Encyclopedic Entry

crust

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"Crust" describes the outermost shell of a terrestrial planet. Our planet's thin, 40-kilometer (25-mile) deep crust—just 1% of Earth's mass—contains all known life in the universe.

Earth has three layers: the crust, the mantle, and the core. The crust is made of solid rocks and minerals. Beneath the crust is the mantle, which is also mostly solid rocks and minerals, but punctuated by malleable areas of semi-solid magma. At the center of the Earth is a hot, dense metal core.

Earth's layers constantly interact with each other, and the crust and upper portion of the mantle are part of a single geologic unit called the lithosphere. The lithosphere's depth varies, and the Mohorovicic discontinuity (the Moho)—the boundary between the mantle and crust—does not exist at a uniform depth. Isostasy describes the physical, chemical, and mechanical differences between the mantle and crust that allow the crust to "float" on the more malleable mantle. Not all regions of Earth are balanced in isostatic equilibrium. Isostatic equilibrium depends on the density and thickness of the crust, and the dynamic forces at work in the mantle.

Just as the depth of the crust varies, so does its temperature. The upper crust withstands the ambient temperature of the atmosphere or ocean—hot in arid deserts and freezing in ocean trenches. Near the Moho, the temperature of the crust ranges from 200° Celsius (392° Fahrenheit) to 400° Celsius (752° Fahrenheit).

Crafting the Crust

Billions of years ago, the planetary blob that would become the Earth started out as a hot, viscous ball of rock. The heaviest material, mostly iron and nickel, sank to the center of the new planet and became its core. Over millions of years, the surface of the Earth slowly cooled and hardened. Surface rocks became the crust.

From mud and clay to diamonds and coal, Earth's crust is composed of igneous, metamorphic, and sedimentary rocks. The most abundant rocks in the crust are igneous, which are formed by the cooling of magma. Earth's crust is rich in igneous rocks such as granite and basalt. Metamorphic rocks have undergone drastic changes due to heat and pressure. Slate and marble are familiar metamorphic rocks. Sedimentary rocks are formed by the accumulation of material at Earth's surface. Sandstone and shale are sedimentary rocks.

Dynamic geologic forces created Earth's crust, and the crust continues to be shaped by the planet's movement and energy. Today, tectonic activity is responsible for the formation (and destruction) of crustal materials.

Earth's crust is divided into two types: oceanic crust and continental crust. The transition zone between these two types of crust is sometimes called the Conrad discontinuity. Silicates (mostly compounds made of silicon and oxygen) are the most abundant rocks and minerals in both oceanic and continental crust.

Oceanic Crust

Oceanic crust, extending 5-10 kilometers (3-6 kilometers) beneath the ocean floor, is mostly composed of different types of basalts. Geologists often refer to the rocks of the oceanic crust as "sima." Sima stands for silicate and magnesium, the most

abundant minerals in oceanic crust. (Basalts are a sima rocks.) Oceanic crust is dense, almost 3 grams per cubic centimeter (1.7 ounces per cubic inch).

Oceanic crust is constantly formed at mid-ocean ridges, where tectonic plates are tearing apart from each other. As magma that wells up from these rifts in Earth's surface cools, it becomes young oceanic crust. The age and density of oceanic crust increases with distance from mid-ocean ridges.

Just as oceanic crust is formed at mid-ocean ridges, it is destroyed in subduction zones. Subduction is the important geologic process in which a tectonic plate made of dense lithospheric material melts or falls below a plate made of less-dense lithosphere at a convergent plate boundary.

At convergent plate boundaries between continental and oceanic lithosphere, the dense oceanic lithosphere (including the crust) always subducts beneath the continental. In the northwestern United States, for example, the oceanic Juan de Fuca plate subducts beneath the continental North American plate. At convergent boundaries between two plates carrying oceanic lithosphere, the denser (usually the larger and deeper ocean basin) subducts. In the Japan Trench, the dense Pacific plate subducts beneath the less-dense Okhotsk plate.

As the lithosphere subducts, it sinks into the mantle, becoming more plastic and ductile. Through mantle convection, the rich minerals of the mantle may be ultimately "recycled" as they surface as crust-making lava at mid-ocean ridges and volcanoes.

Largely due to subduction, oceanic crust is much, much younger than continental crust. The oldest existing oceanic crust is in the Ionian Sea, part of the eastern Mediterranean basin. The seafloor of the Ionian Sea is about 270 million years old. (The oldest parts of continental crust, on the other hand, are more than 4 billion years old.)

Geologists collect samples of oceanic crust through drilling at the ocean floor, using submersibles, and studying ophiolites. Ophiolites are sections of oceanic crust that have been forced above sea level through tectonic activity, sometimes emerging as dikes in continental crust. Ophiolites are often more accessible to scientists than oceanic crust at the bottom of the ocean.

Continental Crust

Continental crust is mostly composed of different types of granites. Geologists often refer to the rocks of the continental crust as "sial." Sial stands for silicate and aluminum, the most abundant minerals in continental crust. Sial can be much thicker than sima (as thick as 70 kilometers kilometers (44 miles)), but also slightly less dense (about 2.7 grams per cubic centimeter (1.6 ounces per cubic inch)).

As with oceanic crust, continental crust is created by plate tectonics. At convergent plate boundaries, where tectonic plates crash into each other, continental crust is thrust up in the process of orogeny, or mountain-building. For this reason, the thickest parts of continental crust are at the world's tallest mountain ranges. Like icebergs, the tall peaks of the Himalayas and the Andes are only part of the region's continental crust—the crust extends unevenly below the Earth as well as soaring into the atmosphere.

Cratons are the oldest and most stable part of the continental lithosphere. These parts of the continental crust are usually found deep in the interior of most continents. Cratons are divided into two categories. Shields are cratons in which the ancient basement rock crops out into the atmosphere. Platforms are cratons in which the basement rock is buried beneath overlying sediment. Both shields and platforms provide crucial information to geologists about Earth's early history and formation.

Continental crust is almost always much older than oceanic crust. Because continental crust is rarely destroyed and recycled in the process of subduction, some sections of continental crust are nearly as old as the Earth itself.

Extraterrestrial Crust

Our solar system's other terrestrial planets (Mercury, Venus, and Mars) and even our own Moon have crusts. Like Earth, these extraterrestrial crusts are formed mostly by silicate minerals. Unlike Earth, however, the crusts of these celestial bodies are not shaped by the interaction tectonic plates.

Despite the Moon's smaller size, lunar crust is thicker than crust on Earth. Lunar crust is not a uniform thickness and in

general tends to be thicker on the “far side,” which always faces away from Earth.

Although Mercury, Venus, and Mars are not thought to have tectonic plates, they do have dynamic geology. Venus, for instance, has at partly-molten mantle, but the Venusian crust lacks enough trapped water to make it as dynamic as Earth’s crust.

The crust of Mars, meanwhile, features the tallest mountains in the solar system. These mountains are actually extinct volcanoes formed as molten rock erupted in the same spot on the Martian surface over millions of years. Eruptions built up enormous mountains of iron-rich igneous rocks that give the Martian crust its characteristic red hue.

One of the most volcanic crusts in the solar system is that of Jupiter’s moon Io. The rich sulfide rocks in the Ionian crust paint the moon a dappled collection of yellows, greens, reds, blacks, and whites.

VOCABULARY

Term	Part of Speech	Definition
abundant	*adjective*	in large amounts.
accessible	*adjective*	relatively easy to approach, use, or obtain.
accumulation	*noun*	a buildup of something.
ambient	*adjective*	having to do with the surrounding area or environment.
arid	*adjective*	dry.
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.
basalt	*noun*	type of dark volcanic rock.
basement rock	*noun*	oldest underlying rock formation in any region.
boundary	*noun*	line separating geographical areas.
characteristic	*noun*	physical, cultural, or psychological feature of an organism, place, or object.
Conrad discontinuity	*noun*	seismic boundary between the continental crust and oceanic crust.
continental crust	*noun*	thick layer of Earth that sits beneath continents.
convergent plate boundary	*noun*	area where two or more tectonic plates bump into each other. Also called a collision zone.
core	*noun*	the extremely hot center of Earth, another planet, or a star.
craton	*noun*	old, stable part of continental crust, made up of shields and platforms.
crucial	*adjective*	very important.
crust	*noun*	rocky outermost layer of Earth or other planet.
dappled	*adjective*	spotted, or having areas of differently colored shades or tones.
dense	*adjective*	having parts or molecules that are packed closely together.
desert	*noun*	area of land that receives no more than 25 centimeters (10 inches) of precipitation a year.
dike	*noun*	a barrier, usually a natural or artificial wall used to regulate water levels.
ductile	*adjective*	capable of withstanding a certain amount of force by changing form before fracturing or breaking.

dynamic	*adjective*	always changing or in motion.
Earth	*noun*	our planet, the third from the Sun. The Earth is the only place in the known universe that supports life.
erupt	*verb*	to explode or suddenly eject material.
eventually	*adverb*	at some point in the future.
extinct volcano	*noun*	volcano that will no longer erupt.
extraterrestrial	*adjective*	located or formed outside Earth's atmosphere.
geologic	*adjective*	having to do with the physical formations of the Earth.
granite	*noun*	type of hard, igneous rock.
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hue	*noun*	tint or general variety of color.
iceberg	*noun*	large chunks of ice that break off from glaciers and float in the ocean.
igneous rock	*noun*	rock formed by the cooling of magma or lava.
iron	*noun*	chemical element with the symbol Fe.
isostasy	*noun*	equilibrium of Earth's crust, where the forces tending to elevate landmasses balance those tending to depress them. Also called isostatic equilibrium.
lava	*noun*	molten rock, or magma, that erupts from volcanoes or fissures in the Earth's surface.
lithosphere	*noun*	outer, solid portion of the Earth. Also called the geosphere.
lunar	*adjective*	having to do with Earth's moon or the moons of other planets.
magma	*noun*	molten, or partially melted, rock beneath the Earth's surface.
magnesium	*noun*	chemical element with the symbol Mg.
malleable	*adjective*	flexible and capable of reforming itself without breaking when under stress.
mantle	*noun*	middle layer of the Earth, made of mostly solid rock.
mantle convection	*noun*	slow movement of Earth's solid mantle caused by convection currents transferring heat from the interior of the Earth to the surface.
metal	*noun*	category of elements that are usually solid and shiny at room temperature.
metamorphic rock	*noun*	rock that has transformed its chemical qualities from igneous or sedimentary.
mid-ocean ridge	*noun*	underwater mountain range.
mineral	*noun*	inorganic material that has a characteristic chemical composition and specific crystal structure.
Mohorovicic discontinuity	*noun*	point between Earth's crust and the mantle below. Also called the Moho.
molten	*adjective*	solid material turned to liquid by heat.
ocean basin	*noun*	depression in the Earth's surface located entirely beneath the ocean.
oceanic crust	*noun*	thin layer of the Earth that sits beneath ocean basins.

ocean trench	*noun*	a long, deep depression in the ocean floor.
ophiolite	*noun*	remnant of oceanic crust (certain igneous rocks) embedded in continental crust.
orogeny	*noun*	the way mountains are formed.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
platform	*noun*	ancient rocks that formed as part of continental crust, now overlain with sediment and sedimentary rock, located in the interior of continents.
rock	*noun*	natural substance composed of solid mineral matter.
sediment	*noun*	solid material transported and deposited by water, ice, and wind.
sedimentary rock	*noun*	rock formed from fragments of other rocks or the remains of plants or animals.
shield	*noun*	ancient rocks that formed as part of continental crust and are located in the interior of continents.
sial	*noun*	rocks, mostly silicates and aluminum, making up most of Earth's continental crust.
silica	*noun*	chemical compound (SiO_2) that makes up most of the Earth's rocks.
silicate	*noun*	most common group of minerals, all of which include the element silicon (Si).
sima	*noun*	rocks, mostly silicates and magnesium, making up most of Earth's oceanic crust.
subduction	*noun*	process of one tectonic plate melting or going beneath another.
subduction zone	*noun*	area where one tectonic plate slides under another.
submersible	*noun*	small submarine used for research and exploration.
sulfide	*noun*	negatively charged ion of sulfur, or a chemical compound containing such an ion.
tectonic activity	*noun*	movement of tectonic plates resulting in geologic activity such as volcanic eruptions and earthquakes.
tectonic plate	*noun*	large, moveable segment of the Earth's crust.
temperature	*noun*	degree of hotness or coldness measured by a thermometer with a numerical scale.
terrestrial planet	*noun*	one of the four planets closest to the sun: Mercury, Venus, Earth, or Mars.
transition zone	*noun*	areas in the Earth's interior between the upper mantle, near the Earth's crust, and the lower mantle, near the Earth's core.
uniform	*adjective*	exactly the same in some way.
universe	*noun*	all known matter, energy, and space.
viscous	*adjective*	liquid that is thick and sticky.
volcano	*noun*	an opening in the Earth's crust, through which lava, ash, and gases erupt, and also the cone built by eruptions.

For Further Exploration

Audio & Video

- National Geographic Channel: How the Earth Changed History—Beneath the Crust

Websites

- National Geographic Science: Inside the Earth
- USGS: Earthquake Hazards Program—Crustal Deformation Monitoring