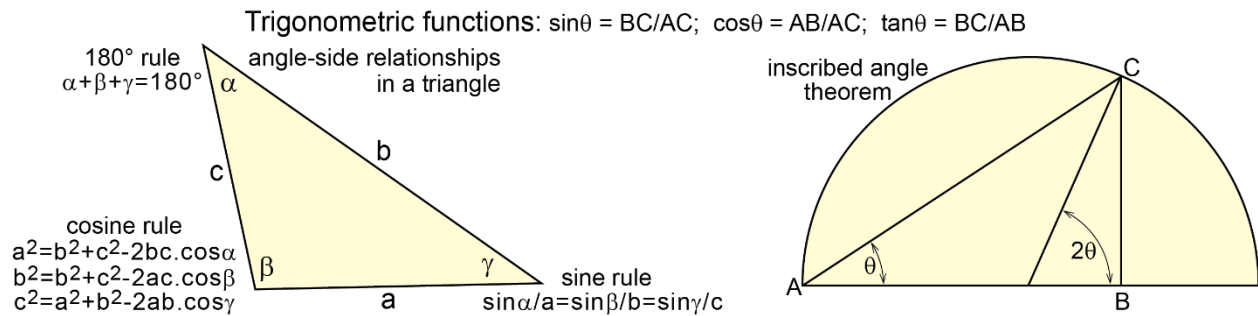
**Finite Element Methods (FEM):** A practical computational technique that breaks the model into small, manageable elements, usually triangles or tetrahedra. It calculates stress, strain, and displacement for each element and then combines these to show the overall deformation.

**Finite Difference Method (FDM):** Similar in purpose to FEM but based on a fixed grid; it approximates derivatives numerically to solve the governing equations.

**Particle-Based Methods:** Advanced simulations that model materials (such as salt) as interacting particles, enabling more realistic modeling of flow and fracture.

Triangulation has been essential from ancient surveying methods to today's supercomputing, serving as the foundational geometric principle for structural analysis.

These applications are based on the Pythagorean theorem and its extensions (Fig1-13).



These rules are crucial for tracking changes in angles and distances between node points and triangle vertices. Using trigonometry, they enable precise calculations of angles, lengths, and areas. This system is especially valuable for measuring tectonic deformation, from tiny shifts to significant crustal movements.

### Vector operations

Vector algebra and matrices are crucial for understanding how complex structures change shape. In a Cartesian coordinate system, vectors represent the displacement between points, with their length indicating the magnitude of movement or force. Operations like decomposition, addition, scalar multiplication, and the dot product help analyze deformation across scales, from tiny grains to large rock masses. Matrices streamline these calculations, making them essential for solving large systems of linear equations in structural geology. These mathematical tools are fundamental in continuum mechanics, which combines mathematics, mechanics, motion, and material physics. The Finite Element Method models continuous rock deformation, while Discontinuum approaches focus on fractures and block interactions.

### Differential and integral calculus

Earth sciences study ongoing and sometimes nonlinear processes, like how Earth materials change shape over time. To understand these processes, we use math tools such as differentiation and integration, which depend on basic operations like addition, multiplication, and substitution. A full explanation of calculus is beyond this simple overview.

#### **Differentiation**

Differential equations are essential for making Earth's dynamic processes easier to understand by linking changing physical quantities.

- Ordinary differential equations (ODEs) involve just one independent variable, like how position  $x$  changes over time  $t$  ( $dx/dt$ ). They're often used in modeling heat transfer or one-dimensional fluid flow.
- Partial differential equations (PDEs) extend this idea to phenomena that vary over space and time. For example, rock deformation and seismic waves depend on multiple coordinates ( $x, y, z$ ) and time, requiring PDEs for accurate description.

#### **Integration**

Integration is key in Earth sciences because it reveals how tiny, momentary changes build into larger effects, giving a complete view of Earth's dynamic processes. In structural geology, derivatives show how fast a rock deforms at a specific time, while integrals sum these changes over periods or areas. For example, integrating a fault's average slip rate over time helps determine total movement, crucial for understanding earthquakes and tectonic activity. In geophysics, measurements like gravity, magnetism, and seismic waves are affected by underground materials. Integration helps geophysicists pinpoint the location, size, and shape of hidden formations by analyzing their overall influence. Additionally, in

natural sciences, integrals describe how fluids flow through porous or fractured rocks, summing flow rates over time and layers to find total fluid volume moved or stored. This is vital for managing groundwater, estimating oil reserves, designing geothermal systems, and tracking pollution spread.

### To conclude this invitation

Escher's transformation of a fish into a bird shows a powerful truth: an entity is not about a fixed look but about how it changes. Its identity is a journey, not a static form. Modern geological models encourage us to see beyond fixed shapes and focus on processes, transformations, and interactions.

Beneath our feet lies a dynamic puzzle, a living world in constant motion. Earth's tectonic plates are always shifting, colliding, stretching, and breaking apart. These simple features (folds, stretches, fractures) tell the epic story of our planet, shaped by immense pressure and gravity.

Zoom in: Under a microscope, even a single rock reveals a world of structures, delicate patterns, tiny fractures, and subtle imperfections. These features silently record deep geological processes, preserving clues to pressures and movements from millions of years ago.

Zoom out: Across landscapes, massive folds rise toward the sky, while large faults slice through the crust. These striking features show Earth's relentless internal energy shaping mountains, valleys, and basins across the planet.

In this exploration, geologists are detectives uncovering Earth's history. They map structures, analyze clues across landscapes, and build 3D models of tectonic events. A simple crack or bend can reveal powerful insights into Earth's forces. As the saying goes, "You find what you look for," and knowledge guides perception. Observation isn't passive; it depends on our skills to recognize patterns and interpret their significance. In the field, we do not just see what is there: we perceive what our understanding allows us to uncover. Tracking a geological structure over time offers a dynamic view of science itself. Scientific truth is not fixed; it is constantly evolving. Progress comes not only from sharper observations but also from new ways of seeing.

Start with **Structural Geology**, which studies cracks, bends, and breaks in rocks. This field links theory and practice, from small lab models of deformation to advanced computer simulations. Each fold and fault captures a moment in Earth's past, showing how rocks react to stress and recording the forces that shaped the planet, even at microscopic scales.

Next, explore **Tectonics**: the dynamic theater where plates shift, mountains rise, and basins form. Here, slow movements of uplift and sinking unfold, driven by internal forces and surface processes like erosion. This is where Earth's inner energy sculpts its surface, famously called *Das Antlitz der Erde* (The Face of the Earth) by Eduard Suess in 1892.

Finally, examine local details: tiny changes and surface features that reveal how small forces can make a big difference. In geology, even the smallest structure can reflect the strongest forces.

Ready to explore Earth's secrets? These notebooks are your straightforward, theme-by-theme guide to the incredible forces shaping our dynamic planet. Are you ready to begin the journey?

### On the road to more knowledge

Structural geology reveals the dynamic processes shaping our planet's surface, where forces elevate mountains, fold rocks, and sculpt landscapes. This updated notebook series offers a fresh take on the original collection of 2018 course scripts @

<https://www.research-collection.ethz.ch/handle/20.500.11850/279493>

transforming them into an engaging, refreshed resource for Bachelor students, this collection incorporates classic textbooks like "Structural Geology" that provide valuable insights. It also includes online posts. The notebooks combine rigorous science with approachable storytelling, classification, and

clear illustrations. Each figure and equation is clearly labeled for straightforward navigation. The first number indicates the notebook's position in the recommended sequence, while the second specifies the particular item. Some photos and many others are accessible @

<https://www.diogenes.uni-potsdam.de/diogenes>.

Inspired by Gary Larson's Far Side comics, the playful cows sprinkled throughout these pages celebrate Switzerland's charming fascination with its cow icons. (Even geology can be humorous!) Edited with AI tools like Grammarly and Le Chat, this series aims for a harmony of clarity and creativity. Let your curiosity guide you. Dive in, explore, and follow your intuition and inspiration (Fig1-14).

### Geology in Art



Untitled, painted educational boards in Natural History Museum, 2013-2015 (Azilal, Morocco)  
Yto Barrada; ReCollect! temporary exhibition at Kunsthaus, Zürich, summer 2025