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
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.

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.

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?

![Composition Table]

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 (CaCO₃). 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.

![Marble Image]

Questions to consider: Since this rock is mostly composed of calcite, what 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 going down the handicap access ramp to S&R-1. Be careful not to block access.

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 limestone. In Texas, you can find oolitic limestone in Upper Cretaceous rocks near Fredericksburg.

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.

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 3a

Location: Limestone outside the Fleming (home of the Geoscience Learning Center building 564)

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 Fredericksburg 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. This stone is used in many buildings on campus as well as the Art Guys “Statue of Four Lies” near Lynn Eusan Park and Cougar Village.

STOP 3b

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.

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?


STOP 4

Location: Wall next to the entrance to STL (Science Teaching Lab building 576)

Description: Look carefully at this surface and decide whether it is a rock or concrete. On the UH campus, many buildings and walkways are made of concrete. Often they look like a sedimentary rock made from an aggregate of fine and coarse grains similar to sandstone or conglomerate. All concrete is a mixture of lime based cement binder and aggregate. You can test whether or not the binder is cement (lime) by using dilute HCl. The aggregate is commonly a silicate such as quartz grains or chert pebbles. It is extremely unusual to find natural rocks with both limestone matrix and silicate pebbles. This is a clue that it is a man-made concrete and not a sedimentary rock. You can also look at the aggregate to see if the grains are both broken and rounded which is another clue that it is mad-made. Also look at any fossils and see if they look natural. Do they occur in a pattern? If so, they are probably not natural. In the Houston area, concrete can be made
with oyster shells dredged from Galveston bay. Oyster shell dredging was outlawed in the 1970’s. So, if you see oyster shell concrete in Houston, you know you are looking at old concrete. Concrete has been used in buildings since the time of ancient Greeks (~1400 BC) in the royal palace of Tiryns. The ancient Romans were extremely good at using concrete in many structures including the Colosseum. There are also Mayan ruins at Uxmal that use concrete back in 600 AD.

You might want to think twice about using concrete as 0.9 lbs. of CO₂ are released from using 1 lb. of concrete. Some have estimated that 8% of the world’s CO₂ emissions come from concrete. On the other hand, concrete can absorb CO₂ and store it. So, using traditional concrete for buildings is probably detrimental in our push for a carbon neutral world.

Questions to consider: Is this a fossiliferous limestone similar to Fleming or is it concrete? Why?

Why would UH use this building material?

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](image)

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
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 in the 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.

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. best seen at the bottom of the stairwell.
**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.

![Mammoth Hot Springs, Yellowstone National Park](image1)

![Mammoth Hot Springs, Yellowstone National Park](image2)

**Questions to Consider:**

1. What was the original orientation of the rock from which the panels were cut?
2. Do you see evidence of past microbial action in the travertine wall panels?

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**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.

**Question to consider:** How much do these blocks weigh?

(Hint: use density of granite (2.5-2.8 gm/cm³) and their size to calculate...
Abandoned quarry a few miles north west of 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. GoogleEarth image of the quarry with lots of blocks still lying around.

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!

Questions to Consider: Stalactites are composed of ____________.

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.

![Diagram of metamorphism](image)


**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 serpentinitization. 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 (Fe₃O₄). 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 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

Question to Consider: Are serpentinites found along convergent plate boundaries?

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

STOP 1

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 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

- Flowstone, Inner Space Cavern, Georgetown TX
  [Image](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?