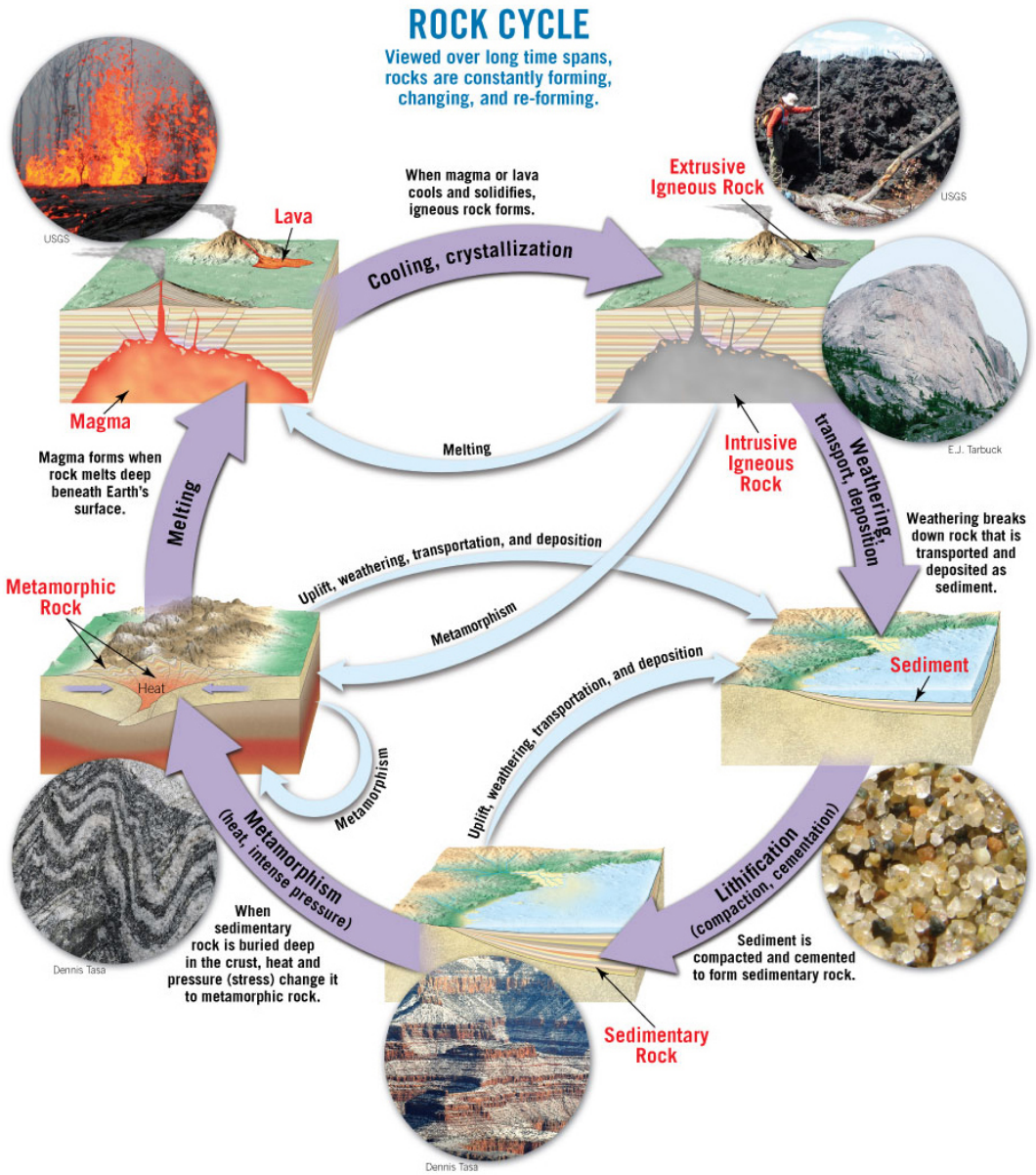
Campus Field Trip Guidebook

Department of Earth and Atmospheric Sciences
University of Houston



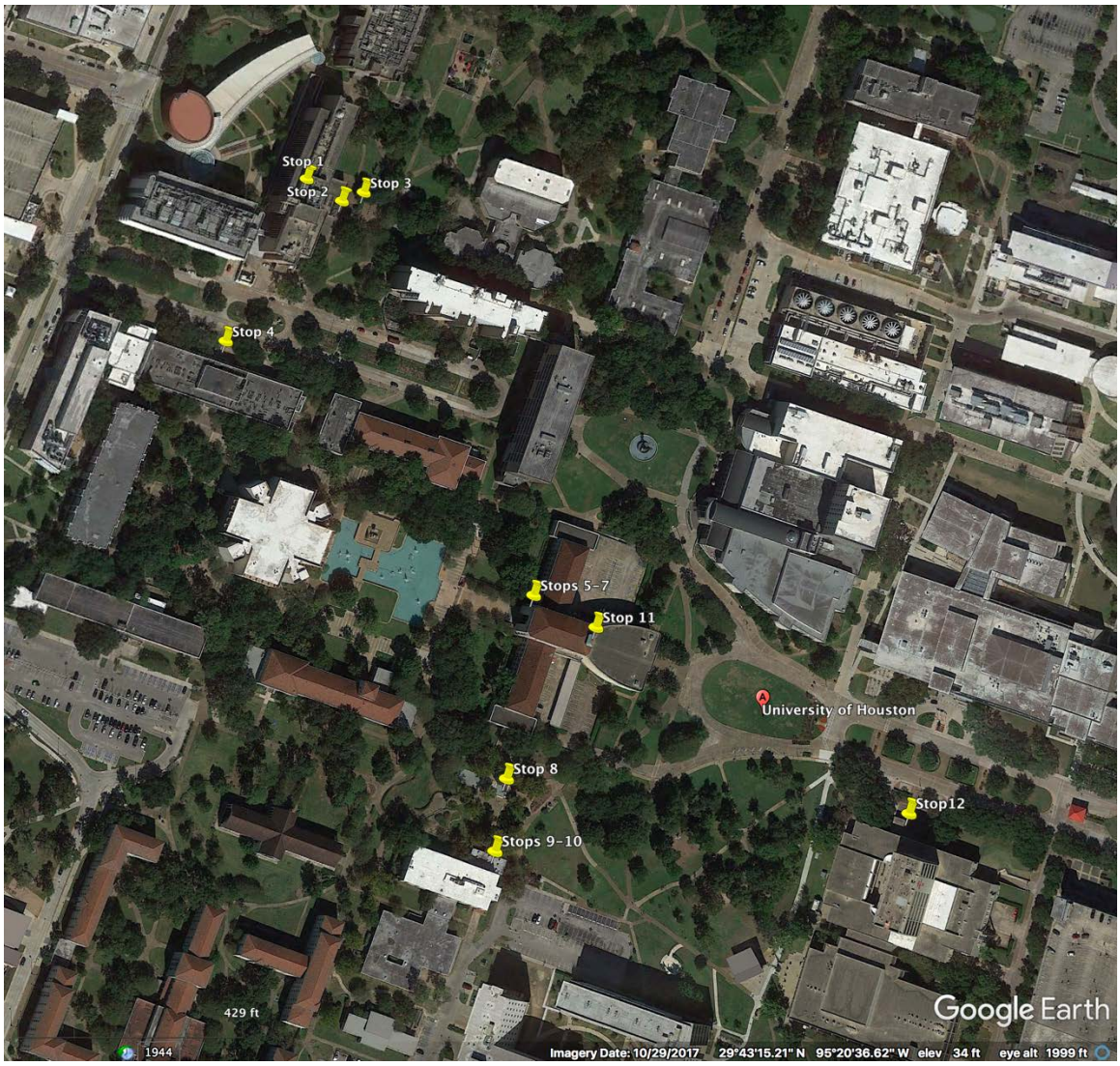
Art on the UH campus uses rocks! Download the UH ARTour app for Apple and Android

Laurentian Pink Granite in sculpture – Benches by Scott Burton at the south entrance of the Gerald D. Hines College of Architecture, sculpted in 1985

Town Mountain Granite in the sculpture – Lotus by Jesus Bautista Moroles in the courtyard of the Graduate School of Social Work, sculpted in 1982

Black Cambrian Granite in the untitled sculpture by Matt Mullican at the plaza of the Science Center Building, sculpted in 1991

UH Campus Map showing locations of various stops in your Guide Book



Most of the figures and images used in this guide are from GEOL 1330 textbook – Earth by Tarbuck, Lutgens and Tasa, 12th edition, 2017

Figure on the front page is Figure 1.22, see https://goo.gl/dYWRsL

STOP 1

Location: first floor lobby S&R 1 (building 550). All three types of rocks are used for various facing stones within the lobby.

Sedimentary Rock: *travertine* wall panels on lobby walls.

Description: Travertine is a chemical sedimentary rock formed by precipitation of carbonate minerals often influenced by microbial activity. Travertine is composed of aragonite and calcite, although iron and organic impurities can alter its color to yellow, grey, brown and even red. Travertine deposits are located either in hot or cold springs in karst areas. Water dissolves limestone at depth and become saturated with CO_2. The CO_2 makes the water acidic. As the groundwater resurfaces, a sudden drop in pressure causes the release of CO_2 and crystallization of calcium carbonate.

Romans may have been the first to use travertine; the Roman Colosseum is the world's largest travertine building. Travertine is quarried in Italy, Iran, Turkey, Mexico and New Mexico but not Texas.

Badab-e Surt Samaee travertine deposit, Iran. photo by M. Samaee (Wikipedia) Badab means 'gassed waters' in Persian

Questions to consider:

What causes the layering?

Why is this rock red colored?

Is this a good rock for building?

Igneous Rock: *gabbro*, wall panels at floor level by elevator.

Description: Gabbro is a dark plutonic (intrusive) igneous rock made up of calcic plagioclase feldspar and mafic minerals such as pyroxene. There are no preferred mineral orientations. For the most part, it can be described as having an equigranular texture. Gabbro is rare in Texas and only occurs southeast of Llano.

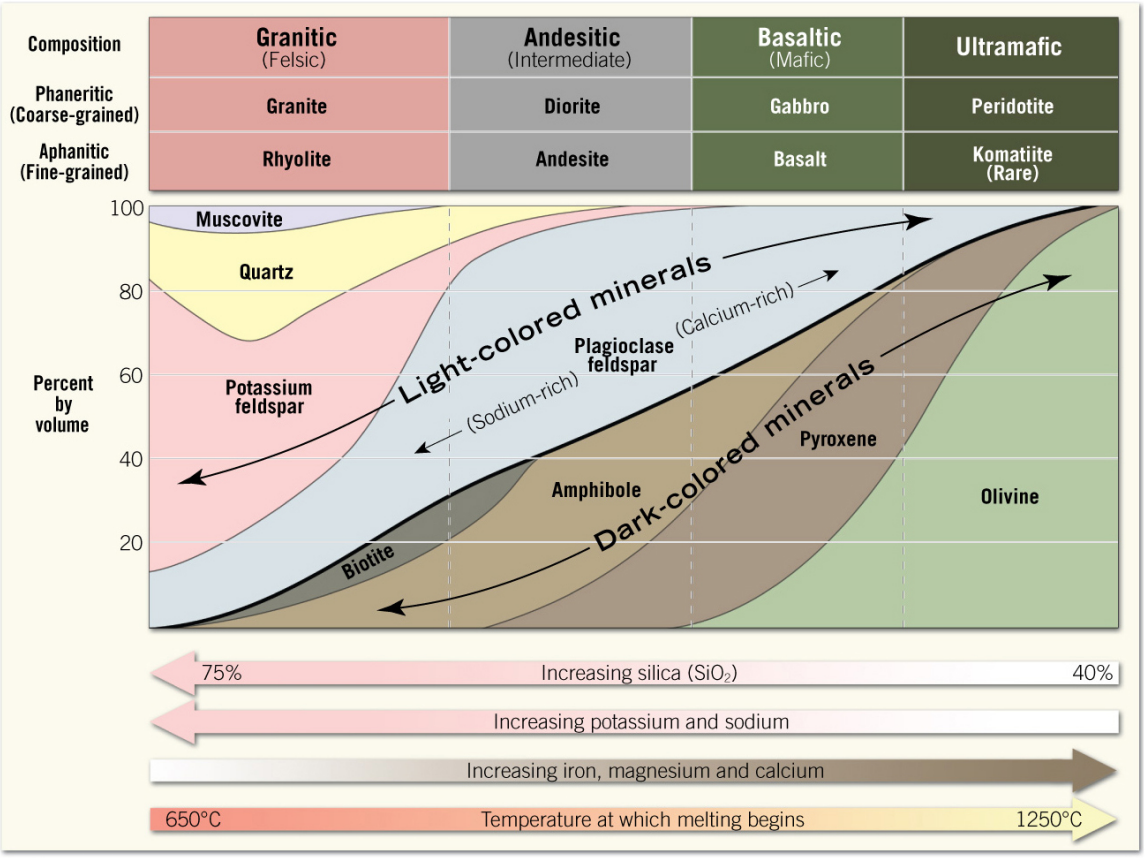


Figure 4.5 also see https://goo.gl/vST3z8, Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to consider:

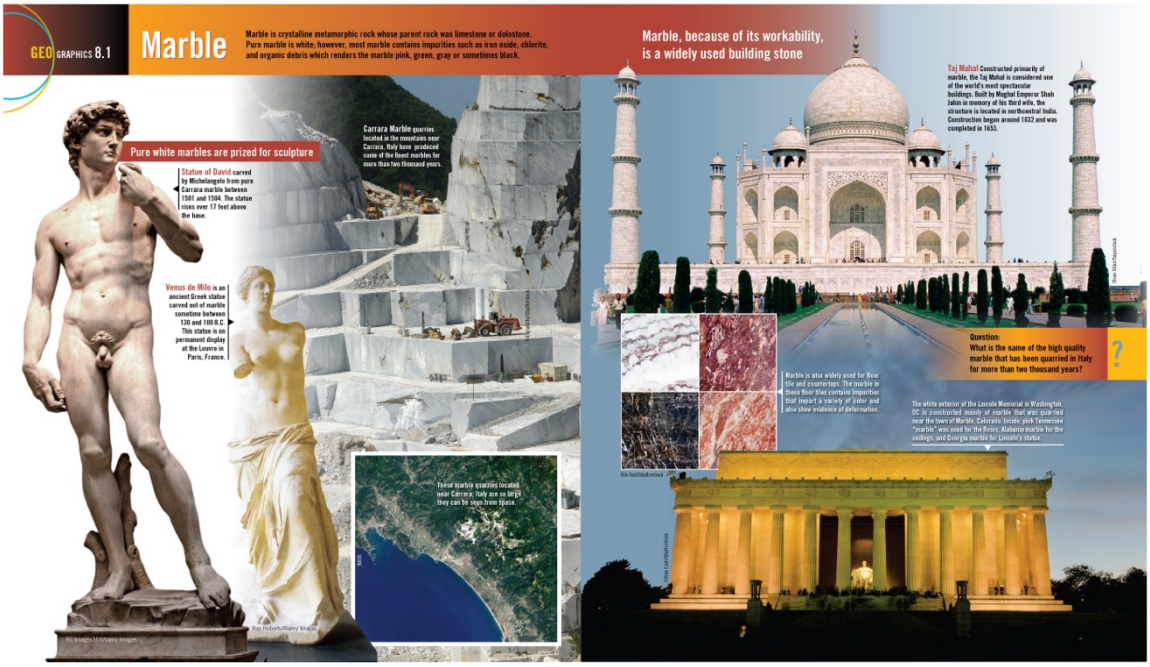
What mafic minerals could make up a gabbro?

In what type of tectonic environment might you find a gabbro?

Thinking about composition, what is the equivalent volcanic (extrusive) rock?

Metamorphic rock: *marble* wall panel, lobby next to front entrance of S&R 1

Description: The panels are composed of marble, a metamorphic rock. It is homogeneous, and made up entirely of calcite ($CaCO_3$). Texture is described as sugary. There are well-defined fractures that are filled with calcite. Marble occurs in many places in Texas including the Hill Country where it is mined for terrazzo.



Geographics 8.1, Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017

Questions to consider:

Since the chemistry of this rock is mostly composed of calcite, what could you infer was the protolith to this rock?

When do you think the fractures formed: before, during or after metamorphism to marble?

Why doesn't marble exhibit foliation?

STOP 2

Location: Ledge of the oolitic limestone in east side of S&R-1

Description: Surface feels like course sand paper. Light colored, reacts with acid (information provided). The rock consists of tiny spheres of carbonate called ooid.

The cross-stratifications show alternating current directions throughout the rock. Those opposite current directions caused the little spheres to roll to and fro on the surface during precipitation of carbonate. The grains became spheres called oolites. So, this is an oolitic sandstone / limestone. In Texas, you can find oolitic limestone in Upper Cretaceous rocks near Fredricksburg.

This rock was quarried from the Indiana Bedford Limestone, a Mississippian (~350-330 Ma) grain stone. It also covers the Empire State Building in New York City, NY.

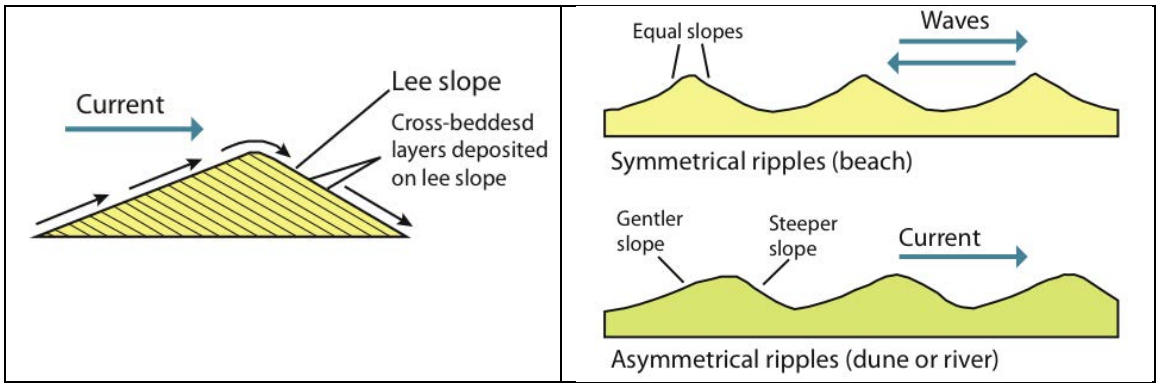


Figure drawn by J. Sisson


Small spherical grains called *ooids* are formed by chemical precipitation of calcium carbonate around a tiny nucleus and are the raw material for oolitic limestone.

Figure 7.16, Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to consider:
How is cross stratification produced?

What was the direction of the current(s)?

What kind of environment can produce opposite directions of cross-stratifications? (Hint: Tide and Ebb)

STOP 3

Location: John C. Butler/GeoSociety Rock Garden – John Butler was a beloved geology professor, department chair, associate dean of Natural Science and Mathematics, and finally retired as Dean of NSM. In addition to this memorial garden, there is a teaching award named in his honor.

Description: Recently, the undergraduate GeoSociety replanted and added rocks to the garden. Here there are examples of all three different rock types: igneous, metamorphic, and sedimentary rocks.

W1 – Garnet amphibolite gneiss
W2 – Petrified trees
W3 – Fossil Brain Coral
W4 – Rhyolite with vesicles
W5 – Shale
W6 – Slickensides on limestone
W7 – Epidosite, Timber Hill MT
W8 – Grantiic gneiss with cross-cutting granite and gneiss xenolith
W9 – Polished granite with K-feldspar megacrysts

E1 – Layered mafic intrusive, Stillwater Mine MT
E2 – Norite, Stillwater Mine MT
E 3 – Chromite ore, Stillwater Mine MT
E 4 – Gabbro, Stillwater Mine MT
E 5 – Polished granite
E 6 – Buda limestone, Big Bend area TX
E 7 – Fault breccia, Heart Mountain MT
E 8 – Inoceramid fossil, Big Bend area TX
E 9 – Cross-bedded sandstone

West Side:

East Side:

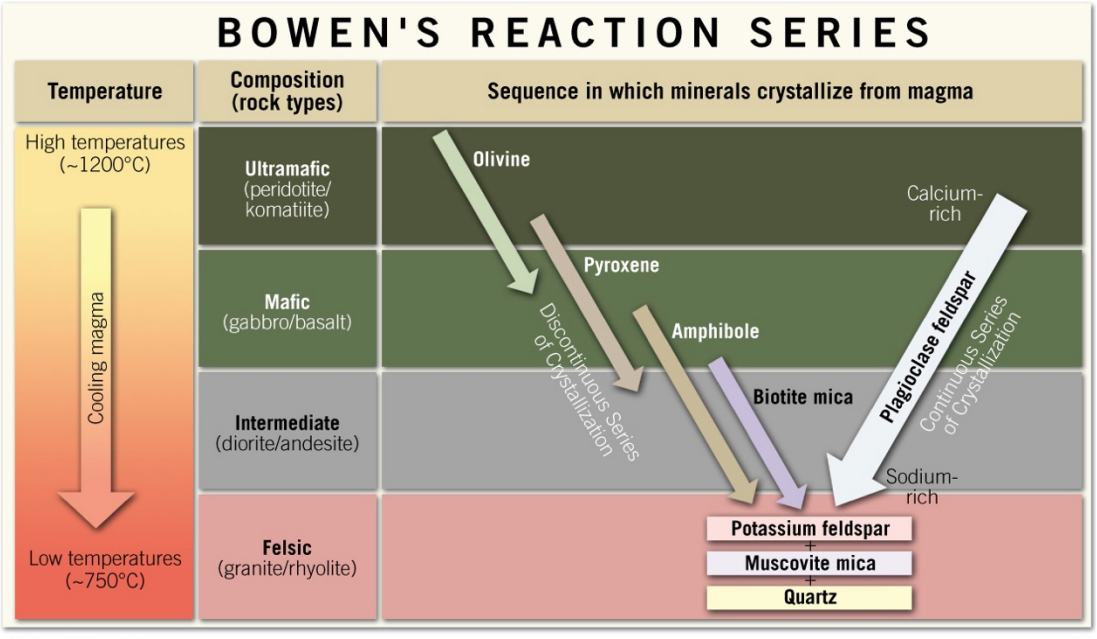


Figure 4.21, Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to consider:
Consider Bowen's Reaction Series. What do you think was the sequence of crystallization for the granitic magma? What about the gabbroic magma?

How would you describe the texture of the granite?

What percentage by volume does each of the main minerals comprise (quartz, plagioclase, orthoclase)?

STOP 4a

Location: Limestone outside the Fleming (home of the Geoscience Learning Center)

Description: Beautiful molds of fossil bivalve shells. Note the variation of concentration, type and size of the shells. The environment must have been favorable to living organisms. This type of environment is a combination of shallow water depth (required for light penetration), warm and optimum nutrient supply. This rock reacts with acid so it is a fossiliferous limestone.

There are some finer grained, non-fossiliferous clasts (interclasts) that were ripped up from the adjacent barrier island during deposition.

This building stone is from Albian Fredricksburg Group quarried at the Armadillo Quarry near Florence TX., a Cretaceous (~ 113 - 100 Ma) exposure near Austin, TX. One colloquial name is Texas Cordova Shell limestone and another is Austin Shell stone (e.g. http://www.texasquarries.com/limestone.htm). Similar rocks will be visited on the field trips to Central Texas.

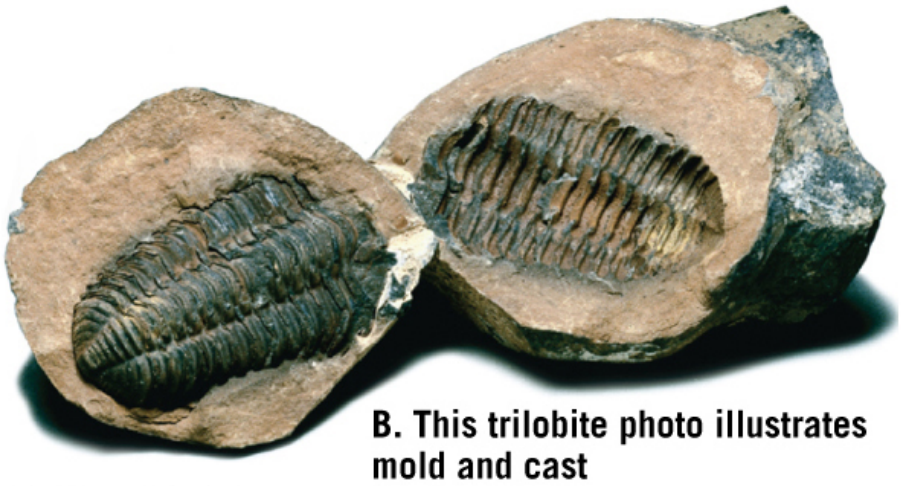


Figure 9.15b, Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to Consider:
In addition to bivalves, can you identify any other fossils?

Do these fossils represent the original remains of ancient shelly organisms?

How does a fossil mold form? What are fossil casts?

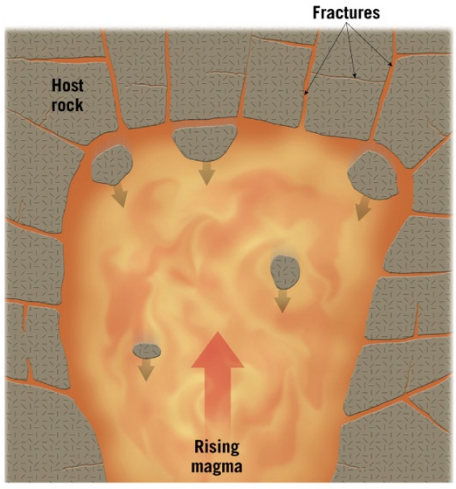
What type of depositional environment does this limestone represent? What were the water conditions (i.e. temperature, depth, oxygen abundance, etc.) within which these ancient shelly organisms thrived?

STOP 4b

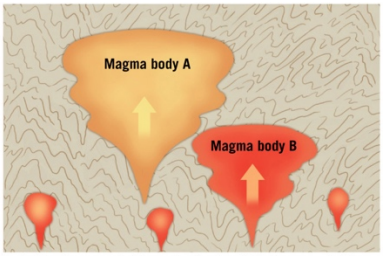
Location: polished granite, east steps of the Lamar Fleming Bldg

Description: This particular granite shows a type of igneous structure indicating magma mixing. There are more mafic fine-grained portions embedded in the host rock, the only difference being in the texture: the fine-grained margin versus the coarser grained surrounding rock. The finer texture implies rapid cooling and crystallization. Note the inclusions within the granite with reaction textures around the rims (rapakivi texture). Also note that some of the feldspar crystals display crystal zoning.

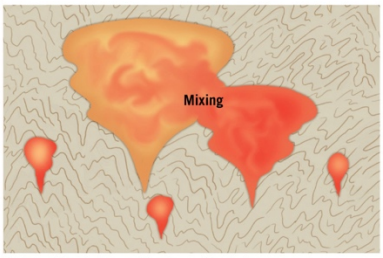
This building stone was quarried in the Town Mountain Granite near Llano TX in the Texas Hill Country. Most of the quarried stone comes from Granite Mountain and is ~ 1 billion years old. This region has been quarried since 1882. The Texas capitol building, in Austin, is made entirely of Town Mountain Granite. You can also see this stone in the jetties near Freeport and seawall in Galveston if you go on the Galveston off-campus field trip. Also, we visit several outcrops on the Central TX off-campus and virtual field trips to look at the Town Mountain granite.



As magma rises through Earth's brittle upper crust, it may dislodge and incorporate the surrounding host rocks. Melting of these blocks, a process called *assimilation*, changes the overall composition of the rising magma body.



A. During the ascent of two chemically distinct magma bodies, the more buoyant mass may overtake the slower rising body.



B. Once joined, convective flow will mix the two magmas, generating a mass that is a blend of the two magma bodies.

Figures 4.24 & 4.25, Tarbuck, Lutgens and Tasa, Earth, 12th ed., 2017.

Questions to consider:

What is the difference in texture (appearance of crystals) between the chilled margin and the host rock?

What is the mineralogy of the rock?

Is this a mafic or felsic rock?

What causes crystal zoning?

What was the source of the inclusions (see illustration above)?

STOP 5

Location: The inscribed rock on the wall left of the entrance of E. Cullen (building 516)

Description: Feel the surface with your hand. It feels like sand paper. This rock is comprised of sand-sized clastic particles (grains). It does not react with acid and thus it is quartz sandstone. Although stratification or laminations are not apparent, this rock shows numerous wormy structures. These features are burrows and tunnels through which organisms lived and/or moved through the sediment. When organisms churn the sediments, they destroy all of the sedimentary structures. Only burrows (i.e. biogenic structures) are left within the rocks. These bioturbation structures are considered to be trace fossils. Sandstones are found in Cambrian, Cretaceous and Cenozoic strata in Texas.

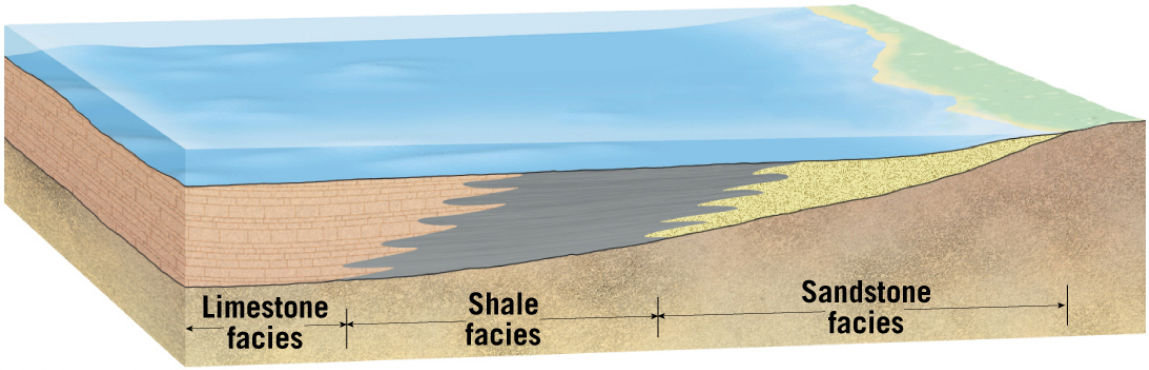
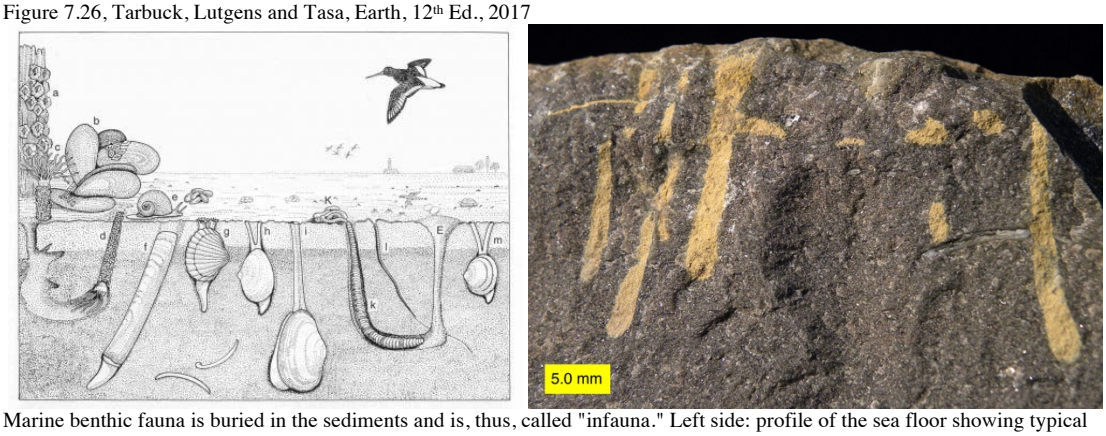


Figure 7.26, Tarbuck, Lutgens and Tasa, Earth, 12th Ed., 2017



Marine benthic fauna is buried in the sediments and is, thus, called "infauna." Left side: profile of the sea floor showing typical infaunal organisms. a) Barnacles (Balaniden), b) Blue mussels (*Mytilus edulis*), c) Polychaete *Lanice conchilega*, d) Polychaete *Lagis koreni*, e) Snail *Littorina littorea*, f) Rasor clam (*Ensis americanus*), g) Bivalve *Cerastoderma edule*, h) Bivalve *Scrobicularia plana*, i) Bivalve *Mya arenaria*, k) Polychaet *Arenicola marina*, l) Polychaete *Hediste diversicolor*, m) Bivalve *Macoma balthica* from http://www.senckenberg.de/root/index.php?page_id=2447 Right side: *Trypanites* borings in Ordovician limestone, northern Kentucky. The borings are filled with diagenetic dolomite (yellowish). Note that the boring on the far right cuts through a shell in the matrix. https://en.wikipedia.org/wiki/Trace_fossil#/media/File:Trypanites01.jpg

Questions to Consider:

What is a trace fossil?

What types of organisms may have produced the burrows in the ancient sediment?

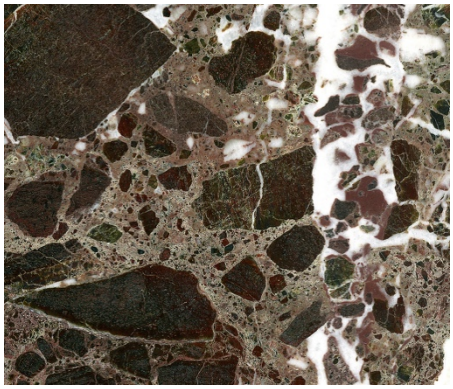
What type of sedimentary environment does the sandstone represent? Note: see the illustration above.

STOP 6

Location: Marble breccia wall panels just inside the entrance to E. Cullen Bldg.

Description: These polished panels were cut from a tectonic breccia containing many fractures. This rock reacts with weak hydrochloric acid, indicating that the mineral is calcite. It is possible to identify sets of fractures that are younger than another set by their cross-cutting relationships.

The breccia contains abundant angular fragments and blocks. This building stone is marketed as Lucedo Chiaro Marble from Nuvolera, Italy. This is near the town of Brescia that may be the type locality for breccia.



There are two types of sedimentary breccia. These are (1) sedimentary breccia made of angular fragments in a fine grain matrix formed in alluvial fans and (2) karst breccia made of angular fragments that form during dissolution of limestone. These are often associated with collapse and karst formation in limestone or marble. You can see a sedimentary breccia formed in Cienequita Formation, Chinati Mountains north of Presidio, TX. If you want to find a karst breccia, look for paleokarst features in the Ellenberger Formation, a major oil reservoir in west Texas.

Left Fig. 7.11, Tarbuck et al., Earth, 12th Ed., Prentice Hall, 2017; Right https://c1.staticflickr.com/8/7641/16392849344_372fe43b2b_b.jpg.

Questions to Consider**:**
Marble forms through metamorphism of _____?

Why are the marble blocks angular?

When did the cross-cutting calcite veins form relative to the large marble blocks?

STOP 7

Location: Travertine wall panels in stairwell of E. Cullen Bldg

Description: As described previously, travertine is a chemical sedimentary rock formed by precipitated carbonate minerals. Many hot springs and geyser fields also have colorful travertine deposits. The texture of travertine can be massive or porous with large cavities. The laminations in some travertine are created by seasonal variation of microbial growth. The orientation of laminae can tell us the original orientation of the rock. Travertine is also called travertine limestone, tufa (with large pores), calc-sinter, calcareous tufa,

onyx marble, Mexican onyx, and Egyptian or Oriental alabaster. Travertine is frequently used in modern architecture as facade material, wall cladding, and flooring. Several buildings in downtown Houston use travertine including the Jesse Jones building at 712 Main St and One Shell Plaza at 900 Louisiana St. This is marketed as Roman Travertine marble imported from Italy and was also used to build the Colosseum and St. Peter's Basilica in Rome.

Figure Chapter 7 Eye on Earth 7.2 Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Figure 17.25 Mammouth Hot Springs, Yellowstone National Park, WY Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to Consider:
What was the original orientation of the rock from which the panels were cut?

Do you see evidence of past microbial action in the travertine wall panels?

STOP 8

Location: Blocks of granite in fountain near the Student Service Center

Description: This granite shows a type of igneous structure indicating magma mixing. There are more mafic fine-grained portions embedded in the host rock, the only difference being in the texture: the fine-grained margin versus the coarser grained surrounding rock. The finer texture implies rapid cooling and crystallization. Also, note that some of the feldspar crystals change from plagioclase (gray) to k-feldspar (pink); this is called anti-rapikivi texture which supports the magma mingling hypothesis.

This is a similar stone to what you saw near Stop 4 at Fleming. Building stone from this quarry was used to construct the Texas State Capitol building in Austin TX.

Questions to consider:
How much do these blocks weigh?

(Hint: use density of granite (2.5-2.8 gm/cm^3) and their size to calculate

Abandoned quarry near Enchanted Rock State Natural Area. The large crane is for moving blocks much larger than these in the fountain. Photo by Jack Morelock – he first visited the area in 1951 on a UH field trip to the Llano region.

STOP 9

Location: Stalactites, outside entrance to Student Service Center (building 524)

Description: A stalactite (Greek stalaktos for dripping), or dripstone, is a type of speleothem that hangs from the ceiling of limestone caves. A stalagmite (from the Greek stalagma for drop) is a type of speleothem that rises from the floor of a limestone cave due to mineralized solutions and the deposition of calcium carbonate. Each stalactite begins with a drop of mineral-laden water. When the drop falls, it leaves behind the small ring of calcite. Each subsequent drop that forms and falls deposits more calcite. Eventually, these rings form a narrow hollow tube commonly known as a *soda straw*. These can grow quite long. An average growth rate is 0.13 mm (0.005 inches) a year. If they become plugged by debris, water begins flowing over the outside, depositing more calcite and creating the more familiar cone-shaped stalactite. The same water drops that fall from the tip of a stalactite can deposit more calcite on the floor below, resulting in a rounded or cone-shaped stalagmite. Unlike stalactites, stalagmites are never hollow. The longest stalactite (20 meters) is in the Chamber of Rarities, Gruta Rei do Mato (Brazil). If a stalactite and stalagmite grow together and meet in the middle, they can join and form a column or pillar. The process of forming stalactites is still going on. Stalactites and stalagmites can form on concrete and plumbing, but at much faster rates then in a natural cave. There are over 5000 caves in Texas!

Soda straw
Part of Figure 7.12

Stalactites: Chinese Theater area in New Mexico's Carlsbad Caverns
Figure 6.9 Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to Consider:
What is the main composition of a stalactite?

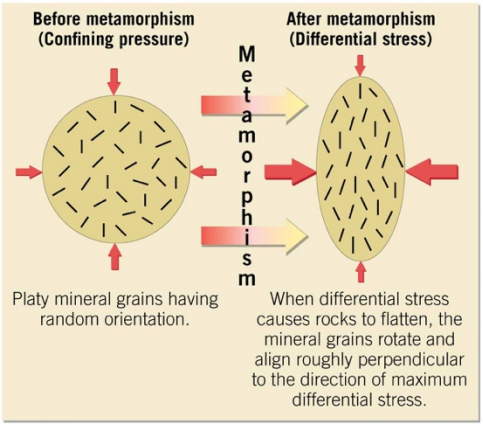
What are two physical properties of this mineral that would help you readily identify it?

Why are these forming on this ceiling?

STOP 10

Location: Ledge of slate along perimeter of entrance to Student Service Center

Description: Slate typically forms due to low-grade metamorphism of shale. In the past, slate was used as blackboards because of its hard surface and good rock cleavage, which allows the rock to be easily split into flat tiles. The tendency of slate to break apart is called slaty cleavage. Slaty cleavage forms when differential stress causes platy mineral grains like micas and chlorite to become preferentially oriented as illustrated below. Look at the broken portion of the ledge to see excellent slaty cleavage. Slate is rare in Texas with a few occurrences in the Carrizo and Van Horn Mountains. Compare this to the shale at Stop 3.



Figures 8.7 and 8.10 see https://goo.gl/V2tgtQ, Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to Consider:
Although the minerals in slate are too small to be seen without a microscope, what platy minerals do you think are present?

Along what type of plate boundary would slate most likely form?

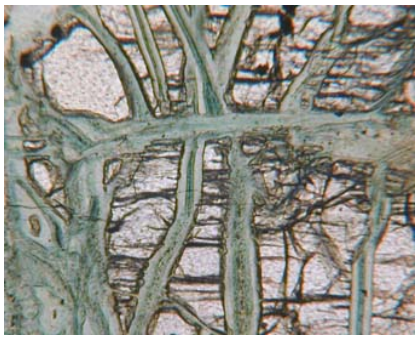
At higher metamorphic grades, slate transforms into _____

STOP 11

Location: Serpentinite wall panels in the lobby of E. Cullen Auditorium (building 517)

Description: This nonfoliated metamorphic rock is serpentinite. It consists of a green mineral called serpentine that forms during metamorphism of ultramafic rock such as peridotite or dunite. Associated with this are veins of calcite and a dark mineral, magnetite. Serpentine rock is composed of one or more minerals: lizardite, chrysotile and antigorite. Chrysotile, in fibrous form, is called asbestos; whereas, lizardite and antigorite are non-hazardous plate-like minerals. The process of transforming ultramafic rock

is called serpentinization. This can occur along deep fractures under the ocean where seawater reaches mantle rock (peridotite = olivine and pyroxene rock). These minerals alter to serpentine plus brucite ($Mg[OH]_2$), and magnetite (Fe_3O_4). This metamorphic reaction releases heat that drives high-temperature venting near mid-ocean ridges. As the warm fluids mix with cold seawater, calcium carbonate crystallizes from the vent fluids, sometimes constructing impressive mounds and chimneys on the seafloor up to 60 meters tall. Serpentinite occurs in Coal Creek in the Texas Hill Country. Some have proposed this is a part of a Precambrian ophiolite (a fragment of oceanic crust). Fun fact: this stone is marketed as Forest Green marble from the Italian Alps. It is NOT marble as those in the building stone industry think that if it was marketed as serpentinite that non-geologists will not know what it is and and won't to buy their product.



Partial alteration of olivine to a serpentine as seen with a microscope
(http://www.ucl.ac.uk/~ucfbrxs/PLM/serp.html)

Serpentine from Teanaway Beverly Creek, WA
https://www.flickr.com/photos/brewbooks/339746828

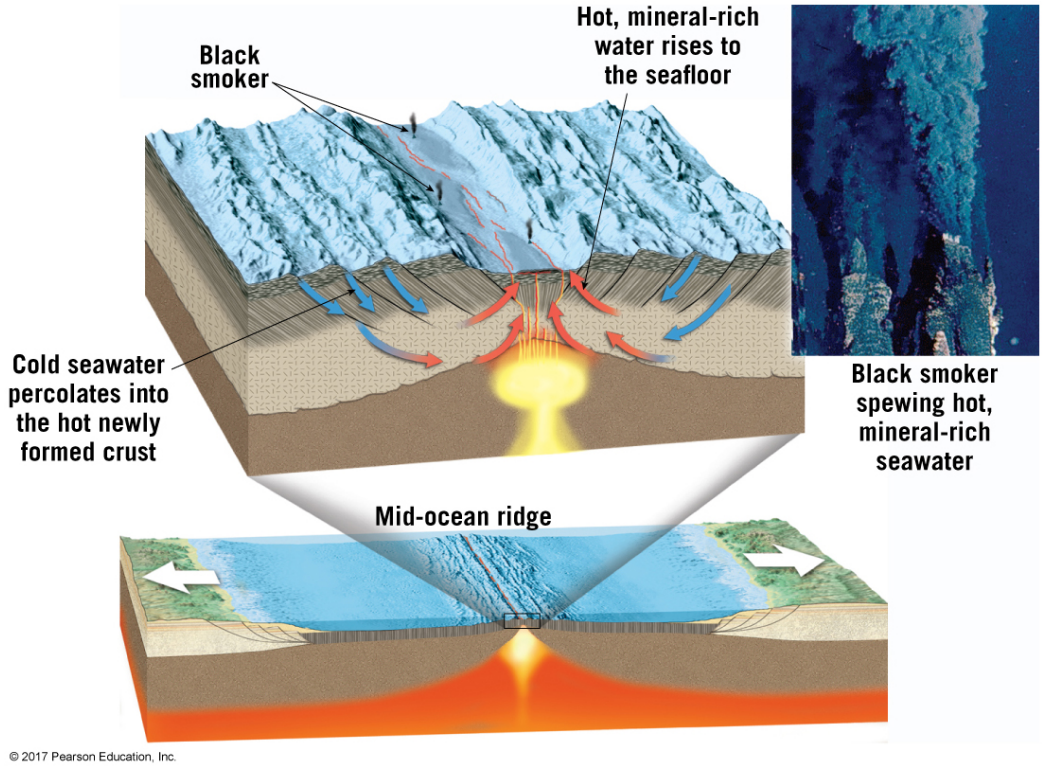


Figure 8.22, Tarbuck, Lutgens, and Tasa, Earth, 12th Ed., Prentice Hall, 2017.

Questions to Consider:
Can the dark pods in the wall panels represent relict ultramafic rocks?

Are serpentinites found along convergent plate boundaries?

STOP 12

Location: Carbonate flowstone at entrance to the UH Hilton Hotel (building 590)

Description: Chemically formed deposits are due to the solution and redeposition of carbonate (see stops 1, 7 and 9). Caves are typically found in areas with limestone where ground water percolates and dissolves away material. Flowstones are composed of sheet-like deposits formed where water flows down the walls or along the floors of the cave. These films of water build up layers of calcium carbonate (calcite), aragonite, gypsum, or other cave minerals. These minerals are are deposited when the water loses its dissolved carbon dioxide through the mechanism of agitation. The deposits form thin sheets called "draperies" or "curtains" where they overhang portions of a wall. Some draperies are translucent, and some have brown and beige layers that look much like bacon (often termed "cave bacon").

Though flowstones are among the largest speleothems, they can be damaged by a single touch. The oil from human fingers causes the water to avoid the area, which then dries out. Flowstones are also good identifiers of periods of past droughts, since they need some form of water to precipitate, the lack of that water for long periods of time can leave traces in the rock record via flowstones.

There are many caves you can visit in Texas that show evidence for annual cycles in flowstones. Here are two examples:

Cave Bacon with fringe, Sonora TX
http://www.billcaid.com/2010/HogHunting20100323/Part2/JPEG/img-28.jpg

Flowstone, Inner Space Cavern, Georgetown TX
https://innerspacecavern.com/images/main-hero2.jpg

Questions to consider:
Consider the size of the crystals. How long do you think it took for these crystals to form?

What do the faint brown lines indicate? Do they represent seasons or periods of wet versus dry cycles in a cave?