Common Rock Types of New Mexico and the World
Rock Sample Kit and Identification Manual

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Rocks and the Basic Rock Cycle

The Earth is made mainly of rocks arranged in three concentric layers. The inner core is solid and composed mainly of metallic iron and nickel, but the outer core is liquid (not rock) of the same composition. The intermediate level is called the mantle, and is overlain by the crust, the thinner outer layer.

The Earth's crust contains the rocks we see at the surface. It ranges from ~6 to ~100 kilometers thick (~4 to ~60 miles) and can be divided into continental and oceanic crust. The two crust types contain over 100 elements, with oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg) representing greater than 98% of all the crustal material. Continental and oceanic crust contain the same elements but the oceanic crust contains more iron and magnesium and less silica and potassium, making it denser, which is why it is generally present below sea level.

Most rocks are a collection of one or more minerals (see below), but some contain noncrystalline inorganic material (like obsidian) or organic material (such as coal). Minerals are naturally occurring inorganic material having an orderly internal arrangement and distinctive chemical composition, crystalline form, and physical properties. The ultimate origin of all rocks in the Earth's crust is the mantle (magma or lava), space (meteorites), or organisms such as plants and animals (organic matter).

Rock-forming materials are commonly modified many times by mechanical and chemical processes during the rock cycle. Surface and subsurface processes affect these materials and existing rocks producing a continuous recycling of Earth's materials.

Magma is molten or partly molten rock that is created in the interior of the Earth where temperatures and pressures are enough to cause melting. Magma then migrates into Earth's crust to form intrusive bodies, or it may continue to the surface to erupt as lava flows or explosive volcanic deposits. The magma then cools and solidifies, producing crystalline minerals and/or glass, creating igneous rocks.

Igneous rocks that are exposed at the surface undergo weathering from atmospheric influences that slowly breakdown the rocks both mechanically and chemically. The fragmented material is then moved downslope by gravity and is picked up and carried by erosional agents such as water, glaciers, wind, and waves. Particles are transported and deposited as clastic sediments in the oceans, floodplains, swamps, dunes, and desert basins and dissolved minerals are precipitated either chemically or biochemically, mostly in oceans and lakes.

The sediments are converted to rock by lithification: sediments are compacted by overlying material (younger sediment deposited on top), and the grains are cemented together by dissolved minerals carried by water that percolates through the sediment. The continents are exposed to the natural elements that breakdown and erode existing rocks, so continental materials are the source of most sediments. The sediment eventually may form rocks that are exposed by uplift and erosion. This is why sedimentary rocks are the most common rocks found on the continents.

Sediments that are buried deeply in the Earth and deformed (for example, beneath active orogenic belts where mountains form) or exposed to magmatic heat will react to the changes in temperature, pressure, and shape. Given sufficient time, minerals that are in equilibrium with their new environment will form, making metamorphic rock. In turn, metamorphic rock that is exposed to higher temperatures will melt, becoming magma and recrystallizing into igneous rock. Metamorphic rock that becomes exposed to the atmosphere will be weathered, transported, deposited, and form sedimentary rock. Even igneous rocks may remain deeply buried, be

subjected to compressional forces and high temperatures from mountain building and be transformed into metamorphic rock. Sedimentary rocks that are returned to the surface after lithification will weather, be transported, deposited, and form new sedimentary rocks.

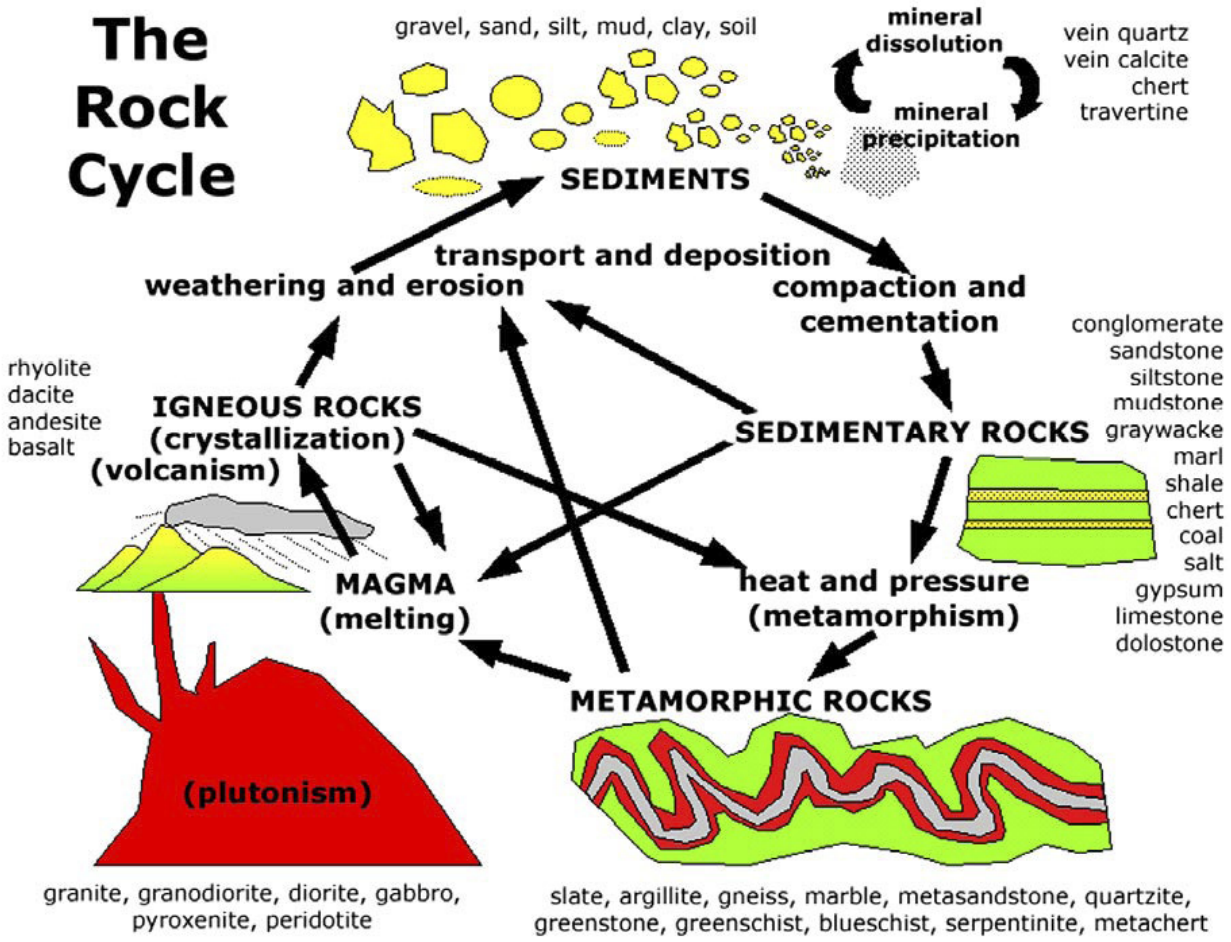

Figure 1. The Rock Cycle (Stoffer 2002).

Rock Sample 1

Rock Name: Granite
Rock Type: Igneous-Intrusive

How does granite form?

Granite is an intrusive rock (formed at depth by crystallization of magma), and is commonly found in large bodies (one to many kilometers across) called plutons. Chemically, granite is rich in silicon, potassium, and sodium, with lesser amounts of iron and magnesium (compare to basalts and obsidian below). Granite is typically formed of equidimensional interlocking crystals of light-colored feldspar and quartz, plus dark minerals such as biotite and hornblende. The crystals can be seen with the unaided eye, being medium to coarse grained. Quartz typically makes up 10% to 30% of the light minerals, with one or two types of feldspars (potassium- and sodium + calcium-rich) making the remainder of the light-colored minerals. While molten, granitic magma is at ~ 850°C (that's 1560° F)!

Do all examples of granite look the same? If not, how do they differ?

The color of granites is dependent on the abundance of quartz and feldspars and their proportion to dark minerals. Usually granite is medium- to light-gray, sometimes even white. Close up it commonly has a "salt-and-pepper" appearance from the mix of light quartz and feldspar and dark (iron- and magnesium-rich) minerals such as biotite and hornblende. Some granites are pink, or red to deep red. The latter types, if not too fractured, are used as building stones and counter tops.

H**ow do I know if I have found granite rock -- what are some distinguishing features of this rock?**

Granite has medium- to coarse-grained crystals that can be seen with the unaided eye. Colors may vary from dark gray to gray to white, or from pink to red to deep red crystals. Some granite outcrops/masses appear as rounded, dome-shaped forms and mountains that maintain their shape by exfoliation (concentric plates or shells of rock that are from one centimeter to several meters thick that spall off of the rock mass like layers from a gigantic onion). The rock will appear smooth after exfoliation, however the rock will be rough after exposure to long-term weathering. In other places, some granites weather into distinctive boulder fields. Many spectacular cliff exposures are made of granite, such as the glaciated Yosemite Valley, or the sculpted Mount Rushmore.

Where can I find granite in New Mexico?

- Priest Pluton in the Manzano Mountains
- Sandia Mountains
- Taos Range
- San Augustin Pass, east of Organ
- Sangre de Cristo Mountains
- Tijeras Canyon
- Northeast of Corona
- Organ Mountains
- Cimarron Canyon State Park

Rock Sample 2

Rock Name: Rhyolite
Rock Type: Igneous-Volcanic

How does rhyolite form?

Rhyolite is an igneous rock with a relatively silica-rich (like granite or obsidian) composition. Rhyolite, like basalt, generally erupts at the Earth's surface, or occasionally forms shallow intrusions (dikes or sills). Rhyolite lava is more viscous (thicker) than basalt, so it typically forms thicker flows. Some rhyolite magma erupts explosively due to rapid exsolution of gases from the magma when the pressure suddenly drops (much like CO_2 bubbles that come out of soda when the pressure is released by removing the top). These eruptions can be huge, with many cubic kilometers erupted in a few hours, days or weeks. They form giant collapsed calderas (low, sub-circular depressions where the underlying magma body was emptied). Such eruptions are devastating, and can change the Earth's climate by cutting off much sunlight as the cloud of gas and ash circles the globe for months or years, cutting down on sunlight reaching the Earth's surface. Fortunately none of these huge eruptions has occurred in recorded human history. Generally, no, or only a few, crystals are formed in the magma before it erupts, and the rapid cooling at the surface causes the bulk of the rock to be noncrystalline (but not glassy like obsidian).

Do all examples of rhyolite look the same? If not, how do they differ?

Rhyolite typically has a color in shades of gray, buff, pink to red, and yellow. Flow banding is common with phenocrysts (a few crystals) aligned in the direction of flow. Spherulites (crystals radiating from a central point) and vesicles (frozen bubbles) may be prominent on the outer layers of a flow.

How do I know if I have found rhyolite -- what are some distinguishing features of this rock?

Rhyolite can be distinguished by its generally noncrystalline nature, possible presence of sparse crystals, flow banding, and the colors of gray, pink to red, and yellow. It will commonly scratch a knife or hammer.

Where can I find rhyolite in New Mexico?

- Magdalena Peak
- Socorro area
- Mule Creek
- Red Canyon
- Cerro del Abrigo
- Valles Caldera in the Jemez Mountains near Los Alamos
- Bandelier National Monument
- San Antonio
- Canovas Canyon

Rock Sample 3

Rock Name: Basalt
Rock Type: Igneous-Volcanic

How does basalt form?

Basalt is an igneous rock that crystallized quickly from a melt. It is poor in silicon, potassium, and sodium, but is rich in calcium, iron, and magnesium relative to granite, rhyolite, and obsidian. Most basalt is an extrusive volcanic rock, but some forms as shallow intrusions (dikes). Crystals are typically small, (difficult to see with the unaided eye), and are primarily composed of calcic plagioclase, with less pyroxene or olivine. Some basalt may contain phenocrysts (relatively large and conspicuous crystals).

Do all examples of basalt look the same? If not, how do they differ?

The color of basalt is usually gray to black with weathered flows having a dark brown to reddish rust color. Common minerals are plagioclase feldspar, pyroxene, and olivine, and less commonly biotite, hornblende, magnetite, hematite, apatite and quartz. Basalt flows commonly form rough terrain, very difficult to cross with horses, that the Spanish immigrants called malpais.

How do I know if I have found basalt -- what are some distinguishing features of this rock?

Basalt typically occurs as massive flows that may accumulate to large thicknesses and cover vast areas. The edges of eroded basalt flows are commonly jointed (split) into near-vertical, five- or six-sided columns. The surface of the flow may be relatively smooth (if old), or (if young) have a ropey appearance, or be very rough and jagged. The surface may appear shiny or glassy on very recent flows and duller on weathered surfaces. The crystals are typically very small with the rock having a dark gray to black or dark brown to reddish rust color. Vesicles (small cavities formed by bubbles of gas that came out of the magma) are common near the surface of many basalt flows. Basalt is a major constituent of the ocean crust (which covers about 3/4 of Earth), so most basalt of the world is under water, having formed at midocean ridges. Hawaii is largely made of basalt erupted from a huge volcano that grew from the sea floor, larger than Mount Everest in total height, with just its "tip" (well, 10,000 feet or so) above water. Many of the words we use to describe basalt surfaces are Hawaiian--pahoehoe for the ropey surface and aa, (pronounced ah′-ah), for the blocky surface. When erupted, the temperature of basalt is a whopping 1150°C (2100°F)! This makes granite seem luke warm!

Where can I find basalt in New Mexico?

- McCarty Lava Flow, near Grants
- Mount Taylor
- West and south of Red Hill
- Albuquerque Volcanoes and West Mesa
- San Acacia
- Valley of Fires, West of Carrizozo
- North of Velarde
- West of Clayton
- Sugarite Canyon State Park
- Capulin Volcano

Rock Sample 4

Rock Name: Obsidian
Rock Type: Igneous-Volcanic

How does obsidian form?

Obsidian is a natural glass that forms when a "granitic" (silica-rich) magma flows onto the Earth's surface and solidifies rapidly, before many minerals are able to nucleate and crystallize (some obsidian contains a few crystals that formed in the magma before it was erupted).

Do all examples of obsidian look the same? If not, how do they differ?

Obsidian is most commonly black or smoky, and thin pieces can be clear. Other common colors are gray, reddish- brown, and dark green. Sometimes black is swirled with the other colors to form thin bands or create a marbled effect. Spherulites (a mass of needle shape crystals radiating outward from a central point) and small vesicles may also occur. Many rock shops sell smooth, rounded bits of obsidian as "Apache tears".

How do I know if I have found obsidian -- what are some distinguishing features of this rock?

Obsidian occurs in volcanic flows that are thick and can be recognized by the glassy, lustrous, and flow banded appearance with black, smoky, gray, reddish brown, or dark green colors. "Conchoidal" fractures are common--these are smooth, gently curved fracture surfaces that intersect along sharp edges--be careful: obsidian breaks just like glass (because it *is* glass). Obsidian was revered by ancient cultures because it can be worked to form razor sharp edges and was often used as commodity for trade. The obsidian in the kit was purchased from Mommas Minerals in Arizona.

Where can I find obsidian in New Mexico?

- Bandelier National Monument
- Magdalena Peak area
- Battleship Rock

Rock Sample 5

Rock Name: Metaquartzite
Rock Type: Metamorphic

How does metaquartzite form?

Metaquartzite is, simply, metamorphosed quartzite or quartz sandstone. Quartz is one of the most common minerals on Earth, and is formed from the chemical compound silica (SiO_2). The texture of metaquatzite is normally evenly granular. The parent rock is quartz sandstone that has undergone thermal and/or regional metamorphism. It can be very difficult to tell from a quartzite that is well cemented by silica cement!

Do all examples of metaquartzite look the same? If not, how do they differ?

Metaquartzite has a white color when it is pure but may be brown, pinkish, or light to dark gray due to impurities. A slightly glassy look is common on freshly broken surfaces, but the fractures are rarely as smooth as in obsidian. Much metaquartzite is granular with fine to medium size grains. It is a hard rock that will typically scratch a hammer or knife.

How do I know if I have found metaquartzite -- what are some distinguishing features of this rock?

Metaquartzite is usually found as prominent outcrops in the form of ledges and cliffs. The lack of significant mineral content other than quartz, and generally a white to grey color help to identify metaquartzite. Metaquartzite is often used as flooring in construction and is also used in the ceramic and glass industries.

Where can I find metaquartzite in New Mexico?

- Manzano Mountains
- Ojo Sarco area
- Picuris Range east and north of Dixon

Rock Sample 6

Rock Name: Marble
Rock Type: Metamorphic

How does marble form?

Marble is a metamorphic rock that is composed predominately of calcite or dolomite. The protolith (parent rock) is typically limestone or dolostone (limestone with magnesium). Marble is formed by contact metamorphism (reconstitution of rocks that takes place at or near the contact with intrusive rocks), or dynamothermal metamorphism (metamorphism involving the effects of pressure, shearing stress, and elevated temperatures related to folding and other deformation caused by regional tectonic events).

Do all examples of marble look the same? If not, how do they differ?

Marble is normally white to snowy white, however when other minerals are present swirled bands or streaks of black, green, red, yellow, or brown may occur. Marble is commonly massive and does not have foliation. The presence of other minerals or deformation during metamorphism can lead to weak or distinct foliation. Crystals can be fine to coarse grained--some pure, white, evenly fine-grained marble is favored by sculptors (for example, Michelangelo's David).

How do I know if I have found marble -- what are some distinguishing features of this rock?

Marble is distinguished by the white to snowy white color, the presence of black, green, red, yellow, or brown bands, and its typically massive structure. If fractured or finely foliated, marble will form slopes or valleys, due to the lack of resistance to erosion, but massive marble bodies in desert climates can form cliffs. Like limestone and dolomite, which are made from the same minerals, calcite marble effervesces with cold dilute hydrochloric acid, dolomite marble will effervesce if it is ground to a powder or hot hydrochloric acid is used. Marble is a relatively soft rock and will not scratch a knife or hammer.

Where can I find marble in New Mexico?

Marble is fairly rare in New Mexico, but in limestones surrounding igneous intrusions in southwestern New Mexico contact metamorphic marble can be found. The marble in this kit was graciously donated by Thunderbird Tile and Stone, which gave us scrap pieces from countertop and flooring material.

Rock Sample 7

Rock Name: Schist
Rock Type: Metamorphic

How does schist form?

Schist is a metamorphic rock formed during low-grade to high-grade metamorphism. Parent rocks include common sedimentary rocks (especially shale and sandstone) and volcanic rocks such as rhyolite and basalt. Schist is typically formed during dynamothermal metamorphism involving deep burial, increase of pressure and temperature, and deformation.

Do all examples of schist look the same? If not, how do they differ?

Schist is medium to coarse grained and has abundant platy minerals such as biotite and muscovite, which make it look sparkly in the sunlight. These minerals also give the rock a foliated texture. Most schist also contains quartz and feldspar.

How do I know if I have found schist? What are some distinguishing features of this rock?

Schist has medium- to coarse-grained parallel minerals that are silvery white (muscovite) or black (biotite), and overall the rock is commonly gray with yellow to brown tones. Fresh samples sparkle in the sunlight. Samples commonly show foliation caused by alignment of the platey micas muscovite and biotite. Schist that is derived from basalt is used to make talc, a lubricating and dusting powder.

Where can I find schist in New Mexico?

- Manzano Mountains
- Picuris Range east and northeast of Dixon
- Taos County
- Ojo Sarco area

Rock Sample 8

Rock Name: Gypsum Rock
Rock Type: Sedimentary-Chemical

How does gypsum rock form?

Gypsum is the name of both a rock type and a mineral (made of the chemical hydrous calcium sulfate, $CaSO_4 \cdot 2H_2O$). The rock is a chemical sedimentary rock that forms in arid or semiarid climates by the evaporation of saline, marine or lacustrine waters in environments with restricted replenishment of fresh water. Gypsum rock can also form through hydration of the mineral anhydrate ($CaSO_4$) in the weathering zones, and often is associated with other salt deposits and minerals, such halite (common table salt), the chemical sodium chloride: NaCl.

Do all examples of gypsum rock look the same? If not, how do they differ?

Gypsum is usually white to light gray with iron oxide pigments producing brown or red colors and organic impurities producing dark gray colors. Gypsum is fine to course grained and may be crumbly. Gypsum often occurs in beds that may be a few centimeters to tens of meters thick, and that are often contorted due to its soft and easily deformed nature and due to removal of more soluble salts.

How do I know if I have found gypsum -- what are some distinguishing features of this rock?

Gypsum is often associated with halite and anhydrate in extensive and sometimes thick beds of evaporite rocks. When gypsum is freshly broken the sample will sparkle under sunlight with a pearly to vitreous sparkle. The crystalline grains often interlock and may be mixed with other evaporites. Gypsum crystals are very soft and can be scratched with your fingernail. Because it is so soft, even in arid and semiarid regions gypsum generally is found in slopes and valleys.

Where can I find gypsum in New Mexico?

- Quebradas in Socorro County
- San Andres Mountains
- White Sands National Monument, (gypsum and grains)
- East of Abo Pueblo
- Living Desert State Park
- South of Ysidro
- Cerrillos area
- Tucumcari
- Bottomless Lakes State Park

Rock Sample 9

Rock Name: Shale
Rock type: Sedimentary-Clastic

How does shale form?

Shale consists of very fine-grained clay minerals and of silt- and clay-sized particles (too fine to be seen with the naked eye) that are deposited in a low-energy environment of lake and ocean bottoms. Most clay minerals are formed by chemical weathering of feldspars and micas, originally derived from granitic or volcanic rocks. As the clay and silt accumulate, get buried, and compact under the weight of younger sediment deposited above, thin layers, or laminae, are formed as the platey clay particles become oriented in parallel alignment. These very fine-grained particles become closely packed, preventing fluids with cementing material from freely circulating through the rock, generally creating a poorly cemented or lithified rock.

Do all examples of shale look the same? If not, how do they differ?

Shales are normally light to dark gray or black, olive green, or shades of brown depending on the amount of organic material present and on the cement that is present. Iron oxides may color some shales buff, brown, reddish brown, or deep red. Shale is laminated and tends to split into flat fragments.

How do I know if I have shale -- what are some distinguishing features of this rock?

Shale can be distinguished by the thin parallel bedding that splits into fragments. It is only rarely resistant to erosion, so outcrops tend to be subdued and found in slopes or valleys. Shale, being made up fine grained material, often preserves fossils with minute detail.

Where can I find shale in New Mexico?

- Quebradas
- San Antonio
- North of Springer
- Wagon Mound to Raton
- Ship Rock
- Angel Peak National Recreation Area
- Bisti Badlands
- Bluewater Lake State Park

Rock Sample 10

Rock Name: Limestone
Rock Type: Sedimentary-Biochemical/Chemical

How does limestone form?

Most limestone forms from the precipitation of calcium carbonate ($CaCO_3$, which forms the mineral calcite) out of marine water, either inorganically or due to the action of marine animals and plants. Other limestone is made of calcite grains (essentially, these are calcium carbonate sandstones!), such as broken shell fragments or ooids (which are tiny sand or shell fragments that become coated with calcium carbonate, making nearly perfectly spherical millimeter-scale grains). Limestone may also form from peloids, small carbonate grains that are commonly excreted from organisms that have ingested carbonate muds. Small skeletal fragments also commonly make up limestone.

During and after lithification in the presence of sea water or pore water, which contains considerable magnesium in solution, much limestone is altered to dolostone--made of the mineral dolomite, which is calcium-magnesium carbonate $(Mg, Ca)(C0_3)_2$

Do all examples of limestone look the same? If not, how do they differ?

Limestone is usually white or light to dark gray to black and may contain recognizable fossils. Some can be very fine grained and others can be formed of calcite sand grains or cobbles.

How do I know if I have found limestone -- what are some distinguishing features of this rock?

Limestone will effervescence from dilute hydrochloric acid (dolostone must be powdered first). Limestone may be pitted, crumbly, pockmarked in outcrops, especially if it is impure or thin bedded, but it often forms grey cliffs in desert conditions. Because limestone is easily dissolved by weak acids--even naturally occurring water is commonly slightly acidic--it can form extensive cavern systems, such as Carlsbad Caverns in southern New Mexico. It is easily scratched by a hammer or knife.

Where can I find limestone in New Mexico?

- Quebradas in Socorro County
- Northwest Espanola Basin
- Guadalupe Mountains and Carlsbad Caverns
- Zuni Mountains
- Derry Hills, Sierra County
- Bishop Cap, Dona Ana County
- Bluewater State Park

Rock Sample 11

Rock Name: Sandstone
Rock type: Sedimentary-Clastic

How does this rock form?

Sandstone is a clastic sedimentary rock composed primarily of quartz grains deposited in floodplains, deltas, beaches, and dune fields, and held together by cements of silica, carbonate, clay, or iron oxides. The quartz grains are commonly white or gray but may be stained red, brown, pink, or yellow from iron oxides. The mineral quartz (crystalline silica, or SiO_2) is hard and resistant to both chemical and mechanical weathering, so resists breaking down and can exist at the Earth's surface for a long time. The quartz grains most likely have gone through several cycles of deposition, cementation, and weathering (during which time less resistant minerals have been destroyed or removed) prior to being deposited as quartz sand. Some sandstone includes minerals other than quartz, such as feldspar grains, or small rock fragments.

Do all examples of this rock type look the same? If not, how do they differ?

Sandstone has grain sizes of 0.05 to 2.0 millimeters, and the grains may well rounded and well sorted, or angular and poorly sorted. Sandstone occurs in thin to thick beds, sometimes massive or with cross-bedding and ripple marks. Quartz sandstone is commonly white, light to dark gray, or stained red, pink, yellow, or brown due iron oxide cements. Many of the spectacular and colorful cliffs in state and national parks, such as Echo Amphitheater (New Mexico) or Zion National Park (Utah), are made of quartz sandstone.

How do I know if I've found this rock --What are some distinguishing features of this rock?

Sandstones usually have a gritty feel and will fracture through the cement. The grains are angular to well rounded and there is very little clay in the matrix. Sandstones are usually relatively resistant to weathering and will stand out in relief to rocks that are more susceptible to erosion, such as shale.

Where can I find this rock type in New Mexico?

- Eastern Cibola County, Red Sandstone
- Zuni Mountains by Fort Wingate, Red Sandstone
- Zuni Pueblo, Red Sandstone
- East of Gallup, White Sandstone

Rock Sample 12

Rock Name: Conglomerate
Rock type: Sedimentary-Clastic

How does conglomerate form?

Older rocks of any kind are broken down, through processes of weathering and erosion, into fragments that are large enough that the original rock type is preserved. The rocks are then transported and deposited by fluid flow (rivers, streams) and sediment gravity flow (mud and debris flows). Finer grained material is also commonly present and forms a matrix between the larger clasts, all of which is cemented by silica, carbonate, iron oxides, clay, or other cements.

Do all examples of conglomerate look the same? If not, how do they differ?

Different conglomerates can look different from one another due to differences in their source, or parent, rock types. Individual rock fragments can have a range of sizes, colors, and be angular to very well rounded.

How do I know if I have found conglomerate -- what are some distinguishing features?

In general the clasts in conglomerate will be easily seen with the naked eye: larger than a few millimeters in diameter and up to meters. Some clasts in conglomerates that were deposited near to steep topography in their source region can be as large as buildings! Conglomerate can be thickly bedded to massive.

Where can I find conglomerate in New Mexico?

- Quebradas in Socorro County
- East of San Antonio
- Zuni Mountains along NM 400
- East of Grants
- Espanola Basin
- Ute Creek

Definitions of Some Common Terms

aphanitic - Fine-grained igneous rock whose constituents are too small to be distinguished with the unaided eye.

batholiths - A large, generally equidimensional plutonic mass that has more than 100 km^2 of surface area and no known floor.

bedded - Deposited in layers or beds of sedimentary rocks or of stratified material of volcanic ash or other material.

crossbedding - A bedding structure produced by current action from fluids or air that creates bedforms (such as ripples on the bottom of a stream) and that results in laminae at an angle to the general bedding.

effervesce - To give off bubbles, gas, or foam.

exfoliation - The process by which concentric scales, plates, or shells of rock, from less than a centimeter to several meters thick, are spalled or stripped from the bare surface of a large rock mass, usually a pluton. Generally caused by internal elastic forces in a rock that has been unburied from great depth.

extrusion - The eruption of lava onto the Earth's surface.

flow banding - A layer of volcanic rock differing in mineral composition, texture, or color from adjacent layers.

foliation - Planar arrangement of textural or structural features in any type of rock, especially the planar structure that results from alignment of mineral grains of metamorphic or volcanic rocks.

geological - Pertaining to geology.

geology - **The** study of the materials, processes materials, history, and products formed on the earth.

igneous - Rock or mineral that solidified from molten or partially molten material.

intrusion - The subsurface emplacement of magma into pre-existing rock.

lamina - The thinnest layer in sedimentary rock. The layers differ in colors, composition, or particle size.

magma - Naturally occurring molten rock material generated in the Earth, which may be intruded into older rocks in the subsurface or extruded onto the surface.

magmatic - Pertaining to or derived from magma.

massive - Rocks of any origin that lack foliation, cleavage, bedding, or layering.

matrix - The ground mass or finer grained material enclosing larger grains of igneous or sedimentary rock.

metamorphism - Mineralogical, chemical, and structural changes of solid rocks due to changes in their physical (pressure, temperature and/or chemical) conditions imposed at depth below the zones of weathering and cementation.

phaneritic - Texture of igneous rocks in which the individual mineral grains are distinguishable with the unaided eye.

phenocrysts - Crystals in an igneous rock that are significantly larger than the average grain size. Intrusive rocks with such crystals are called porphyritic

plutonic - Igneous rocks intruded at depth as large (kilometer scale), roughly equant bodies.

porphyritic - Intrusive igneous rocks that contain phenocrysts in a fined-grained groundmass.

porphyroblasts - Large crystals formed in metamorphic rock by recrystallization.

rounded - Sedimentary grains that have had original edges smoothed off.

sediment - Solid fragmental material that is transported and deposited by wind, water, ice, or chemically precipitated from solution or organisms.

spherulites - A mass of needle-shaped crystals radiating outward from a central point. Typically formed by late-stage crystallization of the glassy matrix of silicic volcanic rocks.

spall - A thin curved piece of rock produced by exfoliation or peeling.

tectonics - A branch of geology that deals with the structural, deformation, origin, and historical features of the Earth.

vesicles - A small cavity in an aphanitic or glassy rock igneous rock. Formed by the expansion of a bubble of gas or steam during the solidification of the rock. Vesicles are particularly common in basalt flows.

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