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# Glossary

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	Note: Words in <b>bold font</b> are also defined in this glossary.
'a'a	a <b>dense</b> and blocky <b>lava</b> flow, made up of a massive front of hardened fragments. Cooled 'a'a is a jagged landscape of sharp lava rubble. 'A'a is produced by lava that has a high viscosity and strain rate, as well as high gas effusion.
<i>ablation zone</i>	the front part of a <b>glacier</b> , where ice is lost due to melting and calving.
<i>accretion, accrete</i>	the process by which a body of rock increases in size due to the addition of further <b>sedimentary</b> particles or of large chunks of land, such as <b>terranes</b> .
<i>accumulation zone</i>	the highly elevated part of a <b>glacier</b> , where annual snow accumulation outpaces snow loss.
<i>active plate boundary, active plate margin</i>	the boundary between two <b>plates</b> of the Earth's <b>crust</b> that are colliding, pulling apart, or moving past each other.  See also: <b>plate tectonics</b>
<i>aeolian</i>	pertaining to, caused by, or carried by the <b>wind</b> . Aeolian sediments are often polished, giving them a "frosty" appearance.  The name comes from Aeolus, the Greek god of wind.
<i>aerosol</i>	tiny solid or liquid particles in the air. Examples include dust, smoke, mist, and human-made substances such as particles emitted from factories and cars.
<i>agate</i>	a crystalline <b>silicate</b> rock with a colorful banded pattern. It is a variety of <b>chalcedony</b> . Agates usually occur as <b>nodules</b> in <b>volcanic</b> rock.
<i>Alfisols</i>	a <b>soil order</b> ; these are highly fertile and productive agricultural <b>soils</b> in which clays often accumulate below the surface. They are found in humid and subhumid <b>climates</b> .
<i>alluvium, alluvial</i>	a thick layer of river-deposited sediment.
<i>aluminum</i>	a metallic chemical element (Al), and the most abundant metal in the Earth's crust.  Aluminium has a low <b>density</b> and an excellent ability to resist corrosion. Structural components made from the metal and its alloys are commonly used in the aerospace industry, transportation, and household goods.
<i>ammonoid, ammonite</i>	a group of <b>extinct cephalopods</b> belonging to the Phylum Mollusca, and possessing a spiraling, tightly-coiled shell characterized by ridges, or septa.
<i>amphibole</i>	a group of dark-colored <b>silicate minerals</b> , or either <b>igneous</b> or <b>metamorphic</b> origin.
<i>andesite</i>	a fine-grained <b>extrusive volcanic</b> rock, with a <b>silica</b> content intermediate between that of <b>basalt</b> and <b>dacite</b> .

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<i>Andisols</i>	a <b>soil order</b> ; these are highly productive <b>soils</b> often formed from volcanic materials. They possess very high water- and nutrient-holding capabilities, and are commonly found in cool areas with moderate to high levels of precipitation.
<i>anthracite</i>	a dense, shiny <b>coal</b> that has a high carbon content and little volatile matter. Anthracite is as much as 95% carbon. Found in deformed rocks, anthracite is the cleanest burning of the three types of coal, because it contains the highest amount of pure carbon.
<i>anthropogenic</i>	caused or created by human activity.
<i>anticline</i>	a layer of rock folded (bent) along an axis, concave side down (i.e., in an upside down “u” or “v” shape). Thus rocks at the center of the anticline, along the fold (crest), are lifted up relative to the rest of the layer.
<i>antimony</i>	a lustrous gray metallic element (Sb), mainly found in nature as the <b>sulfide</b> mineral stibnite (Sb <sub>2</sub> S <sub>3</sub> ). Antimony compounds have been known since ancient times, when it was used in cosmetics. Today, the largest applications for the element are as an alloying material for <b>lead</b> and tin, and for plates in lead-acid batteries.
<i>Antler Orogeny</i>	a period of mountain building that deformed rocks in a belt extending from the California–Nevada border northward into Idaho. The Antler Orogeny began in the late <b>Devonian</b> and continued into the <b>Carboniferous</b> .  See also: <b>orogeny</b>
<i>aquifer</i>	a water-bearing formation of <b>gravel</b> , <b>permeable</b> rock, or <b>sand</b> that is capable of providing water, in usable quantities, to springs or wells.
<i>archaeocyathid</i>	a vase-shaped organism with a <b>carbonate</b> skeleton, generally believed to be a <b>sponge</b> . Archaeocyathids were the first important animal <b>reef</b> builders, originating in the early <b>Cambrian</b> . They were very diverse, but went <b>extinct</b> by the end of the Cambrian. Archeocyathids are often easiest to recognize in <b>limestones</b> , by their distinctive cross-section.
<i>Archean</i>	a <b>geologic time</b> period that extends from 4 billion to 2.5 billion years ago. It is part of the <b>Precambrian</b> .
<i>arête</i>	a thin ridge of rock with an almost knife-like edge, formed when two <b>glaciers erode</b> parallel valleys.
<i>Aridisols</i>	a <b>soil order</b> ; these are formed in very dry (arid) <b>climates</b> . The lack of moisture restricts <b>weathering</b> and <b>leaching</b> , resulting in both the accumulation of <b>salts</b> and limited subsurface development. Commonly found in deserts.
<i>arthropod</i>	an invertebrate animal, belonging to the Phylum Arthropoda, and possessing an external skeleton (exoskeleton), body segments, and jointed appendages.  Arthropods include crustaceans, arachnids, and insects, and there are over a million described arthropod species living today. <b>Trilobites</b> are a major group of extinct arthropods.

<i>asthenosphere</i>	a thin semifluid layer of the Earth, below the outer rigid <b>lithosphere</b> , forming the upper part of the <b>mantle</b> . The <b>heat</b> and pressure created by the overlying lithosphere make the solid rock of the asthenosphere bend and move like metal when heated. The layer is thought to flow vertically and horizontally with circular <b>convection</b> currents, enabling sections of lithosphere to subside, rise, and undergo lateral movement.
<i>atmosphere</i>	a layer of gases surrounding a planet. Earth's atmosphere protects living organisms from damage by solar ultraviolet radiation, and it is mostly composed of nitrogen. Oxygen is used by most organisms for respiration. Carbon dioxide is used by plants, algae and <b>cyanobacteria</b> for photosynthesis.
<i>badlands</i>	a type of <b>eroded topography</b> that forms in semi-arid areas experiencing occasional periods of heavy rainfall. Sloping ground composed of <b>sandstones</b> and calcareous sediments underlain by <b>clay</b> or other soft materials is eroded over time into an intricate series of gullies and ravines. Different layers of rock <b>weather</b> at different rates, resulting in a variety of sculpted spurs and buttresses, as well as tall pillars of softer rock with a hard <b>capstone</b> .
<i>basalt</i>	<p>an <b>extrusive igneous rock</b>, and the most common rock type on the surface of the Earth. It forms the upper surface of all oceanic <b>plates</b>, and is the principal rock of ocean/seafloor ridges, oceanic islands, and high-volume continental eruptions. Basalt is fine-grained and mostly dark-colored, although it often <b>weathers</b> to reds and browns because of its high iron content.</p> <p>Basaltic <b>magmas</b> are produced by partial melting of the upper <b>mantle</b>. Materials melt when we increase their temperature, but a second way to melt a solid is to decrease the pressure. In the interior of the Earth this second mechanism—decompression—is far more important. When pressure on the mantle is released as it is forced up through the crust due to <b>subduction</b>, it becomes basaltic magma.</p>
<i>basement rocks</i>	the foundation that underlies the surface geology of an area, generally composed of <b>igneous</b> or <b>metamorphic</b> crystalline rock. In certain areas, basement rock is exposed at the surface because of <b>uplift</b> or <b>erosion</b> .
<i>batholith</i>	a large exposed structure of <b>intrusive igneous rock</b> that solidified at depth, and covers an area of over 100 square kilometers (40 square miles). While batholiths may appear uniform, they are actually composed of multiple <b>plutons</b> that converged to form one mass.
<i>bauxite</i>	a whitish, grayish, brown, yellow, or reddish-brown rock composed of hydrous <b>aluminum oxides</b> and aluminum hydroxides; the principal commercial source of aluminum.
<i>Belt Supergroup</i>	<p>a 1.45-billion-year-old series of <b>sedimentary rocks</b>, found in the Northern Rocky Mountains, that contain <b>sandstones</b> and mudstones.</p> <p>The Belt Supergroup is of particular note due to its age and excellent preservation. It is extremely rare that sedimentary rocks of over a billion years in age have not been warped, tilted, <b>metamorphosed</b>, or otherwise altered. The Belt Supergroup is also famous for its abundant and well-preserved <b>stromatolites</b>.</p>
<i>bentonite</i>	a <b>clay</b> , formed from decomposed volcanic ash, with a high content of the <b>mineral</b> montmorillonite.

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<i>beryl</i>	a white, blue, yellow, green, or pink <b>mineral</b> , found in coarse <b>granites</b> and <b>igneous rocks</b> . It is a source of beryllium and used as a <b>gemstone</b> ; the green variety is called emerald, the blue is known as aquamarine.
<i>biodiversity</i>	the number of kinds of organisms at any given time and place. Global changes in biodiversity through <b>geologic time</b> tells paleontologists that something is happening to the rate of <b>extinction</b> or the rate of origin of new species. Regional changes are influenced by migration, or the number of species supported by available food and space resources.
<i>biofuel</i>	carbon-based <b>fuel</b> produced from renewable sources of <b>biomass</b> like plants and garbage. Energy is obtained through combustion, so <b>greenhouse gases</b> are still produced. Because plants get their carbon from the air, <b>burning them for energy and re-releasing it into the air has less effect on climate than</b> fossil fuels, whose carbon is otherwise sequestered away from the <b>atmosphere</b> .
<i>biomass</i>	organic material from one or more organisms.
<i>biostratigraphy</i>	the branch of geology that uses <b>fossils</b> to determine the relative age of <b>sedimentary</b> layers.
<i>biota</i>	the organisms living in a given region, including plants, animals, fungi, <b>protists</b> , and bacteria.
<i>bitumen</i>	any of various flammable mixtures of hydrocarbons and other substances, occurring naturally or obtained by distillation from <b>coal</b> or <b>petroleum</b> , that are a component of asphalt and tar and are used for surfacing roads and for waterproofing.
<i>bituminous coal</i>	a relatively soft <b>coal</b> containing a tarlike substance called <b>bitumen</b> , which is usually formed as a result of high pressure on <b>lignite</b> .
<i>bivalve</i>	<p>a marine or freshwater invertebrate animal belonging to the Class Bivalvia (or Pelecypoda) in the Phylum Mollusca. Bivalves are generally called “clams,” but they also include scallops, mussels, cockles, and oysters.</p> <p>Bivalves are characterized by right and left calcareous shells (valves) joined by a hinge. Most are <b>filter feeders</b>, collecting food particles from the water with their gills.</p> <p>During the <b>Paleozoic</b>, bivalves lived mostly on the surface of the ocean floor. In the <b>Mesozoic</b>, bivalves became extremely diverse and some evolved the ability to burrow into ocean floor sediments.</p>
<i>blastoid</i>	an <b>extinct</b> form of stemmed <b>echinoderm</b> , similar to a <b>crinoid</b> . Blastoids possessed a nut-shaped body covered with interlocking plates, which was covered with fine hairlike structures for use in <b>filter feeding</b> . The body was held above the sea floor by a stalk of stacked disc-shaped plates.
<i>body fossils</i>	<b>fossils</b> that consist of an actual part of an organism, such as a bone, shell, or leaf.

<i>brachiopod</i>	<p>a marine invertebrate animal belonging to the Phylum Brachiopoda, and characterized by upper and lower calcareous shell valves joined by a hinge, and a crown of tentacles (lophophore) used for <b>filter feeding</b> and respiration. Brachiopods are the most common <b>fossil</b> in <b>Paleozoic sedimentary rocks</b>.</p> <p>Brachiopods look somewhat similar to the clams that you find at the beach today. Brachiopods and <b>bivalves</b> both have a pair of hinged shells (valves) to protect themselves while feeding. However, the soft parts of modern brachiopods tell us that they are completely unrelated to bivalves. Brachiopods have a special structure formed by tissue with thousands of tiny hair-like tentacles stretched along a coiled piece of internal shell material. These tentacles catch and move small particles towards the mouth. This body plan is very different from that of bivalves, which have a larger fleshy body and collect particles with their gills.</p> <p>To tell the difference between a brachiopod and a bivalve, look for symmetry on the surface of the shell. Bivalve valves are of equal size and mirror image shapes. Brachiopods' bottom valves, however, are slightly bigger and often have a different shape.</p>
<i>braided stream</i>	a stream consisting of multiple, small, shallow channels that divide and recombine numerous times, forming a pattern resembling strands of braided hair. A braided stream carries more sediment than a typical stream, causing the formation of sandbars and a network of crisscrossing streams.
<i>breccia</i>	a <b>pyroclastic</b> rock composed of volcanic fragments from an explosive eruption.
<i>brine</i>	See <b>hydrothermal solution</b>
<i>British Thermal Unit (BTU or Btu)</i>	the most commonly used unit for heat energy. One Btu is approximately the amount of heat required to raise one pound of water by one degree Fahrenheit. A Btu is also about the amount of energy released by burning a single wooden match.
<i>bryozoan</i>	<p>a marine or freshwater, colonial invertebrate animal belonging to the Phylum Bryozoa, and characterized by an encrusting or branching calcareous skeleton from which multiple individuals (zooids) extend from small pores to filter-feed using crowns of tentacles (lophophores).</p> <p>Bryozoans have a long and exemplary <b>fossil</b> record. One of the more common <b>Paleozoic</b> varieties looks like fine mesh cloth with numerous tiny holes in which the individual animals in the colony lived. Although they function somewhat like coral, and are often found in similar environments, bryozoans are more closely related to <b>brachiopods</b>.</p>
<i>butte</i>	an isolated hill with steep, often vertical sides and a small, relatively flat top.
<i>calcite</i>	a <b>carbonate mineral</b> , consisting of <b>calcium carbonate</b> (CaCO <sub>3</sub> ). Calcite is a common constituent of <b>sedimentary rocks</b> , particularly <b>limestone</b> .
<i>calcium carbonate</i>	a chemical compound with the formula CaCO <sub>3</sub> , commonly found in rocks in the mineral forms <b>calcite</b> and aragonite, as well as the shells and skeletons of marine organisms.
<i>caldera</i>	a collapsed, cauldron-like <b>volcanic</b> crater formed by the collapse of land following a volcanic eruption.

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<i>calving</i>	the process by which ice breaks off from the end of a <b>glacier</b> (sometimes into a lake or ocean, sometimes over the edge of a cliff).
<i>calyx</i>	the head of a <b>crinoid</b> .
<i>Cambrian</i>	a <b>geologic time</b> period lasting from 541 to 485 million years ago. During the Cambrian, multicellular marine organisms became increasingly diverse, as did their mineralized <b>fossils</b> .  The Cambrian is part of the <b>Paleozoic</b> era.
<i>Canadian Shield</i>	the stable core of the North American continental landmass, containing some of the oldest rocks on Earth. The shield has experienced very little tectonic activity ( <b>faulting</b> or folding) for millions of years. As the stable cores of all continents, shields are often covered by layers of younger material.
<i>capstone, caprock</i>	a harder, more resistant rock type that overlies a softer, less resistant rock. The harder rock typically helps to control the rate of <b>erosion</b> .
<i>carbonate rocks</i>	rocks formed by accumulation of <b>calcium carbonate</b> , often made of the skeletons of aquatic organisms such as corals, clams, <b>snails</b> , <b>bryozoans</b> , and <b>brachiopods</b> . These organisms thrive in warm, clear shallow waters common to tropical areas, therefore modern carbonate rocks are observed forming in places such as the Florida Keys and the Bahamas. They are also one of the dominant rock forms of the bottom of the ocean, where sediments form from the skeletons of planktonic organisms such as <b>foraminifera</b> .  Carbonate rocks include <b>limestone</b> and <b>dolostone</b> .
<i>Carboniferous</i>	a <b>geologic time</b> period that extends from 359 to 299 million years ago. It is divided into two subperiods, the <b>Mississippian</b> and the <b>Pennsylvanian</b> . By the Carboniferous, terrestrial life had become well established.  The name Carboniferous means "coal-bearing," and it is during this time that many of today's coal beds were formed.  The Carboniferous is part of the <b>Paleozoic</b> .
<i>cementation</i>	the precipitation of <b>minerals</b> , such as <b>silica</b> and <b>calcite</b> , that binds together particles of rock, bones, etc., to form a solid mass of <b>sedimentary rock</b> .
<i>Cenozoic</i>	the <b>geologic time</b> period spanning from 66 million years ago to the present. The Cenozoic is also known as the age of mammals, since extinction of the large reptiles at the end of the <b>Mesozoic</b> allowed mammals to diversify.  The Cenozoic includes the <b>Paleogene</b> , <b>Neogene</b> , and <b>Quaternary</b> periods.

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<i>cephalopod</i>	<p>a marine invertebrate animal belonging to the Class Cephalopoda in the Phylum Mollusca, and characterized by a prominent head, arms and tentacles with suckers, and jet propulsion locomotion.</p> <p>Cephalopods are swimming predators with beak-shaped mouthparts. The shells of cephalopods range from long straight cones to spirals, but some have internal shells or no significant shell at all, like the octopus. The group includes belemnites, ammonoids, nautilus, squid, and octopuses.</p> <p>A <b>mass extinction</b> between the <b>Cretaceous</b> and <b>Paleogene</b> eliminated many varieties of cephalopods.</p>
<i>chalcedony</i>	a crystalline <b>silicate mineral</b> that occurs in a wide range of varieties.
<i>chalcopyrite</i>	a yellow <b>mineral</b> consisting of a <b>copper-iron</b> sulfide ( $\text{CuFeS}_2$ ). Chalcopyrite is the most common and important source of copper, and can also be called copper <b>pyrite</b> .
<i>chalk</i>	a soft, fine-grained, easily pulverized, white-to-grayish variety of <b>limestone</b> , composed of the shells of minute planktonic single-celled algae.
<i>chemical fossils</i>	chemicals produced by an organism that leave behind an identifiable trace in the geologic record. Chemical <b>fossils</b> provide some of the oldest evidence for life on Earth.
<i>chemical reaction</i>	a process that involves changes in the structure and <b>energy</b> content of atoms, molecules, or ions but not their nuclei.
<i>chert</i>	<p>a <b>sedimentary rock</b> composed of microcrystalline <b>quartz</b>. It is often found as <b>nodules</b> or <b>concretions</b> in <b>limestone</b> and other marine sedimentary rocks. As these rocks form, water moving through them transports small amounts of <b>silicon</b> dioxide that accumulate into clumps of microscopic crystals. The resulting rocks are extremely hard and have no planes of weakness.</p> <p>For thousands of years, humans exploited these qualities, breaking chert nodules into blades and other tools.</p>
<i>chordate</i>	an animal that possesses the following five traits during at least one stage of its development: a notochord (the flexible rod that, in vertebrates, becomes the backbone), a hollow dorsal nerve cord, pharyngeal gill slits, an endostyle (precursor to the thyroid gland), and a post-anal tail.
<i>chromium</i>	a lustrous, hard, steel-gray metallic element (Cr), resistant to tarnish and corrosion. Chromium is used as a component of certain pigments, as a component of steel (providing resistance and hardness), and in the production of chrome and stainless steel.
<i>cinder</i>	a type of <b>pyroclastic</b> particle in the form of gas-rich <b>lava</b> droplets that cool as they fall.
<i>cirque</i>	a large bowl-shaped depression carved by <b>glacial erosion</b> and located in mountainous regions.
<i>clay</i>	the common name for a number of very fine-grained, earthy materials that become plastic (flow or change shape) when wet. Chemically, clays are hydrous <b>aluminum silicates</b> .

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<i>cleavage</i>	<p>a physical property of <b>minerals</b>. Cleavage occurs when a mineral breaks in a characteristic way along a specific plane of weakness.</p> <p><b>Mica</b> and <b>graphite</b> have very strong cleavage, allowing them to easily break into thin sheets.</p>
<i>climate</i>	<p>a description of the average temperature, range of temperature, humidity, precipitation, and other <b>atmospheric</b>/hydrospheric conditions a region experiences over a period of many years (usually more than 30). These factors interact with and are influenced by other parts of the Earth <b>system</b>, including geology, geography, insolation, currents, and living things.</p> <p>The climate of a region represents the average <b>weather</b> over a long period of time.</p>
<i>climate change</i>	See <b>global warming</b>
<i>coal</i>	<p>a combustible, compact black or dark-brown carbonaceous rock formed by the compaction of layers of partially decomposed vegetation.</p> <p>By far the greatest abundance of coal is located in strata of <b>Carboniferous</b> period.</p>
<i>coalification</i>	the process by which <b>coal</b> is formed from plant materials through <b>compression</b> and <b>heating</b> over long periods of time.
<i>coccolithophore</i>	a marine phytoplankton with a skeleton made up of microscopic calcareous disks or rings, and forming much of the content of <b>chalk</b> rocks.
<i>cold front</i>	the boundary between the warm air and the cold air moving into a region. At this boundary, <b>denser</b> , colder air moves in, making the less dense, warm air rise. This displaced warm air cools as it rises because air pressure decreases with increasing height in the <b>atmosphere</b> . As the air cools, it becomes saturated with water vapor, and condensation begins to occur, eventually leading to dramatic rainstorms.
<i>color (mineral)</i>	a physical property of <b>minerals</b> . Color is determined by the presence and intensity of certain elements within the mineral.
<i>color (soil)</i>	a physical property of <b>soils</b> . Soil color is influenced by <b>mineral</b> content, the amount of organic material, and the amount of water it routinely holds. These colors are identified by a standard soil color chart called the Munsell chart.
<i>Colorado Plateau</i>	a <b>physiographic</b> region that covers an area of 337,000 square kilometers (130,000 square miles) of desert and forest within Colorado, New Mexico, Arizona, and Utah. Most of the area is drained by the Colorado River and its tributaries.
<i>columnar joint</i>	five- or six-sided columns that form as cooling <b>lava</b> contracts and cracks. Columnar joints are often found in <b>basalt</b> flows, but can also form in ashflow <b>tuffs</b> as well as shallow <b>intrusions</b> . The columns are generally vertical, but may also be slightly curved.
<i>commodity</i>	a good for which there is demand, but which is treated as equivalent across all markets, no matter who produces it.

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<i>compression, compressional force</i>	forces acting on an object from all or most directions, resulting in compression (flattening or squeezing). Compressional forces occur by pushing objects together.
<i>concretion</i>	a hard, compact mass, usually of spherical or oval shape, found in <b>sedimentary rock</b> or <b>soil</b> . Concretions form when <b>minerals</b> precipitate around a particulate nucleus within the sediment.
<i>conglomerate</i>	a <b>sedimentary rock</b> composed of multiple large and rounded fragments that have been <b>cemented</b> together in a fine-grained <b>matrix</b> . The fragments that make up a conglomerate must be larger than grains of <b>sand</b> .
<i>conifer</i>	a woody plant ( <b>tree</b> ) of the division Coniferophyta. Conifers bear cones that contain their seeds.
<i>conodont</i>	an extinct, eel-shaped animal classified in the class Conodonta and thought to be related to primitive <b>chordates</b> . Originally, conodonts were only known from small phosphatic tooth-like <b>microfossils</b> , which have been widely used for <b>biostratigraphy</b> . Knowledge about their soft tissues still remains limited.
<i>Conservation of Energy</i>	a principle stating that <b>energy</b> is neither created nor destroyed, but can be altered from one form to another.
<i>contact metamorphism</i>	the process by which a <b>metamorphic rock</b> is formed through direct contact with <b>magma</b> . Changes that occur due to contact metamorphism are greatest at the point of contact. The further away the rock is from the point of contact, the less pronounced the change.
<i>convection</i>	the rise of buoyant material and the sinking of denser material. In the <b>mantle</b> , variations in <b>density</b> are commonly caused by the melting of <b>subducting</b> materials.
<i>convergent boundary</i>	an <b>active plate boundary</b> where two tectonic <b>plates</b> are colliding with one another. <b>Subduction</b> occurs when an oceanic plate collides with a continental plate or another oceanic plate. If two continental plates collide, mountain building occurs.  See also: <b>plate tectonics</b>
<i>copper</i>	a ductile, malleable, reddish-brown metallic element (Cu).  Copper is used extensively as wiring in the electrical industry as well as in alloys such as brass and bronze.
<i>Cordilleran Ice Sheet</i>	one of two continental <b>glaciers</b> that covered Canada and parts of the Western US during the last major <b>Pleistocene ice age</b> .
<i>corundum</i>	an <b>aluminum oxide mineral</b> (Al <sub>2</sub> O <sub>3</sub> ) that is, after <b>diamond</b> , the hardest known natural substance. Corundum is best known for its <b>gem</b> varieties, ruby (red) and sapphire (blue).

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<p><b>craton</b></p>	<p>the old, underlying portion of a continent that is geologically stable relative to surrounding areas. The portion of a craton exposed at the surface is termed a shield, while that overlain by younger layers is often referred to as a platform.</p> <p>A craton can be thought of as the heart of a continent—it is typically the oldest, thickest, and most stable part of the bedrock. It is also usually far from the margins of tectonic <b>plates</b>, where new rock is formed and old destroyed. This rock has usually been <b>metamorphosed</b> at some point during its history, making it resistant to <b>erosion</b>.</p>
<p><b>creep</b></p>	<p>the slow movement or deformation of a material under the influence of pressure or stress (such as gravity); the slow progression of rock and <b>soil</b> down a slope due to the interacting factors of gravity, vegetation, water absorption, and steepness.</p>
<p><b>Cretaceous</b></p>	<p>a <b>geologic time</b> period spanning from 144 to 66 million years ago. It is the youngest period of the <b>Mesozoic</b>. The end of the Cretaceous bore witness to the <b>mass extinction</b> event that resulted in the demise of the <b>dinosaurs</b>.</p> <p>“Cretaceous” is derived from the Latin word, “creta” or “chalk.” The white (<b>chalk</b>) cliffs of Dover on the southeastern coast of England are a famous example of Cretaceous chalk deposits.</p>
<p><b>crevasse</b></p>	<p>a deep crack in an <b>ice sheet</b> or <b>glacier</b>, which forms as a result of shear stress between different sections of the moving ice.</p>
<p><b>crinoid</b></p>	<p>a marine invertebrate animal belonging to the Class Crinoidea of the Phylum Echinodermata, and characterized by a head (<b>calyx</b>) with a mouth on the top surface surrounded by feeding arms. Several groups of stemmed <b>echinoderms</b> appeared in the early <b>Paleozoic</b>, including crinoids, <b>blastoids</b>, and <b>cystoids</b>.</p> <p>Crinoids have five-fold symmetry and feathery arms (sometimes held off the sea floor on a stem) that collect organic particles from the water. The stems, the most often preserved part, are made of a series of stacked discs. Upon death, these stems often fall apart and the individual discs are preserved separately in the rock.</p> <p>The crinoid’s feathery arms make it look something like a flower on a stem. Thus, crinoids are commonly called “sea lilies,” although they are animals, not plants.</p>
<p><b>cross-bedding</b></p>	<p>layering within a bed in a series of rock strata that does not run parallel to the plane of stratification. Cross-beds form as flowing water or <b>wind</b> pushes sediment downcurrent, creating thin beds that slope gently in the direction of the flow as migrating ripples. The downstream slope of the ripple may be preserved as a thin layer dipping in the direction of the current, across the natural flat-lying repose of the beds. Another migrating ripple will form an additional layer on top of the previous one.</p>
<p><b>crust</b></p>	<p>the uppermost, rigid outer layer of the Earth, composed of tectonic <b>plates</b>. Two types of crust make up the <b>lithosphere</b>. Oceanic crust is <b>denser</b> but significantly thinner than continental crust, while continental crust is much thicker but less dense (and therefore buoyant).</p> <p>When continental crust collides with oceanic crust, the denser oceanic crust will be dragged (<b>subducted</b>) under the buoyant continental crust. Although mountains are created by these oceanic/continental crust collisions due to the <b>compression</b> of the two plates, much taller ranges are produced by continental/continental collisions. When two buoyant continental crusts collide, there is nowhere for the crust to go but up! The modern Himalayas, at the collision site of the Asian and Indian plates, are a good example of very tall mountains formed by a collision between two continental crusts.</p>

<i>Cryogenian</i>	a geologic period lasting from 850 to 635 million years ago, during the <b>Precambrian</b> . During this period, the Earth was subject to a 200-million-year-long <b>ice age</b> .
<i>crystal form</i>	a physical property of <b>minerals</b> , describing the shape of the mineral's crystal structure (not to be confused with <b>cleavage</b> ). A mineral might be cubic, rhomboidal, hexagonal, or polyhedral.
<i>cyanobacteria</i>	a group of bacteria, also called "blue-green algae," that obtain their energy through photosynthesis.
<i>cycad</i>	a palm-like, terrestrial seed plant ( <b>tree</b> ) belonging to the class Cycadopsida, and characterized by a woody trunk, a crown of stiff evergreen leaves, seeds without protective coatings, and no flowers. Cycads were very common in the <b>Mesozoic</b> , but are much reduced in diversity today, restricted to the tropical and subtropical regions of the planet.
<i>cystoid</i>	<b>extinct</b> , stalked <b>echinoderms</b> related to <b>crinoids</b> , but with an ovoid body and triangular pore openings.
<i>dacite</i>	a fine-grained <b>extrusive igneous rock</b> , with a <b>silica</b> content intermediate between that of <b>andesite</b> and <b>rhyolite</b> .
<i>debris flow</i>	a dangerous mixture of water, mud, rocks, <b>trees</b> , and other debris that can move quickly down valleys. Such flows can result from sudden rainstorms or snowmelt that create flash floods. Areas that have experienced a recent wildfire are particularly vulnerable to debris flows, since there is no vegetation to hold the <b>soil</b> .
<i>degrade (energy)</i>	the transformation of <b>energy</b> into a form in which it is less available for doing work, such as <b>heat</b> .
<i>delta, deltaic</i>	a typically wedge-shaped deposit formed as sediment is <b>eroded</b> from mountains and transported by streams across lower elevations. The Mississippi Delta is a modern delta containing sediment being transferred from the Mississippi River into the Gulf of Mexico.
<i>density</i>	a physical property of <b>minerals</b> , describing the mineral's mass per volume.
<i>derecho</i>	a set of powerful straight-line <b>winds</b> that exceed 94 kilometers per hour (58 miles per hour) and can often approach 160 kilometers per hour (100 miles per hour). These powerful windstorms can travel over 400 kilometers (250 miles) and cause substantial wind damage, knocking down trees and causing widespread power outages. The lightning associated with these intense storms can cause both forest fires and house fires.  Derecho is the Spanish word for "straight ahead."
<i>derrick</i>	a lifting device in the form of a framework steel tower that is built over a deep drill hole, typically an oil well. An oil derrick is composed of machinery for hoisting and lowering tools required during the drilling process, and readying the well for extraction of <b>petroleum</b> .

# Glossary

## d–e

<i>Devonian</i>	<p>a <b>geologic time</b> period spanning from 419 to 359 million years ago. The Devonian is also called the “age of fishes” due to the diversity of fish that radiated during this time. On land, seed-bearing plants appeared and terrestrial <b>arthropods</b> became established.</p> <p>The Devonian is part of the <b>Paleozoic</b>.</p>
<i>diamond</i>	<p>a <b>mineral</b> form of carbon, with the highest <b>hardness</b> of any material. Most natural diamonds are formed at high temperature and pressure deep in the Earth’s <b>mantle</b>.</p>
<i>dike</i>	<p>a sheet of <b>intrusive igneous</b> or <b>sedimentary rock</b> that fills a crack in a pre-existing rock body.</p>
<i>dimension stone</i>	<p>the commercial term applied to quarried blocks of rock cut to specific dimensions and used for buildings, monuments, facing, and curbing.</p>
<i>dinosaur</i>	<p>a member of a group of terrestrial reptiles with a common ancestor and thus certain anatomical similarities, including long ankle bones and erect limbs. All of the large reptile groups, including the dinosaurs, disappeared at or before the <b>mass extinction</b> at the end of the <b>Cretaceous</b>.</p>
<i>divergent plate boundary</i>	<p>an <b>active plate boundary</b> where two tectonic <b>plates</b> are pulling apart from one another, causing the <b>mantle</b> to well up at a <b>rift</b>. Mid-ocean ridges are the most common divergent boundary and are characterized by the eruption of bulbous pillow-shaped <b>basalt lavas</b> and <b>hydrothermal</b> fluids.</p>
<i>dolomite</i>	<p>a <b>carbonate mineral</b>, consisting of calcium magnesium carbonate (<math>\text{CaMg}(\text{CO}_3)_2</math>). Dolomite is an important reservoir rock for <b>petroleum</b>, and also commonly hosts large <b>ore</b> deposits.</p>
<i>dolostone</i>	<p>a rock (also known as dolomitic <b>limestone</b> and once called magnesian limestone) primarily composed of <b>dolomite</b>, a <b>carbonate</b> mineral. It is normally formed when magnesium bonds with <b>calcium carbonate</b> in limestone, forming dolomite.</p>
<i>double refraction</i>	<p>the result of light passing through a material that splits it into two polarized sets of rays, doubling images viewed through that material. For example, a single line on a sheet of paper will appear as two parallel lines when viewed through a clear <b>calcite</b> crystal.</p>
<i>downwarp</i>	<p>a segment of the Earth’s <b>crust</b> that is broadly bent downward.</p>
<i>drift</i>	<p>unconsolidated debris transported and deposited by a <b>glacier</b>.</p>
<i>drumlin</i>	<p>a teardrop-shaped hill of <b>till</b> that was trapped beneath a <b>glacier</b> and streamlined in the direction of the flow of the ice moving over it. The elongation of a drumlin is an excellent clue to the direction of flow during an <b>ice sheet</b>’s most recent advance.</p>
<i>dynamic metamorphism</i>	<p>See <b>regional metamorphism</b></p>
<i>earthquake</i>	<p>a sudden release of energy in the Earth’s <b>crust</b> that creates seismic waves. Earthquakes are common at <b>active plate boundaries</b>.</p>

## e

# Glossary

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<i>echinoderm</i>	a member of the Phylum Echinodermata, which includes starfish, sea urchins, and <b>crinoids</b> . Echinoderms have radial symmetry (which is usually five-fold), and a remarkable ability to regenerate lost body parts.
<i>effervesce</i>	to foam or fizz while releasing gas. <b>Carbonate minerals</b> will effervesce when exposed to hydrochloric acid.
<i>efficiency</i>	the use of a relatively small amount of <b>energy</b> for a given task, purpose, or service; achieving a specific output with less energy input.
<i>energy</i>	the <b>power</b> derived from the use of physical or chemical resources. Everything we do depends upon energy—without it there would be no civilization, no sunlight, no food and no life. Energy moves people and goods, produces electricity, heats our homes and businesses, and is used in manufacturing and other industrial processes.
<i>energy carrier</i>	a source of <b>energy</b> , such as electricity, that has been subject to human-induced energy transfers or transformations.
<i>entelodont</i>	an <b>extinct</b> family of omnivorous artiodactyl mammals that look somewhat like pigs but are actually thought to be more closely related to hippos. They roamed the forests and plains of North America, Europe, and Asia during the <b>Eocene</b> and <b>Miocene</b> . Entelodonts had bulky bodies and powerful teeth, and some grew up to 2 meters (7 feet) tall at the shoulder.
<i>Entisols</i>	a <b>soil order</b> ; these are <b>soils</b> of relatively recent origin with little or no <b>horizon</b> development. They are commonly found in areas where <b>erosion</b> or deposition rates outstrip rates of soil development, such as <b>floodplains</b> , mountains, and <b>badland</b> areas.
<i>Eocene</i>	a <b>geologic time</b> period extending from 56 to 33 million years ago. The Eocene is an epoch of the <b>Paleogene</b> period.
<i>erosion</i>	<p>the transport of <b>weathered</b> materials. Rocks are worn down and broken apart into finer grains by <b>wind</b>, rivers, wave action, freezing and thawing, and chemical breakdown.</p> <p>Over millions of years, weathering and erosion can reduce a mighty mountain range to low rolling hills. Some rocks wear down relatively quickly, while others can withstand the power of erosion for much longer. Softer, weaker rocks such as <b>shale</b> and poorly <b>cemented sandstone</b> and <b>limestone</b> are much more easily worn than hard, crystalline <b>igneous</b> and <b>metamorphic rocks</b>, or well-cemented sandstone and limestone. Harder rocks are often left standing as ridges because the surrounding softer, less resistant rocks were more quickly worn away.</p>
<i>erratic, glacial erratic</i>	<p>a piece of rock that differs from the type of rock native to the area in which it rests, carried there by <b>glaciers</b> often over long distances.</p> <p>Erratics are often distinctive because they are a different type of rock than the bedrock in the area to which they've been transported. For example, boulders and pebbles of <b>igneous</b> and <b>metamorphic rocks</b> are often found in areas where the bedrock is <b>sedimentary</b>; it is sometimes possible to locate the origin of an erratic if its composition and textures are highly distinctive.</p>

<i>esker</i>	<p>a sinuous, elongated ridge of <b>sand</b> and <b>gravel</b>. Most eskers formed within ice-walled tunnels carved by streams flowing beneath a <b>glacier</b>. After the ice melted away, the stream deposits remained as long winding ridges.</p> <p>Eskers are sometimes mined for their well-sorted sand and gravel.</p>
<i>eukaryotes</i>	<p>organisms with complex cells containing a nucleus and organelles. <b>Protists</b> and all multicellular organisms are eukaryotes.</p>
<i>evaporite</i>	<p>a <b>sedimentary rock</b> created by the precipitation of <b>minerals</b> directly from seawater, including <b>gypsum</b>, <b>carbonate</b>, and <b>halite</b>.</p>
<i>exfoliation</i>	<p>a type of physical <b>weathering</b>. When overlying layers are weathered away, the reduction of downward pressure allows the underlying rock to expand toward the surface. This expansion causes <b>joints</b>, or cracks, to form parallel to the surface, producing slabs that resemble the curved layers of an onion.</p>
<i>extinction</i>	<p>the end of species or other taxonomic groups, marked by death of the last living individual. Paleontologists estimate that over 99% of all species that have ever existed are now extinct. The species of modern animals that we study in biology today represent less than 1% of what has lived throughout <b>geologic time</b>.</p>
<i>extrusion, extrusive rock</i>	<p>an <b>igneous rock</b> formed by the cooling of <b>lava</b> after <b>magma</b> escapes onto the surface of the Earth through <b>volcanic</b> craters and cracks in the Earth's <b>crust</b>.</p>
<i>fault</i>	<p>a fracture in the Earth's <b>crust</b> in which the rock on one side of the fracture moves measurably in relation to the rock on the other side.</p>
<i>fault scarp</i>	<p>an escarpment directly beside a <b>fault</b> line, where the ground on one side of the fault has moved vertically with respect to the other side, creating step-like <b>topography</b>.</p>
<i>feldspar</i>	<p>an extremely common, rock-forming <b>mineral</b> found in <b>igneous</b>, <b>metamorphic</b>, and <b>sedimentary rocks</b>.</p> <p>There are two groups of feldspar: alkali feldspar (which ranges from potassium-rich to sodium-rich) and plagioclase feldspar (which ranges from sodium-rich to calcium-rich). Potassium feldspars of the alkali group are commonly seen as pink crystals in igneous and metamorphic rocks, or pink grains in sedimentary rocks. Plagioclase feldspars are more abundant than the alkali feldspars, ranging in color from light to dark.</p> <p>Feldspars are commercially used in ceramics and scouring powders.</p>
<i>felsic</i>	<p><b>igneous rocks</b> with high <b>silica</b> content and low <b>iron</b> and magnesium content. They are light in color and are typically found in continental <b>crust</b>.</p>
<i>filter feeder</i>	<p>an animal that feeds by passing water through a filtering structure that traps food. The water may then be expelled and the food digested. This strategy is employed by a wide range of animals today, from clams and krill to flamingos and whales.</p>

<i>firn</i>	compacted <b>glacial</b> ice, formed by the weight of snow on top. Individual flakes break down by melting, refreezing, and bonding to the snow around them, eventually forming compacted grains.
<i>flint</i>	a hard, high-quality form of <b>chert</b> that occurs mainly as <b>nodules</b> and masses in <b>sedimentary rock</b> . Due to its <b>hardness</b> and the fact that it splits into thin, sharp flakes, flint was often used to make tools during the Stone Age. Flint will also create sparks when struck against steel, and has been used to ignite gunpowder in more modern times.
<i>floodplain</i>	the land around a river that is prone to flooding. This area can be grassy, but the sediments under the surface are usually deposits from previous floods.
<i>fluorite, fluorspar</i>	the <b>mineral</b> form of calcium fluoride (CaF <sub>2</sub> ). Fluorite is used in a variety of commercial applications, including as lenses for microscopes, the production of some glass, and the chemical industry.  Fluorite lent its name to the phenomenon of fluorescence, which occurs in some fluorites due to impurities in the crystal.
<i>fluvial</i>	See <b>outwash plain</b>
<i>foliation</i>	the arrangement of the constituents of a rock in leaflike layers, as in <b>schists</b> . During <b>metamorphism</b> , the weight of overlying rock can cause <b>minerals</b> to realign perpendicularly to the direction of pressure, layering them in a banded pattern.
<i>foraminifera</i>	a class of aquatic <b>protists</b> that possess a calcareous or <b>siliceous</b> exoskeleton. Foraminifera have an extensive <b>fossil</b> record.
<i>fossil</i>	preserved evidence of ancient life, including, for example, preserved skeletal or tissue material, molds or casts, and traces of behavior. Fossilization may alter biological material in a variety of ways, including <b>permineralization</b> , <b>replacement</b> , and <b>compression</b> .  Remains are often classified as fossils when they are older than 10,000 years, the traditional start of the <b>Holocene</b> (Recent) epoch. However, this date is only a practical guideline—scientists studying successions of plant or animal remains would not recognize any sudden change in the material at 10,000 years, and would typically refer to all material buried in sediments as fossil material.  The word fossil is derived from the Latin word fossilis, meaning “dug up.”
<i>fossil fuels</i>	<b>fuel</b> for human use that is made from the remains of ancient <b>biomass</b> , referring to any hydrocarbon fuel source formed by natural processes from anaerobically decomposed organisms, primarily <b>coal</b> , <b>petroleum</b> , and <b>natural gas</b> (methane). Fossil fuels are non-renewable, meaning that because they take thousands to millions of years to form, the rate of use is far greater than the rate of formation, and eventually we will run out.
<i>fracture (mineral)</i>	a physical property of <b>minerals</b> , formed when a mineral crystal breaks; also a crack in rocks, sometimes known as a <b>joint</b> .
<i>frost wedging</i>	<b>weathering</b> that occurs when water freezes and expands in cracks.

# Glossary

## f–g

<b><i>fuel</i></b>	a material substance that possesses internal <b>energy</b> that can be transferred to the surroundings for specific uses—including are <b>petroleum</b> , <b>coal</b> , and <b>natural gas</b> (the <b>fossil fuels</b> ), and other materials, such as uranium, hydrogen, and <b>biofuels</b> .
<b><i>gabbro</i></b>	a usually coarse-grained, <b>mafic</b> and <b>intrusive igneous rock</b> . Most oceanic <b>crust</b> contains gabbro.
<b><i>galena</i></b>	an abundant <b>sulfide mineral</b> with cubic crystals. It is the most important <b>ore</b> of <b>lead</b> , as well as an important source of <b>silver</b> .
<b><i>gastropod</i></b>	a marine, freshwater, or terrestrial invertebrate animal belonging to the class Gastropoda of the Phylum Mollusca, and characterized by a single, coiled, calcareous shell, a muscular foot for gliding, and internal asymmetry caused by an embryonic process (torsion). Gastropods include snails and slugs.
<b><i>Gelisols</i></b>	a <b>soil order</b> ; these are weakly <b>weathered soils</b> formed in areas that contain <b>permafrost</b> within the soil profile.
<b><i>gem, gemstone</i></b>	a <b>mineral</b> that has been cut and polished for use as an ornament.
<b><i>geologic time scale</i></b>	a standard timeline used to describe the age of rocks and fossils, and the events that formed them. It spans Earth's entire history, and is often subdivided into four major time periods: the <b>Precambrian</b> , <b>Paleozoic</b> , <b>Mesozoic</b> , and <b>Cenozoic</b> .
<b><i>geyser</i></b>	a hot spring characterized by the intermittent explosive discharge of water and steam. Superheated water becomes highly pressurized when it enters underground <b>fractures</b> ; once pressure builds to a certain level, it is released in an eruption of steam and hot water and the process of pressurization begins again.
<b><i>ginkgo</i></b>	a terrestrial <b>tree</b> belonging to the plant division Ginkgophyta, and characterized by broad fan-shaped leaves, large seeds without protective coatings, and no flowers. Ginkgos were very common and diverse in the <b>Mesozoic</b> , but today only one species exists, <i>Ginkgo biloba</i> .
<b><i>glacier</i></b>	<p>a body of dense ice on land that does not melt away annually and has sufficient mass to move under its own weight. Glaciers form when snow accumulates faster than it melts over many years. As long as melt does not exceed accumulation, the ice and snow pile up and become a self-sustaining system.</p> <p>As glaciers slowly flow, they abrade and <b>erode</b> the landscape around them to create <b>crevasses</b>, <b>moraines</b>, and other distinguishing features. Glaciers form only on land, and are much thicker than ice that forms on the surface of water.</p> <p>99% of Earth's glacial ice exists as vast polar <b>ice sheets</b>, but glaciers are also found high in the mountains of every continent except Australia.</p>
<b><i>glassy rock</i></b>	a <b>volcanic</b> rock that cooled almost instantaneously, resulting in a rock with tiny crystals or no crystals at all. <b>Obsidian</b> , <b>tuff</b> , and <b>scoria</b> are examples of glassy rocks.

## g

# Glossary

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<i>global warming</i>	the current increase in the average temperature worldwide, caused by the buildup of <b>greenhouse gases</b> in the <b>atmosphere</b> . With the coming of the Industrial Age and exponential increases in human population, large amounts of gases have been released into the atmosphere (especially carbon dioxide) that give rise to global warming. The term “climate change” is preferred because warming contributes to other climatic changes such as precipitation and storm strength.
<i>gneiss</i>	a <b>metamorphic rock</b> that may form from <b>granite</b> or layered <b>sedimentary rock</b> such as <b>sandstone</b> or siltstone. Parallel bands of light and dark <b>minerals</b> give gneiss its striated texture.
<i>gold</i>	a soft, yellow, corrosion-resistant element (Au), which is the most malleable and ductile metal on Earth.  Gold has an average abundance in the <b>crust</b> of only 0.004 parts per million. It can be profitably mined only where <b>hydrothermal solutions</b> have concentrated it.
<i>Gondwana, Gondwanaland</i>	the supercontinent of the Southern Hemisphere, composed of Africa, Australia, India, and South America. It combined with the North American continent to form <b>Pangaea</b> during the late <b>Paleozoic</b> .
<i>granite</i>	a common and widely occurring type of <b>igneous rock</b> . Granite usually has a medium- to coarse-grained texture, and is at least 20% <b>quartz</b> by volume.
<i>graphite</i>	a <b>mineral</b> , and the most stable form of carbon. Graphite means “writing stone,” a reference to its use as pencil lead.  Graphite occurs in <b>metamorphic rocks</b> , <b>igneous rocks</b> , and <b>meteorites</b> .
<i>graptolite</i>	an <b>extinct</b> colonial invertebrate animal belonging to the Class Graptolithina of the Phylum Hemichordata, and characterized by individuals housed within a tubular or cup-like structure. The soft parts of a graptolite’s body have never been clearly identified.
<i>gravel</i>	unconsolidated, semi-rounded rock fragments larger than 2 millimeters (0.08 inches) and smaller than 75 millimeters (3 inches).
<i>Great Lakes</i>	the largest group of freshwater lakes on Earth (by total surface area and volume), located on the US-Canadian border, and consisting of Lakes Superior, Michigan, Huron, Erie, and Ontario.  Prior to <b>glaciation</b> , the Great Lakes were river valleys that had been <b>scoured</b> and deepened repeatedly by the many ice advances during the <b>Quaternary</b> period. Many sizable glacial lakes were formed at the edge of the melting <b>ice sheet</b> that no longer exist today or have significantly shrunk in size.
<i>greenhouse gas</i>	a gas in the <b>atmosphere</b> that absorbs and emits <b>heat</b> . The primary greenhouse gases in the Earth’s atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.
<i>greenstone belt</i>	a series of interlayered <b>volcanic</b> and <b>sedimentary rocks</b> that have been <b>metamorphosed</b> into meta-sedimentary rocks and <b>amphibolite</b> . The rocks are called ‘greenstones’ due to the presence of metamorphic <b>minerals</b> that give the rock a greenish-gray color. Many geologists believe these belts are the result of deposition in volcanic arc environments.

# Glossary

## g–h

<i><b>gypsum</b></i>	a soft <b>sulfate mineral</b> that is widely mined for its use as fertilizer and as a constituent of plaster. Alabaster, a fine-grained light colored variety of gypsum, has been used for sculpture making by many cultures since ancient times.
<i><b>halite</b></i>	See <b>salt</b>
<i><b>hanging valley</b></i>	a tributary valley that drops abruptly into a much larger and deeper valley. Hanging valleys are most commonly associated with U-shaped valleys that form due to <b>glacial erosion</b> .
<i><b>hardness</b></i>	a physical property of <b>minerals</b> , specifying how hard the mineral is. Hardness helps us understand why some rocks are more or less resistant to <b>weathering</b> and <b>erosion</b> .  See also: <b>Moh's Scale of Hardness</b>
<i><b>heat</b></i>	a form of <b>energy</b> transferred from one body to another as a result of a difference in temperature or a change in phase. Heat is transmitted through solids and fluids by conduction, through fluids by <b>convection</b> , and through empty space by radiation.
<i><b>heat island effect</b></i>	a phenomenon in which cities experience higher temperatures than do surrounding rural communities.
<i><b>heat wave</b></i>	a period of excessively hot <b>weather</b> that may also accompany high humidity. Temperatures of just 3°C (6°F) to 6°C (11°F) above normal are enough to reclassify a warm period as a heat wave.  Under high humidity, the mechanism of sweating does little to cool people down because the humidity prevents sweat from evaporating and cooling off the skin.
<i><b>hectare</b></i>	a metric unit of area defined as 10,000 square meters.
<i><b>helium</b></i>	a gaseous chemical element (He), which is the second most abundant and second lightest element in the universe. Helium is used in cryogenics, as a coolant; it is also used in industrial applications including pressurization, welding, and leak detection. Balloons and blimps, although probably the most well-known and visible application of helium, take up less than an eighth of its total use.
<i><b>hematite</b></i>	a <b>mineral</b> form of <b>iron oxide</b> (Fe <sub>2</sub> O <sub>3</sub> ). The name hematite has its origins in the Greek word haimatos, meaning blood. It is very common in <b>Precambrian</b> banded iron formations.  Iron from hematite is used in the manufacture of steel. The vivid red pigments that iron lends to the mineral also makes it valuable as a commercial pigment.
<i><b>Histosols</b></i>	a <b>soil order</b> ; these are organic-rich <b>soils</b> found along lake coastal areas where poor drainage creates conditions of slow decomposition and <b>peat</b> (or muck) accumulates.
<i><b>Holocene</b></i>	the most recent portion of the <b>Quaternary</b> , beginning about 11,700 years ago and continuing to the present. It is the most recent (and current) <b>interglacial</b> , an interval of glacial retreat.  The Holocene also encompasses the global growth and impact of the human species.

<i>horizon (soil)</i>	a layer in the <b>soil</b> , usually parallel to the surface, which has physical characteristics (usually <b>color</b> and texture) that are different from the layers above and below it. Each type of soil usually contains three or four horizons.
<i>horn</i>	a pointed rocky peak created by <b>glacial erosion</b> .
<i>hornblende</i>	a dark silicate mineral that can occur in a variety of forms. Hornblende is a common constituent of many <b>igneous</b> and <b>metamorphic rocks</b> .
<i>hot spot</i>	<p>a <b>volcanic</b> region thought to be fed by underlying <b>mantle</b> that is anomalously hot compared with the mantle elsewhere. Hot spots form from plumes of <b>magma</b> rising off the mantle. Magma from the hot spot pushes its way up through the <b>crust</b>, creating an <b>igneous intrusion</b> and sometimes a volcano.</p> <p>Although the hot spot remains fixed, the <b>plates</b> of the <b>lithosphere</b> continue to move above it. As a plate continues to move over the hot spot, the original volcano shifts off of the hot spot and a new intrusion or volcano is formed. This gradually produces a chain of <b>volcanic islands</b> such as the Hawaiian Islands. <b>Erosion</b> of volcanoes may eventually wear down the crust to reveal the igneous intrusions that formed the volcano's magma chamber.</p>
<i>humus</i>	a <b>soil horizon</b> containing organic matter.
<i>Huronian glaciation</i>	a <b>glaciation</b> beginning about 2.4 billion years ago, that covered the entire surface of the Earth in ice for as long as 300 million years.
<i>hurricane</i>	<p>a rapidly rotating storm system with heavy <b>winds</b>, a low-pressure center, and a spiral arrangement of thunderstorms. These storms tend to form over large, warm bodies of water. Once winds have reached 119 kph (74 mph), such a storm is classified as a hurricane.</p> <p>Hurricanes usually develop an eye, which is visible as a small, round, cloud-free area at the center of the storm. The eye is an area of relative calm and low <b>atmospheric</b> pressure. The strongest thunderstorms and winds circulate just outside the eye, in the eyewall.</p>
<i>hydrothermal solution</i>	<p>hot, <b>salty</b> water moving through rocks. These solutions are always enriched in salts (such as sodium chloride, potassium chloride, and calcium chloride) and thus are called "brines." The brine is as salty or even saltier than seawater.</p> <p>Salty water can contain minute amounts of dissolved <b>minerals</b> such as <b>gold</b>, <b>lead</b>, <b>copper</b>, and <b>zinc</b>. The presence of salt in the water suppresses the precipitation of the metallic minerals from the brine because the chlorides in the salt preferentially bond with metals. Additionally, because the brine is hot, minerals are more easily dissolved, just as hot tea dissolves sugar more easily than cold tea.</p>
<i>ice age</i>	a period of global cooling of the Earth's surface and <b>atmosphere</b> , resulting in the presence or expansion of <b>ice sheets</b> and <b>glaciers</b> . Throughout the Earth's history, it has been periodically plunged into ice ages, dependent upon the <b>climate</b> and position of the continents. Over the past 2.6 million years, North America has experienced about 50 glacial advances and retreats. The most recent ice age ended about 12,000 years ago.
<i>ice cap</i>	an <b>ice field</b> that lies over the tops of mountains.

# Glossary

<i>ice field</i>	an extensive area of interconnected <b>glaciers</b> spanning less than 50,000 square kilometers (19,305 square miles). Ice fields are usually constrained by an area's <b>topography</b> . Ice fields that lie over the tops of mountains are called <b>ice caps</b> .
<i>ice lobe</i>	a broad, rounded section of a continental <b>glacier</b> that flows out near the glacier's terminus, often through a broad trough.
<i>ice sheet</i>	a mass of <b>glacial</b> ice that covers part of a continent and has an area greater than 50,000 square kilometers (19,000 square miles).
<i>igneous rocks</i>	<p>rocks derived from the cooling of <b>magma</b> underground or molten <b>lava</b> on the Earth's surface.</p> <p>Igneous rocks differ not only in their cooling rates and subsequent crystal sizes, but also in their chemical compositions. Rocks found in continental <b>crust</b>, such as <b>granite</b>, have high <b>silica</b> content and low <b>iron</b> and magnesium content. They are light in color and are called <b>felsic</b>. Rocks found in oceanic crust, like <b>basalt</b>, are low in silica and high in iron and magnesium. They are dark in color and are called <b>mafic</b>.</p> <p>Although the composition of magma can be the same as lava, the texture of the rocks will be quite different due to different rates of cooling. It is because of this difference in genesis that geologists are able to make the distinction between <b>extrusive</b> and <b>intrusive</b> igneous rocks when encountered at an outcrop at the Earth's surface.</p>
<i>Illinoian glaciation</i>	a period of <b>glaciation</b> that occurred during the <b>Pleistocene</b> , 191 to 131 thousand years ago.
<i>ilmenite</i>	an <b>ore</b> of <b>titanium</b> , produced for use as a white pigment in paint.
<i>Inceptisols</i>	a <b>soil order</b> ; these are <b>soils</b> that exhibit only moderate <b>weathering</b> and development. They are often found on steep (relatively young) <b>topography</b> and overlying <b>erosion</b> -resistant bedrock.
<i>inclusion</i>	a fragment of older rock located within a body of <b>igneous rock</b> . Inclusions typically form when igneous rock <b>intrudes</b> into and envelopes older material.
<i>index fossil</i>	a <b>fossil</b> used to determine the relative age of <b>sedimentary</b> deposits. An ideal index fossil lived during a short period of time, was geographically and environmentally widespread, and is easy to identify. Some of the most useful index fossils are hard-shelled organisms that were once part of the marine plankton.
<i>inland basin</i>	a depression located inland from the mountains, and formed by the buckling ( <b>downwarping</b> ) of the Earth's <b>crust</b> . Basins naturally preserve thick sediment layers because they accumulate eroded sediment and commonly continue to subside under the weight of the sediment.
<i>inland sea</i>	<p>a shallow sea covering the central area of a continent during periods of high sea level. An inland sea is located on continental <b>crust</b>, while other seas are located on oceanic crust.</p> <p>An inland sea may or may not be connected to the ocean. For example, Hudson Bay is on the North American <b>plate</b> and connects to the Atlantic and Arctic Oceans, while the Caspian Sea is on the European <b>plate</b> but does not drain into any ocean at all.</p>

<i>intensity (earthquake)</i>	a subjective measurement that classifies the amount of shaking and damage done by an <b>earthquake</b> in a particular area.
<i>interglacial</i>	a period of geologic time between two successive <b>glacial</b> stages.
<i>intermontane</i>	between or among mountains.
<i>intertidal</i>	areas that are above water during low tide and below water during high tide.
<i>intrusion, intrusive rock</i>	a <b>plutonic igneous rock</b> formed when <b>magma</b> from within the Earth's <b>crust</b> escapes into spaces in the overlying strata. As the magma rises, pushing through overlying layers of rock, it begins to cool. The cooling magma can crystallize and harden to become intrusive igneous rock, locked within layers of older rock.
<i>iron</i>	<p>a metallic chemical element (Fe). Iron is most often found in combination with other elements, such as oxygen and <b>sulfur</b>, to form <b>ores</b> like <b>hematite</b>, <b>magnetite</b>, siderite, and <b>pyrite</b>.</p> <p>The ready availability of iron at Earth's surface made it one of the earliest mined <b>mineral</b> resources in the US.</p>
<i>isostasy</i>	an equilibrium between the weight of the <b>crust</b> and the buoyancy of the <b>mantle</b> .
<i>jade</i>	a word applied to two green <b>minerals</b> that look similar and have similar properties: jadeite (a kind of <b>pyroxene</b> ) and nephrite (a kind of <b>amphibole</b> ). Both minerals are formed during <b>metamorphism</b> and are found primarily near <b>subduction</b> zones, which explains why jade is abundant in a variety of locations along <b>active plate boundaries</b> .
<i>jasper</i>	<p>a speckled or patterned <b>silicate</b> stone that appears in a wide range of <b>colors</b>. It is a variety of <b>chalcedony</b>.</p> <p>Jasper forms when silica precipitates in a fine particulate material such as soft sediment or <b>volcanic ash</b>. The particulates give the stone its color and patterns.</p>
<i>jet stream</i>	a fast-flowing, narrow air current found in the <b>atmosphere</b> . The polar jet stream is found at an altitude of 7–12 kilometers (23,000–39,000 feet), and the air within can travel as fast as 160 kilometers per hour (100 miles per hour). Jet streams are created by a combination of the Earth's rotation and atmospheric heating.
<i>joint</i>	a surface or plane of fracture within a rock.
<i>joule (J)</i>	the <b>energy</b> expended (or work done) to apply a force of one newton over a distance of one meter.
<i>Jurassic</i>	<p>the <b>geologic time</b> period lasting from 201 to 145 million years ago. During the Jurassic, <b>dinosaurs</b> dominated the landscape and the first birds appeared.</p> <p>The Jurassic is the middle period of the <b>Mesozoic</b>.</p>

# Glossary

k–l

<b><i>kame</i></b>	an irregularly shaped mound made up of sediment that accumulated in a depression on a retreating <b>glacier</b> . The mound-like deposits of sorted sediment are then deposited on the land after the glacier retreats.
<b><i>kaolinite</i></b>	a <b>silicate clay mineral</b> , also known as china clay. Kaolinite is the main ingredient in fine china dishes such as Wedgwood.
<b><i>karst topography</i></b>	a kind of landscape defined by bedrock that has been <b>weathered</b> by dissolution in water, forming features like sinkholes, caves, and cliffs.  Karst <b>topography</b> primarily forms in <b>limestone</b> bedrock.
<b><i>kettle</i></b>	a lake formed where a large, isolated block of ice became separated from the retreating <b>ice sheet</b> . The weight of the ice leaves a shallow depression in the landscape that persists as a small lake.
<b><i>kinetic energy</i></b>	the <b>energy</b> of a body in motion (e.g., via friction).
<b><i>komatiite</i></b>	<b>mafic volcanic</b> rocks richer in magnesium and erupted at a higher temperature than <b>basalts</b> . They are restricted to the <b>Archean</b> , when the <b>mantle</b> temperatures were higher at the depths where <b>magma</b> is generated. Komatiites often exhibit “spinifex texture,” an unusual crystallization-cooling texture that produces large, long crystals.
<b><i>Köppen system</i></b>	a commonly used system of <b>climate</b> categorization developed by Russian climatologist Wladimir Köppen. It is based on the kinds of vegetation that areas sustain, and defines 12 climate types: rainforest, monsoon, tropical savanna, humid subtropical, humid continental, oceanic, Mediterranean, steppe, subarctic, tundra, polar ice cap, and desert. Updated by Rudolf Geiger, it has been refined to five groups each with two to four subgroups.
<b><i>lacustrine</i></b>	of or associated with lakes.
<b><i>Lagerstätte</i></b> ( <i>pl. Lagerstätten</i> )	<b>fossil</b> deposit containing animals or plants that are preserved unusually well, sometimes even including the soft organic tissues. Lagerstätten form in chemical environments that slow decay of organic tissues or enhance preservation through mineralization. Also, quick burial of the organism leaves no opportunity for disturbance of the fossils. Lagerstätten are important for the information they provide about soft-bodied organisms that we otherwise would know nothing about.
<b><i>lamproite</i></b>	an <b>ultramafic volcanic (extrusive)</b> rock with high levels of potassium and magnesium that contains coarse crystals. <b>Diamonds</b> can occur in lamproites.
<b><i>landslide</i></b>	the rapid slipping of a mass of earth or rock from a higher elevation to a lower level under the influence of gravity and water lubrication. Landslides include rock falls, avalanches, <b>debris flows</b> , mudflows, and the <b>slumping</b> of rock layers or sediment.  See also: <b>mass wasting</b>
<b><i>Laramide Orogeny</i></b>	a period of mountain building that began in the late <b>Cretaceous</b> , and is responsible for the formation of the Rocky Mountains.  See also: orogeny

# Glossary

<i>last glacial maximum</i>	the most recent time the <b>ice sheets</b> reached their largest size and extended farthest toward the equator, about 26,000 to 19,000 years ago. Ice sheets over North America melted back until about 10,000 years ago—they have been relatively stable since that time.
<i>Laurentide Ice Sheet</i>	an <b>ice sheet</b> that covered most of Canada during the last major <b>glaciation</b> . In its prime, the Laurentide was more than 5 kilometers (3.1 miles) thick at its thickest point on what is now the Hudson Bay. The sheet began to melt about 13,000 years ago.
<i>lava</i>	molten rock located on the Earth's surface. When <b>magma</b> rises to the surface, typically through a volcano or <b>rift</b> , it becomes lava.  Lava cools much more quickly than magma because it is at the surface, exposed to the <b>atmosphere</b> or ocean water where temperatures are much cooler. Such rocks, with little time to crystallize, have small or no crystals.
<i>lava tube</i>	a natural tube formed by <b>lava</b> moving beneath the hardened surface of a lava flow.
<i>Law of Superposition</i>	the geological principle that states that unless rock layers have been overturned or <b>intruded</b> , older rocks are found at the bottom and younger rocks are found at the top of a <b>sedimentary</b> sequence.  See also: <b>stratigraphy</b>
<i>lead</i>	a metallic chemical element (Pb).  Lead was one of the first metals mined in North America, where it was sought after especially for making shot. It is used in batteries, communication systems, and building construction.
<i>leonardite</i>	a soft, waxy dark-colored mineraloid found in association with near-surface <b>lignite</b> deposits. It is an <b>oxidation</b> product of lignite, and is used as a <b>soil</b> conditioner, a stabilizer in water treatment, and as a drilling additive.
<i>lignite</i>	a soft, brownish-black <b>coal</b> in which the alteration of plant matter has proceeded farther than in <b>peat</b> but not as far as in <b>bituminous coal</b> .
<i>lime</i>	an inorganic white or grayish-white compound made by roasting <b>limestone</b> ( <b>calcium carbonate</b> , $\text{CaCO}_3$ ) until all the carbon dioxide ( $\text{CO}_2$ ) is driven off. Originating from limestone, <b>dolomite</b> , or <b>marble</b> , lime is very important to agriculture, in which it is regularly applied to make <b>soils</b> "sweeter" (less acidic).
<i>limestone</i>	a <b>sedimentary rock</b> composed of <b>calcium carbonate</b> ( $\text{CaCO}_3$ ). Most limestones are formed by the deposition and consolidation of the skeletons of marine invertebrates; a few originate in chemical precipitation from solution.  Limestone is ordinarily white but can be colored by impurities such as <b>iron oxide</b> (making it brown, yellow, or red), or organic carbon (making it blue, black, or gray). The rock's texture varies from coarse to fine.
<i>lithification</i>	the process of creating <b>sedimentary rock</b> through the compaction or <b>cementation</b> of soft sediment. The word comes from the Greek <i>lithos</i> , meaning "rock."

# Glossary

## I–m

<i><b>lithosphere</b></i>	<p>the outermost layer of the Earth, comprising a rigid <b>crust</b> and upper <b>mantle</b> broken up into many plates.</p> <p>The plates of the lithosphere move with the underlying <b>asthenosphere</b>, on average about 5 centimeters (2 inches) per year and as much as 18 centimeters (7 inches) per year.</p>
<i><b>loam</b></i>	a <b>soil</b> containing equal amounts of <b>clay</b> , <b>silt</b> , and <b>sand</b> .
<i><b>loess</b></i>	very fine-grained, wind-blown sediment, usually <b>rock flour</b> left behind by the grinding action of flowing glaciers.
<i><b>luminescence</b></i>	the emission of light.
<i><b>luster</b></i>	a physical property of <b>minerals</b> , describing the appearance of the mineral's surface in reflected light, and how brilliant or dull it is. Luster can range from metallic and reflective to opaque, vitreous like glass, translucent, or dull and earthy.
<i><b>mafic</b></i>	<b>igneous rocks</b> that contain a group of dark-colored minerals, with relatively high concentrations of magnesium and <b>iron</b> compared to <b>felsic</b> igneous rocks.
<i><b>magma</b></i>	molten rock located below the surface of the Earth. Magma can cool beneath the surface to form <b>intrusive igneous rocks</b> . However, if magma rises to the surface without cooling enough to crystallize, it might break through the <b>crust</b> at the surface to form <b>lava</b> .
<i><b>magnetic</b></i>	affected by or capable of producing a magnetic field.
<i><b>magnetite</b></i>	<p>a <b>mineral</b> form of <b>iron oxide</b> (<math>\text{Fe}_3\text{O}_4</math>). It is the most <b>magnetic</b> naturally occurring mineral. The molecules in magnetite align with the North and South Poles when rocks containing magnetite <b>ore</b> are formed. By examining the alignment today, scientists can reconstruct how the rocks have moved since their formation, giving them clues about the previous arrangement of the continents.</p> <p>Magnetite lodestones were used as an early form of compass. Huge deposits of magnetite have been found in <b>Precambrian</b> banded iron formations.</p>
<i><b>magnitude (earthquake)</b></i>	a logarithmic scale used to measure the seismic energy released by an <b>earthquake</b> . Magnitudes range from 1 to 10, with M3 earthquakes classed as minor and earthquakes of M8 or greater being classified as major.
<i><b>mammoth</b></i>	an <b>extinct</b> terrestrial vertebrate animal belonging to the Order Proboscidea of the Class Mammalia. Mammoths are from the same line of proboscideans that gave rise to African and Asian elephants. They had tall bodies with a rather high “domed” skull, and teeth with numerous parallel rows of ridges. Mammoths are among the most common <b>Pleistocene</b> vertebrate <b>fossils</b> in North America, Europe, and Asia.
<i><b>manganese</b></i>	a metallic chemical element (Mn). Manganese is used in the production of steel.

## m

# Glossary

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<i><b>mantle</b></i>	the layer of the Earth between the <b>crust</b> and core. It consists of solid <b>silicate</b> rocks that, over long intervals of time, flow like a highly viscous liquid. Convection currents within the mantle drive the motion of <b>plate tectonics</b> .
<i><b>marble</b></i>	a <b>metamorphic rock</b> composed of recrystallized <b>carbonate minerals</b> , most commonly <b>calcite</b> or <b>dolomite</b> . Not everything commercially called a marble is "true marble," which lacks fossils and is recrystallized from <b>limestone</b> .
<i><b>marl</b></i>	a fine-grained <b>sedimentary rock</b> consisting of <b>clay minerals</b> , <b>calcite</b> and/or aragonite, and <b>silt</b> .
<i><b>mass extinction</b></i>	the <b>extinction</b> of a large percentage of the Earth's species over a relatively short span of <b>geologic time</b> .  Unfortunately, this is not just a phenomenon of the past: it is estimated that the extinction rate on Earth right now may be as much as 1000 times higher than normal, and that we are currently experiencing a mass extinction event.
<i><b>mass wasting</b></i>	a process in which <b>soil</b> and rock move down a slope in a large mass. This can occur both on land (such as a <b>landslide</b> ) or underwater (such as a <b>turbidity current</b> ).
<i><b>mastodon</b></i>	an <b>extinct</b> terrestrial vertebrate animal belonging to the Order Proboscidea of the Class Mammalia, and characterized by an elephant-like shape and size, and massive molar teeth with conical projections. Mastodons are among the most common <b>Pleistocene</b> vertebrate <b>fossils</b> in North America.
<i><b>matrix</b></i>	a fine-grained mass of material around and embedding larger grains or crystals. The term matrix can also describe sediment or rock in which a <b>fossil</b> is embedded.
<i><b>megashear</b></i>	a large <b>shear</b> , typically tens to hundreds of kilometers (miles) in length, formed when rocks have been continuously <b>fractured</b> due to <b>compressive</b> stress.
<i><b>Mesozoic</b></i>	a <b>geologic time</b> period that spans from 252 to 66 million years ago. This period is also called the "age of reptiles" since <b>dinosaurs</b> and other reptiles dominated both marine and terrestrial ecosystems. During this time, the last of the Earth's major supercontinents, <b>Pangaea</b> , formed and later broke up, producing the Earth's current geography.  The Mesozoic contains the <b>Triassic</b> , <b>Jurassic</b> , and <b>Cretaceous</b> periods.
<i><b>metamorphism, metamorphic rocks</b></i>	rocks formed by the recrystallization and realignment of <b>minerals</b> in pre-existing <b>sedimentary</b> , <b>igneous</b> , and metamorphic rocks when exposed to high enough temperature and/or pressure. This can be a result of <b>plate</b> movements, very deep burial, or contact with molten rock or superheated water. This process destroys many features in the rock that would have revealed its previous history, transforming it into an entirely new form.  Tectonic forces can cause minerals to realign perpendicularly to the direction of pressure, layering them in a pattern called <b>foliation</b> , as exemplified in <b>gneiss</b> and <b>schist</b> . <b>Recrystallization</b> , as seen in <b>marble</b> and <b>quartzite</b> , results as rock is heated to high temperatures, and individual grains reform as interlocking crystals, making the resulting metamorphic rock harder than its parent rock.

# Glossary

## m

<i>meteorite</i>	a stony or metallic mass of matter that has fallen to the Earth's surface from outer space.
<i>mica</i>	a large group of sheetlike <b>silicate minerals</b> .
<i>microcontinent</i>	a piece of continental <b>crust</b> , usually <b>rifted</b> away from a larger continent. Microcontinents and other smaller fragments of continental crust ( <b>terranes</b> ) each had their own, often complex, geologic history before they were tacked onto the margin of another continent.
<i>Milankovitch Cycles</i>	cyclical changes in the amount of <b>heat</b> received from the sun, associated with how the Earth's orbit, tilt, and wobble alter its position with respect to the sun. These changes affect the global <b>climate</b> , most notably alterations of <b>glacial</b> and <b>interglacial</b> intervals.
<i>mineral</i>	<p>a naturally occurring inorganic solid with a specific chemical composition and a well developed crystalline structure. Minerals are identified based on their physical properties, including <b>hardness</b>, <b>luster</b>, <b>color</b>, <b>crystal form</b>, <b>cleavage</b>, <b>density</b>, and <b>streak</b>.</p> <p>There are over 4900 identified minerals. However, the number of common rock-forming minerals is much smaller. The most common minerals that form <b>igneous</b>, <b>metamorphic</b>, and <b>sedimentary rocks</b> include <b>quartz</b>, <b>feldspar</b>, <b>mica</b>, <b>pyroxenes</b>, and <b>amphiboles</b>.</p>
<i>mineralogy</i>	the branch of geology that studies the chemical and physical properties and formation of <b>minerals</b> .
<i>Miocene</i>	a <b>geologic time</b> unit extending from 23 to 5 million years ago. During the Miocene, the Earth experienced a series of <b>ice ages</b> , and hominid species diversified. The Miocene is the first epoch of the <b>Neogene</b> period.
<i>mirabilite</i>	a saline <b>evaporite mineral</b> , sodium sulfate ( $\text{NaSO}_4$ ), also known as "Glauber salts" in its processed form. This mineral is used in the manufacture of detergents, paper, and chemical processing, especially in the production of hydrochloric and sulfuric acids.
<i>Mississippian</i>	a subperiod of the <b>Carboniferous</b> , spanning from 359 to 323 million years ago.
<i>Mohs Scale of Hardness</i>	the scale of relative <b>hardness of minerals</b> , developed by the Austrian mineralogist, Frederick Mohs, in 1824. The scale is very useful as a means for identifying minerals or quickly determining hardness. A piece of glass has a hardness of approximately 5 on the scale; our fingernails are just over 2; a knife blade is just over 5. Diamond ranks at 10 as the hardest mineral.
<i>Mollisols</i>	a <b>soil order</b> ; these are agricultural <b>soils</b> made highly productive due to a very fertile, organic-rich surface layer.
<i>molybdenum</i>	a metallic chemical element (Mo) which has the sixth-highest melting point of any element at 2623°C (4753°F). Molybdenum is mainly used in the creation of alloys, such as stainless steel and cast <b>iron</b> , and its strong ability to withstand <b>heat</b> makes it useful in applications that utilize extreme heat, such as the manufacture of motors and aircraft parts.

<i>moraine</i>	<p>an accumulation of unconsolidated <b>glacial</b> debris (<b>soil</b> and rock) that can occur in currently glaciated and formerly glaciated regions, such as those areas acted upon by a past <b>ice age</b>. The debris is scraped from the ground and pushed forward by the glacier, to be left behind when the ice melts. Thus, many moraines mark the terminus or edge of a glacier. Lateral moraines can also occur in between and at the sides of glaciers or <b>ice lobes</b>.</p>
<i>mosasaur</i>	<p>an <b>extinct</b>, carnivorous, marine vertebrate reptile. Mosasaurs were characterized by a streamlined body for swimming, a powerful fluked tail, and reduced, paddle-like limbs. They were common in <b>Cretaceous</b> seas and were powerful swimmers, reaching 12–18 meters (40–59 feet) in length.</p>
<i>natural gas</i>	<p>a hydrocarbon gas mixture composed primarily of methane (CH<sub>4</sub>), but also small quantities of hydrocarbons such as ethane and propane.</p> <p>See also: <b>fossil fuel</b></p>
<i>natural hazard</i>	<p>events that result from natural processes and that have significant impacts on human beings.</p>
<i>Neogene</i>	<p>the <b>geologic time</b> period extending from 23 to 2.6 million years ago. During the Neogene, global <b>climate</b> cooled, the continents moved close to their current positions, mammals and birds continued to evolve, and the first hominins appeared.</p> <p>The Neogene is a portion of the <b>Cenozoic</b>.</p>
<i>nickel</i>	<p>a ductile, silvery-white metallic element (Ni). Nickel in its pure form is rarely found on Earth's surface; large quantities of nickel are typically found in <b>meteorites</b>. On Earth, nickel is generally found in combination with iron.</p> <p>Nickel is resistant to corrosion and is commonly used to plate metals, coat chemistry equipment, and manufacture alloys such as electrum.</p>
<i>nodule</i>	<p>a small, irregular or rounded <b>mineral</b> deposit that has a different composition from the <b>sedimentary rock</b> that encloses it. Nodules typically form when minerals precipitate from a supersaturated solution within or around features such as <b>biotic</b> remains.</p>
<i>nuclear</i>	<p>pertaining to a reaction, as in fission, fusion, or <b>radioactive</b> decay, that alters the <b>energy</b>, composition, or structure of an atomic nucleus.</p>
<i>obsidian</i>	<p>a <b>glassy volcanic</b> rock, formed when <b>felsic lava</b> cools rapidly. Although obsidian is dark in color, it is composed mainly of <b>silicon</b> dioxide (SiO<sub>2</sub>), and its dark color is a result of the rapid cooling process.</p> <p>Obsidian is extremely brittle and breaks with very sharp edges. It was valuable to Stone Age cultures for its use as cutting implements or arrowheads.</p>
<i>oil</i>	<p>See <b>petroleum</b></p>
<i>Oligocene</i>	<p>a <b>geologic time</b> interval spanning from about 34 to 23 million years ago. It is an epoch of the <b>Paleogene</b>.</p>

# Glossary

## o–p

<i>olivine</i>	an <b>iron-magnesium silicate mineral</b> ( $(\text{Mg,Fe})_2\text{SiO}_4$ ) that is a common constituent of magnesium-rich, silica-poor <b>igneous rocks</b> .
<i>opal</i>	a <b>silicate gemstone</b> lacking a rigid crystalline structure (and therefore a “mineraloid” as opposed to a <b>mineral</b> ). It forms when silica-rich water precipitates in fissures of almost any type of rock, as well as occasional organic matter.
<i>Ordovician</i>	a <b>geologic time</b> period spanning from 485 to 443 million years ago. During the Ordovician, invertebrates dominated the oceans and fish began to diversify.  The Ordovician is part of the <b>Paleozoic</b> .
<i>ore</i>	a type of rock that contains <b>minerals</b> with valuable elements, including metals, that are economically viable to extract.
<i>oreodont</i>	an <b>extinct</b> ungulate (hoofed animal) related to modern camels. Oreodonts lived in woodlands and grasslands throughout North America during the <b>Oligocene</b> and <b>Miocene</b> .
<i>orogeny</i>	a mountain-building event generally caused by colliding <b>plates</b> and <b>compression</b> of the edge of the continents. Orogeny is derived from the Greek word <i>oro</i> , meaning mountain.
<i>orthoquartzite</i>	a <b>sandstone</b> composed nearly entirely of well-rounded <b>quartz</b> grains <b>cemented</b> by <b>silica</b> .
<i>outwash plain</i>	large <b>sandy</b> flats created by sediment-laden water deposited when a <b>glacier</b> melts. Outwash sediments are also called fluvial material.
<i>oxidation, oxide</i>	a <b>chemical reaction</b> involving the loss of at least one electron when two substances interact; most often used to describe the interaction between oxygen molecules and the substances they come into contact with. Oxidation causes effects such as rust and cut apples turning brown.
<i>Oxisols</i>	a <b>soil order</b> ; these are very old, extremely leached and <b>weathered soils</b> with a subsurface accumulation of <b>iron</b> and <b>aluminum oxides</b> . Commonly found in humid, tropical environments.
<i>pahoehoe</i>	a type of <b>lava</b> resulting from the rapid motion of highly fluid <b>basalt</b> . It cools into smooth <b>glassy</b> flows, or can form twisted, ropey shapes. Pahoehoe is formed from lava that has a low viscosity and strain rate, as well as a low rate of gas effusion.
<i>Paleocene</i>	a <b>geologic time</b> interval spanning from about 66 to 56 million years ago. It is an epoch of the <b>Paleogene</b> period.
<i>paleoecology</i>	the study of the relationships of <b>fossil</b> organisms to one another and their environment.
<i>Paleogene</i>	the <b>geologic time</b> interval extending from 66 to 23 million years ago. During the Paleogene, mammals and birds diversified into many of the niches that had previously been held by <b>dinosaurs</b> .  The Paleogene is the first part of the <b>Cenozoic</b> .

## p

# Glossary

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<i>Paleozoic</i>	<p>a <b>geologic time</b> period that extends from 541 to 252 million years ago. <b>Fossil</b> evidence shows that during this time period, life evolved in the oceans and gradually colonized the land.</p> <p>The Paleozoic includes the <b>Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian</b> periods.</p>
<i>Pangaea</i>	<p>a supercontinent, meaning “all Earth,” which formed over 250 million years ago and lasted for almost 100 million years, during which all of the Earth’s continents were joined in a giant supercontinent. Pangaea eventually <b>rifted</b> apart and separated into the continents in their current configuration.</p>
<i>parent material</i>	<p>the original geologic material from which <b>soil</b> formed. This can be bedrock, preexisting soils, or other materials such as <b>till</b> or <b>loess</b>.</p>
<i>passive margin</i>	<p>a tectonically quiet continental edge, such as the eastern margin of North America, where <b>crustal</b> collision or <b>rifting</b> is not occurring.</p>
<i>patterned ground</i>	<p>patterns and sorting in the soil caused by repeated freezing and thawing, which causes repeated heaving upward and settling of the rocks and pebbles in the soil.</p>
<i>peat</i>	<p>an accumulation of partially decayed plant matter. Under proper <b>heat</b> and pressure, it will turn into <b>lignite coal</b> over geologic periods of time.</p> <p>As much as 9 meters (30 feet) of peat might need to accumulate to produce an economically profitable coal seam. By the time that a peat bed has been turned into a layer of <b>anthracite</b>, the layer is one-tenth its original thickness.</p>
<i>peds</i>	<p>clumps of <b>soil</b>, identified by their shape, which may take the form of balls, blocks, columns, and plates. These structures are easiest to see in recently plowed fields, where the soil is often granular and loose or lumpy.</p>
<i>pegmatite</i>	<p>a very coarse-grained <b>igneous rock</b> that formed below the surface, usually rich in <b>quartz, feldspar, and mica</b>. Pegmatite <b>magmas</b> are very rich in water, carbon dioxide, <b>silicon, aluminum, and potassium</b>, and form as the last fluids to crystallize from magma or the first <b>minerals</b> to melt at high temperatures during <b>metamorphism</b>.</p>
<i>Pennsylvanian</i>	<p>a subperiod of the <b>Carboniferous</b>, spanning from 323 to 299 million years ago.</p>
<i>perennial</i>	<p>continuous; year-round or occurring on a yearly basis.</p>
<i>periglacial zone</i>	<p>a region directly next to an <b>ice sheet</b>, which, although it was never covered or <b>scoured</b> by ice, has its own distinctive landscape and features because it was next to the ice margin.</p> <p>The average annual air temperature in a periglacial area is between <math>-12^{\circ}</math> and <math>3^{\circ}\text{C}</math> (<math>10^{\circ}</math> and <math>37^{\circ}\text{F}</math>). Though the surface of the ground may melt in the summer, it refreezes in the winter.</p>
<i>permafrost</i>	<p>a layer of <b>soil</b> below the surface that remains frozen all year round. Its thickness can range from tens of centimeters to a few meters. Permafrost is typically defined as any soil that has remained at a temperature below the freezing point of water for at least two years.</p>

# Glossary

p

<i>permeable, permeability</i>	<p>a capacity for fluids and gas (such as water, <b>oil</b>, and <b>natural gas</b>) to move through <b>fractures</b> within a rock, or the spaces between its grains.</p> <p><b>Sandstone</b>, <b>limestone</b>, and fractured rocks of any kind generally are permeable. <b>Shale</b>, on the other hand, is usually impermeable because the small, flat <b>clay</b> particles that make up the rock are tightly packed into a <b>dense</b> rock with very little space between particles. Poorly sorted <b>sedimentary rocks</b> can also be impermeable because smaller grains fill in the spaces between the bigger grains, restricting the movement of fluids.</p>
<i>Permian</i>	<p>the <b>geologic time</b> period lasting from 299 to 252 million years ago. During the Permian, the world's landmass was combined into the supercontinent <b>Pangaea</b>.</p> <p>The Permian is the last period of the <b>Paleozoic</b>. It ended with the largest <b>mass extinction</b> in Earth's history, which wiped out 70% of terrestrial animal species and 90% of all marine animal species.</p>
<i>permineralization</i>	<p>a <b>fossilization</b> method in which empty spaces (such as in a bone or shell) are filled by minerals.</p>
<i>petroleum</i>	<p>a naturally occurring, flammable liquid found in geologic formations beneath the Earth's surface and consisting primarily of hydrocarbons. Petroleum, also called oil, is a <b>fossil fuel</b>, formed when large masses of dead organisms (usually algae or plankton) are buried underneath sediments and subjected to intense <b>heat</b> and pressure. Today, petroleum is used to manufacture a wide variety of materials, and it is commonly refined into various types of fuels. It is estimated that 90 million barrels are consumed globally every day.</p>
<i>Phanerozoic</i>	<p>a generalized term used to describe the entirety of geological history after the <b>Precambrian</b>, from 541 million years ago to the present.</p>
<i>phonolite</i>	<p>an <b>extrusive igneous rock</b> of intermediate composition, which forms from <b>magma</b> with a relatively low <b>silica</b> content. The name phonolite comes from Greek meaning "sounding stone" due to the metallic sound it produces if struck.</p>
<i>phosphate</i>	<p>an inorganic <b>salt</b> of phosphoric acid, and a nutrient vital to biological life.</p>
<i>physiography</i>	<p>a subfield of geography that studies the Earth's physical processes and patterns, including consideration of the shape (not just the height) of land forms, as well as the bedrock, <b>soil</b>, water, vegetation, and <b>climate</b> of an area, and how they interacted in the past to form the landscape we see today.</p>
<i>placer deposit</i>	<p>a <b>mineral</b> deposit occurring in rivers and streams where less <b>dense</b> sediment has been carried downstream but denser minerals such as <b>gold</b> have been left behind.</p>
<i>plate tectonics</i>	<p>the process by which the <b>plates</b> of the Earth's <b>crust</b> move and interact with one another at their boundaries. The Earth is dynamic, consisting of constantly moving plates that are made of rigid continental and oceanic <b>lithosphere</b> overlying a churning, plastically flowing <b>asthenosphere</b>. These plates are slowly pulling apart, colliding, or sliding past one another with great force, creating strings of <b>volcanic islands</b>, new ocean floor, <b>earthquakes</b>, and mountains.</p>

## p

# Glossary

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<i>plates</i>	<p>large, rigid pieces of the Earth's <b>crust</b> and upper <b>mantle</b>, which move and interact with one another at their boundaries.</p> <p>See also: <b>plate tectonics</b></p>
<i>playa lakes</i>	<p>ephemeral or dry lakebeds that occasionally contain only a thin layer of quickly evaporating water. Soluble minerals such as <b>halite</b>, <b>gypsum</b>, and <b>calcite</b> precipitate from evaporating playa lakes, leaving behind rock <b>salt</b>, gypsum, and <b>limestone</b>.</p>
<i>Pleistocene</i>	<p>a subset of the <b>Quaternary</b>, lasting from 2.5 million to about 11,700 years ago. During the Pleistocene, continental <b>ice sheets</b> advanced south and retreated north several dozen times.</p>
<i>plesiosaur</i>	<p>a member of a group of <b>extinct</b> long-necked <b>Mesozoic</b> marine reptiles.</p>
<i>Pliocene</i>	<p>a <b>geologic time</b> interval extending from roughly 5 to 2.5 million years ago. The Pliocene epoch is a subdivision of the <b>Neogene</b> period, and is the time period directly preceding the onset of <b>Pleistocene glaciations</b>.</p>
<i>plucking</i>	<p>process by which a <b>glacier</b> "plucks" sediments and larger chunks of rock from the bedrock. The flowing ice cracks and breaks rock as it passes over, pieces of which become incorporated into the sheet or bulldozed forward, in front of the glacier's margin.</p>
<i>plunge pool</i>	<p>a stream pool, lake, or pond that is small in diameter, but deep.</p>
<i>pluton, plutonic rock</i>	<p>a large body of <b>intrusive igneous rock</b> that formed under the Earth's surface through the slow crystallization of <b>magma</b>. The term comes from the name of Pluto, Roman god of the underworld.</p>
<i>polar vortex</i>	<p>a regularly occurring area of low pressure that circulates in the highest levels of the upper <b>atmosphere</b>. Typically, the polar vortex hovers above Canada. However, a pocket of the counter-clockwise rotating low-pressure center can break off and shift southward at a lower altitude. The <b>jet stream</b> then shifts to a more southward flow than usual. A polar vortex can lock the jet stream in this new pattern for several days to more than a week</p>
<i>porosity</i>	<p>the percentage of openings in a body of rock such as pores, <b>joints</b>, channels, and other cavities, in which gases or liquids may be trapped or migrate through.</p>
<i>porphyry, porphyritic</i>	<p>an <b>igneous rock</b> consisting of large grained crystals, or <b>phenocrysts</b>, cemented in a fine-grained matrix.</p>
<i>potash</i>	<p>a name used for a variety of <b>salts</b> containing potassium, with mined potash being primarily potassium chloride (KCl). The majority of potash is used as fertilizer, but an increasing amount is being used in a variety of other ways: water softening, snow melting, a variety of industrial processes, as a medicine, and to produce potassium <b>carbonate</b> (K<sub>2</sub>CO<sub>3</sub>).</p>
<i>pothole</i>	<p>a shallow, rounded depression <b>eroded</b> in bedrock by a <b>glacier</b>.</p>
<i>power (energy)</i>	<p>the rate at which <b>energy</b> is transferred, usually measured in <b>watts</b> or, less frequently, horsepower.</p>

# Glossary

# p

<b><i>Precambrian</i></b>	<p>a <b>geologic time</b> period that spans from the formation of Earth (4.6 billion years ago) to the beginning of the <b>Cambrian</b> (541 million years ago). Relatively little is known about this time period since very few <b>fossils</b> or unaltered rocks have survived. What few clues exist indicate that life first appeared on the planet as long as 3.9 billion years ago in the form of single-celled organisms.</p> <p>The Precambrian contains the Hadean, <b>Archean</b>, and <b>Proterozoic</b> eons.</p>
<b><i>pre-Illinoian glaciation</i></b>	<p>a grouping of the Midwestern <b>glacial</b> periods that occurred before the <b>Wisconsinian</b> and <b>Illinoian glaciations</b>.</p>
<b><i>primary energy source</i></b>	<p>a source of <b>energy</b> found in nature, that has not been subject to any human-induced energy transfers or transformations (like conversion to electricity). Examples include <b>fossil fuels</b>, solar, <b>wind</b>, and hydropower.</p>
<b><i>Proterozoic</i></b>	<p>a <b>geologic time</b> interval that extends from 2.5 billion to 541 million years ago. It is part of the <b>Precambrian</b>.</p> <p>During this eon, the Earth transitioned to an oxygenated <b>atmosphere</b> and eukaryotic cells, including fungi, plants, and animals, originated.</p>
<b><i>protists</i></b>	<p>a diverse group of single-celled <b>eukaryotes</b>.</p>
<b><i>protolith</i></b>	<p>the original parent rock from which a <b>metamorphosed</b> rock is formed.</p>
<b><i>pterosaurs</i></b>	<p><b>extinct</b> flying reptiles with wingspans of up to 15 meters. They lived during the same time as the <b>dinosaurs</b>.</p>
<b><i>pumice</i></b>	<p>a <b>pyroclastic</b> rock that forms as frothing and sputtering <b>magma</b>tic foam cools and solidifies. It is so <b>vesicular</b> that it can float. Pumice is a common product of explosive eruptions. Today it is used in a variety of mediums, including construction materials and abrasives.</p>
<b><i>pyrite</i></b>	<p>an <b>iron</b> sulfide <b>mineral</b> (FeS<sub>2</sub>). Pyrite's superficial resemblance to <b>gold</b> has led to the common nickname "fool's gold."</p>
<b><i>pyroclastic rocks</i></b>	<p>rocks that form during explosive <b>volcanic</b> eruptions, and are composed from a variety of different volcanic ejecta. The term comes from Greek, and means "broken fire." Pyroclastic debris of all types is known as <b>tephra</b>.</p>
<b><i>pyroxene</i></b>	<p>dark-colored rock-forming <b>silicate minerals</b> containing <b>iron</b> and magnesium, found in many <b>igneous</b> and <b>metamorphic rocks</b>. They are often present in <b>volcanic rocks</b>.</p>

<b>quartz</b>	<p>the second most abundant <b>mineral</b> in the Earth's continental crust (after feldspar), made up of <b>silicon</b> and oxygen (SiO<sub>2</sub>). It makes up more than 10% of the <b>crust</b> by mass.</p> <p>There are a wide variety of types of quartz: onyx, <b>agate</b>, and petrified wood are fibrous, microcrystalline varieties collectively known as chalcedony. Although agate is naturally banded with layers of different colors and porosity, commercial varieties of agate are often artificially colored.</p> <p><b>Flint</b>, <b>chert</b>, and <b>jasper</b> are granular microcrystalline varieties of quartz, with the bright red color of jasper due to the inclusion of small amounts of iron within the mineral structure.</p> <p>The most common, coarsely crystalline varieties include massive quartz veins, the distinct, well formed crystals of "rock crystal", and an array of colored quartz, including amethyst (purple), rose quartz (pink), smoky quartz (gray), citrine (orange), and milky quartz (white).</p>
<b>quartzite</b>	<p>a hard <b>metamorphic rock</b> that was originally <b>sandstone</b>. Quartzite usually forms from sandstone that was metamorphosed through tectonic <b>compression</b> within <b>orogenic</b> belts.</p> <p>Quartzite is quarried for use as a building and decorative stone.</p>
<b>Quaternary</b>	<p>a <b>geologic time</b> period that extends from 2.6 million years ago to the present. This period is largely defined by the periodic advance and retreat of continental <b>glaciers</b>.</p> <p>The Quaternary is part of the <b>Cenozoic</b>.</p>
<b>radioactivity</b>	<p>The emission of radiation (<b>energy</b>) by an unstable atom.</p>
<b>radon</b>	<p>a naturally occurring <b>radioactive</b>, colorless, odorless gas. It is one of the products of decay from the breakdown of radioactive elements in <b>soil</b>, rock, and water, released by <b>weathering</b>.</p>
<b>rare earth elements</b>	<p>a set of 17 heavy, <b>lustrous</b> elements with similar properties, some of which have technological applications. Although they are relatively common in the <b>crust</b>, these metals are not usually found concentrated in economically viable <b>ore</b> deposits.</p>
<b>recrystallization</b>	<p>the change in structure of <b>mineral</b> crystals that make up rocks, or the formation of new mineral crystals within the rock.</p> <p>Recrystallization commonly occurs during <b>metamorphism</b>. When rocks are metamorphosed, individual grains that make up the original rock are melted slightly and recrystallize. The pressure allows crystals to grow into a tighter, interlocking arrangement than in an unmetamorphosed rock.</p>
<b>reef</b>	<p>a feature lying beneath the surface of the water, which is a buildup of sediment or other material built by organisms, and which has positive <b>relief</b> from the sea floor.</p> <p>While some reefs result from abiotic processes such as deposition or wave action, the best-known reefs are built by corals and other marine organisms.</p>
<b>regional metamorphism</b>	<p>a <b>metamorphic rock</b> that has been altered due to deep burial and great pressure. This type of metamorphic rock tends to occur in long belts at the center of mountain ranges. Different types of metamorphic rock are created depending on the gradients of <b>heat</b> and pressure applied.</p>
<b>regression</b>	<p>a drop in sea level.</p>

# Glossary

## r–s

<i>relief (topography)</i>	the change in elevation over a distance.
<i>renewable energy, renewable resource</i>	<b>energy</b> obtained from sources that are virtually inexhaustible (defined in terms of comparison to the lifetime of the Sun) and replenish naturally over small time scales relative to human life spans.
<i>replacement</i>	a <b>fossilization</b> method by which the original material is chemically replaced by a more stable <b>mineral</b> .
<i>residual weathering deposit</i>	a <b>mineral</b> deposit formed through the concentration of a <b>weathering</b> -resistant mineral, in which the other minerals around it have been weathered away.
<i>rhyolite, rhyolitic</i>	a <b>felsic volcanic</b> rock high in abundance of <b>quartz</b> and <b>feldspar</b> .
<i>rift</i>	a break or crack in the <b>crust</b> that can be caused by tensional stress as a landmass breaks apart into separate <b>plates</b> .
<i>rift basin</i>	a <b>topographic</b> depression caused by <b>subsidence</b> within a <b>rift</b> ; the basin, since it is at a relatively low elevation, usually contains freshwater bodies such as rivers and lakes.
<i>ripple marks</i>	surface features created when sediment deposits are agitated, typically by water currents or <b>wind</b> . The crests and troughs formed by this agitation are occasionally <b>lithified</b> and preserved, providing information about the flow of water or wind in the paleoenvironment.
<i>rock flour</i>	very fine sediments and <b>clay</b> resulting from the grinding action of <b>glaciers</b> .
<i>rockburst</i>	spontaneous, violent <b>fracturing</b> of rock occurring in deep mines.
<i>Rodinia</i>	a supercontinent that contained most or all of Earth's landmass, between 1.1 billion and 750 million years ago, during the <b>Precambrian</b> . Geologists are not sure of the exact size and shape of Rodinia. It was analagous to but not the same supercontinent as <b>Pangaea</b> , which formed was assembled several hundred million years later during the <b>Permian</b> .
<i>rudist</i>	an <b>extinct</b> group of box- or tube-shaped <b>bivalves</b> that arose during the <b>Jurassic</b> . They were major <b>reef</b> formers, but went extinct at the end of the <b>Cretaceous</b> .
<i>rugose coral</i>	an <b>extinct</b> group of corals that were prevalent from the <b>Ordovician</b> through the <b>Permian</b> . Solitary forms were most common; these were horn-shaped, leading to their common name, "horn corals."
<i>salt</i>	a <b>mineral</b> composed primarily of sodium chloride (NaCl). In its natural form, it is called rock salt or halite.  Salt is essential for animal life, and is a necessary part of the diet. In addition, salt is used for de-icing roads in winter and is also an important part of the chemical industry.

## S

# Glossary

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<i>sand</i>	rock material in the form of loose, rounded, or angular grains, and formed as a result of the <b>weathering</b> and decomposition of rocks. Particles of sand are between 0.05 and 2 millimeters in diameter.
<i>sandstone</i>	<b>sedimentary rock</b> formed by cementing together grains of <b>sand</b> .
<i>schist</i>	a medium grade <b>metamorphic rock</b> with sheet-like crystals flattened in one plane. The flattened crystals are often muscovite or biotite <b>mica</b> , but they can also be <b>talc</b> , <b>graphite</b> , or <b>hornblende</b> .
<i>scleractinian coral</i>	<p>a modern “stony” coral; a colonial or solitary marine invertebrate animal belonging to the Order Scleractinia in the Class Anthozoa of the Phylum Cnidaria, and characterized by an encrusting calcareous skeleton from which multiple individuals (polyps) extend from small pores to capture prey with small tentacles equipped with stinging cells (nematocysts). Although scleractinians look somewhat similar to extinct <b>rugose</b> and <b>tabulate corals</b>, each group possesses distinctive features in the shape of the skeletal cup holding the individual polyps.</p> <p>Modern scleractinians host commensal algae (zooxanthellae) whose photosynthetic activities supply the coral with energy.</p>
<i>scoria</i>	a highly <b>vesicular</b> form of <b>basalt</b> . It tends to form as <b>cinders</b> in the early stages of a <b>volcanic</b> eruption, when gas bubbles are still caught up in the frothy erupting <b>magma</b> . Once the gas has escaped, the remaining magma can flow out, creating basalt <b>lava</b> flows that spread out over the landscape.
<i>scour, scouring</i>	<b>erosion</b> resulting from <b>glacial</b> abrasion on the landscape.
<i>sedimentary rocks</i>	<p>rocks formed through the accumulation and consolidation of grains of broken rock, crystals, skeletal fragments, and organic matter.</p> <p>Sediment that forms from <b>weathering</b> is transported by <b>wind</b> or water to a depositional environment such as a lakebed or ocean floor; here they build up, burying and compacting lower layers. As water permeates the sediment, dissolved <b>minerals</b> may precipitate out, filling the spaces between particles and <b>cementing</b> them together. Sedimentary rocks may also accrete from fragments of the shells or skeletal material of marine organisms like clams and coral.</p> <p>Sedimentary rocks are classified by their sediment size or their mineral content. Each one reveals the story of the depositional environment where its sediments accumulated and the history of its <b>lithification</b>.</p>
<i>seismic belt</i>	a narrow geographic zone along which most <b>earthquakes</b> occur.
<i>seismic tomography</i>	a technique for imaging Earth’s sub-surface characteristics, in which the velocity of <b>seismic waves</b> is analyzed in an effort to understand deep geologic structure.
<i>seismic waves</i>	the shock waves or vibrations radiating in all directions from the center of an <b>earthquake</b> or other tectonic event.
<i>seismic zone</i>	a regional zone that encompasses areas prone to seismic hazards, such as <b>earthquakes</b> or <b>landslides</b> .

# Glossary

# S

<i>sessile</i>	unable to move, as in an organism that is permanently attached to its substrate.
<i>Sevier Orogeny</i>	a mountain-building event resulting from <b>subduction</b> along the western edge of North America, occurring mainly during the <b>Cretaceous</b> . During this <b>orogeny</b> , compressive forces and <b>heating</b> resulted in major <b>crustal</b> folding and thrust <b>faulting</b> .
<i>shale</i>	a dark, fine-grained, laminated <b>sedimentary rock</b> formed by the <b>compression</b> of successive layers of <b>silt-</b> and <b>clay-</b> rich sediment. Shale is weak and often breaks along thin layers.  Shale that is especially rich in unoxidized carbon is dark grey or black. These organic-rich black shales are often source rocks for <b>petroleum</b> and <b>natural gas</b> .
<i>shark</i>	a large fish characterized by a cartilaginous skeleton and five to seven gill slits on the side of the head. Sharks first appeared 420 million years ago, and have since diversified to over 470 species.
<i>shearing, shear</i>	the process by which <b>compressive</b> stress causes the <b>fracturing</b> and <b>faulting</b> of brittle rocks.
<i>silica, silicon, silicate</i>	a chemical compound also known as silicon dioxide (SiO <sub>2</sub> ). Silica is most commonly found as <b>quartz</b> , and is also secreted as skeletal material in various organisms. It is one of the most abundant materials in the <b>crust</b> .
<i>silt</i>	granular sediment most commonly composed of <b>quartz</b> and <b>feldspar</b> crystals. Particles of silt have diameters of less than 0.074 millimeters.
<i>Silurian</i>	a <b>geologic time</b> period spanning from 443 to 419 million years ago. During the Silurian, jawed and bony fish diversified, and life first began to appear on land.  The Silurian is part of the <b>Paleozoic</b> .
<i>silver</i>	a metallic chemical element (Ag).  Silver is used in photographic film emulsions, utensils and other tableware, and electronic equipment.
<i>slump</i>	a slow-moving <b>landslide</b> in which loosely consolidated rock or <b>soil</b> layers move a short distance down a slope.  See also: <b>mass wasting</b>
<i>snail</i>	See <b>gastropod</b>
<i>Snowy Pass Supergroup</i>	a 2.4–2.5 billion year old series of <b>sedimentary rocks</b> , located in the Medicine Bow Range in southern Wyoming. These strata, containing thick sequences of <b>sandstone</b> , <b>conglomerate</b> , and <b>limestone</b> , were deposited in a continental shelf environment on the passive margin of proto-North America. The sediments were later <b>metamorphosed</b> by an <b>orogenic</b> episode accompanied by <b>volcanic</b> activity.

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<b>soapstone</b>	a <b>metamorphic</b> schistose rock composed mostly of <b>talc</b> . Soapstone has a flaky texture and a greasy or soapy feel, and is an effective medium for carving.
<b>soil</b>	the collection of natural materials that collect on Earth's surface, above the bedrock. Soil consists of layers ( <b>horizons</b> ) of two key ingredients: plant litter, such as dead grasses, leaves, and fallen debris, and sediment derived from the <b>weathering</b> of rock. Both of these components can influence the texture and consistency of the soil, as well as the <b>minerals</b> available for consumption by plants.  The word is derived from the Latin "solum," which means "floor" or "ground."
<b>soil orders</b>	the twelve major units of <b>soil taxonomy</b> , which are defined by diagnostic horizons, composition, <b>soil</b> structures, and other characteristics. Soil orders depend mainly on climate and the organisms within the soil.  These orders are further broken down into 64 suborders based on properties that influence soil development and plant growth, with the most important property being how wet the soil is throughout the year.
<b>soil taxonomy</b>	the system used to classify <b>soils</b> based on their properties.
<b>solifluction</b>	a type of <b>mass wasting</b> where waterlogged sediment moves slowly downslope, over impermeable material. Solifluction is similar to a <b>landslide</b> or mudslide.
<b>solution mining</b>	the extraction of soluble <b>minerals</b> from subsurface strata by the injection of fluids, and the controlled removal of mineral-laden solutions.
<b>Sonoman Orogeny</b>	a period of mountain building along the western edge of North America, in what is now Nevada and eastern Oregon. This <b>orogeny</b> is related to <b>accretion</b> at the <b>convergent plate boundary</b> , and is thought to have occurred around 250 million years ago.
<b>speleothem</b>	an often delicate <b>mineral</b> deposit in <b>limestone</b> or <b>dolostone</b> caves, formed through the dissolution of <b>carbonate</b> minerals.
<b>Spodosols</b>	a <b>soil order</b> ; these are acidic <b>soils</b> in which <b>aluminum</b> and <b>iron oxides</b> accumulate below the surface. They typically form under pine vegetation and sandy parent material.
<b>spodumene</b>	a translucent <b>pyroxene mineral</b> (lithium aluminum inosilicate) occurring in prismatic crystals, and a primary source of <b>lithium</b> . Some varieties of spodumene are also prized as <b>gems</b> .
<b>sponge</b>	a marine invertebrate belonging to the Phylum Porifera, and characterized by a soft shape with many pores and channels for water flow. Because they have no nervous, digestive, or circulatory systems, some consider them to be colonies of specialized single cells. Sponges come in a variety of shapes and body forms, and have been around at least since the <b>Cambrian</b> . Entire sponges are rarely preserved, but their tiny skeletal pieces (spicules) are common in <b>sedimentary rocks</b> .  See also: <b>archaeocyathid</b>

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<b><i>stratigraphy, stratigraphic</i></b>	the branch of geology specifically concerned with the arrangement and age of rock units.  See also: <b>Law of Superposition</b>
<b><i>streak</i></b>	a physical property of <b>minerals</b> , obtained by dragging the mineral across a porcelain plate and effectively powdering it. During identification, the color of the powder eliminates the confounding variables of external <b>weathering</b> , <b>crystal form</b> , or impurities.
<b><i>stromatolite</i></b>	regularly banded accumulations of sediment created by the trapping and cementation of sediment grains in bacterial mats (especially photosynthetic <b>cyanobacteria</b> ). Cyanobacteria emit a sticky substance that binds settling <b>clay</b> grains and creates a chemical environment leading to the precipitation of <b>calcium carbonate</b> . The calcium carbonate then hardens the underlying layers of bacterial mats, while the living bacteria move upward so that they are not buried. Over time, this cycle of growth combined with sediment capture creates a rounded structure filled with banded layers.  Stromatolites peaked in abundance around 1.25 billion years ago, and likely declined due to the evolution of grazing organisms. Today, stromatolites exist in only a few locations worldwide, such as Shark Bay, Australia. Modern stromatolites form thick layers only in stressful environments, such as very salty water, that exclude animal grazers. Even though there are still modern stromatolites, the term is often used to refer specifically to <b>fossils</b> .
<b><i>subduction</i></b>	the process by which one <b>plate</b> moves under another, sinking into the <b>mantle</b> . This usually occurs at <b>convergent plate boundaries</b> . <b>Denser plates</b> are more likely to subduct under more buoyant plates, as when oceanic <b>crust</b> sinks beneath continental crust.
<b><i>subsidence</i></b>	the sinking of an area of the land surface.
<b><i>subsoil</i></b>	the layer of <b>soil</b> beneath the <b>topsoil</b> , composed of <b>sand</b> , <b>silt</b> , and/or <b>clay</b> . Subsoil lacks the organic matter and <b>humus</b> content of topsoil.
<b><i>sulfur, sulfate</i></b>	a bright yellow chemical element (S) that is essential to life. It acts as an <b>oxidizing</b> or reducing agent, and occurs commonly in raw form as well as in <b>minerals</b> .
<b><i>supervolcano</i></b>	an explosive <b>volcano</b> capable of producing more than 1000 cubic kilometers (240 cubic miles) of ejecta.
<b><i>sustainable</i></b>	able to be maintained at a steady level without exhausting natural resources or causing severe ecological damage, as in a behavior or practice.
<b><i>suture</i></b>	the area where two continental <b>plates</b> have joined together through continental collision.  See also: <b>convergent boundary</b> , <b>plate tectonics</b>
<b><i>syenite</i></b>	a durable, coarse-grained <b>intrusive igneous rock</b> , which is similar to <b>granite</b> but contains less <b>quartz</b> . It can exhibit <b>columnar jointing</b> .
<b><i>system</i></b>	a set of connected things or parts forming a complex whole—in particular, a set of things working together as parts of a mechanism or an interconnecting network.

<b><i>tabulate coral</i></b>	an <b>extinct</b> form of colonial coral that often formed honeycomb-shaped colonies of hexagonal cells.
<b><i>talc</i></b>	hydrated magnesium silicate, formed during <b>hydrothermal</b> alteration accompanying <b>metamorphism</b> . Talc can be formed from <b>calcite</b> , <b>dolomite</b> , <b>silica</b> , and some <b>ultramafic</b> rocks.
<b><i>talus</i></b>	debris fields found on the sides of steep slopes, common in <b>periglacial</b> environments.
<b><i>tephra</i></b>	fragmented material produced by a <b>volcanic</b> eruption. Airborne tephra fragments are called <b>pyroclastic</b> .
<b><i>terrane</i></b>	a piece of <b>crustal</b> material that has broken off from its parent continent and become attached to another plate. Due to their disparate origins, terranes have distinctly different geologic characteristics than the surrounding rocks. Florida is a good example of an exotic terrane, originating as part of the supercontinent <b>Gondwana</b> . Parts of the western coast of North America (including Alaska and the Northeastern US) are also terranes that have been <b>sutured</b> onto the coast.
<b><i>Tertiary</i></b>	an unofficial but still commonly used term for the time period spanning from 66 to 2.5 million years ago, including the <b>Paleogene</b> , <b>Neogene</b> , and part of the <b>Pleistocene</b> . Although the Tertiary period was officially phased out in 2008 by the International Commission on Stratigraphy, it can still be found in scientific literature. (In contrast, the <b>Carboniferous</b> and <b>Pennsylvanian</b> and <b>Mississippian</b> periods all enjoy official status, with the latter pair being more commonly used in the US.)
<b><i>thorium</i></b>	a <b>radioactive rare earth element</b> , with potential applications in next-generation <b>nuclear</b> reactors that could be safer and more environmentally friendly than current uranium reactors.
<b><i>till</i></b>	unconsolidated sediment that is <b>eroded</b> from the bedrock, then carried and eventually deposited by <b>glaciers</b> as they recede. Till may include a mixture of <b>clay</b> , <b>sand</b> , <b>gravel</b> , and even boulders.  The term originated with farmers living in glaciated areas who were constantly removing rocks from their fields while breaking the <b>soil</b> for planting, a process known as tilling.
<b><i>tillite</i></b>	<b>glacial till</b> that has been compacted and <b>lithified</b> into solid rock.
<b><i>titanium</i></b>	a metallic chemical element (Ti). Titanium is important because of its lightweight nature, strength and resistance to corrosion.
<b><i>topography</i></b>	the landscape of an area, including the presence or absence of hills and the slopes between high and low areas. These changes in elevation over a particular area are generally the result of a combination of deposition, <b>erosion</b> , <b>uplift</b> , and subsidence. These processes that can happen over an enormous range of timescales.
<b><i>topsoil</i></b>	the surface or upper layer of <b>soil</b> , as distinct from the subsoil, and usually containing organic matter.

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<b>tornado</b>	<p>a vertical funnel-shaped storm with a visible horizontal rotation.</p> <p>The word tornado has its roots in the Spanish word <i>tonar</i>, which means “to turn.”</p>
<b>trace fossils</b>	<p><b>fossils</b> that record the actions of organisms, such as footprints, trails, trackways, and burrows. Trace fossils cannot always be associated at least with a group of organisms or way of life. The first trace fossils appear a couple hundred million years before the first animal (body) fossils.</p>
<b>transform boundary</b>	<p>an <b>active plate boundary</b> in which the <b>crustal plates</b> move sideways past one another.</p>
<b>transgression</b>	<p>a relative rise in sea level in a particular area, through global sea level rise or <b>subsidence</b> of land.</p>
<b>tree</b>	<p>any woody <b>perennial</b> plant with a central trunk. Not all trees are closely related; different kinds of plants have evolved the tree form through geological time. The trees of the <b>Paleozoic</b> were more closely related to club mosses or ferns than they were to today’s trees.</p>
<b>Triassic</b>	<p>a <b>geologic time</b> period that spans from 252 to 201 million years ago. During this period, <b>dinosaurs</b>, <b>pterosaurs</b>, and the first mammals appear and begin to diversify.</p> <p>The Triassic begins directly after the <b>Permian-Triassic mass extinction</b> event, and is the first period of the <b>Mesozoic</b>.</p>
<b>trilobite</b>	<p>an extinct marine invertebrate animal belonging to the Class Trilobita of the Phylum Arthropoda, and characterized by a three-part body and a chitinous exoskeleton divided longitudinally into three lobes. Trilobites have been extinct since the end of the Paleozoic.</p> <p>Trilobites were primitive arthropods distantly related to horseshoe crabs. As bottom dwellers, they were present in a variety of environments. Like crabs and lobsters, trilobites molted their exoskeletons when they grew. Most fossils of trilobites are actually molts, broken as they were shed off the trilobite. Thus, it is common to find only parts of trilobites, such as the head, mid-section, or tail.</p>
<b>tuff</b>	<p>a <b>pyroclastic</b> rock made of consolidated <b>volcanic ash</b>. Tuff is the result of pyroclastic flows, in which the violent expansion of hot gas shreds the erupting <b>magma</b> into tiny particles that cool in the air to form dense clouds of volcanic ash.</p> <p>The tremendous explosions that are necessary to create ash-flow tuffs are caused by <b>rhyolitic</b> magma, which is <b>felsic</b>. High <b>silica</b> content makes the magma quite viscous, preventing gas bubbles from easily escaping, thus leading to pressure build-ups that are released by explosive eruptions. The ash flows from these violent explosions tend to hug the ground, eventually solidifying into tuffs. Tuffs and other pyroclastic materials are <b>vesicular (porous)</b> due to gases expanding within the material as it cools.</p>
<b>turbidity current</b>	<p>a submarine sediment avalanche. These fast-moving currents of sediment are often caused by <b>earthquakes</b> or other geological disturbances that loosen sediment on a continental shelf.</p> <p>These massive sediment flows have extreme <b>erosive</b> potential, and often carve out underwater canyons. Turbidity currents deposit huge amounts of sediment during flow; such deposits are called turbidites. Because of the rate at which turbidity currents deposit <b>dense</b> sediments, they are often responsible for the effective preservation of many <b>fossil</b> organisms, which are swept up from shallow marine environments and buried in the deep sea.</p>

<i>Ultisols</i>	a <b>soil order</b> ; these are <b>soils</b> with subsurface <b>clay</b> accumulations that possess low native fertility and are often red hued (due to the presence of <b>iron oxides</b> ). They are found in humid tropical and subtropical <b>climates</b> .
<i>ultramafic rocks</i>	<b>igneous rocks</b> with very low <b>silica</b> content (< 45%), which are composed of usually greater than 90% <b>mafic minerals</b> . The Earth's <b>mantle</b> is composed of ultramafic rocks, which are dark green to black in color due to their high magnesium and <b>iron</b> content.
<i>unconformity</i>	the relation between adjacent rock strata for which the time of deposition was separated by a period of nondeposition or <b>erosion</b> ; a break in a <b>stratigraphic</b> sequence.
<i>uplift</i>	upward movement of the <b>crust</b> due to <b>compression</b> , <b>subduction</b> , or mountain building. Uplift can also occur as a rebounding effect after the removal of an <b>ice sheet</b> reduces the amount of weight pressing on the crust.
<i>vanadium</i>	a metallic element (V) that occurs naturally in <b>fossil fuel</b> deposits as well as in a variety of different <b>minerals</b> . Vanadium is mainly used to produce specialty steel alloys.
<i>Vertisols</i>	a <b>soil order</b> ; these are <b>clayey soils</b> with a high moisture capacity. During dry periods, these soils shrink and develop wide cracks; during wet periods, they swell with moisture.
<i>vesicular</i>	porous or pitted with vesicles (cavities). Some <b>extrusive igneous rocks</b> have a vesicular texture.
<i>volcanic ash</i>	fine, unconsolidated <b>pyroclastic</b> grains under 2 millimeters (0.08 inches) in diameter. Consolidated ash becomes <b>tuff</b> .
<i>volcanic islands</i>	a string of islands created when molten rock rises upward through oceanic <b>crust</b> . Volcanic islands are common in several contexts, including at <b>subduction zones</b> between colliding oceanic <b>plates</b> , above oceanic <b>hot spots</b> , and along mid-ocean ridges.  At subduction zones, the friction between the plates generates enough <b>heat</b> and pressure to melt some of the crust. In the case of hot spots, islands form as <b>magma</b> from the mantle breaks through the sea floor.
<i>volcanic, volcanism</i>	the eruption of molten rock onto the surface of the <b>crust</b> . Most volcanic eruptions occur along tectonic <b>plate</b> boundaries, but may also occur at <b>hot spots</b> . Rocks that form from molten rock on the surface are also called volcanic.  Prior to eruption, <b>magma</b> ascends from the <b>mantle</b> to a relatively shallow (1–10 kilometers / 0.5–6 miles) magma chamber. Upward movement reduces the pressure on the magma until it is low enough to permit dissolved gas to exsolve (come out of solution and form bubbles). All eruptions are driven by the exsolution of dissolved gas. As the gas forms bubbles, it expands in volume and forces the magma out of the vent/chamber system onto the surface. The combination of magma viscosity and gas content can produce a range of eruptive styles, from gentle, effusive eruptions to violent explosions.
<i>water table</i>	the upper surface of groundwater, that is, the underground level at which groundwater is accessible.

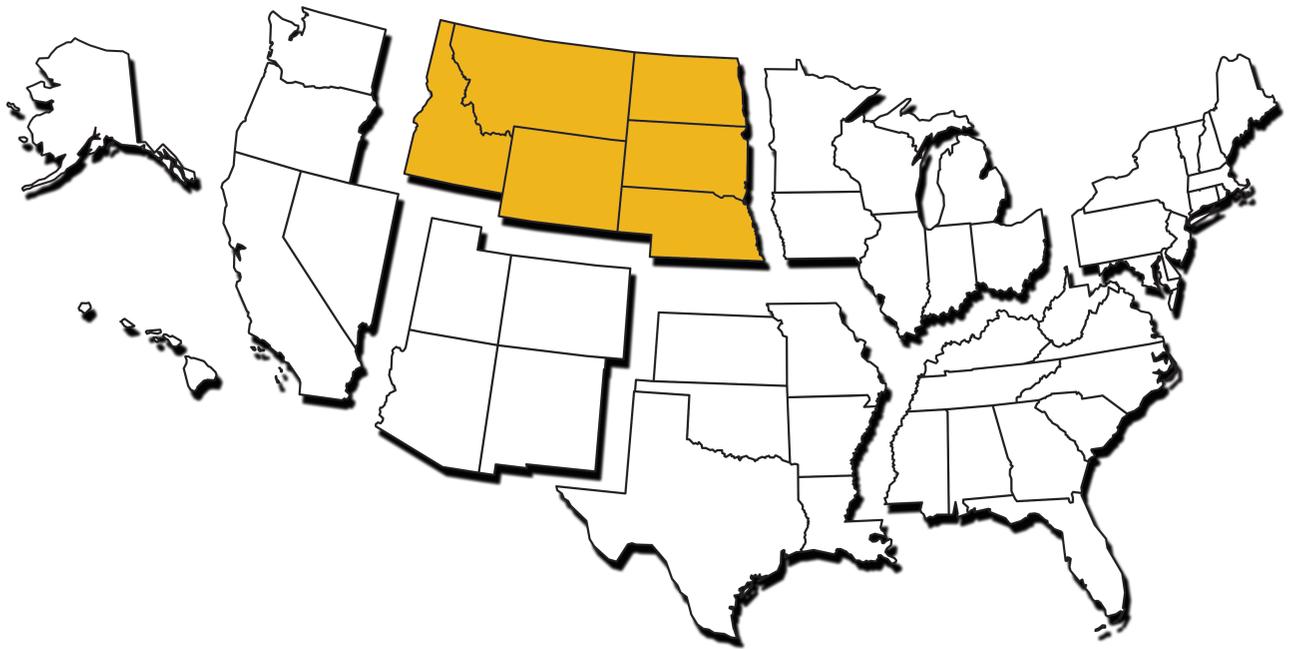
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## W–Z

<i>watershed</i>	an area of land from which all water under or on it drains to the same location.
<i>watt</i>	a unit of <b>power</b> measuring the rate of <b>energy</b> conversion or transfer designated by the International System of Units as one <b>joule</b> per second.
<i>weather</i>	the measure of short-term conditions of the <b>atmosphere</b> such as temperature, <b>wind</b> speed, and humidity. These conditions vary with the time of day, the season, and yearly or multi-year cycles.
<i>weathering</i>	<p>the breakdown of rocks by physical or chemical means. Rocks are constantly being worn down and broken apart into finer and finer grains by <b>wind</b>, rivers, wave action, freezing and thawing, and chemical breakdown.</p> <p>Over millions of years, weathering and <b>erosion</b> can reduce a mighty mountain range to low rolling hills. Some rocks wear down relatively quickly, while others can withstand the power of erosion for much longer. Softer, weaker rocks such as <b>shale</b> and poorly <b>cemented sandstone</b> and <b>limestone</b> are much more easily worn away than hard, crystalline <b>igneous</b> and <b>metamorphic rocks</b>, or well-cemented sandstone and limestone. Harder rocks are often left standing alone as ridges because surrounding softer, less resistant rocks were more quickly worn away.</p>
<i>wind</i>	the movement of air from areas of high pressure to areas of low pressure. The greater the temperature difference, the greater the air pressure difference and, consequently, the greater the speed at which the air will move.
<i>wind shear</i>	when <b>wind</b> speed and/or direction changes with increasing height in the atmosphere. Wind shear can happen when a <b>cold front</b> moves rapidly into an area with very warm air. There, the condensing water droplets mix with the cooler, drier air in the upper <b>atmosphere</b> to cause a downdraft.
<i>Wisconsinian glaciation</i>	the most recent interval of <b>glaciation</b> , which occurred during the Pleistocene, 85,000 to 11,000 years ago.
<i>zeolites</i>	<b>porous</b> aluminosilicate <b>minerals</b> , often formed some time after <b>sedimentary</b> layers have been deposited, or where <b>volcanic</b> rocks and ash react with alkaline groundwater. Zeolites are often used as catalysts and water softeners, and their microporous surface structure makes them useful in concentrating and condensing molecular substances.
<i>zinc</i>	a metallic chemical element (Zn). Zinc is typically used in metal alloys and galvanized steel.

The  
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**On the back cover:** Blended geologic and digital elevation map of the Northwest Central US. Each color represents the age of the bedrock at the surface. Adapted from Barton, K.E., Howell, D.G., Vigil, J.F., *The North America Tapestry of Time and Terrain*, US Geological Survey Geologic Investigations Series I-2781, <http://pubs.usgs.gov/imap/i2781>.