

# GEOGRAPHY

## *The Earth*

### THE STRUCTURE OF THE EARTH



#### **Welcome to School To Go and today's lesson!**

This is a course in the subject "Geography" about the Earth in three episodes, with the three themes: "Earth's structure", "Plate tectonics", and finally "Continents and oceans". There will be both listening texts and exercises in the episodes.

#### **Introduction**

Understanding the structure of the Earth is like having the key to an incredible treasure chest full of secrets and explanations. Although we are on the surface of this great globe, knowing what is happening beneath our feet can open the door to a world of science, exploration and fascination. In this lesson we will explore the

structure of the Earth, learn about its inner layers, and most importantly, understand why it is so important, especially for young people like you, to learn about this exciting topic.

But why is it important to study the structure of the Earth? First, it gives us a deeper understanding of our planet, which is essential to protecting and preserving it for future generations. By knowing how the Earth's interior works, we can better understand earthquakes, volcanic eruptions and other natural disasters, and we can also better understand our planet's climate and geological history.

In addition, knowledge of the Earth's structure is fundamental to many scientific disciplines such as geology, geophysics, and oceanography. It can also open doors to exciting career opportunities in these fields, making it a valuable investment in your future. So let's begin our journey into the Earth's interior and discover the amazing secrets it hides.

### **Learning Objectives:**

- I must be able to describe the Earth's internal structure and identify the different layers - crust, mantle and core - and understand their composition and properties.
- I need to be able to explain how geologists use seismic data to study the Earth's interior and understand the importance of S and P waves in this context.
- I must be able to analyze how the Earth's internal structure affects geological phenomena such as earthquakes, volcanoes and continental drift.

### **How is the Earth's internal structure divided into different layers, and what are the characteristics of each layer?**

Let's take a deeper look at the Earth's internal structure, which is divided into different layers. This structure helps us understand our planet's composition and what happens beneath its surface. We will describe each layer and its characteristics without using metaphors.

#### **The Earth's internal structure is divided into three main layers:**

**Crust:** The crust is the outermost layer of the Earth and is where we live. It is thin compared to the other layers and varies in thickness from about 3-43 miles (5-70 kilometers) thick. The crust consists primarily of solid rock and minerals. It is divided into two types: the continental crust, which makes up our continents, and the

oceanic crust, which makes up the ocean floors. The continental crust is thicker and less dense than the oceanic crust.

**Mantle:** The mantle lies below the crust and extends to a depth of about 1,800 miles (2,900 kilometers). The mantle consists mainly of solid rocks and minerals, but the materials in the mantle are in a partially molten state, called magma, which can flow slowly over time. This partially melted layer is responsible for the movement of Earth's tectonic plates, which we will learn more about later. The mantle is divided into the upper mantle and the lower mantle, where the temperature and pressure increase with depth.

**Core:** The core is the innermost layer of the Earth and extends from about 1,800 miles (2,900 kilometers) deep to the center, which is about 3,959 miles (6,371 kilometers) from the Earth's surface. The core consists primarily of iron and nickel and is very hot, with temperatures that can reach around 10,292 degrees Fahrenheit (5,700 degrees Celsius). The core is divided into two parts: the outer core and the inner core. The outer core is in a liquid state due to the high temperatures, while the inner core is solid due to the extreme pressure it is subjected to. It is the core that generates the Earth's magnetic field.

So to summarize:

- The crust is the outermost layer where we live, and it varies in thickness.
- The mantle is the middle layer that is partially melted and responsible for the movement of plate tectonics.
- The core is the innermost layer, consisting of solid and liquid materials, and generates the Earth's magnetic field.

This is fundamental information about the Earth's internal structure and helps us understand how our planet works on a deeper level.

## **What materials make up the Earth's mantle and how does it differ from the core and the crust?**

Let's delve into the Earth's mantle and understand what materials make up this crucial layer, as well as how it differs from both the core and the crust.

### **Earth's mantle:**

The Earth's mantle is the middle layer of our planet's internal structure. It extends from the bottom of the crust and goes deep into the earth, about 1,800 miles 2,900 kilometers below the Earth's surface. The mantle consists mainly of solid rock and

minerals with silicates as the primary material. This layer is much hotter than the surface, and the temperature increases gradually as one descends into the mantle. While the temperature is not as high as in the core, it is sufficient to cause some interesting physical and chemical properties.

### **The separation from the core:**

The mantle differs from the core primarily by its composition and physical state. The core consists mainly of iron and nickel and is known for its high temperatures and pressures. The core is in a liquid or semi-liquid state, while the mantle is mainly solid. This difference in state makes the mantle an important layer for our planet's mechanics, especially in relation to plate tectonics, where solid materials in the mantle float as a buoyant mass above the liquid core.

### **The separation from the crust:**

Compared to the crust, the mantle is also different in both composition and its physical properties. The crust is the outermost layer where we live, and it consists primarily of solid rock and minerals, including silicates. The crust is significantly thinner than the mantle and has a lower temperature. The mantle contains more iron and magnesium compared to the crust, giving it a higher density.

Another significant difference is that the mantle is partially molten, meaning that some of its materials are in a liquid or semi-liquid state. This phenomenon is crucial to understanding plate tectonics, as it gives rise to convection currents that drive the movement of Earth's tectonic plates.

It is important to understand these differences as they contribute to our fundamental knowledge of the Earth's internal structure and the dynamic processes that govern the evolution and appearance of our planet. It is also fundamental to understanding natural phenomena such as earthquakes, volcanoes and continental drift, which are directly related to the properties and movements of the mantle.

## **How do geologists use seismic data to study Earth's interior?**

Let's explore how geologists use seismic data to study Earth's interior and understand the meaning of S and P waves.

### **Seismic data and the Earth's interior:**

Geologists use seismic data to study the Earth's interior, and this method is called seismology. Seismology is based on the observation of earthquakes and the waves they emit as they move through the Earth. When an earthquake occurs, seismic

waves are sent out in all directions. These waves are recorded by seismometers and seismographs located around the Earth.

### **S and P waves:**

There are two primary types of seismic waves, which are called S waves (shear waves) and P waves (primary waves). These waves move through the Earth's interior in different ways and give us important information about the Earth's structure.

**P Waves (Primary Waves):** P waves are the fastest seismic waves and are the first to arrive after an earthquake. They are also known as compressional waves as they travel by compressing and expanding material in the direction of the wave. P-waves can travel through both solid and liquid materials, enabling them to pass through both the Earth's mantle and core. Their pattern of movement gives us information about how materials react to pressure and changes in density.

**S-waves (Shear waves):** S-waves are slower than P-waves and arrive later. They move by causing material to swing sideways in a sort of serpentine motion. S-waves can only travel through solid materials and cannot pass through liquids. Therefore, they stop when they reach the liquid outer core, and this phenomenon helps to confirm that the Earth's core is liquid.

### **What can S and P waves tell us?**

S and P waves give geologists a valuable indication of the Earth's internal structure and properties. By analyzing how these waves travel through the Earth, scientists can determine how solid, semi-liquid or liquid materials are and where the boundaries between the different layers of the Earth's interior are. For example, it is when S-waves stop at the outer core that we know the core is liquid.

Through decades of seismic surveys, geologists have mapped the Earth's internal structure, identifying the crust, mantle, and core, as well as their depth and composition. This knowledge is essential to understanding plate tectonics, volcanoes, earthquakes and other geological phenomena. It also helps form the basis for predicting and understanding dynamics of the Earth. This is important for protecting communities from natural disasters and for advancing our knowledge of our planet and its history.

## **What role does the Earth's magnetic field play and how is it related to the core?**

Let's explore the important role of the Earth's magnetic field and how it relates to the core without the use of metaphors.

### **Earth's magnetic field and its role:**

The Earth's magnetic field is an invisible and protective shield around our planet. It plays a vital role in protecting life on Earth by shielding us from harmful solar wind particles and cosmic radiation that would otherwise be dangerous to both our planet and our health. This magnetic field acts like a giant magnet with a north pole and a south pole, and it is thanks to this magnetic field that compasses work and we can navigate using them.

### **Connection with the Earth's core:**

The Earth's magnetic field is closely connected to the Earth's internal structure, especially the core. It is here, at the core, that the process behind the Earth's magnetic field takes place. The core consists primarily of iron and nickel and is divided into two parts: the outer core and the inner core. The outer core is in a liquid state due to the extremely high temperatures in this part of the Earth's interior.

The Earth's magnetic field is created by a process called the geodynamo. In the outer core, where the temperature is high enough, some of the metals, especially iron, melt. When these metals melt, they become able to move freely. At the same time, the heat from the inner core creates a convection current in the outer core, causing the molten metals to move around. These movements of liquid metal create electrical currents in the process.

These electric currents in the outer core acts like a giant dynamo, generating an electric field. This electric field in turn produces a magnetic field that surrounds the Earth and creates our planetary magnetic field. The process itself is complex and is the result of the interaction between heat, pressure, electrical properties of the materials and the Earth's rotation.

So in short: Earth's magnetic field is formed in the core, specifically in the outer liquid core, where electric currents are created due to convection and heat. These electrical currents generate a magnetic field that surrounds the Earth and plays a critical role in protecting our planet from the solar wind and cosmic radiation. This is why understanding the Earth's internal structure and its dynamics is crucial to understanding why our planet has a magnetic field and how it works.

## **How can we use laboratory experiments with materials similar to the Earth's interior to understand the structure of the planet?**

Laboratory experiments with materials similar to Earth's interior play an important role in helping us understand the makeup of the planet. These experiments allow us to simulate the extreme conditions found deep inside the Earth and investigate how materials behave under such conditions. Here's an explanation:

### **Laboratory experiments and the Earth's interior:**

To understand what is happening deep inside the Earth, scientists have developed laboratory experiments that use materials that are chemically and physically comparable to the substances found in the Earth's interior. These experiments allow us to recreate the high temperatures, pressures and other extreme conditions that exist in the Earth's mantle and core.

### **Materials and equipment:**

In these experiments, researchers usually use materials such as silicates (eg, peridotite or olivine), which are the primary rocks and minerals found in the Earth's mantle. They also use equipment that can create the necessary high temperatures and pressures such as high-pressure presses and furnaces that can reach temperatures of thousands of degrees Celsius.

### **What can we learn?**

**Phase changes:** These experiments help us understand how materials change phase (from solid to liquid or vice versa) under extreme conditions. This gives us insight into how materials in the mantle and core behave when exposed to conditions with extreme temperatures and pressures.

**Mineral and crystal formation:** Scientists can study how minerals and crystals form under the internal conditions of the Earth. This gives us information about which minerals are present deep down in the Earth's layers and how they interact with each other.

**Magma and melting processes:** Laboratory experiments can help us understand how magma forms and behaves. This is important as magma is essential for volcanic activity and rock formation.

**Tectonic plates and continental drift:** By studying how materials behave under high-pressure conditions, we can also gain a better understanding of how tectonic plates move and cause continental drift.

**Importance:**

Laboratory experiments with materials similar to the Earth's interior are essential for developing theories and models of Earth's structure and dynamics. They help us answer fundamental questions about our planet, including how the continents move, why volcanoes form, and how earthquakes occur. This knowledge is not only important for scientific research, but also for understanding and predicting geological events that can affect human life and the environment. Together with other scientific methods, laboratory experiments give us a deeper insight into the interior of the Earth and its complex structure.

**How does Earth's internal structure affect our planet: the role of earthquakes, volcanoes, and continental drift?**

The Earth's internal structure plays a crucial role in shaping our planet and influences a number of geological events, including earthquakes, volcanoes and continental drift. Here is an explanation about each :

**Earthquake:**

Earthquakes are tremors or vibrations in the Earth's surface that occur as a result of plate tectonics, which is the movement of the massive plates that make up the Earth's crust. These plates lie on the semi-fluid upper mantle and are in constant motion due to convection currents in the mantle. When two of these plates move in different directions, they can come into contact with each other, slide along each other, or are pressed together. This creates tremendous tension that builds over time.

When the tension becomes too great, energy is released in the form of seismic waves that propagate through the Earth and cause earthquakes. This energy is released as a result of deformation and fractures in the Earth's crust. Earthquakes vary in size and intensity depending on the amount of built-up stress and the nature of the plate movement. It is the constant movement and interaction between the Earth's plates that creates earthquakes, and this phenomenon is deeply influenced by the Earth's internal structure.

**Volcanoes:**

Volcanoes are another consequence of the Earth's internal structure and its influence on plate tectonics. When one plate sinks beneath another in a process called subduction, that plate heats up, causing melting of material in its interior. The molten material rises to the surface and can lead to the formation of volcanoes.



This molten material, known as magma, contains gases and minerals that can accumulate in the volcano. When the pressure inside the volcano becomes high enough, the volcano explodes or erupts, resulting in a volcanic eruption. Volcanoes are a direct result of processes in the Earth's interior and are an important part of the formation of mountain ranges and geological landscapes.

### **Continental drift:**

Continental drift refers to the movement of Earth's continents over time. This phenomenon was first described by Alfred Wegener and is now a fundamental part of plate tectonics theory. The Earth's internal structure plays a central role in continental drift, as it is responsible for the movement of the continental plates.

The plates that carry the continents can move away from each other (divergent boundary), towards each other (convergent boundary), or along each other (transform boundary). These movements are due to convection currents in the upper mantle, where material moves and pushes the continental plates with it. This creates continuous change in the Earth's landscape and shape and is responsible for processes such as mountain formation, continental expansion and the formation of ocean basins.

In summary, the Earth's internal structure affects our planet by shaping the processes behind earthquakes, volcanoes and continental drift. These phenomena are directly related to plate tectonics and the dynamic nature of the Earth's interior, making our understanding of the Earth's internal structure crucial to geological research and predicting natural disasters.

### **What could a problem be, which research method could be used and which model could be used to show the problem or the solution?**

Let's explore a problem, a research method and a model that can be used to show the problem or solution. We will focus on the problem of rising sea levels due to climate change.

#### **Issues:**

A growing problem in the world today is the rising sea levels caused by climate change. Increased emissions of greenhouse gasses such as CO<sub>2</sub> into the atmosphere have led to global warming, which in turn leads to the melting of polar ice caps and glaciers around the world. This results in a gradual rise in sea levels, threatening coastal communities, ecosystems and infrastructure.

**Examination method:**

To understand the scale of the problem and predict future sea-level rise, scientists use a variety of research methods, including satellite observations, sea-level monitoring, ice core drilling, and climate modeling. An important survey method is the use of satellites to accurately measure sea level from space. Satellites such as the Jason series and the Sentinel series accurately monitor sea levels and record changes over time.

**Model to show the problem:**

A model used to visualize the problem of rising sea levels is a topographic model that shows how coastal areas and low-lying areas are flooded with rising sea levels. Geographic information systems (GIS) can be used to develop such models. GIS software combines topographic data with predictions of sea level rise to create maps that show which areas are most vulnerable to flooding.

Another model used is a digital elevation model (DEM) that shows the terrain and elevation differences in coastal areas. By incorporating sea level rise data into a DEM, researchers can predict which areas will be affected by flooding in the future. These models help governments, urban planners and researchers develop strategies to protect coastal communities and take action to mitigate climate change.

In summary, satellite observations, sea level monitoring, ice core drilling and climate modeling are used as investigative methods to understand the problem of rising sea levels. Models such as topographic maps and digital elevation models are used to visualize the consequences of the problem and help develop solutions and decisions to protect our coastal areas and populations from the potential threats.

Now it's time to do a few tasks and think about what we just learned.

## Tasks

1. **Examining Seismic Data:** Work together in groups to analyze seismic data. Identify where earthquakes have occurred and try to understand how these events are related to plate tectonics.
2. **Model of the Earth's Interior:** Create a model of the Earth's interior using materials such as clay or papier-mâché. Your model should illustrate the different layers and their compositions.
3. **Volcano Research:** Choose a specific volcano and research its history and activity. Find out how its location is related to plate tectonics.
4. **Continental Drift Presentation:** Prepare a presentation or a poster about continental drift and how it has shaped Earth's continents over time.

Once you have answered the tasks, this episode ends.

Here start the ideas for the teachers:

## Ideas for the teacher:

5. **Interactive Demonstrations:** The teacher can conduct interactive demonstrations to illustrate concepts such as plate tectonics, seismic waves, and convection currents to make the subject more visual and tangible for students.
6. **Using online resources:** The teacher can introduce students to online simulations and interactive tools that allow them to explore the Earth's internal structure and its influence on geological phenomena.
7. **Guest lectures or field trips:** Invite geologists or arrange field trips to geological sites such as volcanoes or seismic monitoring stations to give students first-hand experience and insight into the field.
8. **Discussion of current events:** The teacher can discuss current events such as earthquakes, volcanic eruptions or continental drift to relate the topic to real situations and highlight the importance of understanding the Earth's structure in daily life.