Outline of Earth Science
November 13, 2012

Contents

Note: To look up references, see the Consciousness Bibliography, listing 10,000 books and articles, with full journal and author names, available in text and PDF file formats at http://www.outline-of-knowledge.info/Consciousness_Bibliography/index.html.

PHYS>Earth Science

earth science

Physical science {earth science} can be about erosion, tectonic processes, terrain, and rocks.

drilling

Drills {drilling} have gone one mile below ocean floor and five miles below continents, to sample rocks.

PHYS>Earth Science>Planet

isostatic compensation

Lowland areas have no gravity decrease {isostatic compensation}, because lowland areas have thin crust, with mantle closer to surface. Mountain areas have no gravity increase, because mountains float on mantle, pushing heavier mantle aside.

PHYS>Earth Science>Planet>Earth Coordinates

analemma

The figure eight {analemma} on globes shows Sun declination for day of year.

PHYS>Earth Science>Planet>Earth Coordinates>Longitude

longitude

Earth locations use lines {longitude}| {meridian} running from pole to pole. Longitude is in degrees, up to 180 degrees east or west from the prime meridian that runs through Greenwich, England.

International Date Line

At meridian 180 degrees east or west {International Date Line}|, time adds one day if traveling east, and time subtracts one day if traveling west.

prime meridian

The reference meridian {prime meridian}| runs through Greenwich, England, at zero degrees longitude.

PHYS>Earth Science>Planet>Earth Coordinates>Latitude

latitude as location

Earth locations use lines {latitude, Earth}| parallel to equator. Latitude is in degrees. Equator is 0 degrees latitude. North Pole is 90 degrees north latitude. South Pole is 90 degrees south latitude.

equator

The reference latitude {equator}| runs horizontally around Earth middle and is zero degrees latitude.

Antarctic Circle

People cannot see Sun in winter in Southern Hemisphere above 66.5 degrees south latitude {Antarctic Circle}|.

Arctic Circle

People cannot see Sun in winter in Northern Hemisphere above 66.5 degrees north latitude {Arctic Circle}|.

Tropic of Cancer

Sunlight falls straight down on Midsummer Day at 23.5 degrees north latitude {Tropic of Cancer}| in Northern Hemisphere.

Tropic of Capricorn

Sunlight falls straight down on Midsummer Day at 23.5 degrees south latitude {Tropic of Capricorn}| in Southern Hemisphere.

semitropics

Zones {semitropics}| can be between tropic and temperate zones.

PHYS>Earth Science>Planet>Climate

climate

Earth climates {climate}| {clime} can be wet or dry.

dry

Deserts and steppes are 25% of Earth land area. Deserts and steppes have large yearly and daily temperature variation, have rain in summer if at high altitude, have rain in winter if at low altitude, and have high winds.

wet

Pacific Ocean surface currents typically make monsoons. With warm El Niño, west North America has wet weather.

wet: plants

Plants absorb rain in roots and evaporate water from leaves, allowing rain to form and fall in one place. If plants die, water goes into ground, and rain is less.

core and surface temperature

Heat flow from core has no effect on Earth surface temperature.

conveyor belt of wind

Tropical winds push warm water north along east North-American coast {conveyor belt}. It becomes denser at it cools and sinks near Greenland, allowing flow to continue. Europe receives warm water that returns south in deep water along east Atlantic Ocean. If melted snow enters North Atlantic, the cold fresh water prevents warmer salty water from sinking, and conveyor belt turns off. Cold, dry winds flow east around north.

forest line

Above 4000 to 6000 feet is line {forest line}| where forest stops.

Indian summer

Temperate climates can have summer-like weather {Indian summer}| in fall.

insolation

Earth receives radiation {insolation}| from Sun. As Venus, Jupiter, and Saturn have different relative positions, Earth orbit varies, which changes insolation. Sun can brighten and darken, changing insolation.

PHYS>Earth Science>Planet>Climate>Heat Radiation

heat radiation

Earth radiates heat {heat radiation}. Soot, particles, and clouds {aerosol, atmosphere} affect heat radiation.

global warming

Chemicals can prevent heat from escaping Earth {greenhouse effect} {global warming}|. Carbon dioxide, methane, ozone, nitrous oxide, and chlorofluorocarbons (CFC) prevent heat radiation from Earth by absorbing infrared radiation. Methane comes from gas and oil wells, landfills, and waste processing. Carbon soot and other dark pollution particles trap heat.

reflective

Sulfate aerosols are reflective and prevent insolation. Clouds affected by aerosols are brighter, last longer, are reflective, and prevent insolation. Volcanoes add soot that blocks sunlight.

ocean

Ocean absorbs excess heat.

forests

Deforestation reduces dark areas and reduces heat absorption.

speculation

Ships with windmills can hydrolyze seawater in windstorms or in normal winds to make and store hydrogen and oxygen, as well as upwell cold seawater from the deep to cool hot spot.

greenhouse gas

Carbon dioxide, chlorofluorocarbons, ozone, nitrous oxide, and methane {greenhouse gas}| prevent heat radiation from Earth by absorbing infrared radiation.

PHYS>Earth Science>Planet>Climate>Kinds

White Earth climate

If ice starts to form on Earth, it reflects more light, Earth gets icier, and water in air becomes less {White Earth climate}, while carbon dioxide forms into carbonates at equator. Perhaps, an Earth ice covering reflected light and kept Earth cold for 10 million years, with no rainfall, dry winds, no water vapor, and low carbon dioxide. Volcanoes release carbon dioxide can warm Earth again over the ten million years, because carbon dioxide does not go into plants or carbonates in cold weather.

highland climate

Above 4000 to 6000 feet, climate {highland climate}| has low air pressure, low humidity, large daily temperature range, large annual temperature range, and no forests.

PHYS>Earth Science>Planet>Climate>Kinds>Dry

arid climate

More evaporation than precipitation causes very dry climate {arid climate}|.

desert

Arid climates {desert}| can have cactus and bushes.

semiarid climate

More evaporation than precipitation causes dry climate {semiarid climate}.

steppe

Semiarid climates {steppe}| can have grass.

PHYS>Earth Science>Planet>Climate>Kinds>Latitude

tropical climate

Humid rainy climate {tropical}| near equator has narrow temperature range, average temperature greater than 65 F, and dry winters if on west coast.

subtropical region

Seasonal humid climate {subtropical}| at 25 to 40 degrees latitude has dry summers if on west coast.

temperate climate

Humid climate {temperate climate}| at 40 to 60 degrees latitude has summer rainy season and rapid weather changes. It has Indian summers, January thaws, blizzards, and heat waves if on east coast or in interior. It has small temperature range if on west coast.

boreal climate

At 50 to 65 degrees latitude, climate {boreal}| has long cold winters, large annual temperature range, small precipitation in summer, targa, permafrost, long winter nights, long summer days, many lakes, and little topsoil.

targa
Boreal climate has regions {targa}| with sparse conifer forests.

permafrost
Boreal climate has frozen subsoil and rock {permafrost}|.

polar climate
At 65 to 90 degrees latitude, cold climate {polar, climate}| has no forest, no sunlight for six months, large annual temperature range, little rain, ice caps, and tundra. Ice caps are 8% of Earth surface.

tundra
Polar climate has land {tundra}| with small and sparse vegetation.

PHYS>Earth Science>Planet>Layers

planet layer
Earth layers {planet layer} are core, mantle, and crust.

PHYS>Earth Science>Planet>Layers>Core

core
Earth center {core, Earth} {Earth core} has been the same since 3,500,000,000 years ago, after heating and layering ceased.

inner core of planet
Earth center {inner core, Earth} is solid iron with some nickel and cobalt. Inner core has pressure 20,000 tons/in^2, temperature 4000 F to 8000 F, and radius 800 miles.

F shell
Layer {F shell} above inner core is 300 miles thick.

outer core
Layer {outer core} above F shell is liquid iron with some nickel, cobalt, silicon, and sulfur. Outer core has pressure 10,000 tons/in^2 and is 1375 miles thick.

D shell
Layer {D shell} above outer core is several hundred miles thick.

PHYS>Earth Science>Planet>Layers>Mantle

mantle of planet
Above core D shell is layer {mantle, Earth}|. Mantle is 1800 miles thick and contains 80% of Earth volume.
temperature
Mantle temperature at 500,000 meters deep is 2300 K. Mantle temperature at 100,000 meters deep is 1500 K. Temperature increases with depth, 1 C every 30 meters. Lower mantle, below 700,000 meters deep, has convection currents caused by heat.
density
Below 650,000 meters deep, density is 5.5 g/cm^3. Between 400,000 to 650,000 meters deep, density is 4.5 g/cm^3. Above 400,000 meters deep, density is 3.5 g/cm^3. In upper mantle, which is 50 miles thick, density is 2.6 g/cm^3.
rock types
Lower mantle has dunite, which is mostly olivine, with some peridotite. Olivine has magnesium, silicon, and oxygen. Upper mantle has serpentine, at 50 miles to 100 miles above olivine, where 0.1% water and some carbon dioxide change olivine and pyroxene into serpentine and hydrogen {serpentinization}.

asthenosphere

Iron and magnesium silicate olivines are 100,000 meters to 250,000 meters deep, in lower upper mantle {asthenosphere}.

dunite

Iron and magnesium silicates {dunite} are mostly olivine and make lighter-color veins in upper mantle.

eclogite

Iron and magnesium silicates {eclogite} are in mantle.

PHYS>Earth Science>Planet>Layers>Crust

crust of planet

Above Mohorovicic discontinuity is surface layer {crust}|.

Mohorovicic Discontinuity

Layer {Mohorovicic discontinuity} above mantle is thin.

lithosphere

Upper-mantle serpentine layer and lower-crust sial layer make layer {lithosphere}.

sial layer

Lower crust is a three-mile thick heavy iron-and-magnesium-silicate basalt layer {sial layer}. Basalt forms from melted upper-mantle serpentine under lower pressure. Basalt crust density is 2.3 g/cm^3.

PHYS>Earth Science>Planet>Layers>Crust>Continent

continent

Upper crust has landmasses {continent, land}|. Continents now cover 25% of Earth surface. Continents average 20 miles thick and can be 40 miles thick. True continent edge is below ocean at continental-shelf edge, up to 400 miles from shore.

rocks

Continental rock is permanent, with no recycling back into crust or mantle. Continents are mostly granite, with density 2.1 g/cm^3 {sima layer}, so they rise above seas.

formation

First continent rocks appeared 4,000,000,000 years ago, as continents grew from upper mantle. After first continent-formation period ended 3,500,000,000 to 3,800,000,000 years ago, continents were 5% to 10% of crust. First-formation-period rocks are in Isua in southwest Greenland. These rocks have greenstone belts, granite-gneiss terrains, or igneous rocks cutting through them from upper mantle. Greenstone belts contain ultramafic rock and mafic rock, as xenolith.

Second continent-formation period, from 2,600,000,000 to 2,900,000,000 years ago, formed 50% to 60% of continental Archean rock.

Third continent-formation period was 1,700,000,000 to 1,900,000,000 years ago.

Fourth continent-formation period was 900,000,000 to 1,100,000,000 years ago.

Fifth continent-formation period was 600,000,000 years ago.

mafic rock

Igneous rock {mafic rock} can be mostly iron and magnesium. Mantle basalt, ocean-floor bedrock, and lava are mafic.

ultramafic rock

Greenstone belts contain volcanic rock {ultramafic rock} and partially melted mafic rock, which have no water.

xenolith

Greenstone belts contain ultramafic and mafic rock, which have no water {xenolith}.

Archean rock

The second continent formation period, from 2,600,000,000 to 2,900,000,000 years ago, formed 50% to 60% of continents {Archean rock}.

subcontinent

Continent has independent masses {subcontinent} that have come together by plate movement.

PHYS>Earth Science>Planet>Magnetism

geodynamo

Earth has magnetic fields {magnetic field, Earth} {Earth magnetic field}, because thermal convection from iron-solidification latent heat and escape of inner-core iron oxide and iron sulfide causes liquid-iron outer-core spin {geodynamo}. Magnetic-field strength is 10,000 gauss at Earth surface. Magnetic field is decreasing. Magnetic field reverses polarity randomly, approximately every 250,000 years. Earth magnetic field has had same polarity for last 780,000 years.

aclinic line

Earth has magnetic equator {aclinic line} between magnetic poles.

aurora in atmosphere

Ions from Sun can enter Earth atmosphere at poles, along magnetic-field lines. They hit atmosphere atoms and make light displays {aurora, pole}| that look like colored curtains, at North Pole {aurora borealis} {northern lights} or South Pole {aurora australis}.

magnetic pole

Earth has magnetic poles {magnetic pole, Earth}|. Magnetic North Pole is in north Canada, not at spin North Pole.

magnetosphere

From 600 to 40,000 miles above Earth surface, magnetic fields {magnetosphere} {Van Allen radiation belt} deflect weak cosmic rays and absorb ions from Sun. Sun ions push magnetosphere out from Sun.

PHYS>Earth Science>Planet>Meteor

meteor

Meteoroids can enter Earth atmosphere and heat until they make light {meteor}|. Every year, Earth adds 1000 to 1,000,000 tons of meteor dust.

chondrule

Stony meteorites can have tiny olivine and pyroxene clumps {chondrule}.

chondrite

Stony meteorites {chondrite} can have olivine and pyroxene chondrules. Stony chondrites are 90% of all meteorites.

achondrite

Stony meteorites {achondrite} can have no clumps.

meteoroid

Space objects {meteoroid}| can be broken-planet pieces from asteroid belt.

meteorite

Meteors {meteorite}| can hit ground. Largest meteorite weighed 30 tons. A 15,000-ton meteorite formed Canyon Diablo Meteor Crater, 4100 feet across and 600 feet deep, in Arizona. Meteorites {iron meteorite} can have more than 98% iron and nickel. Meteorites {stony iron meteorite} can have 50% nickel-iron and 50% olivine. Meteorites {stony meteorite} can be mostly rock, with little nickel and iron.

tektite

Early Moon meteoroid impact melted glass, which splashed up and then landed on Earth in a strip of achondrite drops {tektite}|.

PHYS>Earth Science>Planet>Plate Tectonics

plate tectonics

Continental plates move {plate tectonics}|, when olivine from upper mantle comes through rift in crust basalt, pushing plates apart. See Figure 1.

Plates can slide into each other, pushing one down and one up to make trenches and mountains. See Figure 2.

rates

Pushed plates move two centimeters per year. Sea-floor movement in Chile is 15 centimeters per year.

results

Upwelling at ocean ridges can make volcanoes with basalt lavas. Old rift valleys can fill with aulacogens.

evidence

Coal is in Antarctica. Similar fossils are on separated continents. All over world, iron in volcanic rocks aligns in many different directions, instead of only north and south. East South America and west Africa have similar coastlines.

Sea floor is spreading away from Mid-Atlantic Ocean Ridge. Basalt at Mid-Atlantic Ocean Ridge is younger than basalt near continents. Mid-Atlantic-Ocean Ridge basalt shows alternating iron-particle orientations every 700,000 years, when Earth magnetic field reversed. Sediment at Mid-Atlantic Ocean Ridge is less than at continent edges.

Pacific-Ocean floor has thicker sediments and is older than Atlantic-Ocean floor. Atlantic-Ocean floor is 200,000,000 years old. Atlantic-Ocean sediment averages only several thousand feet thick and in some places is much thinner. If ocean floor had not changed for 200,000,000 years, sediment would be several miles thick.

Figure 1

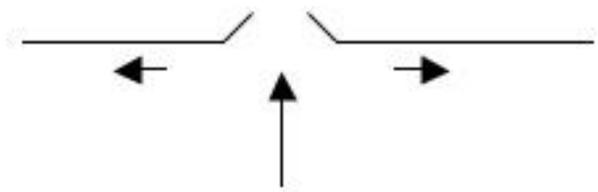
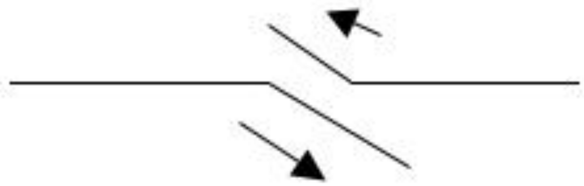


Figure 2



crustal plate

Six major, and many minor, crust pieces {continental plate} {crustal plate}| float on upper mantle.

PHYS>Earth Science>Planet>Plate Tectonics>Rift

rift in crustal plate

Continental plates move when olivine from upper mantle comes through basalt crack {rift}|, pushing plates apart. Pushed plates move one inch per year. Atlantic-Ocean middle has rift north to south that rises above sea level at Iceland, Azores, and Ascension Islands. Southeast South Pacific Ocean and central Indian Ocean have rifts.

aulacogens

Old rift valleys can fill with sediment {aulacogens}.

sea floor spreading

Along rift, lava makes mountain ridge, with valley down middle {sea floor spreading}|.

shield of continent

Continent granite {shield, continent}| can be at surface.

PHYS>Earth Science>Planet>Plate Tectonics>Cline

anticline

Rock layers can have shape like upside-down V {anticline}.

monocline

Rock layers can bend up or down {monocline} {flexure}.

syncline

Rock layers can have shape like V {syncline}.

PHYS>Earth Science>Planet>Plate Tectonics>Earthquake

earthquake

Slips along rock faults cause movements {earthquake}|. Slow plate movements and collisions lead to sudden shifts of one plate against the other. Earthquakes can be several miles deep or even in mantle under ocean trenches. After earthquake, Earth vibrates at low frequency for several days. About 20 major earthquakes and 10^6 minor ones happen each year. Major earthquakes have been in China 1976, Tokyo 1923, San Francisco 1906, Lisbon 1755, Calcutta 1737, and China 1556.

joint in rock

Rock has big cracks {joint, rock}.

fault

Earthquakes can be along rock fractures {fault}|.

seismograph

Instruments {seismograph}| can measure Earth movements.

Richter scale

Seismographs can use logarithmic scales {Richter scale}|, from 1 up. Largest earthquake was 8.5.

silent earthquake

Earthquakes {silent earthquake} can be slow and quiet. Perhaps, water percolation from rain or from trapped water in rocks causes them.

soil liquefaction

Earthquake shaking can cause loose wet sandy soil to become like quicksand {soil liquefaction}|.

tsunami

Earthquakes under ocean can make fast waves, which then slow near shore and bunch to make towering waves {tsunami}|.

PHYS>Earth Science>Planet>Plate Tectonics>Earthquake>Waves

P wave

Earthquake shocks can travel through crust as slow surface waves or through Earth interior as very fast primary waves {P wave}.

S wave

Earthquake shocks can travel through solids as fast secondary shock waves {S wave}.

PHYS>Earth Science>Planet>Plate Tectonics>Mountain Building

orogeny

Both horst and graben processes form mountains {orogeny}.

graben

Mountain building processes can make large lowered masses {graben}|, as in Death Valley USA, Red-Sea basin, and East-Africa rift valleys.

horst

Mountain building processes can make large raised masses {horst}|, as in Sierra Nevada Mountains and Alps Mountains.

hot spot

Upper-mantle convection currents rise near surface at 20 locations {plume, mantle} {hot spot, mantle}|. Plumes have 300,000 meters diameter. Plumes in crustal-plate middle can send alkali-rich basalt lava up to surface to form volcanoes, as in Hawaiian Islands.

pressure ridge

Colliding plates can move straight into each other {pressure ridge} to make mountains, with no overriding. Alternatively, one plate can slide over other one, forming both mountains and ocean trenches.

ridge at rift

Along rift, lava makes mountain range {ridge, mountain}|, with valley down middle.

subduction

At plate sides opposite from rifts, plates slide under other plates {subduction, plate}|. Plates meet {subduction zone}, and one plate goes up and the other goes down, at 45-degree angles. Plates can go 700 kilometers into mantle. Subduction is at North-America and South-America west coasts, at Asia east coast, and from Spain and north Africa to Italy, to Greece, to Turkey, to India, to Burma, to Celebes.

ophiolite

Ocean crust and underlying mantle {ophiolite} can uplift onto continent.

trench in ocean

Colliding plates can make especially deep and steep ocean floor {trench}|.

PHYS>Earth Science>Planet>Plate Tectonics>Theories

continental drift

Continents move on upper mantle {continental drift}|. Upper-mantle asthenosphere and possibly all mantle has stable constant one-inch-per-year convection currents, caused by heat. Currents provide energy to move continents. Continents have been drifting for last 2,000,000,000 years. Six major and many minor crustal plates float on upper mantle.

diastrophism

Plate movements make crust slide, fold, and fault {diastrophism}.

dilatancy

Increased fluid pressure, changed electrical resistivity, decreased Earth natural electric currents, increased deep-well-water radon content, changed seismic-wave travel time, and seismicity affect crustal-plate movements {dilatancy}. Dilatancy models earth movements as inelastic swelling. Steady stress increase splits crust, allowing water flow. If water flows in slower than cracks open, crust splitting slows. Then water under pressure quickly fills crack, causing sudden slip. Changes from compression waves to shear waves cause seismic-wave travel-time changes.

isostasy

Continents are 10% lighter than crust, and crust is 10% lighter than upper mantle, so continents float on crust, which floats on upper mantle {isostasy}.

tectonic process

Plate movements {tectonic process}| make crust slide, fold, and fault in diastrophism.

PHYS>Earth Science>Planet>Plate Tectonics>Volcano

volcano

Magma comes from mantle, 2 to 100 miles down, to surface {volcano}| through crust fissures. Magma then cools and hardens. Most of Earth water vapor and gases came from volcano eruptions.

types

Thick magma has more gas, is red hot, erupts explosively, and makes steep mountains. Thin magma has little gas, is white hot, and makes wide mountains.

examples

Famous volcanoes are Mount Vesuvius in Italy, which buried Pompeii [79]. Krakatoa in Indonesia exploded island [1869]. Mount Etna in Italy caused enormous avalanche and undersea mudslide [-6000] and started a huge tsunami: it is still active. Mauna Loa in Hawaii is active.

volcanism

Volcanoes can erupt {volcanism} where plates collide, making andesite lava.

batholith

Magma can spread to make stock rock masses, which can be thousands of square miles wide {batholith}.

caldera

Volcano tops have craters {caldera}|.

dike of volcano

Magma can flow into vertical rock fissures and cool and harden {dike, magma}.

kimberlite pipe

Cylindrical columns {kimberlite pipe} from mantle to crust can have 300-meter diameter.

lava

Magma {lava}| can reach surface.

magma

Molten igneous rock {magma}|, mixed with gas and water vapor, comes from mantle, 2 to 100 miles down, to surface through crust fissures.

sill of magma

Magma can make underground pools {sill, magma}.

stock of magma

Magma can spread to make large rock masses {stock, rock}.

PHYS>Earth Science>Planet>Temperature History

temperature of Earth

Earth temperature {temperature, Earth} increased until 130,000,000 years ago, then decreased until Ice Ages, and has remained almost the same since then. The year -8000 was warmest in recent history, until 20th century. Climate has been slowly cooling since then. Sea can rise or fall by 400 feet between Ice Age and warm period. Increased-volcanic-eruption periods correlate with Ice Ages, because volcanic dust reflects more sunlight and makes Earth cooler.

biomarker

Strata can contain organic molecules {biomarker} from organism classes, because some cell-membrane lipids do not decompose.

carbon isotope ratio plant

Carbon isotopes are carbon-12, carbon-13, and carbon-14. Photosynthetic plants use more carbon-12 than carbon-13, so abundant plants lower carbon-12 ratio {isotope ratio, carbon} {carbon isotope ratio} in air. Air trapped in ancient rocks and ice can show relative amounts of photosynthetic plant life at past times.

catastrophe on Earth

Large meteors or comets and high volcanism can cause widespread death {catastrophe, Earth}.

meteor

Large meteor or comet hit 65 million years ago. Iridium level is higher in that rock stratum than in other layers. Iridium is more abundant in space than on Earth. That stratum also has pressure-shocked minerals.

volcanoes

Volcanic activity was high 443 million years ago, 374 million years ago, 251 million years ago, and 201 million years ago. Volcanoes put hydrogen sulfide, sulfur dioxide, carbon dioxide, and methane into air, which cause greenhouse effect and warm air.

ocean

With ocean warming, surface absorbs less oxygen, and chemocline rises. At high enough warming, chemocline comes to surface, and hydrogen sulfide enters air. Hydrogen sulfide kills land animals and plants directly. It also attacks ozone shield, allowing more UV radiation, which kills animals and plants.

chemocline

Water absorbs oxygen. Water absorbs less oxygen at higher temperature, so oceans have less oxygen at surface and more at lower depths, which are cooler. At ocean bottoms, hydrogen sulfide comes from thermal vents. It rises and prevents further oxygen absorption at ocean depth {chemocline}. Below chemocline is high hydrogen sulfide, and above chemocline is high oxygen. Green sulfur bacteria and purple sulfur bacteria use hydrogen sulfide and are near ocean bottom. Photosynthetic organisms use dissolved carbon dioxide and sunlight so they stay near surface. Zooplankton use oxygen and so stay above chemocline.

glaciation era

Glaciers are largest every 100,000 years {glaciation era}, when Earth-axis tilt toward Sun minimizes, and perihelion shortest distance from Earth to Sun is in December in Northern Hemisphere, which has more land. Glaciers are smallest every 100,000 years, when Earth-axis tilt toward Sun maximizes, and perihelion shortest distance from Earth to Sun is in June in Northern Hemisphere, which has more land.

land mass

Continental {land mass} drift affects Earth temperature. When more land is in tropics, Earth absorbs more heat. When less land is at poles, glaciers decrease, reflective ice is less, and Earth reflects less heat.

Milankovich model

Earth-axis tilt, axis wobble, and orbit cycles change sunlight amount that falls on Earth, in an overall cycle that caused Ice Ages {Milankovich model}. Earth-axis tilt cycles over 90,000 to 100,000 years. Earth axis wobble has a 39000-year to 42000-year cycle. Earth orbital path has a 17000-year to 21000-year cycle. Summer in Northern Hemisphere can be when Earth is closest to Sun, making hotter land temperatures.

PHYS>Earth Science>Atmosphere

atmosphere

Earth gases {atmosphere, Earth} are five miles thick at poles and ten miles thick at equator. Carbon dioxide and water absorb infrared radiation. Ground absorbs infrared, because it has water and wet dirt. Atmosphere layers are troposphere, tropopause, stratosphere, mesosphere, D layer, E layer, ionosphere, F layer, G layer, exosphere, and magnetosphere.

advection radiation

Warm air can flow and warm cold air {advection radiation}.

contrail

Jet airplanes leave water-drop or ice-drop white lines {contrail}|.

firmament

sky {firmament}|.

rainbow

If sunlight from behind observer hits air water droplets, droplets act like prisms and spread sunlight into color spectrum {rainbow}|.

welkin

sky {welkin}.

PHYS>Earth Science>Atmosphere>Cloud

cloud

Water vapor can condense on sea salt, dust, smoke particles, volcanic ash, or nitrous oxide, to make drops one millionth raindrop size {cloud}|. Nitrous oxide forms by lightning. Tiny drops coalesce. When big enough, they drop. Fine raindrops come from low clouds, and big raindrops come from high or thick clouds. Clouds are white if water density is small and are dark if water density is great. Cloud shapes depend on fronts that make them.

ceiling at cloud

Cloud-cover lower side has altitude {ceiling}|. Above ceiling is limited visibility.

mackerel sky

Light and dark clouds {mackerel sky, cloud}| indicate rain.

reflectance of planet

Upper-atmosphere dust and clouds reflect 30% of solar energy {reflectance, atmosphere}. Ozone, dust, and clouds absorb 20%. Ground absorbs 50%.

seeding clouds

Dry ice and silver iodide crystals {seeding}| in clouds can cause rain or reduce fog.

squall line

Cold fronts can make dark-cloud lines {squall line}|, from which can come tornados or waterspouts.

PHYS>Earth Science>Atmosphere>Cloud>Kinds

altostratus cloud
Warm front first makes cirrus clouds, then cirrostratus clouds, then gray clouds {altostratus cloud}, and then nimbostratus clouds.

cirrostratus cloud
Warm front first makes cirrus clouds, then wispy clouds {cirrostratus cloud}, then altostratus clouds, and then nimbostratus clouds.

cirrus cloud
Clouds {cirrus cloud}| can be white, feathery, and 4 to 8 miles high.

cumulonimbus cloud
Cold front first makes high and thick clouds {cumulonimbus cloud} and later makes dark, low clouds and small strong storms.

cumulus cloud
Clouds {cumulus cloud}| can be billowy, deep, fluffy, white, and one mile high.

nimbostratus cloud
Warm front first makes cirrus clouds, then cirrostratus clouds, then altostratus clouds, and then low, thick, dark clouds {nimbostratus cloud} with broad light rain.

nimbus cloud
Clouds {nimbus cloud}| can be gray or dark.

stratus cloud
Clouds {stratus cloud}| can be flat, scattered, low or high, and white or gray.

PHYS>Earth Science>Atmosphere>Effects

fata morgana
Mirages {fata morgana}| can be high in sky, unrelated to surface conditions.

green flash
Brilliant green or blue light {green flash}| can flash at sunset, by prism effect. Prism effects cause Sun to appear flattened and/or irregular on horizon.

mirage
Atmosphere refraction bends light rays, so light seems to come from ground {mirage}|, instead of from sky. Temperature differences, with hotter air closer to ground, cause mirages.

PHYS>Earth Science>Atmosphere>Inversion Layer

air inversion
Still warm-air layer can lie under cool air {air inversion}|.

dew point
Humid air can cool to temperature {dew point} at which water condenses.

PHYS>Earth Science>Atmosphere>Inversion Layer>Condensation

dew
Water can condense on ground {dew}|, instead of in air, when ground is cooler than air, often after midnight on still autumn nights.

fog

In air inversion, ground can lose heat by radiation at night and condense water {fog}| from warm air. Warm air cooled by rain can condense water and make fog.

frost

Dew {frost}| can freeze.

hoarfrost

Frost {hoarfrost}| can form on artificial surfaces.

PHYS>Earth Science>Atmosphere>Layers

troposphere

Air layer {troposphere} next to surface has 3/4 of all air and has all clouds, dust, wind, and storms. Surface pressure is 15 lb/in^2. Average surface temperature is 63 F. At troposphere top, temperature is -60 F to -100 F. Troposphere is 78% nitrogen, 21% oxygen, 2% average water vapor, 0.9% argon, and 0.03% carbon dioxide. On hot humid days, water vapor can be 3% or 4%.

tropopause

Above troposphere is a boundary layer {tropopause}.

stratosphere

Above tropopause, a 10-to-15-mile-thick layer {stratosphere}| has temperature -60 F to -100 F. Lower part is sulfate layer. Higher part is ozone layer. Ozone absorbs ultraviolet rays from Sun.

mesosphere

Above stratosphere, a 25-to-35-mile-thick layer {mesosphere} has temperature 50 F.

D layer

Above mesosphere is an ionized boundary layer {D layer}.

noctilucent cloud

Above D layer is a dust belt {noctilucent cloud}, with high thin clouds visible at night.

Heaviside layer

Above dust belt is an ionized boundary layer {E layer} {Heaviside layer}.

ionosphere

Above E layer, a 300-to-550-mile thick layer {ionosphere} has temperature 2000 F. It contains mostly oxygen ionized by x-rays and ultraviolet rays. It reflects short-wave radio waves.

F layer

In ionosphere is an ionized layer {F layer}.

G layer

Above ionosphere is an ionized boundary layer {G layer}.

exosphere

Above G layer {exosphere} contains mostly helium for 900 miles and then mostly hydrogen for 4000 miles and has magnetosphere.

PHYS>Earth Science>Atmosphere>Lightning

lightning

Electric discharges {lightning}| can go between clouds or between clouds and ground. Strength can be 10^8 volts. Lightning strikes 44,000 times a day and makes 200 forest fires a day. Lightning can be streaks or sheets. Rare lightning form is hot ionized gas {ball lightning}. Lightning makes nitrous oxide, which fertilizes soil.

process

As warm air rushes up and raindrops fall, they rub each other and separate charges, making voltage. If charge path is between cloud and ground or another cloud, first a thin current streak {leader, lightning} flows, followed by main discharge at more than 1000 amperes for 10^-2 seconds.

lightning rod

Metal conductors {lightning rod}| can conduct lightning current into ground, to dissipate it.

thunder

Lightning heats air suddenly and expands it rapidly, making noise {thunder}| as shock waves. People can hear thunder up to 15 kilometers away.

whistler radio waves

Lightning can make radio waves {whistler}| that strike magnetosphere and come back along magnetic-force lines. High frequencies come back first, followed by low frequencies.

PHYS>Earth Science>Atmosphere>Lightning>Kinds

blue jet

Lightning {blue jet} can flash between upper clouds and ionosphere, 44 to 50 miles away, in tree-like structure.

heat lightning

Far-away lightning reflections {heat lightning} can be on horizon clouds on hot summer evenings. Thunder is too far away to hear.

red sprite

Lightning can cause mushroom-shaped flashes {red sprite} in ionosphere.

PHYS>Earth Science>Atmosphere>Precipitation

precipitation of water

Water returns to ground from clouds as rain, sleet, hail, or snow {precipitation, weather}|. Pressure changes and wind surges cause storms in tropics. Above tropics, fronts cause precipitation.

rain

Yearly rainfall {rain}| averages 30 inches per year. Sea precipitation averages 44 inches per year. Land precipitation averages 26 inches per year. 25% goes into rivers, and 75% is on land.

hail as ice

When frozen raindrops pass through thunderstorm, they {hail}| pick up snow and ice.

sleet

When raindrops pass through very cold air, they {sleet}| can freeze.

snow as precipitation

If clouds are 0 C, snowflakes {snow, precipitation} form. Snowflakes have thin surface unfrozen-water film, which makes them stick to other snowflakes in special ways. That is why snowflakes are always hexagons. Snow can fall only above latitude 30 degrees. One foot of snow equals one inch of rain.

PHYS>Earth Science>Atmosphere>Water

aridity

water-saturation percentage {aridity}|.

evaporation

Air water decreases with humidity and increases with temperature and wind speed {evaporation}|. Latitudes from 10 to 40 degrees have more evaporation than precipitation, and lose heat. Other latitudes have more precipitation than evaporation, and gain heat. Oceans have more evaporation than precipitation. Land has more precipitation than evaporation.

humidity

Air can hold variable water amounts {humidity}|. Water in air is 0% to 4%.

measurement

Humidity can be water mass in air mass {specific humidity}. It can be water mass in air volume {absolute humidity}. It can be water vapor mass compared to maximum amount possible at that temperature and pressure, expressed in percent {relative humidity}.

levels

Relative humidity is most comfortable at 50%. High humidity makes cold air feel colder and warm air feel warmer. High temperatures feel cooler if humidity is lower. Higher humidity makes temperature feel higher or lower, because water does not evaporate from skin as easily.

altitude

Humidity is highest at surface and decreases greatly with altitude.

latitude

Humidity is highest at equator and decreases toward poles.

time of day

Humidity increases at night as air cools. Humid air can cool to dew point.

air pressure

More water in air makes lower air pressure, because water molecules weigh less than average air molecule. Wet days have low air pressure. Dry days have high air pressure.

hygrometer

Human-hair-length change {hygrometer}| can measure humidity.

PHYS>Earth Science>Atmosphere>Weather

weather

Signs {weather sign} that forecast fair weather are evening rainbow or deep-blue sky color, even between clouds. Signs that forecast rain are gray and lowering sunset, green or yellow-green sky at sunset, red sunrise with clouds lowering later, sun dog around Sun or Moon after fine weather, morning rainbow, or sky whiteness. Clouds that look like lenses indicate high winds. Light and dark clouds {mackerel sky, weather} indicate rain. Low dark clouds indicate stormy weather.

air mass

Prolonged air contact with surface gives air {air mass}| same temperature and humidity as surface. Air masses {tropical mass} over Sahara Desert are warm and dry. Tropical masses in tropics are warm and wet. Air masses {polar mass} over plains of Canada or Siberia are cold and dry. Cold air masses make high pressure. High-pressure air masses can stay offshore, blocking east-west wind flow.

air pressure

Atmosphere pressure {air pressure}| depends on temperature, water content, friction, centrifugal force, and flow. Cooler air has higher pressure. Spinning air can have higher pressure. Air with less water has higher pressure. Air blocked by mountains has higher pressure. Air-pressure patterns vary by latitude. High-pressure swirling cells are more near poles and in subtropics. Low-pressure cells are more in temperate zones.

degree-day

Difference, between average daily temperature and 20 C, times number of days in month {degree-day}, directly relates to fuel to use to keep warm.

depression in atmosphere

Warm air mass makes low pressure {depression, atmosphere}|, because it is less dense than cold air.

meteorology

Weather forecasting {meteorology}| depends on atmosphere, humidity, pressure, and wind photographs and measurements.

sun dog

A halo {sun dog}| around Sun or Moon after fine weather forecasts rain.

PHYS>Earth Science>Atmosphere>Weather>Map

weather map

Weather maps {weather map} {map, weather} can show isotherms and isobars.

isobar

Equal-pressure points {isobar} can be on weather maps.

isotherm

Equal-temperature points {isotherm} can be on weather maps.

PHYS>Earth Science>Atmosphere>Wind

wind

Temperature differences cause air movement {wind}|. Hot air rises, and cool air falls.

mountains

Wind goes up mountains by day, because top heats first, and goes down by night, because top cools first.

land and sea

During day, wind goes from sea to land, as land heats first and air rises from it. At night, wind goes from land to sea, because water's high heat capacity causes sea to stay warmer longer.

ocean

Jet streams and polar winds make oceans flow clockwise in Northern Hemisphere and counterclockwise in Southern Hemisphere, making west coasts dry near equator and wet near pole, and east coasts humid, with big storms.

Earth rotation

Warm air at equator rises and flows toward poles under tropopause. Cold air at poles stays near ground and moves toward equator. Earth rotation makes air at surface flow from east to west in Arctic and east to west in equatorial zone.

Equatorial hot air rises and flows north as cold air from north slides under it, while spinning Earth spins these masses clockwise in Northern Hemisphere and counterclockwise in Southern Hemisphere. Middle, temperate latitudes have no steady surface winds but usually two or three great swirls, with eddies.

Beaufort scale

Tropical-cyclone wind speed has score 0 to 12 {Beaufort scale}|, or 0 to 17, for 0 to 200 miles per hour.

cell of air

High-pressure swirls {cell, air}| are more near poles and in subtropics. Low-pressure cells are more in temperate zones.

Coriolis force

Earth rotation causes {Coriolis force} air-spin direction.

eye of storm

Tropical-cyclone centers {eye, storm}| are calm and several kilometers wide.

PHYS>Earth Science>Atmosphere>Wind>Front

front of air

Cold-air mass and warm-air mass can contact {front, air}| when air masses start to move. Polar easterlies can meet southern westerlies {polar front}. At fronts, warm air rises and cools to make clouds and precipitation.

cold front

Cold air can replace warm air {cold front}|, or cold-air masses can move into regions. Cold fronts bring rolling dark clouds and lightning, moving fast and steep, as cold air tunnels under warm air, with hard rain. Cold fronts first make cumulonimbus clouds and later make dark low clouds and small strong storms. Cold fronts can make squall lines, from which can come tornados.

warm front

Warm air masses can move into regions {warm front}|. Warm fronts first bring high clouds, because warm air goes over cold-air top, and then low clouds, moving slow and long with steady rain. Warm fronts first make cirrus clouds, then cirrostratus clouds, then altostratus clouds, and then nimbostratus clouds, with broad light rain.

PHYS>Earth Science>Atmosphere>Wind>Direction

leeward

Objects can be downwind {leeward}|.

windward

Objects can be upwind {windward}|.

PHYS>Earth Science>Atmosphere>Wind>Kinds

Arctic Oscillation

Winds go clockwise around high-pressure region near Azores. Winds {Arctic Oscillation} (AO) go counterclockwise around low-pressure region near Iceland. If low pressure is very low, north Europe, north Asia, and Alaska receive warm wind, and Greenland, east Canada, and south Europe receive cold wind.

bora

Yugoslavia mountains make cold air {bora} that flows to Adriatic Sea.

brickfielder

Warm winds {brickfielder} can be in Australia.

bull's eye squall

Squalls {bull's eye squall} can be at Cape of Good Hope.

buran

Strong winds {buran} can be in Russia.

chinook

Warm day winds {chinook}| can come down east Rocky Mountains, because that side receives no sunlight and is cool.

cyclone

Warm air surrounded by cold air rises and spins counterclockwise {cyclone}| in Northern Hemisphere or clockwise in Southern Hemisphere. Earth rotation causes spin direction. Warm air can hold more water than cold air. As warm moist air rises, it cools and condenses water, causing precipitation.

anticyclone

If surrounded by warm air, cold air falls and spins clockwise {anticyclone} in Northern Hemisphere or counterclockwise in Southern Hemisphere. Cold air is drier, so as it rises, it causes clear skies.

density

In Northern Hemisphere, warm air goes north to cooler regions and rises, because it is less dense, and cool air goes south to warmer regions and falls, because it is more dense. Moving air masses can cause air to swirl counterclockwise or clockwise. Cyclone makes warmer, wetter air rise, causing low pressure and wet days. Anti-cyclones make colder, dryer air fall, causing high pressure and dry days.

datoo

West winds {datoo} can be in Gibraltar.

doldrums
Just north or south of equator {doldrums}|, winds are weak.

etesian
Cool Greek winds {etesian} can blow in summer.

foehm
Warm day winds {foehm} can come down north Alps, because that side receives no sunlight and is cool.

frisk vind
strong Swedish wind {frisk vind}.

horse latitudes
From 25 to 30 degrees south latitude or north latitude {horse latitudes}|, winds are small.

jet stream
Temperate-zone high-altitude winds {jet stream}| flow east at lower latitudes and west at higher latitudes.

matsukaze
Japan has gentle breezes {matsukaze} in pines.

mistral
Rhone-River-valley glacier makes cold air {mistral}| that flows to Mediterranean Sea.

North Atlantic Oscillation
Winds go clockwise around high-pressure region near Azores. Winds {North Atlantic Oscillation} (NAO) go counterclockwise around low-pressure region near Iceland. If low pressure is very low, north Europe, north Asia, and Alaska receive warm wind, and Greenland, east Canada, and south Europe receive cold wind.

Santa Ana
Hot dry summer winds {Santa Ana}| can be in California.

sirocco
Sahara Desert heats wind {sirocco}|, which picks up water from Mediterranean Sea and rains on Italy.

solano
Winds {solano} can be in Spain.

trade wind
Equator east-to-west winds {trade wind}| are steady at low altitude.

tsumuji
Japan has strong winds {tsumuji}.

vento coado
Winds {vento coado} can flow on Portuguese hills.

waimea
Humid winds {waimea} are in Hawaii.

williwaw
Winds {williwaw} can blow in Alaska.

zephyr wind

gentle warm wind {zephyr}|.

zonda
Hot dry winds {zonda} from Andes Mountains can blow across Argentina pampas.

PHYS>Earth Science>Atmosphere>Wind>Kinds>Storm

gale
Winds {gale}| can blow from 51 to 102 kilometers per hour.

haboob
Desert sandstorms have high humidity, low temperature, and 45-mph winds {haboob}, such as along Nile River.

hurricane
In Caribbean Sea, cool air can surround warm moist air that rises faster, spinning into tropical cyclones {hurricane}| with winds up to 200 mph. About 48 hurricanes and typhoons happen a year, usually in late summer.

monsoon
In Southeast Asia, warm land and cool sea causes summer storms {monsoon}|, but October to April is cool and dry.

northeaster
In northeast USA, northeastern winds {northeaster}| can bring storms.

simoom
Sandy hot strong winds {simoom}| can be in Sahara and Arabian deserts.

squall
Cool winds {squall}| can come suddenly and finish soon, typically with rain or snow.

tornado
Strong cold fronts can cause funnel-shaped clouds {tornado}| {whirlwind}, 300 to 600 feet diameter, with 200 mile per hour winds. Tornadoes move 25 miles per hour and travel up to 100 miles. Tornadoes are mostly in central USA and in Australia. 1500 tornadoes happen each year.

typhoon
Pacific Ocean and Indian Ocean have tropical cyclones {typhoon}|. About 48 hurricanes and typhoons happen a year, usually in late summer.

waterspout
Squall lines can make sea tornados {waterspout}|.

PHYS>Earth Science>Land

landforms
Land includes erosion and landforms {landforms}.

PHYS>Earth Science>Land>Erosion

erosion
Rocks can move, break down, and wear away {gradational process} {erosion}|. Moving glaciers, flowing water, freezing, and thawing can cause erosion. Ocean waves cause erosion. Water movements and chemical reactions cause most erosion. Erosion is faster if water flows faster or contains more chemicals that react with minerals. Erosion also involves plants and plant roots. Sand blown by wind does little eroding.

shore
Ocean erodes centimeters from rocky shores {shore} each year. On deep and steep shores, ocean-wave erosion makes cliffs. On shallow gently sloping shores, ocean-wave erosion builds sandy beaches or sandbars.

fluvial landform

Water can carve rock channels {fluvial landform}|.

sapping

Water can flow under surface {sapping} and cause ground erosion.

PHYS>Earth Science>Land>Erosion>Glacier

glacier

Large ice masses {glacier}| move 1 to 40 feet per day.

crevasse

Glacier can have large deep crack {crevasse}|.

iceberg

If glaciers reach sea, parts {iceberg}| can break off.

loess

Ice-Age glaciers were one mile thick. When they receded and dried, wind blew fine dust {loess}| all over world.

moraine

Glacier front edge pushes up soil and rock ridge {moraine}|.

moulin

Glaciers can have vertical holes {moulin, hole}, caused by flowing water.

PHYS>Earth Science>Land>Land Forms

terrain

Slope, material, and size determine land types {terrain}| {land forms}.

slope

Varying slope makes plain, hill, or mountain.

material

Surface material can be soil, bedrock, sand, cobblestone, boulders, ice, or water.

types

Surface can be piedmont rolling plains, caused by running water, glacial erosion, or wind sand-dune formation. Surface can be hilly plains, caused by minor tectonic processes or tableland erosion. Surface can be plains, from running-water sediment deposits. Surface can be tableland, mesa, butte, canyon, or escarpment. Surface can be low mountains, from long erosion. Surface can be high mountains, formed recently.

layers

Limestone layers were shallow sea. Coal layers were swamp. Salt or gypsum indicates sea dried instead of receding.

lode

ore layer {lode}|.

prospect region

mineral-deposit area {prospect, land}|.

talus rocks

Rocks {talus, cliff} can be at cliff base.

PHYS>Earth Science>Land>Land Forms>High Area

aiguille

vertical rock point {aiguille}.

alp
mountain {alp}|.

badlands hills
plant-less eroded mesas or hills {badlands}|.

bluff as cliff
cliff top {bluff}|.

butte
small mesa {butte}|.

chine
crest or ridge {chine}.

col
pass or gap {col}.

Cordilleran belt
A mountain chain {Cordilleran belt} goes from Atlas Mountains, to Alps, to Himalayas, to Pacific-Ocean volcanic islands, to north China, to east Siberia, to west North-America coast, and then to west South-America coast.

crag
rocky promontory {crag}|.

crest of hill
hill top {crest, hill}|.

cuesta
above-plain inclined rock strata {cuesta}.

divide of hills
watershed {divide}|.

eminence as hill
hill {eminence}|.

escarpment
mesa side {escarpment}|.

great divide
Two large watersheds have boundary {great divide}.

hillock
small hill {hillock}|.

hummock
knoll or mound {hummock}|.

knoll
small hill {knoll}|.

massif
mountain {massif}|.

mesa
tableland tops {mesa}| {upland}.

palisade cliff
river cliffs {palisade, cliff}|.

piedmont
Rolling plains {piedmont}| form by running water, glacial erosion, or wind sand-dune formation.

plateau
high flatland {plateau, land}|.

promontory
sea or lake highland projection {promontory}|.

scarp
cliff {scarp}.

sierra
un-eroded mountain range {sierra}.

tableland
Plains cut by streams make mesa, butte, canyon, and escarpment {tableland}|.

timberline
Trees do not grow above a mountain line {timberline}| {timber line}.

tor
Hilltops {tor} can have rocks or be bare rock.

PHYS>Earth Science>Land>Land Forms>Low Area

abyss
deep crevice {abyss}|.

arroyo
usually dry stream gully {arroyo}|.

canyon
mesa spaces {canyon}|.

chasm
gorge or crevice {chasm}|.

cirque
glaciated-valley heads {cirque}.

coulee
gulch or ravine {coulee}.

crevice
fissure {crevice}|.

dale
valley {dale}|.

dell
small valley {dell}|.

dust bowl
dry region {dust bowl}.

fissure
long narrow crack {fissure}|.

glen
valley {glen}|.

gorge
river-caused deep narrow area {gorge}|.

gully
stream channel {gully}|.

morass
low and wet region {morass}|.

ravine
water-made deep narrow area {ravine}|.

slough
muddy area {slough}|.

tarn
Glaciers can form small mountain lakes {tarn}.

tideland
Lower shore {tideland}| is under water at high tide.

tidewater
low coastal land {tidewater}|.

vale
valley {vale}|.

wadi
dried riverbed {wadi}.

PHYS>Earth Science>Land>Land Forms>Plain

champaign
plain {champaign}.

wold
un-forested rolling plain {wold}.

PHYS>Earth Science>Land>Land Forms>Sand

brachan
Sand dunes {brachan} can be separated sand crescents.

seif

Sand dunes {seif}| can be parallel to wind.

PHYS>Earth Science>Land>Land Forms>Shore

archipelago islands
island group {archipelago}|.

cape as land
Land {cape, land}| can project into sea.

headland
Land {headland}| can extend into water.

isthmus
Narrow land {isthmus}| can be between two oceans.

peninsula
Large land {peninsula}| can project into sea.

reef
Coral rings {reef}| {atoll} can form around volcanic islands.

sandbar
Sandy areas {sandbar}| can be near shore.

shoal
sandbar {shoal}|.

strand shore
shore {strand, shore}|.

PHYS>Earth Science>Land>Land Forms>Vegetation

arbor
tree-shaded area {arbor}|.

bower of leaves
tree-shaded area {bower}|.

chaparral
shrub and thicket area {chaparral}|.

clearing as field
treeless field {clearing}|.

glade
forest open area {glade}|.

heath field
heather-covered land {heath, land}|.

moor
Rolling plains {moor}| can have shrubs and no forests.

oasis vegetation
Desert planted areas {oasis}| have water.

verdure

Areas {verdure, area}| can have healthy green plants.

vineyard

grapevine field {vineyard}.

warren

rabbit land {warren}|.

PHYS>Earth Science>Land>Land Forms>Vegetation>Grass

pampas as plain

South-America treeless grassy plain {pampas}|.

sod

Grassy soil {sod, soil}| can have intertwined roots.

tuffet

small grassy area {tuffet}| {tuft}.

tussock

small grassy area {tussock}|.

veldt

South Africa has flat grassy areas {veldt}|, where animals graze.

PHYS>Earth Science>Land>Land Forms>Vegetation>Tree

taiga

Firs and spruces {taiga} cover north Eurasia south of tundra.

weald

woodland or hilly land {weald}.

windbreak

Hedges or tree rows {windbreak} can be on windward side.

PHYS>Earth Science>Land>Movements

avalanche

rock or snow slide {avalanche}|.

creep in land

Regolith can move slowly {creep}.

landslide

Loose regolith can break away {landslide}| from valley wall.

regolith

Rivers and streams transport eroded, decomposed, and disintegrated rock {regolith}.

PHYS>Earth Science>Land>Soil

pedology

Soils {soil, land} have types and properties {pedology}|. Soil comes from eroded rocks and decayed organic matter. Soil {mountain soil} derived from lava is rich in minerals. Iron oxides cause red, yellow, or brown soil color. Humus causes black or dark-brown soil color. Soil can be acid or alkaline. Soil has layers.

fertility of soil
Soil can have varying calcium, sodium, potassium, phosphorus, nitrogen, iron, magnesium, and sulfur amounts {soil fertility} {fertility, soil}|.

marl
Clay and shell mixtures {marl}| can be fertilizers.

peds
Soil types {soil texture} depend on soil particle size {peds}|. Gravel has largest peds and coarse texture. Sand is next largest. Silt is third largest. Clay has smallest peds and fine texture.

PHYS>Earth Science>Land>Soil>Layers

azonal soil profile
Soil can have no soil profile {azonal soil profile}.

intrazonal soil profile
Soil can have unstable but layered soil profile {intrazonal soil profile}.

zonal soil profile
Soil can have stable soil profile {zonal soil profile}.

pan layer
Hardened soil layers {pan layer} can be below topsoil.

topsoil
Soil surface layers {topsoil} can be porous and 0 to 24 inches thick.

PHYS>Earth Science>Land>Soil>Kinds

alluvial soil
Sediment from rivers makes sandy soil {alluvial soil}|.

chernozem
humus and sand {chernozem}.

humus
decayed organic matter {humus}|.

loam
clay, silt, and sand mixture {loam}|.

chernozemic soil
Dry soils have different types {chernozemic soil} {grunosolic soil} {decentic soil}.

podzolic soil
Humid soils have different types {podzolic soil} {latosolic soil} {tundra soil}.

PHYS>Earth Science>Water

water on Earth
Water {water, Earth} includes ocean and fresh water. Water is 0.001% of Earth mass.

PHYS>Earth Science>Water>Fresh

fresh water

Water {fresh water} is where rainfall is plentiful or snow accumulates. People require five gallons of fresh water a day. In USA, people use 60 gallons per person per day.

drought

Rainfall can be small for long period {drought}|.

irrigation

Field can receive water from source {irrigation}|. Irrigation by dribbling has less evaporation than spraying or flooding.

PHYS>Earth Science>Water>Fresh>Areas

basin

enclosed water area {basin}|.

paddy

flooded or irrigated rice field {paddy}.

PHYS>Earth Science>Water>Fresh>Areas>Ice

floe

large flat iceberg {floe}|.

pack ice

large floating ice blocks {pack ice}|, from ice field.

PHYS>Earth Science>Water>Fresh>Areas>Marsh

marsh

wetland {marsh}|.

bayou

river or lake marsh {bayou}|.

bog

marsh {bog}|.

fen

bog or marsh {fen}|.

wash

In England, tides cause marshes {wash}|. Southwest USA has dry stream beds.

PHYS>Earth Science>Water>Fresh>Areas>River

river

Streams and rivers {river, water} receive water directly from rain and indirectly from water runoff from land. Streams are usually wider than they are deep, and erosion sediments can fill them within years. Stream first erodes into valley. Then tributaries enter valley and join first stream. Then valley sides wear down to make wide valley or wear back to make deep valley.

delta of river

Undertows pull sediment from rivers out to sea. River mouths have sediment triangles {delta}|. Mississippi River makes 600,000,000 tons each year. In sea, corals use minerals, or minerals precipitate out, as at Hudson-River mouth and in Baltic Sea.

eddy
circular river current {eddy}|.

ford
shallow river area {ford}|, where people or horses can cross.

freshet
Stream can enter salt water, or stream can have sudden flow {freshet}|.

headwaters
river beginning {headwaters}|.

meander river
Rivers curve many times {meander}| if banks are soft, because river cuts away outer bank, deposits soil on inner bank, and widens all curves. Rivers run straight and cut through rock if banks are hard, to make canyons.

rill
rivulet {rill}|.

rivulet
stream {rivulet}|.

tributary
Rivers {tributary}| can flow into larger river.

PHYS>Earth Science>Water>Fresh>Areas>River>Falls

falls
In stream, hard rock plate {falls}| can persist after lower rock has eroded.

cascade
waterfall series {cascade}|.

cataract of river
big waterfall {cataract, water}|.

rapids
Stream or river shallow parts can have rocks resistant to erosion, where water flows faster {rapids}|.

white water
rapids {white water}|.

PHYS>Earth Science>Water>Fresh>Areas>Spring

spring of water
water {spring, water}| burbling from ground.

geyser
Warm water from Earth interior can make hot water spouts {geyser}| that erupt several times a day.

thermal spring
hot spring {thermal spring}|.

warm springs

Warm water {warm springs}| can come from underground.

PHYS>Earth Science>Water>Fresh>Cave

cave

Groundwater can dissolve carbon dioxide to make carbonic acid, which can dissolve rock {cave}|.

karst

Landscapes {karst} can have caves and sinkholes.

sinkhole

Carbonic acid can dissolve limestone to make holes {sinkhole}| and collapsed ground in flat areas.

stalactite

In cave, dripping water can dry and precipitate carbonates, to make up-pointing structures {stalactite}|.

stalagmite

In cave, dripping water can dry and precipitate carbonates, to make down-pointing structures {stalagmite}|.

PHYS>Earth Science>Water>Fresh>Mechanical

desalination

Distillation or freezing can remove seawater salt {desalination}|. If water has low salt, reverse osmosis, electrodialysis, or ion exchange can remove salt.

reverse osmosis

High pressure can force water through membrane that retains salts {reverse osmosis}|, making purer water come out. If water has low salt, reverse osmosis, electrodialysis, or ion exchange can remove salt.

PHYS>Earth Science>Water>Fresh>Soil

aquifer

Porous and permeable rock {aquifer}| can hold water.

artesian well

Wells {artesian well}| can reach water table.

groundwater

Soil and rock water {groundwater}| depends on precipitation, evaporation, rock porosity, and soil permeability.

water table

Water-saturated-rock upper-surface level {water table}| is same as nearby lake and pond surface level.

PHYS>Earth Science>Water>Fresh>Soil>Spaces

infiltration

Soil water permeability and movement {infiltration}| is most for sand, middle for loam, and least for clay.

permeability of soil

Water infiltration is most for sand, middle for loam, and least for clay {permeability, soil}|.

porosity

Below soil, rainwater goes into rock-crystal open spaces {porosity}|, down to 100,000 feet.

PHYS>Earth Science>Water>Ocean

ocean

Oceans {ocean} have salt water and currents.

El Nino

Upwelling water can cause tropical Pacific Ocean warming {El Niño}|, every six years.

La Nina

Downward flowing water can cause tropical Pacific Ocean cooling {La Niña}|.

salinity

Ocean has 0.9% salt concentration {salinity}|.

PHYS>Earth Science>Water>Ocean>Areas

comber

long-wave breaker {comber}|.

cove

small bay {cove}|.

current in ocean

Ocean has water flows {current, ocean}|. Surface currents flow in same direction as wind. Beneath them, surface ocean currents have colder-water counter-currents flowing more slowly in opposite direction.

names

Gulf Stream flows along North-America east coast.
Labrador Current flows past Iceland to England.
Peru or Humboldt Current flows along South-America west coast.
California Current flows along North-America west coast.
Kuroshio Current flows off Japan.
Brazil Current flows along South-America east coast.
Besquela Current flows along Africa west coast.
Antarctic Circumpolar Current (ACC) circles Antarctica and keeps tropic waters out.

drift in ocean

Ocean has surface currents {drift, ocean}|.

firth

narrow inlet {firth}|.

main as ocean

open ocean {main}|.

rip current

fast outward current {rip current}|.

riptide

fast outward beach current {riptide}|.

strait in ocean

water area {strait}| between islands, allowing passage.

vortex

whirlpool {vortex, water}|.

whirlpool

Intersecting currents cause swirling water {whirlpool}|.

PHYS>Earth Science>Water>Ocean>Coast

coast

Sea meets land {coast, ocean}.

bay of sea

Sea can make small coastline indentations {bay}|.

estuary

At shore, low valleys {estuary}| can fill with rising water.

inlet

narrow bay {inlet}|, or narrow area between two islands.

fjord

At shore, steep glacier valleys {fjord} can fill with rising waters.

gulf

Sea can make big coastline indentations {gulf}|.

lagoon

Oblique currents and waves create beaches, sandbars, and spits on shore, and make offshore sandbars if beach has shallow slope. Quiet water {lagoon}| can be between a sandbar and shore.

littoral tidal

Sea has a region {littoral}| between high and low tides.

sound in ocean

Water {sound, shore} can be between island and shore.

PHYS>Earth Science>Water>Ocean>Floor Zones

ocean floor zones

Ocean zones {ocean floor zones} relate to light. 0 to 600 feet has sunlight. 600 to 4000 feet has twilight. 4000 to 36,000 feet is dark. Deepest trench is 36,000 feet deep.

abyssal plain

Sea floor {abyssal plain} is 34 F and has 1000-atmosphere pressure.

continental shelf

Under-sea continent region {continental shelf}| is 8% of ocean and is 400 to 600 feet deep.

continental slope

Continental shelf goes down to sea floor {continental slope}.

PHYS>Earth Science>Water>Ocean>Tide

tide

Moon and Sun gravitation moves Earth sea and land {tide}|. Earth gravity and land-and-sea elasticity oppose tides. Shallow-water tide motion makes heat by friction, which takes energy from Earth rotational energy. Earth rotation slows, making each day slightly longer. Earth-Moon distance increases slightly each day.

high tide

When Moon is overhead or on opposite side of Earth, continents rise up to six inches and oceans rise several feet {high tide}.

low tide

When Moon is to right or left, continents and oceans are at low height {low tide} {slack tide}.

neap tide

When Moon is overhead or on opposite side of Earth and Sun is to right or left, high tides {neap tide}| are lower, at first-quarter or third-quarter moon.

spring tide

When Moon and Sun are both overhead or opposite sides of Earth, tide {spring tide}| is extra high, at new or full moon.

tidal range

Difference {tidal range} between high and low tide is 2 feet in sheltered bays, 5 to 10 feet on open coast, and 30 to 50 feet in V-shaped bays. Tidal currents flow 5 to 10 miles per hour.

PHYS>Earth Science>Water>Ocean>Wave

wave on ocean

Winds cause waves {wave, ocean}|. Wave height and distance increase with wind speed, wind duration, and distance wave has traveled.

breaker

Sea bottom near shore slows wave bottom, and top wave part becomes narrow and falls over {breaker}|, where water level becomes less than wave height.

tidal wave

Small swells can superimpose to make big wave {tidal wave}|.

undertow

Wave water flows back to ocean along bottom {undertow}|.

whitecap

Strong winds cause open-water waves {whitecap}| to break.

PHYS>Earth Science>Mineral

mineral as rock

Rocks {mineral} have definite chemical composition. People know properties of 2000 minerals. Main elements in rocks are oxygen 48%, silicon 28%, aluminum 8%, iron 5%, sodium, magnesium, sulfur, and calcium. Together, they are 98% of crust.

types

Elements make pure minerals, like gold and copper. Sulfides, selenides, tellurides, arsenides, antimonides, and bismuthides are similar. Halides are similar. Oxides and hydroxides are similar. Carbonates, borates, and nitrates are similar, but borates and nitrates are rare. Sulfates, tellurates, chromates, molybdates, and tungstates are similar. Phosphates, arsenates, and vanadates are similar. Silicates are similar and include nesosilicates, sorosilicates, cyclosilicates, inosilicates, phyllosilicates, and tektosilicates.

color

Rocks have color and color under fluorescence.

crystal form

Most rocks are crystals {crystal form}, such as cubic crystal, with definite geometry.

density

Rocks have definite specific gravity, depending on composition and crystal structure.

homogeneous mineral

Most minerals {homogeneous mineral} are the same throughout, but bauxite, sand, granite, and porphyry are not homogeneous.

melting

Most rocks have exact melting points, but glasses, resins, and colloids have melting-point ranges.

particle size

Minerals have particle sizes. Clay has fine, cohesive particles. Silt has cohesive particles. Sand has grains. Gravel has small rocks.

refraction

Rocks have definite refractive index.

outgas

Materials can emit trapped gases over time {outgas}|.

PHYS>Earth Science>Mineral>Properties

fracture plane

Crystal form determines flat-surface shape {fracture plane} that appears after breaking rock.

luster

Rocks, such as diamond, can be shiny and lustrous {luster}|. Metals, such as silver, can be lustrous, because dielectric constant is negative.

pleochroism

Some rocks split light into two colors {pleochroism}.

PHYS>Earth Science>Mineral>Properties>Hardness

hardness of rock

Rocks have relative strength {hardness}|, depending on chemical-bonding patterns.

Moh scale

Hardness scale {Moh's scale} {Moh scale} goes from 1 to 10. Diamond is 10. Cubic boron nitride is 9.5. Corundum is 9. Quartz is 7. Glass is 6. Steel is 5. Fluorite is 4. Calcite is 3. Salt is 2. Talc is 1.

PHYS>Earth Science>Mineral>Shapes

lenticular rock

Rocks can have biconvex-lens shapes {lenticular}.

rosette

Rocks can be concentric with radial arms {rosette}.

sphenoid rock

Rocks {sphenoid rock} can have wedge shapes.

PHYS>Earth Science>Mineral>Textures

acicular

Rocks can be needle-like {acicular}.

calcareous

Rocks can be chalky {calcareous}.

efflorescence crust

Rocks can have powdery surface crust {efflorescence, rock}.

patina
Rocks can have surface film {patina}|.

vitreous rock
Rocks, such as obsidian, can be glass-like {vitreous, rock}|.

PHYS>Earth Science>Mineral>Categories

concretion
Rocks can have built-up masses {concretion}| around them.

druse
Rocks {druse}| can have crystal linings.

lacustrine mineral
Rocks {lacustrine mineral} can form in lakes.

PHYS>Earth Science>Mineral>Kinds

aerogel
Pure silicon can form very low-density gel {aerogel}.

basic mineral
Minerals {basic mineral} can have low silica content.

halide mineral
Compounds with group VII elements {halide mineral} have low hardness, low density, and vitreous luster. NaCl {halite} has sodium and chloride. KCl {sylvite} has potassium and chloride. CaF2 [2 is subscript] {fluorite} has calcium and fluoride.

metal as mineral
Most elements {metal, mineral} are shiny, hard, electric-charge conducting, and heat conducting.
Aluminum comes from aluminum oxide in bauxite.
Calcium is from limestone.
Gold is pure in Latin America, California, Australia, Alaska, and South Africa.
Iron is from iron oxides.
Manganese comes from ocean-floor nodules.
Mercury comes from cinnabar.
Coking coal or freezing air frees nitrogen.
Phosphorus comes from calcium phosphates in limestone deposits.
Potassium comes from many rock types. Potassium-40 is radioactive.
Sulfur is half as free sulfur and half as metal sulfides, in Gulf of Mexico, Italy, Japan, and Russia.
Tin comes from cassiterite.
Scheelite is tungsten ore.
Uranium is in Congo, Romania, Canada, and Colorado.
Zinc comes from zinc oxides.

phosphate mineral
Compounds {phosphate mineral} with phosphorus and oxygen are secondary minerals and have color. Phosphates include apatite, turquoise, and autunite.

Rochelle salt
Unlike most substances, some crystals {Rochelle salt} become less symmetrical and more ordered at high temperature.

PHYS>Earth Science>Mineral>Kinds>Carbonates

carbonate mineral

Carbon-oxygen compounds {carbonate mineral} can have medium or low hardness, be white or highly colored, and effervesce if dissolved in hydrochloric acid. Calcite has calcium and is the most-common mineral, as chalk and limestone. Dolomite has calcium and magnesium and is second most-common mineral. Carbonates include siderite, magnesite, cerussite, azurite, malachite, soda, and borax.

soda as mineral

Na2CO3 [2 and 3 are subscripts] {soda}| has sodium and is hydrous.

PHYS>Earth Science>Mineral>Kinds>Oxides

oxide mineral

Compounds {oxide mineral} with oxygen vary. Oxides include bauxite, spinel, magnetite, chromite, corundum, cuprite, zincite, hematite, rutile, cassiterite, and uraninite.

barite

BaSO4 [4 is subscript] {barite} is main barium ore.

cassiterite

SnO2 [2 is subscript] {cassiterite} is main tin ore.

rutile

TiO2 [2 is subscript] {rutile} has titanium and is semiconductor. It can catalyze water to oxygen and hydrogen under ultraviolet light {photolysis}, and organic molecules to carbon dioxide and water under ultraviolet light, by making superoxide and hydroxyl radicals. Titania thin films make things wettable {wettability} and so self-cleaning.

spinel

Aluminum or iron oxides can form rocks {spinel} that have no cleavage.

uraninite

UO2 [2 is subscript] {uraninite} has uranium.

wad

Manganese oxide can be in hydrous ore {wad}.

PHYS>Earth Science>Mineral>Kinds>Sulfates

sulfate mineral

Compounds {sulfate mineral} with sulfur and oxygen have low hardness, have vitreous luster, and are not opaque. Sulfates include anhydrite, gypsum, selenite, alabaster, barite, and jarosite.

alum

Hydrous NaAlSO4, KAlSO4, and NH4AlSO4 [4 is subscript] {alum} are aluminum sulfates with sodium, potassium, and ammonia. Alum treats canker sores and is for water purification. Aluminum potassium sulfate is AlK(SO4)2 [4 and 2 are subscripts].

vitriol

Hydrous sulfates {vitriol} are secondary minerals formed in ore and can be green or blue-green {iron vitriol}, white {zinc vitriol}, pale green {nickel vitriol}, or blue {copper vitriol}.

PHYS>Earth Science>Mineral>Kinds>Sulfides

sulfide mineral

Compounds {sulfide mineral} with sulfur have metallic luster. Sulfides include pyrite, chalcopyrite, galena, cinnabar, molybdenite, argentite, and marmatite.

argentite
Ag2S [2 is subscript] {argentite} has silver.

cinnabar
HgS {cinnabar}| is the most-important mercury ore.

molybdenite
MoS2 [2 is subscript] {molybdenite} is the most-common molybdenum mineral.

stibnite
Sb2S [2 is subscript] {stibnite} has antimony.

PHYS>Earth Science>Mineral>Kinds>Aluminum

bauxite
Aluminum-oxide, iron-hydroxide, and silicate mixture {bauxite}| is main aluminum ore and is mainly in Yugoslavia, France, Italy, and Guyana.

alexandrite
BeAl2O4 [2 and 4 are subscripts] {chrysoberyl} {alexandrite} has beryllium and aluminum and makes violet gems and cat's eyes.

corundum
Al2O3 [2 and 3 are subscripts] {corundum} {emery} has aluminum.

ruby mineral
Corundum can be red transparent jewels {ruby, mineral}|.

sapphire
Corundum can be blue jewels {sapphire}|.

PHYS>Earth Science>Mineral>Kinds>Boron

borax
Na2BO3 hydrous [2 and 3 are subscripts] {borax}| is colorless, translucent, and hydrous.

ulexite
Calcium and boron carbonate fibers {ulexite} {television stone} let light travel through their fibers.

PHYS>Earth Science>Mineral>Kinds>Calcium

anhydrite
CaSO4 [4 is subscript] {anhydrite} has calcium.

apatite
Ca3F(PO4)3 [3 and 4 are subscripts] {apatite} has calcium and iron and is yellow-green.

autunite
Ca(UO2)2(PO4)2 . 12 H2O [2 and 4 are subscripts] {autunite} has calcium and uranium oxide and is hydrous.

dolomite
CaMg(CO3)2 [3 and 2 are subscripts] {dolomite}| has calcium and magnesium and is second most-common mineral.

scheelite

CaWO4 [4 is subscript] {scheelite} is tungsten ore.

calcite

CaCO3 [3 is subscript] {calcite} has calcium and is the most-common mineral, as chalk and limestone.

limestone

Calcite {limestone}| is the most-common mineral.

gypsum

CaSO4 . 2 H2O [4 and 2 are subscripts] {gypsum}| has calcium and is hydrous, colorless, laminar, and light. It can be selenite and alabaster.

alabaster mineral

Gypsum can be layered, compacted, and colored {alabaster, mineral}.

selenite

Gypsum can be individual crystals {selenite}.

PHYS>Earth Science>Mineral>Kinds>Carbon

carbon mineral

Starting 345,000,000 years ago, swamps formed and sea sediments covered them hundreds of times, making many rock and dead-plant layers. Layer weight created high pressure that changed organic matter into carbon forms {carbon mineral}.

types

Under pressure, organic matter turns slowly into first peat, then lignite, then bituminous coal, and then anthracite coal, as it becomes more crystalline.

coal

Many places that used to be under sea have coal, such as USA, Canada, England, and Russia.

petroleum

Decaying organic matter trapped in anti-clinal deposits became petroleum, with natural gas above it, as in Saudi Arabia, Middle East, and Russia.

diamond

Diamonds are covalently bound pure carbon and form at 5000 F and 1,000,000 lb/in^2 pressure, 240 miles below surface. Almost all diamonds are in South Africa. Diamond size is by weight {carat}.

graphite

Graphite is soft carbon. Hexagon graphite layers include heptagons, resulting in negative curvature. Hexagon graphite layers include pentagons, resulting in positive curvature.

amorphous carbon

Pure carbon can be amorphous {amorphous carbon}, with diamond bonds and graphite bonds.

buckyball

Pure carbon can form into balls {buckyball} {buckminsterfullerene} with five-carbon and six-carbon rings, like soccer ball hexagons and pentagons.

carbon aerogel

Pure carbon can form low-density gel {carbon aerogel}.

carbon isotope ratio test

Yams, soybeans, and tropical plants have lower carbon-13 to carbon-12 ratio than temperate-zone plants {carbon isotope ratio test} (CIR).

chaoite

Pure graphite hit by meteorites forms hexagonal structure {chaoite}.

filamentous carbon

Pure carbon fibers can have small plates in chains {filamentous carbon}.

graphene

Pure carbon {graphene} can form plane hexagonal arrays. Array is flexible but stronger than diamond. Graphene has strong bonds and flexibility and so rarely has missing atoms or impurities. Graphene conducts electricity fastest, because bonds are strong and crystal defects are few. Charge carriers move at 1/300 light speed and have relativistic effects.

lonsdaleite

Pure carbon can form hexagonal-pattern diamonds {lonsdaleite} {hexagonal diamond}.

nanofoam

Pure carbon can form aerogel-like structure {nanofoam} that is ferromagnetic.

nanorod

Pure carbon can make material {nanorod} harder than diamond.

nanotube of carbon

Pure carbon can form into six-carbon-ring tubes {buckytube} {nanotube, carbon}, 10 or more carbons diameter, 10000 carbons long, strong, heat-resistant, radiation-resistant, resilient, flexible, conducting or semiconducting, and nested or single (Sumio Iijima) [1991]. Random nanotubes arrangements {nanonet} conduct electricity.

schwartzite

Pure carbon can form hexagonal structure {schwartzite} with included heptagons.

PHYS>Earth Science>Mineral>Kinds>Copper

azurite

Cu3(CO3)2(OH)2 [3 and 2 are subscripts] {azurite} is blue copper ore and is hydrous.

calcocite

Cu2S [2 is subscript] {calcocite} has copper.

chalcopyrite

CuFeS2 [2 is subscript] {chalcopyrite} is the most-common copper ore.

cuprite

Cu2O [2 is subscript] {cuprite} has copper.

malachite

Cu2CO3(OH)2 [2 and 3 are subscripts] {malachite} has copper, is green, and is hydrous.

turquoise mineral

CuAl6(PO4)4(OH)8 . 5 H2O [6, 4, 8, and 2 are subscripts] {turquoise, mineral}| has copper, is hydrous, and is sky blue. It is in Iran, Siberia, Turkestan, New Mexico, and Arizona.

PHYS>Earth Science>Mineral>Kinds>Iron

chromite

FeCr2O4 [2 and 4 are subscripts] {chromite} has iron and chromium and can be spinel {ruby spinel} {balas ruby}.

hematite

Fe2O3 [2 and 3 are subscripts] {hematite} {oligist} is iron ore.

jarosite
KFe3(SO4)2(OH)6 or NaFe3(SO4)2(OH)6 or AgFe3(SO4)2(OH)6 or PbFe3(SO4)2(OH)6 [3, 4, 2, 6, and 3 are subscripts] {jarosite} are iron sulfates with potassium, sodium, silver, or lead.

limonite
Iron oxides can be hydrous ores {limonite}.

magnetite
Fe3O4 [3 and 4 are subscripts] {magnetite} has iron and is spinel.

marmatite
ZnFeS2 [2 is subscript] {marmatite} has zinc and iron.

pyrite
FeS2 [2 is subscript] {pyrite}| {fool's gold} has iron and is the most-common sulfide.

siderite
FeCO3 [3 is subscript] {siderite} is minor iron ore.

PHYS>Earth Science>Mineral>Kinds>Lead

cerussite
PbCO3 [3 is subscript] {cerussite} is lead ore.

galena
PbS {galena} has lead and often associates with silver.

PHYS>Earth Science>Mineral>Kinds>Magnesium

Epsom salt
MgSO4 . 7 H2O [4, 7, and 2 are subscripts] {epsonite} {Epsom salt}| has magnesium, is hydrous, forms by evaporation, and is white.

magnesite
MgCO3 [3 is subscript] {magnesite} has magnesium.

PHYS>Earth Science>Mineral>Kinds>Zinc

sphalerite
ZnS {sphalerite} {zincblende} {schalenblende} has zinc.

zincite
ZnO {zincite} has zinc.

PHYS>Earth Science>Mineral>Kinds>Organic

organic mineral
Rocks are inorganic, but living things make resin, bitumen, and amber {organic mineral}.

amber mineral
Living things make minerals {amber, mineral}.

bitumen
Dead living things can form minerals {bitumen}|.

lagerstatten

Rocks {lagerstätten} can retain traces of soft-bodied animals and animal burrows. Solnhofen Limestone in Germany has fossil Archaeopteryx. Burgess Shale in British Columbia, Canada, has Cambrian fossils. Chienjiang in Yunnan Province, China, has early Cambrian fossils. Doushantuo Formation in Guizhou Province, China, has early Precambrian fossils in calcium phosphate. Ediacara Hills in Australia have Precambrian fossils.

mother-of-pearl

pearl-oyster inside shell {nacre} {mother-of-pearl}|.

pearl

pearl-oyster round excretion {pearl, gem}|.

resin as mineral

Plants make minerals {resin, mineral}|.

PHYS>Earth Science>Mineral>Kinds>Silicates

silicate mineral

Silicon and oxygen compounds {silicate mineral} are hard and are 1/3 of all minerals. SiO2 [2 is subscript] is triangular. Silicon dioxide is in granite and obsidian. It forms at 600 C to 900 C. It has density 2.7 g/cm^3. SiO4 [4 is subscript] is tetrahedral. Silicon oxides can have another form {tridimyte}. Silicates can be nesosilicate, sorosilicate, cyclosilicate, inosilicate, phyllosilicate, or tektosilicate.

silica

Silicon oxides {silica}| can be grains.

flint

hardness-7 gray silicate {flint}.

gabbro

Calcium silicate, magnesium silicate, and iron silicate {gabbro} can be together.

rhinestone

Hard glass {rhinestone}| has many colors and is for jewels.

sorosilicate

Tetrahedral silicates {sorosilicate} can have two tetrahedra. Zn4Si2O7(OH)2 . H2O [4, 2, and 7 are subscripts] {hemimorphite} {calamine} is sorosilicate, is secondary zinc mineral, and is milk white or blue.

PHYS>Earth Science>Mineral>Kinds>Silicates>Opal

opal

SiO2 . n H2O [2 is subscript] {opal}| is colloidal and can have iridescence {precious opal}, red reflections {fire opal}, or be in trees {wood opal}.

hyalite

Opal can have glassy appearance {hyalite} in granite.

PHYS>Earth Science>Mineral>Kinds>Silicates>Quartz

quartz mineral

SiO2 [2 is subscript] {quartz}| has crystals and is glassy or milky {rock crystal}, brown {smoky quartz}, black {morion quartz}, citrine, pink {rose quartz}, amethyst, chalcedony, agate, onyx, or jasper.

agate

Quartz {agate}| can have different color bands.

amethyst

Quartz {amethyst}| can be violet.

chalcedony

Quartz {chalcedony} can have translucent microcrystals.

citrine

Quartz {citrine} can be yellow.

jasper

Quartz {jasper} can be many-colored.

onyx

Quartz {onyx}| can have straight black-and-white bands.

PHYS>Earth Science>Mineral>Kinds>Silicates>Cyclosilicate

cyclosilicate

Tetrahedral silicates {cyclosilicate} can be rings.

dioptase

CuSiO2(OH)2 [2 is subscript] {dioptase} is copper cyclosilicate and is green.

PHYS>Earth Science>Mineral>Kinds>Silicates>Cyclosilicate>Beryl

beryl

Be3Al2Si6O18 [3, 2, 6, and 18 are subscripts] {beryl}| is aluminum cyclosilicate and can be hexagonal beryllium ore {pegmatite}, emerald, or aquamarine.

aquamarine mineral

Beryl can be blue minerals {aquamarine, mineral}.

emerald

Beryl can be green minerals {emerald}|.

PHYS>Earth Science>Mineral>Kinds>Silicates>Cyclosilicate>Tourmaline

tourmaline

(Na,Ca)(Li,Mg,Fe,Al)3(Al,Fe)6B3Si6O27(O,OH,F)4 [3, 6, and 27 are subscripts] {tourmaline}| is aluminum and iron cyclosilicate and commonly is schorl.

schorl

Tourmaline commonly is a black mineral {schorl}.

PHYS>Earth Science>Mineral>Kinds>Silicates>Inosilicate

inosilicate

Triangular silicates {inosilicate} can be long chains.

PHYS>Earth Science>Mineral>Kinds>Silicates>Inosilicate>Pyroxene

pyroxene

Inosilicate {pyroxene} can be green or black and granular or fibrous.

diopside

CaMgSi2O6 [2 and 6 are subscripts] {diopside} is calcium and magnesium pyroxene.

basalt

feldspar and pyroxene mixture {basalt}|.

PHYS>Earth Science>Mineral>Kinds>Silicates>Inosilicate>Amphibole

amphibole

Inosilicate {amphibole} can be white to black-green.

jade mineral

Hard green amphibole {jade}| is for jewelry.

hornblende

(Ca,Na,K,Mg,Fe,Al)Si2O6 [2 and 6 are subscripts] {hornblende} is calcium, sodium, potassium, magnesium, iron, and aluminum amphibole and is monoclinic.

PHYS>Earth Science>Mineral>Kinds>Silicates>Nesosilicate

nesosilicate

Silicates {nesosilicate} can be isolated tetrahedra.

olivine

(Mg,Fe)2SiO4 [2 and 4 are subscripts] {olivine}| {chrysolite} {peridotite} is magnesium and iron nesosilicate and is green to yellow-brown. Peridotite igneous rock in mantle can react with seawater to make hydrogen. Hydrogen reacts with carbon-containing molecules to make methane.

titanite

CaTiSiO5 [5 is subscript] {titanite} is titanium nesosilicate.

topaz mineral

Al2SiO4(OH,F)2 [2 and 4 are subscripts] {topaz, mineral}| is aluminum nesosilicate and can be yellow, amber, or blue. Transparent form {chiastolite} is in Spain.

PHYS>Earth Science>Mineral>Kinds>Silicates>Nesosilicate>Almandine

almandine mineral

Fe3Al2(SiO4)3 [3, 2, and 4 are subscripts] {almandine, mineral} is aluminum nesosilicate.

garnet

Almandine can be isometric, red, and translucent {garnet}|.

PHYS>Earth Science>Mineral>Kinds>Silicates>Nesosilicate>Zircon

zircon mineral

Zr(SiO4) [4 is subscript] {zircon, mineral}| is zirconium nesosilicate and can be orange or red {hyacinth, zircon}.

adamantine

Zircon can be prismatic {adamantine}.

PHYS>Earth Science>Mineral>Kinds>Silicates>Phyllosilicate

phyllosilicate

Triangular silicates {phyllosilicate} can have flat layers.

biotite

K2(Mg,Fe,Al)4-6(Si,Al)8O20(OH)4 [2, 4, 6, 8, and 20 are subscripts] {biotite} {black mica} is phyllosilicate and is lustrous and lamellar.

chlorite

Chlorine-containing phyllosilicates {chlorite} are lamellar and dark green or blue-green.

mica

KAl3Si3O10(OH)2 [3 and 10 are subscripts] {white mica} {mica}| is phyllosilicate and is pearly and lamellar. Aluminum silicates form at 900 C to 1400 C. They have density 2.6 g/cm^3 to 3.5 g/cm^3. Aluminum-silicate compounds include feldspar, hornblende, and biotite. Aluminum silicates with minerals are clays.

serpentine mineral

Mg3Si2O5(OH)4 [3, 2, 5, and 4 are subscripts] {serpentine, mineral}|, from Alps and Apennines, is phyllosilicate and can be chrysolite, asbestos serpentine, and antigonite.

PHYS>Earth Science>Mineral>Kinds>Silicates>Phyllosilicate>Talc

talc

Mg3Si4O10(OH)2 [3, 4, and 10 are subscripts] {talc}| is phyllosilicate and is white or gray, greasy, and monoclinic.

soapstone

Talc can form stone {soapstone}|.

PHYS>Earth Science>Mineral>Kinds>Silicates>Tektosilicate

tektosilicate

Triangular silicates {tektosilicate}, such as feldspar, can be three-dimensional structures. Tektosilicates are the most-common silicates.

andesite

feldspar and plagioclase mixture {andesite}.

anorthite

CaAl2Si2O8 [2 and 8 are subscripts] {anorthite} is tektosilicate.

lapis lazuli

CaB2Si2O8 [2 and 8 are subscripts] {lazurite} {lapis lazuli}| is tektosilicate, is blue or dark blue, and is granular.

orthoclase

KAlSi3O8 [3 and 8 are subscripts] {orthoclase} is tektosilicate and is monoclinic.

plagioclase

NaAlSi3O8 [3 and 8 are subscripts] {plagioclase} is tektosilicate.

PHYS>Earth Science>Mineral>Kinds>Silicates>Tektosilicate>Stillbite

stillbite

NaCa2Al5Si13O36 . 14 H2O [2, 5, 13, and 36 are subscripts] {stillbite} is tektosilicate and can be zeolite.

zeolite

Stillbite can be aluminum silicate {zeolite} that swells under heat.

PHYS>Earth Science>Mineral>Kinds>Silicates>Tektosilicate>Feldspar

feldspar

Triangular silicates {feldspathoid} {feldspar}| can be low in silicon. Feldspar is the most-common silicate.

moonstone

Feldspar {moonstone}| can have pearl luster.

porphyry mineral

Fine-grained igneous rock has large feldspar crystals {porphyry}.

PHYS>Earth Science>Mineral>Kinds>Rock

rock types

Rocks {rock, types} can be igneous, metamorphic, or sedimentary.

PHYS>Earth Science>Mineral>Kinds>Rock>Igneous

igneous rock

Molten minerals from mantle cool and harden at different rates to make rock {igneous rock}|.

granite

Igneous-rock slow cooling makes coarse grain crystals {granite}|.

diorite

dark, hard, smooth {diorite}.

obsidian rock

Igneous-rock rapid cooling makes fine grain crystals {obsidian}.

pumice

Rhyolite {pumice} can form with gas bubbles.

rhyolite

Fine-grained glassy granite {rhyolite} has color bands.

scoria

Basalt lava flows have red-brown, porous rocks {scoria} that contain gas bubbles.

sialic rock

Igneous rocks {sialic rock} can be mostly silicon and aluminum. Granite, continental rock, and sediments are sialic.

tufa

soft volcanic rock {tufa}.

tuff

aerated light volcanic rock {tuff}.

PHYS>Earth Science>Mineral>Kinds>Rock>Sedimentary

sedimentary rock

Sand or clay layers can make rock {sedimentary rock}|. Water, wind, or ice makes sand or clay layers. Layers can be clastic rock, crystallize from shallow lakes or seas by evaporation to make sediment, or precipitate to make sediment. Sedimentary rocks can be calcite limestone and calcium-and-magnesium carbonate dolomite. Sedimentary rocks are the only rocks that have no reheating, so they can retain fossil imprints.

clastic rock

Layers can cement together by pressure {clastic rock}.

conglomerate rock

Sedimentary rocks {conglomerate rock} can come from stones and gravel in hardened clay.

sandstone
Sedimentary rocks {sandstone}| can come from sand.

shale
Sedimentary rocks {shale}| can come from clay and wood.

PHYS>Earth Science>Mineral>Kinds>Rock>Metamorphic

metamorphic rock
Igneous or sedimentary rocks can change to new forms {metamorphic rock}| by heat and pressure deep in Earth.

breccia
Metamorphic rocks {breccia} can come from conglomerate.

diabase
Metamorphic rocks {diabase} can come from basalt.

gneiss
Metamorphic rocks {gneiss} can come from granite.

marble
Metamorphic rocks {marble}| can come from limestone or dolomite.

quartzite
Metamorphic rocks {quartzite} can come from sandstone.

schist
Metamorphic rocks {schist}| can come from shale and basalt.

slate rock
Metamorphic rocks {slate, rock}| can come from clay or shale.

PHYS>Earth Science>History

Felix A. Vening Meinesz [Meinesz, Felix A. Vening]
geologist
Netherlands
1921 to 1937
Meinesz pendulum
He lived 1887 to 1966 and studied gravity. Strong negative isostatic anomalies {Meinesz belts} parallel deep-sea trenches [1921 to 1937]. Downbuckling results from compression between large, rigid crustal blocks.

Harold Urey [Urey, Harold]
geologist
USA
1931 to 1952
He lived 1893 to 1981 and studied life's origin [1952] and ocean temperature variation [1931].

William Beebe [Beebe, William]
geologist
USA
1934
He lived 1877 to 1962 and went 1000 meters below sea level in bathysphere [1934].

PHYS>Earth Science>History>Invention

Bernard Vonnegut [Vonnegut, Bernard]
geologist/inventor
USA
1946
cloud seeding [1946]
He lived 1914 to 1997 and started cloud seeding [1946] with silver iodide for more rain {cloud seeding}.

PHYS>Earth Science>History>Planet

Charles Lyell [Lyell, Charles]
geologist
England
1833
Principles of Geology [1833]
He lived 1797 to 1875. Wind, water, pressure, and heat forces can make mountains, riverbeds, coastlines, and other land shapes. Events observed in present explain events in past. World always has same laws {uniformitarianism}.

Andrija Mohorovicic [Mohorovicic, Andrija]
geologist
Croatia
1909
He lived 1857 to 1936, studied seisomology, and discovered [1909] discontinuity at crust and mantle {Mohorovicic Discontinuity, Mohorovicic}.

Arthur Holmes [Holmes, Arthur]
geologist
England
1911 to 1913
Age of the Earth [1913]
He lived 1890 to 1965, did first radiometric rock dating [1911], and championed continental drift and plate spreading.

Alfred Wegener [Wegener, Alfred]
geologist
Brunswick, Germany
1912 to 1928
Origin of the Continents and Oceans [1915]
He lived 1880 to 1930 and developed continental-drift theory [1912 to 1928].

Milutin Milankovich [Milankovich, Milutin]
geologist
Russia
1925
He lived 1879 to 1958. Earth-axis variation and atmospheric insulation caused ice ages [1925].

Harry Hess [Hess, Harry]
geologist
USA
1957
He lived 1906 to 1969. Mantle convection caused continental drift and sea-floor spreading [1957].

Bruce C. Heezen [Heezen, Bruce C.]
geologist
USA

1958
He lived 1924 to 1977 and mapped ocean floor [1958].

James Van Allen [Van Allen, James]
geologist
USA
1958
He lived 1914 to 2006 and found radiation belts around Earth [1958].

Frederick Vine [Vine, Frederick]/Drummond Matthews [Matthews, Drummond]
geologist
England
1963
Vine lived 1939 to ?. Matthews lived 1931 to 1997. They studied magnetic pole flipping compared to seafloor spreading [1963].

Lynn Sykes [Sykes, Lynn]
geologist
USA
1968
He studied sea floor spreading and earthquakes, with Jack Oliver and Bryan L. Isacks, and said that plates float [1968].