

# GLOSSARY OF TERMS RELEVANT TO THE GEOLOGIC HISTORY OF THE MIDDLESEX FELLS RESERVATION

Please note that all definitions given here are relative to geology. Some of the terms may have other meanings outside of this field.

**a (annum)** – "a" is used as an abbreviation for annum or years ago.

**abrasion** – erosion caused by the rubbing or grinding of rocks or sediment particles against each other.

**absolute age** – a numerical age or calendar date of a geologic feature or event known with complete accuracy from historical observations or other dating techniques that have essentially no uncertainty. This is exclusively associated with recent features and events. According to this definition not all numerical ages are absolute in that they have some uncertainty associated the precision and accuracy of the technique used to determine the age. (see numerical age)

**accretion, accreting** – the attachment of a land mass (island arc or microcontinent) to a larger continent at a subduction zone leading to an accreted terrane.

**acid test (for calcite)** – test for calcite in which a small drop of dilute hydrochloric acid (HCl) is placed on a rock or mineral to determine whether it reacts with the acid (fizzes or effervesces). Calcite will fizz.

**actinolite** – a mineral in the amphibole group that has the chemical formula:  $\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ . Actinolite is formed during hydrothermal and low-grade metamorphic alteration of mafic igneous rocks or iron-bearing sedimentary rocks.

**albite** – plagioclase feldspar that ranges from a pure sodium end member ( $\text{NaAlSi}_3\text{O}_8$  or Ab 100%) to 90% sodium and 10% calcium (Ab 90% or An 10%). (see also plagioclase)

**alkali feldspar** – feldspars that include microcline, orthoclase, and plagioclase with greater than 95% cations of sodium and potassium. Most of these feldspars are potassium-rich rather than sodium-rich.

**alkaline** - in the IUGS classification, a fine-grained igneous rock that is high in ( $\text{Na}_2\text{O} + \text{K}_2\text{O}$ ). (see subalkaline)

**alluvial fans** – stream deposits created by the net accumulation of sediment at the ends of confined valleys where they enter an open basin or valley floor of lower gradient.

**aluminosilicate** – minerals with a combination of aluminum, silicon, and oxygen forming their anions.

**amphibole** – a group of aluminosilicate minerals with a framework structure and a variety of cations. See hornblende, tremolite, and actinolite for chemical formulas.

**amygdaloidal, amygdules** – materials that have original gas or volatile bubbles filled in with mineral precipitates.

**andesine** – plagioclase feldspar that ranges in composition from Ab 30-50% or An 50-70% or 30-50% Na vs. 70-50% Ca. (see also plagioclase.)

**angular particles** – sediment grains or particles that have sharp corners and edges and have not been smoothed or rounded by transport.

**angular unconformity** – an unconformity that crosscuts dipping sedimentary or volcanic layers (ash or lava) below. It represents an erosion surface. (see unconformity, disconformity, and nonconformity.)

**anions** – negatively charged ions.

**annum** – years ago, see “a.”

**anorthite** – plagioclase feldspar that ranges from a pure calcium end member ( $\text{CaAl}_2\text{Si}_2\text{O}_8$  or An 100%) to 90% calcium and 10% sodium (An 90% or Ab 10%). (see also plagioclase.)

**anorthosite** – according to the IUGS classification, an igneous rock with greater than 90% plagioclase and less than 10% mafic minerals. This rock type is somewhat rare.

**anticline** – a fold in which layers in the center of the fold, or along the fold axis, are bowed upward relative to the limbs of the fold.

**antiperthite, antiperthitic texture** – thin platy streaks of potassium feldspar in albite (sodium plagioclase) formed by the solid-state exclusion of potassium feldspar from albite. (see also perthite.)

**apatite** – phosphate mineral with the formula:  $\text{Ca}_5(\text{PO}_4)_3(\text{F},\text{Cl},\text{OH})$ . Apatite commonly occurs as microscopic slender crystals in igneous rocks.

**aphanitic** – (see fine-grained.)

**argillite** – very hardened shale or mudstone that does not have any characteristics suggesting that it had been metamorphosed with the development of slaty cleavage, but it also does not break apart on bedding planes. This term is commonly used in the Boston area to describe hard mudstone. Unfortunately, this term has become somewhat loosely used as a substitute term for mudstone and shale even when they are not very hard and break apart on bedding planes. It is also sometimes used to describe some rock formations that have some cleavage development, in which case slate would be a better term.

**arkosic sandstone or conglomerate** – sandstone or conglomerate in which at least 25% of the particles are feldspar.

**ash (volcanic ash)** – ejecta (pyroclastic) particles less than 2 mm in diameter. (see lapilli, bombs, blocks.)

**assimilation** – the incorporation of another material into magma by melting and chemical reactions. This changes the magma’s composition.

**asymmetric ripples** – (see current ripples)

**asthenosphere** – a layer beneath the lithosphere and in the mantle that behaves as a soft, plastic material in which warmer (and less dense) materials can rise and cooler (more dense materials) can sink. This creates circulating convection cells that drive plate tectonics by moving lithospheric plates.

**atomic number** – the number of protons in the nucleus of an atom of a particular element.

**augite** – a pyroxene group mineral with the chemical formula:  $(Ca,Na)(Mg,Fe,Al)(SiAl)_2O_6$ . Augite is a common mineral in mafic igneous rocks.

**azimuth** – a compass bearing expressed as a clockwise angle away from geographic north. The true direction of something, See also trend.

**baking** – heating of country rock to high temperatures adjacent to a magma body.

**banding (in obsidian or felsite)** – layering, often folded, formed by mixing of magma during flow where there are slight compositional and color differences. Banding in pyroclastic deposits, such as welded tuff, is due to original ash layering that may be compressed and folded as the still molten and soft material compacts or begins to flow under its own weight before solidifying.

**basal ice** – debris-rich, non-bubbly ice at the base of a glacier that is formed by the freezing of meltwater to the base of the glacier.

**basaltic crust** - (see oceanic crust.)

**baseflow** – the flow of water out of a groundwater system to the base of a lake or stream.

**base map** – map used as a reference for plotting geologic features that provides location.

**bedding** – layering produced by the deposition of sediment.

**bedrock** – solid rock of Earth's crust.

**bedrock geologic map** – geologic map that shows a classification or characteristics of bedrock in a map area.

**biotite** – common mica group mineral that is black and has the chemical formula:  
 $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$ .

**blocks** – non-molten, solid ejecta pieces that are greater than 64 mm in diameter. (see bombs, lapilli, ash.)

**bombs** – molten ejecta pieces that are greater than 64 mm in diameter. (see blocks, lapilli, and ash.)

**breccia** – a conglomerate with angular clasts.

**brittle deformation** – the failure or breakage of a rigid rock along discrete surfaces without pervasive deformation of the rock. (see ductile deformation.)

**Brunton compass** – geologic compass that can be used to not only determine azimuth directions relative to geographic north but also has an inclinometer for determining the dip of features away from horizontal.

**bytownite** – plagioclase feldspar that ranges in composition from Ab 10-30% or An 70-90% with 10-30% sodium vs. 90-70% calcium. (see also plagioclase.)

**calcite** – the most common carbonate mineral that is the primary constituent of limestone and marble and has the formula:  $CaCO_3$ .

**carbonates** – group of minerals with the anion  $CO_3^{2-}$ .

**catastrophism** – a theory that Earth owes its existence and history to large (global), short-lived, catastrophic events. In the 1700's the large events responsible for Earth's history were thought to be due to divine intervention but were inconsistent with the laws of chemistry and physics. In modern times, we recognize that there may be global, short-lived events, but these catastrophic events that we recognize do not violate the laws of chemistry and physics.

**cations** – positively charged ions.

**cement** – chemical precipitates that glue particles together in the formation of sedimentary rocks.

**chemical formula** – formula used to show the chemical make-up of minerals and containing abbreviations for chemical elements and subscript numbers showing their ratios.

**chert** – a non-clastic sedimentary rock composed of chemically or biologically precipitated hydrated quartz.

**chill zone** – the edges of an igneous intrusion where the rock is finer-grained due to more rapid cooling.

**chlorides** – group of minerals with an anion or anions of just Cl<sup>-</sup>.

**chlorite** – green mica group mineral with the formula:  $(\text{Mg,Fe})_3(\text{Si,Al})_4\text{O}_{10}(\text{OH})_2 \cdot (\text{Mg,Fe})_3(\text{OH})_6$ . Chlorite is formed during low grade regional metamorphism and by hydrothermal alteration and may fill veins.

**clasts** – particles that are derived from the break down of other rocks and become particles in clastic sedimentary rocks.

**clastic sedimentary rocks** – sedimentary rocks formed by the deposition of particles eroded from other rocks.

**clay** – sedimentary particles with a diameter smaller than 0.002 mm or 2 microns.

**cleavage** – preferred breakage of a mineral on flat planes controlled by weaknesses in its crystalline structure.

**cleavage directions or planes** – directions within a mineral grain in which it will break with a flat surface.

**coal** - a non-clastic sedimentary rock made of decayed and de-volatilized plant material.

**coarse-grained or phaneritic** – a rock with grains that are visible and distinguishable with the naked eye. The term phaneritic is used to describe coarse igneous rocks.

**colluvium** – any deposit created by mass movement.

**color** – fundamental property of minerals determined by its appearance in the white light spectrum.

**co-magmatic** – with reference to igneous rocks, two rock types derived from separate magmas that intermingled with each other, implying that they were liquid at the same time, and did not mix (they were immiscible) but crystallized at the same time.

**compass** – instrument used to determine directions with reference to Earth's magnetic field. Compasses are adjusted to read relative to geographic or true north.

**compound** – a substance that can be described with a consistent chemical formula and is composed of positively charged ions (cations) bound to negatively charged ions (anions) such that there is a charge balance.

**conchoidal fracture** – breakage of a mineral along curved surfaces.

**coniferous forest** – a forest dominated by coned or conifer (often called softwood) trees.

**contact lines, contacts** – the boundaries or lines separating different geologic units on a geologic map.

**contact metamorphism** – metamorphism of rocks due to heating next to a magma body.

**continental arc** - (see continental-margin subduction zone)

**continental (granitic or sialic) crust** – the outer compositional layer of Earth beneath the continents that is closely approximated in composition by the igneous rock granite and has a density of about 2.7 g/cc. (see crust and oceanic crust.)

**continental drift** – a theory proposed by Alfred Wegener that the current continents had once been together as larger continent and split apart from each other to move to their present positions.

**continental-margin subduction zone** – a convergent plate boundary (or subduction zone) along the edge of a continent where a plate with oceanic crust descends (or is subducted) beneath the plate with continental crust. Also called a continental arc.

**continuity** – a fundamental principle that says that sedimentary units found truncated at Earth's surface, for example at cliff faces, originally extended in all directions until they thinned to nothing or reached the edges of their depositional basin.

**convection** – movement due to density differences created by differences in temperature. Warm, less dense material rises relative to cooler, denser materials, which sink, setting up a circulation system. This type of circulation occurs in the asthenosphere.

**convergent plate boundary** – a lithospheric plate boundary, also called a subduction zone, where plates are moving toward each other, and one plate descends (or is subducted) beneath the other. (see also ocean-ocean subduction zone and continental-margin subduction zone.)

**core (sample)** – a cylindrical sample of rock or surficial materials obtained by drilling.

**core (Earth layer)** – the central spherical part of the Earth at a depth of 2900-6370 km. The outer core down to 5100 km is a liquid while the inner core beneath this is solid. The core is made of an iron-nickel alloy with a density of 10.7 g/cc.

**corestones** – areas of not yet weathered, rounded solid rock within weathered material. Corestones have been isolated by weathering that penetrated downward and into the rock along fractures.

**corrosion** – alteration of an existing mineral by later chemical reactions in a magma or due to attack by hydrothermal (hot water) fluids. This will give the earlier mineral a different composition and a dirty or altered appearance.

**country rock** – pre-existing rocks that are intruded by a magma.

**crevasses** – open surface cracks on a glacier. Crevasses can widen if they are in an area where the glacier surface is melting. They may also fill with snow.

**cross section** – a view of subsurface geology on a vertical panel or slice along a transect on a geologic map or Earth's surface. Used in conjunction with a geologic map it depicts the subsurface geology of an area.

**crossbeds** – sedimentary layers deposited on the down flow sides of ripples, sand and gravel bars in rivers, or on the downwind sides of eolian sand dunes that dip at an angle of up to 30° in a downflow direction. Crossbeds in horizontal beds dip downward from the upper surface of the bed to the bottom of a bed.

**crosscutting** – a fundamental principle that says that any feature such as a fault, intrusion, or erosion surface that interrupts once continuous features must be younger than the things it interrupts or crosscuts.

**crust** – the outer compositional layer of the Earth. (see continental and oceanic crust.)

**crystals, crystalline (in chemistry)** – Material with a crystalline structure in which there is a regularly repeated arrangement of atoms. Minerals are crystalline materials.

**crystals (in pyroclastic rocks or ejecta)** – single mineral grains that are blown into the air and become a part of ejecta, ejecta deposits, or pyroclastic rocks. These are grains that formed in the magma before an eruption.

**crystal form** – the shape a mineral takes when allowed to grow or crystallize into an open space. The shape of a crystal when its growth is unimpeded.

**crystalline structure** – regularly repeated arrangement of atoms in the molecular structure of a mineral.

**current (asymmetric) ripples** – ripples that are asymmetric in cross section and formed by the unidirectional movement of a fluid, either air (eolian ripples) or water.

**daughter isotope** – an isotope that is the product of a radioactive decay reaction.

**deciduous forest** – a forest dominated by broad-leaved or deciduous (hardwood) trees that lose their leaves during the winter.

**derivation** – a fundamental principle that says that the particles, grains, or clasts that make up a sedimentary rock unit must come from older rock units or were created before the sediment was deposited.

**devitrification** – the solid-state crystallization of glass to a microcrystalline material. In the case of obsidian, microcrystalline quartz and feldspar are formed below the crystallization temperature of these minerals.

**dextral strike-slip fault** – (see right-lateral strike-slip fault)

**diamictite** – a poorly sorted conglomerate or conglomerate with a muddy matrix.

**digital elevation model (DEM)** – the portrayal of the land surface by the computer processing of land surface elevation data that is collected on a grid.

**dike** – a tabular igneous rock body formed by the intrusion of magma into a fracture or crack. The British spelling is “dyke”.

**diopside** – a pyroxene group mineral with the chemical formula:  $\text{CaMg}(\text{Si}_2\text{O}_6)$ .

**dip** – the angle and its direction that a plane is inclined versus a horizontal plane.

**dip-slip faults** – faults in which there is vertical displacement of rocks on opposite sides of the fault.

**diorite** – according to the IUGS classification, an igneous rock with more than 10% mafic minerals plus plagioclase that is richer in sodium than calcium.

**discharge** – the flow of water out of the groundwater system to Earth's surface.

**disconformity** – an unconformity that is overlain by bedded units that have the same orientation as bedded units below the unconformity. When deposition resumed following the development of the unconformity, layers were deposited with the same bedding orientation as prior to the development of the unconformity. It represents either an erosion surface or period of non-deposition. (see unconformity, angular unconformity, nonconformity.)

**divergent plate boundary** – a boundary between lithospheric plates where the plates are moving away from each other. This may occur as continents split apart at rift valleys or in the ocean basins at mid-ocean ridges.

**dolomite** – a carbonate mineral with the composition:  $\text{CaMg}(\text{CO}_3)_2$ . (see dolostone.)

**Dolostone (usually called dolomite)** – a non-clastic sedimentary rock made of mostly the mineral dolomite. It almost exclusively forms from the alteration of limestone by the replacement of calcium with magnesium. This rock type is also often called dolomite.

**drumlin** – an elongate, streamlined deposit of till deposited at the base of a moving glacier. It takes the form of a streamlined hill that has a long dimension parallel to the direction of ice flow.

**ductile deformation** – the deformation of a rock involving a shape change through the whole material that induces permanent stretching and flattening much like the slow deformation of silly putty. (see brittle deformation.)

**Earth science (geology)** – the science that studies Earth's formation and history including modern processes of Earth's interior, surface, and oceans and their formation and history.

**earthquake** – the sudden displacement of rocks on a fault where stress has built up over time and with failure on the fault elastic energy is released that cause shock waves to pass through the ground.

**earthy** – a mineral luster that has a very fine-grained, opaque, drab appearance with no reflectivity.

**ejecta** – material that becomes airborne during a volcanic eruption.

**ejecta deposit** – deposit of airborne material from a volcanic eruption. (see pyroclastic rocks.)

**electrons** – negatively charged sub-atomic particles that orbit the nucleus of an atom.

**element** – a type of atom with a specific number of protons in its nucleus.

**end moraine** – a deposit of non-stratified sediment accumulated at the margin of a glacier.

**eon** – in the hierarchy of geologic time the longest type of time division.

**epidote** – a calcium-rich, yellow, olive or pistachio-green aluminosilicate mineral with the formula:  $\text{Ca}_2(\text{Al,Fe})_2\text{Al}_2\text{O}(\text{SiO}_4)(\text{Si}_2\text{O}_7)(\text{OH})$ . Epidote is formed as an alteration product during hydrothermal metamorphism of felsic and mafic igneous rocks and is a common vein mineral.

**epochs** – units of time that are subdivisions of periods.

**eras** – units of time that are subdivisions of eons.

**erosion** – the removal of weathered material and surficial deposits at Earth's surface by water, wind, glacier flow, or mass movement.

**erosion surface** – a surface cut into rocks by erosion or a land surface owing its shape to erosion.

**eskers** – stratified (meltwater-deposited) glacial deposits created by the deposition of sand and gravel in a tunnel at the base of a glacier.

**euhedral grains or crystals** – grains or crystals in a rock that have well preserved flat crystal faces.

**evaporites** – non-clastic sedimentary rocks or minerals left by the evaporation of water in the ocean or a lake. Commonly this is salt (halite) and gypsum, and less commonly calcite and dolomite.

**extinction** – the disappearance of an organism from the fossil record or the dying out of an organism.

**extrusive (or volcanic) igneous rocks** – igneous rocks formed by magma emerging from Earth's subsurface in the form of lava or ejecta, and then cooling and solidifying in air or water.

**facet (glacial)** a flat surface on a rock that was formed by glacial abrasion.

**fault** - a fracture or fracture zone in rocks along which there is displacement of rocks on opposite sides.

**fault zone** – a zone within which displacement of two adjacent bodies of rock occurs.

**feldspar** – a group of aluminosilicate minerals that are the most common minerals at Earth's surface. They have sodium, calcium, and potassium as their cations. See plagioclase, microcline, and orthoclase for chemical formulas.

**feldspathoids** – minerals, most commonly leucite and nepheline, that form in felsic igneous rocks with a low abundance of silicon as compared to most light-colored igneous rocks.

**felsic rocks and minerals** – light-colored igneous minerals and rocks, usually dominated by feldspar and quartz.

**fiammé** - (see flattened pumice)

**field book** – weatherproof notebook used by geologists in the field to record outcrop or other data.

**fine-grained or aphanitic** – a rock with grains that are not distinguishable or identifiable with the naked eye. The term aphanitic is used for igneous rocks.

**flattened pumice** – pieces of pumice that were still hot and soft when deposited such that they collapsed or were flattened under the weight of accumulating material above.

**float** – loose rock fragments at the land surface detached from local bedrock units.



**flow (of lava)** – out pouring of magma at Earth's surface that then spreads as a liquid across the land surface.

**footwall** - the rock surface that is below a fault.

**fossils** – evidence of ancient life forms preserved in sedimentary rocks. They take the form of preserved parts or body impressions of organisms. They can also be their tracks, trails, and burrows, also known as trace fossils.

**formation** – in a geologic context it is the fundamental subdivision of rocks on geologic maps based on similar properties and age and traceability across the land surface.

**fossils** – features left by organisms including body parts or impressions of their bodies or tracks and trails.

**fracture** – any crack that forms in a rock or mineral.

**fragments (in ejecta)** – pieces of older rock formations or deposits that are incorporated into erupting magma from either non-volcanic or volcanic sources and become a part of ejecta, ejecta deposits, and pyroclastic rocks.

**freeze-thaw processes** – processes of weathering, erosion, and mass movement resulting from the freezing of water and thawing of ice.

**fundamental principles** – a set of rules established by Nicholas Steno in the 1600's and in the late 1700's by James Hutton that govern the formation of rocks and other geologic features and their relative ages.

**Ga (giga-annum)** – billions of years ago.

**gabbro** – according to the IUGS classification, an igneous rock with more than 10% mafic minerals plus plagioclase that is richer in calcium than sodium.

**garnet** – a very hard aluminosilicate mineral of varying composition and color and the general chemical formula:  $(\text{Mg,Fe,Ca,Mn})_3\text{Al}_2\text{Si}_3\text{O}_{12}$ . Substitutions by many cations and for aluminum cause many different colors. Garnet crystals are 12-sided (dodecahedrons).

**Geographic Information System (GIS)** – a computer mapping system that allows the placement of data on a map as well as the recording of data associated with points, lines, and polygons that map up the map data. See [GIS](#).

**Geographic (or true) North** – the direction from any place on Earth's surface to the geographic north pole or 90° north latitude or the point on Earth in the northern hemisphere where the rotational axis cuts through Earth's surface.

**geologic map** – any map depicting or classifying any aspect of the geology of an area.

**geologic time scale** – the subdivision of geologic time according to named units.

**geology** – the study of Earth's processes, formation, and history.

**geomagnetic declination** – at any place on Earth's surface it is the angle between geographic north and the direction of the geomagnetic field at that place.

**geomagnetic field** – Earth's magnetic field

**geomagnetic north** – the direction to which a compass needle points at any given place north of the magnetic equator on Earth’s surface.

**geomagnetic north pole** –the north pole of the geomagnetic field.

**geophysical** – having to do with the physical properties of Earth.

**geyser** – an eruption of boiling hydrothermal water from the subsurface in the form of a fountain.

**giga-annum** – billions of years ago, see Ga.

**GIS (Geographic Information System)** – a computer program capable of displaying and interpreting map data including points, lines, and shapes (polygons) as well as raster images. In geology it is used for making geologic maps by allowing the posting of map data collected in any geographic coordinate system on a coordinated base map. This data is then displayed in a map projection. The system also keeps track of information related to each piece of map data, also called its attributes. This data can then be analyzed spatially and displayed in a way that makes the information more understandable.

**glacial deposits** – sedimentary deposits created by direct deposition of sediment by a glacier (non-stratified deposits) or transport and deposition by meltwater from a glacier (stratified deposits).

**glacial erratics** – rocks that are glacially transported to a place where they are not like the underlying bedrock. In the Fells, glacially transported rocks and erratics are common.

**glacial meltwater** – water released from a glacial system by the melting of snow and ice on a glacier. Glacial meltwater is often augmented by runoff from adjacent landscapes.

**glacial pavement** – a large rock surface that has been smoothed by glacial abrasion and is covered with glacial striations and polish.

**glacial polish** – highly polished glacially abraded rock surface created by the grinding action of fine sediment (fine silt) at the base of the glacier.

**glaciations or glacials** - (see ice ages.)

**gneiss** - a metamorphic rock that displays banding formed by the segregation of non-micaceous minerals into layers because of the recrystallization and deformation.

**gneissic banding (metamorphic banding)** – the segregation of different non-micaceous minerals into layers forming a metamorphic foliation due to recrystallization and deformation during metamorphism.

**GPS (Global Positioning System) device** – a device that gives the location or coordinates of a place on Earth’s surface based on signals from satellites. GPS systems are satellite networks that are used to triangulate the exact position or coordinates of a location on Earth’s surface.

**grains** – particles, either minerals or other materials that make up a rock.

**grain size** – the size of mineral grains recorded by their diameter, usually in centimeters, millimeters, or microns.

**granitic crust** - (see continental crust.)

**gravel** – sedimentary particles greater than 2 mm in diameter.

**groundmass** – material that surrounds the coarse crystals or phenocrysts in a porphyritic igneous rock.

**groundwater** – water beneath the water table in the saturated zone where all pore spaces are filled with water. Water above the water table is technically known as soil moisture. Water in the groundwater system has a water pressure in addition to atmospheric pressure.

**group** – a rock unit that is a grouping of rock formations.

**grus** – granular material produced by the separation of mineral grains during weathering of coarse-grained igneous rock.

**gypsum** – a non-clastic sedimentary rock or mineral made of hydrated calcium sulfate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ).

**half-life** – the time it takes for half of a radioactive isotope in a sample to decay to a daughter isotope.

**halite** – naturally occurring sodium chloride ( $\text{NaCl}$ ) with a cubic crystal structure.

**hand lens** – a small diameter handheld magnifying lens or loupe.

**hand samples** – rock samples collected in the field for macroscopic mineral identification or that later may be cut for making slabs or thin sections.

**hardness** – the resistance of a material to abrasion or scratching.

**headwall** - the rock surface that is above a fault.

**hematite** – an iron oxide mineral with the chemical formula:  $\text{Fe}_2\text{O}_3$ . Hematite produces the red cement in sedimentary rocks. Hematite can appear as a bluish-gray metallic mineral if crystals are a visible size or as an earthy red very fine-grained material. Hematite has a reddish-brown streak color.

**horizontal** – (see original horizontality)

**hornblende** – a common amphibole group mineral with the chemical formula:  $(\text{CaNa})_{2-3}(\text{Mg}, \text{Fe}^{+2}, \text{Al})_5\text{Si}_6(\text{Al}, \text{Si})_2\text{O}_{22}(\text{OH})_2$ . Hornblende is usually black with cleavages at  $56^\circ$  and  $124^\circ$ .

**hornfels** – rock formed by contact metamorphism or baking of fine-grained or clay-bearing rocks to a hard and brittle consistency. When clay is involved, the rock will be like a ceramic material.

**host rock** – rocks that are intruded by igneous rock or house an intrusion or other separate mineral deposit. Same as country rock.

**hot spot** – a place in the middle of a plate where rising heat in the mantle (mantle plume) causes the generation of magmas that rise to Earth's surface and produce volcanic eruptions. As the plate moves across the hot spot a string of volcanoes is produced.

**hydrothermal** – having to do with hot water solutions.

**hydroxide** - group of compounds or minerals that have hydroxyl ( $\text{OH}^-$ ) as their anions.

**hypersthene** – a pyroxene group mineral with the chemical formula:  $(\text{Mg}, \text{Fe})\text{SiO}_3$ .

**ice ages, glaciations, or glacials** – periods of cooler climate favorable to the growth of glaciers.

**ice-contact delta** – a body of stratified (meltwater-deposited) sand and gravel accumulating in a lake at the margin of (in contact with) a glacier.

**ice sheets** – large continent-sized glaciers that flow radially outward from their centers.

**igneous rocks** – rocks formed from the cooling of magma or molten rock.

**ilmenite** – a gray to black metallic oxide mineral with the chemical formula:  $\text{FeTiO}_3$ .

**inclinator** – device used to determine the dip or plunge angle of an object. These devices are a part of Brunton compasses.

**inclusion (or xenolith)** – pieces of an older rock formation incorporated into a magma and trapped when the magma solidifies.

**inclusion (principle of)** – a fundamental principle that states that pieces of rock incorporated into a magma and that later become trapped in an igneous rock (inclusions) must be from a rock unit older than the magma and the rock it produces.

**infiltration** – the seepage of water into the unsaturated zone at the land surface.

**ions** – atoms or groups of atoms that have a net charge.

**insolation** – the amount of sunlight received at Earth's surface.

**Interglacials, interglaciations** – periods of warmer climate (like today) when ice sheets in North America and northern Europe had a reduced size.

**interlocking crystals** – texture in a rock in which some crystals surrounded parts of other crystals during mineral growth. This texture dominates igneous rocks. See also non-interlocking texture.

**intrusion** – a body of igneous rock that formed due to magma squeezing into (or intruding) other rocks (host rocks). They include dikes, sills, and plutons.

**intrusion (principle of)** – a fundamental principle that says that intrusive igneous rocks are always younger than the rock that they intrude.

**intrusive or plutonic igneous rocks** – igneous rocks that form due to magma squeezing into other rocks and cooling in the subsurface.

**ions** – atoms or groups of bound atoms that carry a charge.

**island-arc subduction zone or island-arc** - (see ocean-ocean subduction zone)

**isotope** – varieties of atoms of an element that have different numbers of neutrons in their nucleus.

**isotopic or radiometric decay** – the spontaneous change of one isotope to an isotope of another element.

**IUGS** – International Union of Geological Sciences

**IUGS classification of igneous rocks** – a classification of igneous rocks according to four end member types of felsic minerals: quartz, plagioclase, alkali feldspar, and feldspathoids.

**joints** – extensive fractures that form in a rock unit due to stresses applied to the rock or differential cooling and contraction.

**ka (kilo-annum)** – thousands of years ago.

**kilo-annum** – thousands of years ago, ka.

**labrodorite** – plagioclase feldspar that ranges in composition from Ab 30-50% or An 50-70% or 30-50% sodium and 50-70% calcium. (see also plagioclase.)

**lamellae** – thin platey layers within a rock.

**lapilli** – volcanic ejecta particles that are 2-64 mm in diameter.

**lava, lava flows** – magma that escapes from the subsurface, flows as a liquid, and then hardens on Earth's surface.

**lava lake** – lava that pools in a valley (forming a lake) as it is extruded from below. This happens with basaltic magmas.

**LeBas classification** – an alternative to the IUGS classification of fine-grained igneous rocks that relies on chemical compositions instead of mineral percentages. This graphical classification relies on a graph that has axes of weight % (Na<sub>2</sub>O + K<sub>2</sub>O) vs. weight % SiO<sub>2</sub>.

**left lateral (sinistral) strike-slip fault** – a fault separating two areas being displaced horizontally in opposite directions such that when looking across the fault the area on the opposite side is moving to the left.

**lichens** – symbiotic growths of algae and fungus that commonly appear on rock surfaces and the damp (non-sunny) sides of trees.

**LiDAR (Light Detection and Ranging)** – active remote sensing technique used to map the shape of the land surface by beaming laser pulses and observing their return to a detector. It provides a way of precisely determining land surface shape. The data measured can be computer processed to create imagery such as an interpreted contour map or a detailed shaded relief image of the land surface.

**limestone** – a non-clastic sedimentary rock dominantly made of calcite.

**limonite** – a common iron oxide/hydroxide mineral with the chemical formula: FeO·OH·nH<sub>2</sub>O.

**lineation** – any feature in a rock that has a linear shape or pattern.

**lithic fragments (in pyroclastic rocks)** – solid rock fragments that are a part of the airborne material (ejecta) of a volcanic eruption. They can be pieces of volcanic rock from earlier eruptions or pieces of rock from any rock formation through which magma passed on its way to the surface.

**lithic sandstone or conglomerate** – a sandstone or conglomerate in which most of the particles are rock fragments that each have multiple mineral grains.

**lithification** – the processes of compaction, dewatering, and cementation that are responsible for hardening sediment and turn it into sedimentary rock.

**lithosphere** – the outer part of Earth including the crust and upper most mantle that behaves as a rigid solid and is made of separate plates.

**lithospheric plates** – sections of the lithosphere that move relative to each other and are driven by convection in the asthenosphere below.

**luster** – the external appearance of a rock that describes its transparency and reflectance.

**Ma (mega-annum)** – millions of years ago.

**mafic igneous rocks and minerals** – igneous rocks that have a dark color due to the presence of dark, iron-bearing minerals and a reduced percentage of silicon and aluminum.

**magma** – molten rock in the subsurface. It becomes lava when it arrives at the surface.

**magnetite** – an iron oxide mineral that is naturally magnetic and has the chemical formula:  $\text{Fe}_3\text{O}_4$ .

**mantle** – an interior layer of Earth beneath the crust down to a depth of 2900 km where it rests on the core. It is composed of iron and magnesium silicates and oxides and has a density of about 4.5 g/cc.

**mantle plume** – a location in the mantle where there is rising heat and mantle material that can trigger a spot occurrence of volcanism in the plate above. (see also hot spot.)

**mass movement** – down slope movement or erosion of material under the influence of gravity that does not involve transport by a fluid or ice.

**mass number** – the number of protons plus neutrons in the nucleus of a given isotope.

**matrix** – the fine particles that surround the largest particles in a poorly sorted conglomerate or coarse sandstone.

**mega-annum** – millions of years ago, see Ma.

**meltwater channels** – channels carved into the land surface by glacial meltwater either along the edge (margin) of a glacier (ice-marginal) or heading away from a glacier.

**member** – a traceable sub-division of rock within a formation based on readily identifiable rock types.

**metallic** – a mineral luster with a high surface reflectance, i.e. the reflectance of a piece of polished metal.

**metamorphic banding** - (see gneissic banding)

**metamorphic grade** – the degree of metamorphism a rock has experienced as depicted by the minerals in the rock that indicate certain temperature and pressure thresholds.

**metamorphic rock** – any rock that has had its mineralogy or texture altered by later changes in heat and pressure.

**metamorphism** – alteration of a rock's mineralogy or texture by later changes in temperature or pressure.

**mica** – a group of plate-like aluminosilicate minerals. See biotite, muscovite, and chlorite for formulas. All these minerals have a well-developed cleavage that allows it to break into flakes.

**micaceous** – containing or having to do with the mineral mica or having abundant mica.

**microcline** – potassium-rich feldspar usually formed at lower temperatures than other potassium feldspars and often exhibiting a pinkish to salmon red color. It has the chemical formula:  $\text{KAlSi}_3\text{O}_8$  and is formed almost exclusively in plutonic felsic igneous rocks.

**micro-continents** – small, isolated land masses by modern continent standards. In the past these small continents have moved toward subduction zones and have become attached or accreted to larger continents.

**mid-ocean ridge (abbreviated MOR)** – a plate boundary in the middle of the ocean where two plates are diverging from each other and that generates oceanic crust.

**mineral** – a naturally occurring, inorganic solid with a crystalline structure and a composition that can be written as a well-defined chemical formula. Each mineral has a unique set of properties.

**Moho (short for Mohorovičić Discontinuity)** – the boundary between the crust and the mantle below.

**molecule** – a group of elements and their ratios that define the simplest expression or unit of a chemical compound.

**mudcracks** – polygonal cracks formed by the desiccation (drying) of muddy sediment as may occur in a drying puddle. Drying of mud causes it to contract and crack. They are commonly found as sedimentary structures in modern environments as well as preserved in sedimentary rocks where sediment had a chance to dry before being buried by later sediment.

**muscovite** – a mica group mineral that has a transparent or white appearance and the chemical formula:  $\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ .

**natural glass** – an igneous rock formed when magma cools too quickly to crystallize and forms a non-crystalline material. (see also obsidian.)

**neutrons** – sub-atomic particles that have no charge and occur in the nucleus of an atom.

**non-clastic sedimentary rock** – sedimentary rock formed by biological or chemical accumulation or precipitation.

**nonconformity** – an unconformity that overlies an intrusive igneous or metamorphic rock unit. It represents an erosion surface. (see unconformity, angular unconformity, and disconformity.)

**non-interlocking texture** – texture that occurs in clastic sedimentary rocks in which particles or grains touch each other but do not enclose each other or interlock.

**non-stratified (glacial deposits)** – deposits that are non-bedded or have very indistinct layering and are non-sorted due to deposition directly by a glacier or associated ice-marginal mass movement. These deposits are not transported and deposited by water or in water, which will sort them and provide bedding.

**non-welded tuff** – tuff that accumulated as ash and other ejecta that was all solid at the time of deposition so that the particles could not adhere to each other.

**normal fault** – a dip-slip fault with displacement such that the headwall (surface above the fault) moves down the fault plane relative to the footwall (surface below the fault).

**normalization** – the re-calculation of the percentages of a few components to the total of just that group of components.

**nucleus (of an atom)** – the central core of an atom that is composed of protons and neutrons.

**numerical ages** – the ages of geologic features or events expressed in terms of a particular year or years in the past. These ages are estimated based on laboratory techniques and are reported with a (+/-) precision value. As a result they are not known as absolute ages that are known with complete accuracy or sub-annual precision.

**obsidian** – a natural glass formed by hardening of a silicic magma to form a non-crystalline rock. (see volcanic glass.)

**oceanic (basaltic) crust** – the outer compositional layer of the Earth beneath the oceans that has a composition closely approximated by basalt and has a density of 3.0 g/cc. (see crust and continental crust.)

**ocean-ocean subduction zone** – a convergent lithospheric plate boundary where two plates with ocean crust move towards each other (converge) and one of the plates descends beneath the other. Also called an island-arc subduction zone because of the string of volcanoes that results from rising magma from beneath the overriding plate.

**ocean trench** – a deep elongate valley on the ocean floor that marks the position where one plate descends (or is subducted) beneath another along a convergent plate boundary.

**oligoclase** – plagioclase feldspar that ranges in composition from Ab 70-90% or An 10-30% or 70-90% sodium and 30-10% calcium as cations. (see also plagioclase.)

**olivine** – an olive-green glassy appearing silicate mineral with the chemical formula:  $(\text{MgFe})_2\text{SiO}_4$ . Olivine commonly occurs in basalt.

**opaque** – any material that will not transmit light.

**ophiolites** – sequences of rock that represent sections of ancient oceanic crust thrust up onto the land surface.

**original horizontality** – a fundamental principle that states that sedimentary layers, with few exceptions, are laid down as nearly horizontal units. Exceptions are crossbeds and mass movement deposits. If sedimentary units are found with inclined bedding or layers, it means that they were tilted at some time after deposition.

**orthoclase** – a creamy white to pink or salmon-colored alkali (potassium-rich) feldspar that usually forms at intermediate temperatures with the chemical formula:  $\text{KAlSi}_3\text{O}_8$ . It is common in silicic plutonic rocks but can also occur in silicic volcanic rocks and dikes. It is a major constituent of arkosic sandstones and conglomerates.

**oscillatory ripples** – (see wave ripples)

**outcrops** – undisturbed (not eroded or reworked) exposures of bedrock or other geologic materials at Earth's surface.

**outwash** – sometimes used as a general name for sediment washed out from beneath a glacier by glacial meltwater, but also used as a more specific name for sediment deposited in river systems fed by meltwater at and beyond the front of a glacier.



**oxide** – a group of minerals that have just oxygen as their anion.

**paleomagnetism** – the study of ancient magnetism fixed in rocks and sediments at the time they were formed.

**parent isotope** – the starting unstable isotope in a radiometric decay reaction.

**pegmatite** – a very coarse-grained igneous rock. Grains are at least 2 cm in diameter.

**periglacial** - a landscape or climate beyond the limits of glaciers (not being glaciated) but dominated by cold climate processes. It may or may not have permafrost.

**periods** – units of time that are subdivisions of eras.

**permafrost** – areas in cold climate regions where portions of the subsurface remain frozen through the entire year.

**permeability** – the property of a material which is the ease with which water passes through the material.

**perthite, perthitic texture** – thin platy streaks of albite in potassium feldspar formed by the solid-state exclusion of sodium feldspar (albite) from potassium feldspar. (see also antiperthite.)

**petrographic (or polarizing) microscope** – a microscope that takes advantage of polarized light to look at crystalline materials and is used by geologists to study thin sections of rocks.

**petrologists** – scientists that study the formation of rocks. Includes sedimentary, igneous, and metamorphic petrologists. Note: this has nothing to do with petroleum.

**phaneritic** – see coarse-grained.

**phenocrysts** – isolated coarser crystals surrounded by the finer groundmass in a porphyritic rock. (see groundmass and porphyry.)

**phosphate** – a group of minerals with anions composed of phosphorus and oxygen.

**pillow basalt** – subaqueous eruption of basaltic lava in which lava is extruded in the form of a billowing form (pillow) that forms a crust that later splits to allow another pillow mass to extrude.

**plagioclase** – a type of feldspar dominated by sodium and calcium anions and having a chemical formula ranging from:  $\text{NaAlSi}_3\text{O}_8$  to  $\text{CaAl}_2\text{Si}_2\text{O}_8$ . Individual names are given to different compositional ranges of plagioclase according to the percentages of end members (Ab for albite:  $\text{NaAlSi}_3\text{O}_8$  or An for anorthite:  $\text{CaAl}_2\text{Si}_2\text{O}_8$ ) in this sequence.

**plate tectonics** - the system of moving lithospheric pieces (plates) driven by convection in the asthenosphere that causes earthquakes, volcanic activity, and mountain building.

**plucking (or quarrying)** - a form of glacial erosion in which rocks are pulled from the bedrock surface.

**plunge or plunge angle** – the dip of a lineation. Plunge direction is the direction in which a lineation dips or plunges away from horizontal.

**plunge direction** – direction in which a lineation or linear feature dips downward.

**pluton** – a large intrusive igneous rock body. (see also dike)

**plutonic breccia** – an intrusive or plutonic igneous rock with many angular inclusions in it.

**plutonic rocks** - (see intrusive rocks.)

**point count** – analysis of percentages of minerals of various types in a rock slab or thin section through the identification and counting of minerals that occur on a fixed grid. This is used to gage the overall mineral composition of a rock and the exact rock type.

**porphyritic texture** – a texture in igneous rocks in which coarser crystals (phenocrysts) are surrounded by a groundmass of either finer crystals or glass.

**porphyry** – an igneous rock with a porphyritic texture.

**potassic** - in the IUGS classification, a fine-grained igneous rock in which potassium dominates over sodium. (see also sodic.)

**potassium feldspar** - (see alkali feldspar.)

**protolith** –the original rock type that was metamorphosed to produce a metamorphic rock.

**protons** – positively charged subatomic particles in the nucleus of an atom.

**pumice** – highly vesicular silicic glass that has a light density from the large number of air bubbles in it. In some cases, pumice will float because of its low density. (see also flattened pumice fragments)

**pyrite** – a common iron sulfide mineral, also informally called “fool’s gold”, with the chemical formula:  $\text{Fe}_2\text{S}$ .

**pyroclastic rocks** – volcanic rock formed from ejecta deposits.

**pyroxene** – a common chain silicate mineral group that can have a variety of cations and with the general chemical formula:  $\text{XY}(\text{Si},\text{Al})_2\text{O}_6$ , where X is most commonly Na, Ca,  $\text{Fe}^{2+}$ , or Mg, and Y is commonly  $\text{Fe}^{3+}$ , Mg or Ca.

**quartz** – a common, and very hard, silicate mineral that has the chemical formula:  $\text{SiO}_2$ . A major constituent of most felsic and silicic igneous rocks.

**quenching of magma** – extremely fast cooling of magma to form glass.

**radioactivity** – the spontaneous decay of radioactive isotopes.

**radiometric decay** - (see isotopic decay and radioactivity.)

**raindrop imprints** – small crater-like depressions left by falling raindrops on a sticky muddy sediment surface. These features are often preserved with mudcracks.

**rattail** – an erosional feature formed by the sliding of glacial ice across a rock surface of differential resistance such that resistant areas of the rock (the rat) are left standing higher and protect material down ice behind it in the form of a raised ridge parallel to ice flow (the tail).

**recharge** – the addition of water to the groundwater system. This usually occurs when soil moisture that has infiltrated into the unsaturated zone seeps down to the water table.

**regional metamorphism** – metamorphism of rocks due to exposure to heat and pressure over an area on the scale of mountain ranges. Large areas of compression like this are formed at convergent plate boundaries.

**relative age** – the age of a geologic feature or event with respect to the age of another geologic feature or event. It answers the question: Is it older than or younger than some other feature or event.

**resorbed** – (see resorption.)

**resorption** – process in which a mineral grain is taken back into a magma or solution after its initial crystallization. It is resorbed. This will leave it with rounded edges and holes.

**retrograde metamorphism** – metamorphism resulting from a decrease in temperature or pressure that partly reverses the grade of a rock's initial metamorphism.

**reverse fault** – a dip-slip fault with displacement such that the footwall (above the fault surface) moves up the fault plane on the footwall (below the fault surface). (see normal fault and thrust fault.)

**rheological properties** – properties related to the mechanical characteristics of a material such as hardness, rigidity, or plasticity.

**riebeckite** – a mineral in the amphibole group that has the chemical formula:  $\text{Na}_2\text{Fe}^{2+}_3\text{Fe}^{3+}_2\text{Si}_8\text{O}_{22}(\text{OH})_2$ . It is not very common in most places but occurs in the Boston area in the Quincy Granite.

**rift valley** – the central valley of a mid-ocean ridge or a valley formed in the middle of a continent where two plates are splitting apart from each other.

**right-hand rule** – rule describing the angular relationship between strike and dip direction, where the dip direction is always clockwise from the strike direction. When your right hand is laid palm down on a plane with your fingers pointing down the dip slope your thumb points in the strike direction.

**right-lateral (or dextral) strike-slip fault** – a fault separating two areas being displaced horizontally in opposite directions such that when looking across the fault the area on the opposite side is moving to the right. A good example is the San Andreas Fault in California.

**ripples** – linear ridges of sand formed on a bedding plane perpendicular to the motion of a fluid. (see also wave or current ripples.)

**rock cleavage (see slatey cleavage)** – very flat, repeated foliation planes that develop because of microscopic recrystallization of clay minerals to mica that has a preferred orientation. The rock tends to split along the foliation plane in some cases resulting in slate.

**rock cycle** – an idealized progression of rock formation that starts with magma, followed by igneous rock formation, weathering and erosion, sediment transport and deposition, sedimentary rock formation, and then metamorphism eventually leading to high temperature melting and magma formation.

**rock flour** – very fine silt produced by the grinding and crushing of rock debris beneath a glacier.

**rock hammer** – a hammer used in the field by geologists to collect rock samples or remove the exterior of rocks to make an exposure of non-weathered rock that allows better identification.

**rocks** – naturally occurring solids composed of minerals and/or other materials.

**roundness** – the degree to which sedimentary particles have had their sharp edges removed. They may be classified as angular, subangular, subrounded, or rounded particles. (see also sphericity)

**runoff** – water that flows across the land surface due to rain or melting snow that does not seep into the ground or evaporate.

**sand** – sedimentary particles that are 2.0 - 0.0625 mm in diameter.

**sanidine** - high temperature potassium feldspar ( $\text{KAlSi}_3\text{O}_8$ ) found almost exclusively in volcanic and fine-grained sialic rocks as phenocrysts.

**salt** – a non-clastic sedimentary rock made of sodium chloride ( $\text{NaCl}$ ) or the mineral halite.

**saturated zone (or phreatic zone)** – the area beneath the water table where all pore spaces are filled by water.

**schist** – a mica-rich metamorphic rock formed by the macroscopic growth of mica and the development of a wavy micaceous foliation or schistosity. A metamorphic rock displaying schistosity.

**schistosity** – a platy and wavy foliation that occurs in rocks due to the macroscopic growth of mica with a preferred orientation during metamorphism.

**sediment** – particles or grains of material eroded from existing rocks or derived from other materials. (see sedimentary rock.)

**sedimentary rock** – rocks formed by the accumulation of particles eroded from other rocks or organically or chemically accumulated or precipitated materials in surface or near surface environments.

**sedimentary structures** – the arrangements of particles, sorting characteristics, and shapes of beds and bedding features that are sometimes preserved in sedimentary rocks.

**seismology** – the study of mechanical waves and how they propagate through the Earth.

**sense of shear** – the direction of displacement in a rock resulting from a particular stress orientation.

**shards (glass)** – particles that are the shattered, curved walls of bubbles made of volcanic glass that become a part of ejecta, ejecta deposits, and pyroclastic rocks.

**sialic crust** - (see continental crust.)

**sialic igneous rocks** – igneous rocks that are light in color (various shades of tan, red, and gray) due to low iron contents and high silicon and aluminum contents. “sial” in this word stands for silicon (Si) and aluminum (Al).

**silica** – dissolved or molten quartz or a mineral formed of hydrated quartz ( $\text{SiO}_2$ ).

**silicate** – a group of minerals in which anions are composed of some combination of silicon and oxygen.

**silt** – sedimentary particles that are 0.0625 - 0.002 mm (or 62.5 - 2 microns) in diameter.

**sinistral strike-slip fault** – (see left-lateral strike-slip fault)

**site data** – geologic data collected at an outcrop as opposed to data collected along a single contact or other line, or as a polygon.

**skarn** – rocks produced by the contact metamorphism of carbonate rocks including limestone and dolomite. This rock is composed of calcitic or dolomitic marble, and numerous calcium/magnesium silicate minerals depending on the temperature and chemical reactions that take place in the presence of hydrothermal fluids.

**slab sample** – a sample that is cut on a rock saw to reveal fresh, non-weathered rock and creates a flat surface that can be viewed wet or polished allowing more detailed study of the rock's texture.

**slate** – rock that was originally fine-grained sedimentary rock (siltstone, shale, and claystone) that experienced light metamorphism such that clay particles started to microscopically recrystallize as well oriented mica. When the rock is stressed, it tends to break parallel to the mica grains and form flat closely spaced break planes that cut across bedding called slaty cleavage.

**slaty cleavage** – closely-spaced fractures or partings that cut across bedding and form because of metamorphism that causes a preferred orientation of mica crystallization on a microscopic scale.

**slickensides** – a shiny or polished, stepped, and grooved/striated surface along a fault plane that is used to determine the direction of displacement on the fault. It is caused by mineral growth on a fault plane during displacement.

**soil** – a layer at Earth's surface formed by the buildup of material left behind by the weathering of rocks and surficial deposits.

**sodic** - in the IUGS classification, a fine-grained igneous rock in which sodium dominates over potassium. (see potassic.)

**sorting** – the distribution of sizes of particles in a sediment or sedimentary rock. Well sorted sediment has a narrow range of grain sizes while poorly sorted sediment has a wide range of grain sizes.

**sphene** (titanite) -  $\text{CaTiO}(\text{SiO}_4)$  – a titanium calcium silicate mineral that usually has a resinous brown color. It commonly occurs in the tiny spaces between quartz and feldspar crystals in coarse silic igneous rocks that have sufficient titanium.

**sphericity** – the shape of a sedimentary particle as compared to being a perfect sphere. Grains may be spherical, elongate or prolate (having a dominant long axis or dimension), oblate (in the form of a disk), or a combination of these shapes. (see also roundness.)

**stages** – units of time that are subdivisions of epochs.

**stratified (glacial deposits)** – deposits that are bedded and sorted due to transport and deposition by glacial meltwater.

**streak color** – the color a mineral produces when scratched on an abrasive tile or when powdered.

**striations** – scratches and grooves formed by sliding glacial ice as it drags debris across a rock surface or the surface of clasts.

**strike** – the orientation of a horizontal line on a plane. As defined by the right-hand rule strike is  $90^\circ$  counterclockwise from the dip direction. It has been customary in the U.S to record this direction as degrees away from north, but this scheme does not lend itself well to the entry of data into computer programs that plot directions for which the right-hand rule is used.

**strike-slip fault** – a fault separating two areas being displaced horizontally in opposite directions.

**subalkaline** - in the IUGS classification, a fine-grained igneous rock that is low in (Na<sub>2</sub>O + K<sub>2</sub>O). (see alkaline.)

**subaerial** – refers to an environment above water (or below air).

**subaqueous (or sub-aquatic)** – refers to an environment below water.

**sub-atomic particles** – the particles that make up atoms.

**subduction zone** - (see convergent plate boundary.)

**subside** - net downward vertical movement of Earth's crust; land surface subsidence is less than this where deposition piles sediment onto the crust.

**sulfate** – a group of minerals that has a combination of sulfur and oxygen (usually SO<sub>4</sub><sup>2-</sup>) as its anion.

**sulfide** – a group of minerals that has just sulfur as its anion.

**supercontinent** – large continent that later split or rifted apart to form individual smaller continents or a continent formed by the fusing of many continents. Rodinia, Laurasia, Pangea and Gondwana are examples in the geologic past.

**superposition** – a fundamental principle that says that sedimentary layers are laid down one on top of the other with the unit at the bottom being the oldest and the unit at the top being the youngest. Sediment is always deposited on some other sediment or rock that is older.

**surficial deposits** – non-lithified deposits sitting on the bedrock surface produced by surface processes such as river, wind, and coastal processes, mass movement, weathering, and glaciation.

**surficial geologic map** – a map that attempts to classify surficial deposits at the modern land surface and shows where bedrock is exposed but it does not attempt to classify bedrock units.

**syncline** – a fold in which layers in the center of the fold, or along the fold axis, are bowed downward relative to the limbs.

**talus** – colluvium in the form of a steep pile of angular rocks at the base of a steep slope or cliff. Talus often dips at steeper than 40° at an angle referred to as the angle of repose (steepest possible slope).

**tension gashes** – tensional openings that occur in a rock adjacent to a larger compressional structure or displacement. The gashes open along the direction of compressive stress and perpendicular to tension.

**terrane** – a land mass that was accreted to the margin of a continent and is now a distinct fault bounded set of rock units that is a part of the continent.

**terrane accretion** - (see accretion.)

**terrane docking** - (see accretion.)

**texture** – the size, shape, and arrangement of mineral grains in a rock.

**thin section** – a thin (~30 micron) slice of rock glued to a glass slide for viewing in a microscope.

**thrust fault** – a reverse fault that dips at an angle less than 30°.

**till** – sediment directly deposited by or released from glacial ice without any subsequent modification by mass movement or meltwater. Note: it is redundant to say “glacial till” since by the definition above till is defined as glacial and can only be glacial. There is no such things as a non-glacial till.

**titanite** - (see sphene.)

**topographic map** – map displaying contour lines that show the topography or shape of the land surface as well as other features such as water features (hydrography) and cultural features such as roads, railroads, and buildings.

**transform boundary** – a boundary between tectonic plates where the plates pass by each other horizontally along a strike-slip faults zone.

**translucent** – a mineral that will transmit some light but will not transmit an image.

**transparent** – a mineral that transmits light as well as an image.

**transport** – the movement of sediment.

**tremolite** – a mineral in the amphibole group that has the chemical formula:  $\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ . It occurs in metamorphic rocks derived from rocks with original carbonate minerals.

**trench** – (see ocean trench)

**trend** – the orientation of a line that has no preferred direction or azimuth, i.e. it is not a vector.

**true north** - (see geographic north.)

**tuff** – pyroclastic rock composed of a mixture of volcanic ash and other ejecta that may include lava fragments, pumice, crystals, and fragments of older rock formations. (see also welded tuff.)

**type area, type section** – an area for which a rock formation has been named and has outcrops that allowed an initial description and definition of the rock unit.

**tundra** – a cold climate environment without trees, often with permafrost, and dominated by herbs, shrubs, and grasses.

**type section** – a specific outcrop of a formation where it was first described and defined.

**ultramafic igneous rocks** – igneous rocks composed of more than 90% dark-colored (mafic) minerals.

**unconformity** - a surface that represents a break in time (a missing part of time not represented by the rock record) and is overlain by a sedimentary unit, lava flow, or pyroclastic deposit. It represents either an erosion surface or a period of non-deposition. (see angular unconformity, disconformity, and nonconformity.)

**uniformitarianism** – an overriding theory on the development and history of Earth that says that processes that occurred in the past conformed to the laws of mathematics, chemistry, and physics, much like events today conform to these laws. Processes that have operated on Earth have varied as conditions changed but always the processes have conformed to the physical, chemical, and

mathematical laws that govern processes today. A cliché phrase: “The present is the key to the past.” is often used to express this principle. However, the past is only a good analogue for the present if conditions were the same, which they often were not, but the laws of chemistry and physics still applied to past events.

**unsaturated zone (or vadose zone)** – the zone above the water table where only some pore spaces are filled with water, and others are filled with air.

**uplift** – net upward vertical movement of Earth’s crust; land surface uplift is less than this because of erosion.

**veins** – the filling of fractures by mineral growths from water solution, most notably quartz, calcite, iron oxide and hydroxide, and epidote.

**vesicles** – bubbles in lava or other igneous rocks resulting from the formation of gas bubbles.

**vesicular** – an igneous rock texture in which the rock has bubbles.

**viscosity** – the resistance of a fluid to flow.

**vitrification** – the formation of natural glass.

**volatiles** – water and gas constituents dissolved in a magma that can be released rapidly due to drops in pressure.

**volcanic ash** - (see ash.)

**volcaniclastic sediment and volcaniclastic rock** – sediment, or later sedimentary rock, that is formed from the erosion and re-deposition of dominantly volcanic material, possibly with a mixture of non-volcanic sediment.

**water table (or phreatic surface)** – a subsurface boundary beneath which all pore spaces are filled with water. The water table is a place with only atmospheric fluid pressure.

**wave or oscillatory ripples** – ripples that are symmetric in cross section and formed by an oscillatory current action of waves.

**weathering** – the natural break down and decomposition of rocks and minerals at Earth’s surface due to exposure to water, oxygen, acids, biological activity, and changes in temperature.

**weathering rind** – an outer layer of a rock surface that is altered and discolored due to weathering.

**Wegener, Alfred** – German meteorologist and arctic explorer and researcher who proposed the idea of continental drift.

**welded tuff** – pyroclastic rock composed of a mixture of volcanic ash and other ejecta that may include lava fragments, pumice, crystals, and fragments of older rock formations in which some of the material was still molten and sticky when deposited such that the ejecta adhered to itself and formed a coherent mass at the time of deposition. (see also tuff.)

**wetlands** – areas of saturated soil or shallow water dominated by vegetation and the accumulation of organic sediment.

**xenolith** - (see inclusion.)



**zircon** – a zirconium silicate mineral,  $Zr(SiO_4)$ , found as scattered microscopic crystals in silic igneous rocks (volcanic and plutonic) and as sand grains in sedimentary and metasedimentary rocks. Zircon is very hard, resistant to chemical weathering, and resistant to metamorphism. It also contains trace amounts of radioactive uranium isotopes making it the most useful mineral for determining the radiometric (numerical) ages of rocks.

**zoisite** – a calcium aluminosilicate,  $Ca_2Al_3(SiO_4)(Si_2O_7)O(OH)$ , found as an alteration product in calcium-rich metamorphic rocks and as a vein mineral. It is recognized by its abnormal blue colors when viewed with crossed polarizers in a petrographic microscope. Zoisite is closely related to epidote.