
BUILDING STONES OF THE BROOKLYN COLLEGE CAMPUS

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LEARNING OBJECTIVES:

- Students will be able to differentiate between crystals and clastic grains
- Students will be able to identify common fossils with the aid of photographs.
- Students will be able to identify common rock fabrics.
- Students will be able to identify rocks commonly used for building stone, and document the evidence

PREREQUISITE KNOWLEDGE AND SKILLS:

- Minerals lab

PRE-LAB PREPARATION:

- Read the material leading to the assignment

MATERIALS FOR STUDENTS TO BRING:

- A magnifying glass will be useful.

Rocks and Stones

A **rock** is a natural material that is composed of an aggregate of one or more minerals (naturally occurring, solid, inorganic, crystalline substances), or organic materials (e.g., coal). A **stone** is a piece of rock that is used for a specified function. Accordingly, the outcrops of marble in the southern Bronx neighborhood of Kingsbridge are referred to as rock, whereas the grave markers in Lower Manhattan’s Trinity churchyard that were carved from this material in the 1700’s are referred to as stone (gravestones).

Rocks are subdivided into three broad families based on the general processes and environments of formation:

- **Sedimentary Rocks** form from the settling of eroded materials at the surface, most commonly under water. This group includes clastic sedimentary rocks that are composed of weathered pieces of pre-existing rock (e.g., sandstone), and chemical sedimentary rock that form from the precipitation of minerals from solution (e.g., limestone). When grains settle they may form layers, or beds, that may be defined by differences in color or grain size (see Examples of Rock Fabrics plate). This layering is called **bedding**.
- **Igneous Rocks** form from the solidification of molten rock. Plutonic (intrusive) igneous rocks cool slowly, deep within the Earth, and so exhibit large crystals. In contrast, volcanic (extrusive) igneous rocks cool quickly after they have erupted to the surface from volcano, and so do not have crystals that are large enough to be seen without a microscope. Most volcanic rocks make poor building stone because they may be weak, cracked, inconsistent in color, and/or contain large pores. Accordingly, volcanic rocks will not be discussed further in this lab.
- **Metamorphic Rocks** form from the recrystallization and deformation of pre-existing rocks due to extreme heat and pressure. The directed pressure that is commonly associated with metamorphism reorients and rearranges mineral grains. This may result in the alignment of long or flat minerals to define a **foliation** (see Examples of Rock Fabrics plate). Under more extreme metamorphic conditions the minerals may segregate into distinct light and dark colored bands, forming a rock called **gneiss** (see Examples of Rock Fabrics plate). Metamorphism may also deform banding in rocks to form folded patterns (see Examples of Rock Fabrics plate).

The list of rocks that commonly have qualities that are suitable for building stone is relatively short, and is summarized in the table below:

Rock Family	Rock Name	Common Colors	Common Features
Sedimentary	Sandstone	Reddish Brown, Beige, White, Grey	Grainy; composed of rounded grains up to 2 mm in diameter. “Sandy” feel. Bedding is common.
	Limestone	Grey, Beige	Grainy. Fossils are common. Bedding is common
Igneous	Granite	White, Pink, Speckled	Crystalline. Crystals large enough to see. Light colored
	Granodiorite	“Salt and Pepper”	Crystalline. Crystals large enough to see.
	Gabbro	Black, Green, Dark Grey	Crystalline. Crystals large enough to see. Dark colored
Metamorphic	Marble	White, Pink	Crystalline. Wispy textures are common. Stylolites are common. No fossils.
	Gneiss	Pink, Black and White	Crystalline. Bands of distinctly different color. Bands may be irregular and folded.

Crystals and Grains

Since rocks are aggregates of mineral grains, it is logical that the rocks will be differentiated/classified based upon which minerals are present, and how the mineral components are arranged. The most important distinction in terms of the arrangement of the minerals is the distinction between crystals (found in igneous and metamorphic rocks) and sedimentary grains. **Crystals** are produced by the growth/replication of a regular, ordered arrangement of atoms. Accordingly, crystals tend to have regular, polygonal shapes. Adjectives such as blocky, bladed, needle-like, prismatic, rectangular, and hexagonal are commonly used to describe crystals. **Sedimentary grains** are formed by forces acting on minerals. Abrasion due to transport of sedimentary grains tends to break off sharp edges, producing spherical or ellipsoidal grains; sandstone is a sedimentary rock that is composed of small (<2mm diameter) rounded grains. Fracture and collapse of rock tends to form irregular, angular fragments. Once cemented, these angular clasts (rock fragments) form a rock called **breccia**. Biological activity may force minerals to grow into intricate shapes in animal shells and skeleton. Such **fossil** grains can be recognized by complex, non-polygonal shapes such as spirals, discs, and net-like structures.

Classification of Plutonic Igneous Rocks

Plutonic igneous rocks are classified based upon their chemical composition, which is reflected in their color. Rocks that are low in iron and calcium are light in color and are composed predominantly of white and/or pink feldspars and quartz. Rocks that are rich in iron and calcium are dark in color, and are composed predominantly of grey feldspars and black or green minerals such as amphibole, pyroxene or olivine. Based on this simple color-based scheme, three distinct plutonic rocks can be identified:

- **Granite**: a light-colored (felsic) intrusive rock with crystals of quartz, white feldspar, pink feldspar, and mica
- **Granodiorite**: an intermediately colored intrusive rock composed of light colored white to light grey feldspar and dark green to black amphibole and/or biotite. The mix of light and dark minerals gives the rock a coarse “salt-and-pepper” appearance.
- **Gabbro**: a dark-colored (mafic) intrusive rock that consists of dark grey feldspar and black to dark green Fe-rich minerals such as amphibole and pyroxene.

Stone-workers and sculptors apply a different definition of granite. To them a granite is any hard rock that contains crystals. These dual definitions of “granite” explain why, for example, the Brooklyn Museum of Art labels ancient Egyptian sculptures that are carved from gabbro as being composed of “black granite”. To a geologist, the term “black granite” would be an oxymoron, since by definition a granite must be light colored. A stone mason’s definition of granite would also include the banded metamorphic rock called gneiss.

Limestone and Marble

Limestone is a sedimentary rock that is composed predominantly of the mineral **calcite** (calcium carbonate; CaCO_3). Most limestone forms in shallow, tropical, marine environments, and a common component of limestones are the calcium carbonate skeletons of animals that live in these settings. Accordingly, limestones can often be identified by the presence of marine fossils such as **bivalves** (e.g., clams), **corals**, and the coiled shells of **gastropods** (snails) (see following photo plate). Other common fossil organisms that are less familiar to most people include bryozoans and crinoids. Fossils of **bryozoans** commonly look like small pieces of lace or like a corkscrew (see following photo plate). The most common fossil remains of **crinoids** are the discs that once comprised the stalk of this animal; in rocks these fossils look like small buttons or poker chips (see following photo plate). Another distinct type of grain that is common in limestone is an **oid**, a BB-sized spherical or ellipsoidal grain that is composed of concentric bands of calcite around a central sand grain (see Examples of Grainy Textures Plate). Ooids form in very shallow marine environments where waves agitate and roll sand grains, allowing them to be coated on all sides by calcite precipitates. As with other sedimentary rocks, limestones commonly exhibit the **bedding**.

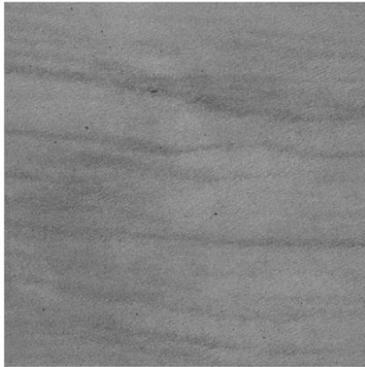
Calcite is a relatively soluble mineral. (Remember that a diagnostic property of calcite is that it effervesces with dilute acids.) Ground water seeping through limestone may result in local dissolution to form caves and caverns. The weight of overlying rock may cause the roofs of such caves to collapse, filling the caves with broken pieces of

limestone with irregular, angular shapes. When such deposits of broken rock are cemented together, they form a rock called **breccia** in which the irregular, angular fragments are still evident (see Examples of Grainy Textures Plate). Pressure increases the solubility of calcite, and so the burial of limestones may result in the formation of **stylolites**, distinctive form of highly localized dissolution defined by a dark, irregular, zigzag discontinuity in the rock (see Examples of Rock Fabrics plate).

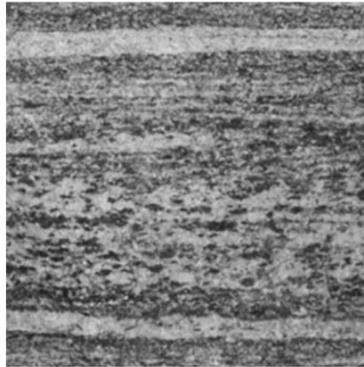
If a limestone is deeply buried then it will metamorphose to become a **marble**. During the process of metamorphism, the calcite (and/or dolomite) grains in the limestone will recrystallize, grow larger, and form crystals. Primary features such as fossils and ooids are usually destroyed in this process, leaving a more uniform rock in which the calcite occurs as polygonal, interlocking crystals that commonly have a sugary appearance. Layering such as bedding or stylolites (see Examples of Rock Fabrics plate) that once existed in the limestone precursor may be deformed and diffused, forming a wispy, “marbled” pattern (see Examples of Rock Fabrics plate).

To a geologist a marble is a metamorphosed limestone. However, to an architect, stone mason, or sculptor, a marble is defined as any soft rock that will take a polish. This includes marbles, as well as densely-packed limestones, and some less common rocks such as serpentinites. This difference in the specific meaning of the word “marble” commonly leads to confusion. Some of the most common stones that are referred to as marble by builders, are actually not metamorphosed and retain primary features such as fossils, ooids, and bedding. To determine whether a polished soft rock is a true marble, you must examine the components and fabrics of the rock carefully. Are there fossils or ooids that would indicate that it is a limestone? Are there angular fragments that would indicate that it is a breccia? Or are there polygonal or sugary crystals of calcite, and wispy marbling that are characteristic of a true marble?

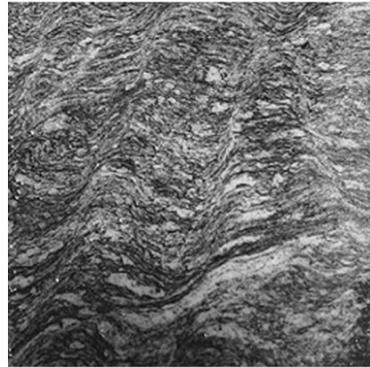
Examples of Rock Fabrics



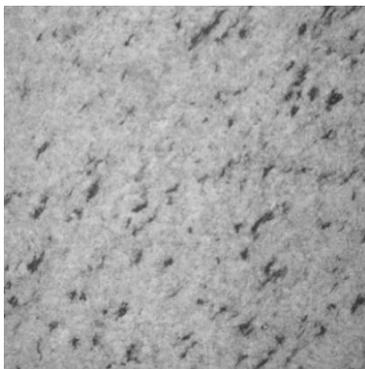
Bedding in sandstone



Banded gneiss



Folded Gneiss



Foliated granite with aligned amphibole crystals

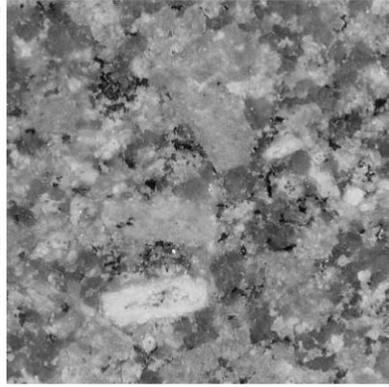


Wispy, folded layers in marble

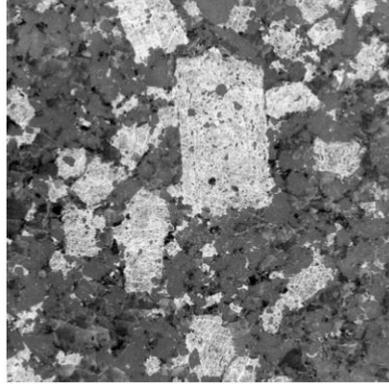


Stylolite in a grainy limestone

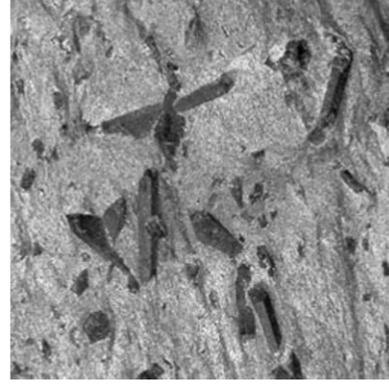
Examples of Crystalline Textures



Granites with plagioclase crystals that exhibit typical blocky polygonal forms



Metamorphic rocks with crystals that exhibit prismatic and bladed polygonal forms

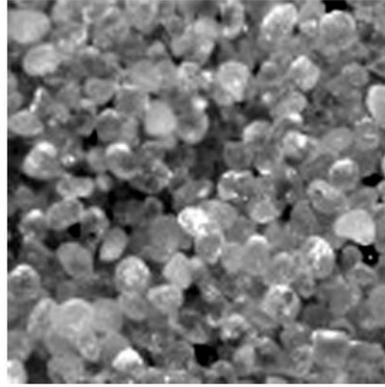


Limestone containing ooids, which are round grains with concentric layers

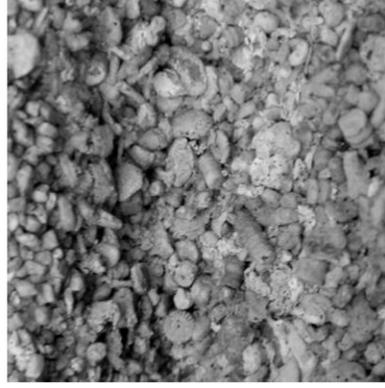


Breccia containing angular fragments

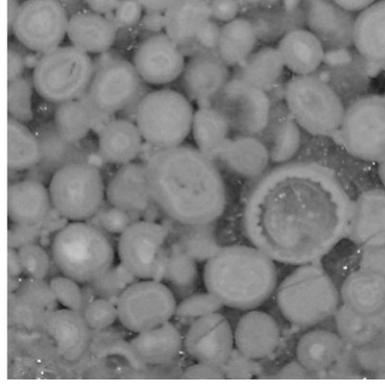
Examples of Grainy Textures



Sandstone composed of near-spherical sand grains of quartz and feldspar

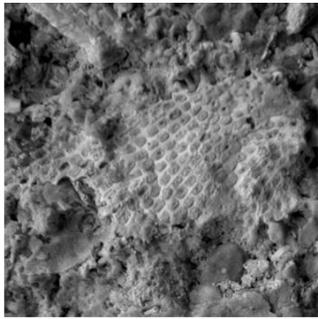
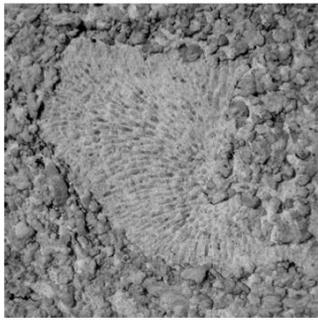


Sandstone composed of rounded fragments of fossil material

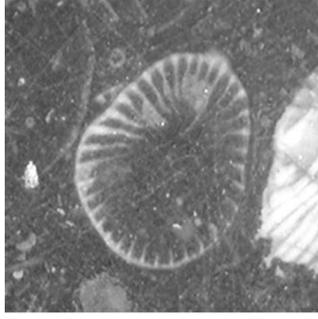
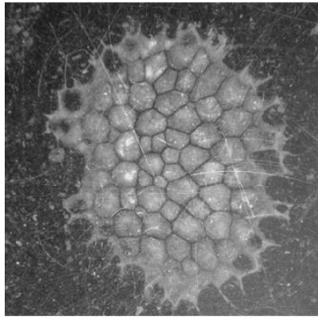


Breccia containing angular fragments

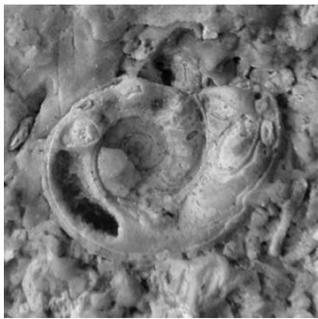
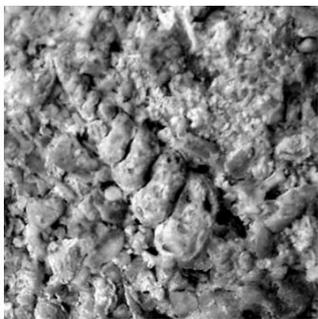
Examples of Fossils that Are Common in Limestone



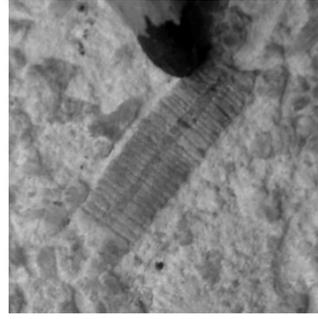
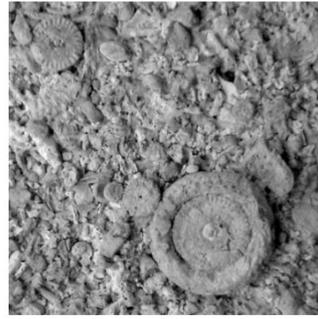
Bryozoans



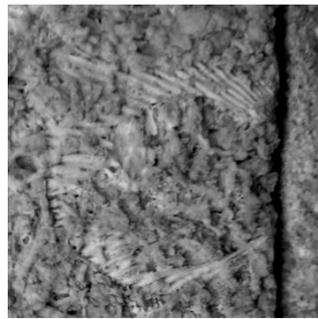
Corals



Gastropods (Snails)

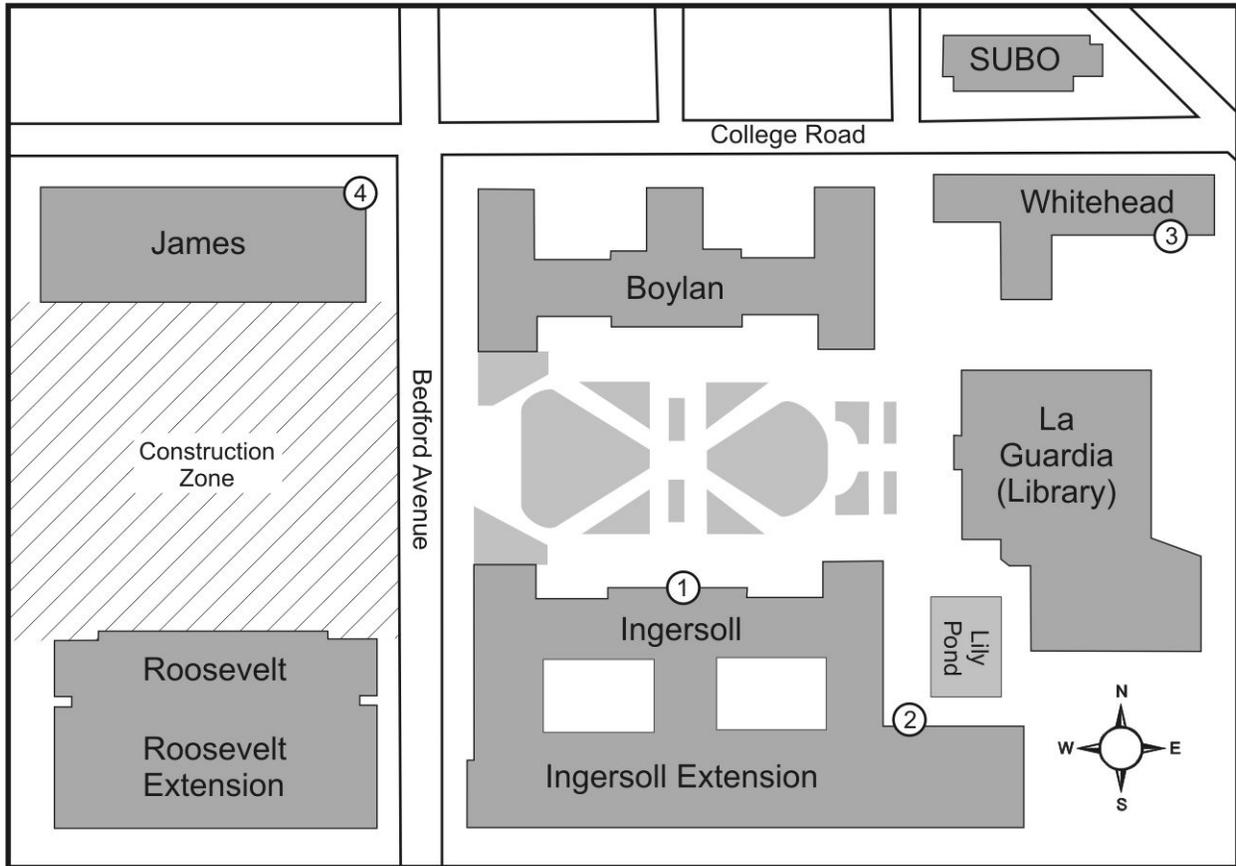


Crinoids



Bivalves (Clams, Oysters)

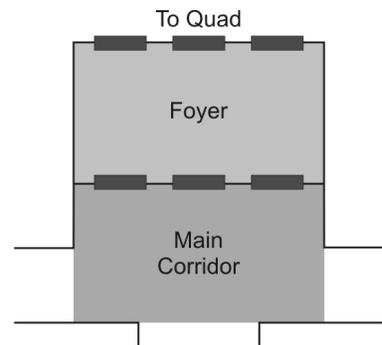
The Assignment



Station 1: Ingersoll Hall Foyer and Main Corridor

The foyer and main corridor immediately inside of the main doors of Ingersoll Hall are lined with four examples of polished stone that would be classified as marble by a stone mason or architect. The foyer contains a pinkish-tan stone on the walls, and a pink-grey stone on the corners and decorative false columns. The main corridor contains a medium grey stone on the walls and a deep pink stone on the corners and decorative false columns.

Examine each of the three stones listed below and determine whether each of these building stones is a limestone or a true marble (metamorphosed limestone). Document your evidence and provide sketched of the diagnostic features.



Main Corridor Grey Stone: Limestone Marble (Circle One)

Supporting Evidence 1: _____

Supporting Evidence 2: _____

Supporting Evidence 3: _____

Sketch 1	Sketch 2	Sketch 3
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Foyer Pinkish-Tan Wall Stone:

Limestone

Marble

(Circle One)

Supporting Evidence 1:

Supporting Evidence 2:

Sketch 1	Sketch 2
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Foyer Pink-Grey Corner Stone:

Limestone

Marble

(Circle One)

Supporting Evidence 1:

Supporting Evidence 2:

Sketch 1	Sketch 2
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Station 2: Ingersoll Extension Steps by the Lily Pond

Examine the components of the multi-colored rock that comprises the steps to Ingersoll Extension. What are the grains? Sketch characteristic grains.

Pebbles Fossils Crystals (Circle all that apply)

Identify the rock (Circle One):

Sandstone Limestone Marble Granite Gneiss

Describe Your Supporting Evidence:



Station 3: Wall of Whitehead Hall

Examine the pale beige rock that covers the lower walls of Whitehead Hall.

Run your hand along the surface of this unpolished rock. Describe how it feels.

What are the rusty-orange bands within the pale beige rock?

Bedding Gneissosity Stylolite (Circle One)

Identify the pale beige rock: Sandstone Limestone Marble Granite Gneiss (Circle One)

Describe Your Supporting Evidence:

Station 4: Wall around James Hall

The 3 to 4 foot wall around James Hall is composed of two rocks. Most of the wall is covered with a pale beige rock. The lowest 6 to 12 inches of the wall is composed of a multi-colored rock. Examine these two rocks and answer the following questions:

Examine the components that comprise the **beige rock**. What are the grains? Sketch characteristic examples.

Sand Fossils Crystals (Circle all that apply)

Sketch 1	Sketch 2
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Is the **beige rock** metamorphosed? Yes No (Circle One)

Describe Your Supporting Evidence:

Identify the **beige rock**: Sandstone Limestone Marble Granite Gneiss (Circle One)

Describe Your Supporting Evidence:

Examine the grains within the **multi-colored rock** at the base of the wall.
What are the grains? Sketch characteristic grains.

Sand Fossils Crystals (Circle all that apply)

Has this rock been metamorphosed? Yes No (Circle One)

Identify the beige rock (Circle One):

Sandstone Limestone Marble Granite Gneiss

Sketch 1

Describe Your Supporting Evidence:

Which of the two rocks in this wall is more resistant to weathering and erosion?

Top of Wall

Base of Wall

(Circle One)

Describe Your Supporting Evidence:
