National Museum of the Marine Corps

History at Home

Marines in the Gulf War: Soil and Stratigraphy of the

ARABIAN PENINSULA

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Soil and Stratigraphy

The materials included in this resource guide highlight the geology of the Arabian Peninsula where Marines fought during the Gulf War. This resource guide will supplement the material included on Marines in the Gulf War on the National Museum of the Marine Corps website.

Table of Contents

Education Resource Guide

Age Range:

Our Soil and Stratigraphy resource guide is ideally suited for grades 6-8. The activities and questions are best discussed in a group setting.

Objective:

Read this packet and use what you have learned to comprehend the various ways Marines battled not only enemy combatants in the Gulf War, but the environment of the Arabian Peninsula as well. The activities included in the back of this packet will serve as a comprehensive guide for students.

Materials:

- *Marines in the Gulf War Video* [LINK]
- *Pen(s) or Pencil(s)*
- *Materials for "How the Marine Corps Builds" Activity (Listed on Activity Page)*
- *Spare blank paper and graph paper*

Instructions:

1. For background to the role of the Marine Corps in the Persian Gulf and conflict in the Middle East, watch the introduction video **HERE**.

2. This packet is separated into two parts. The first part deals with instructive materials about the soil and stratigraphy of the Arabian Peninsula, where Marines fought during the Gulf War. Read through the first section (pages 4-11), filling in the answers along the way.

3. After you read through the first section, use what you have learned to complete the activity portion of this packet, which includes a crossword puzzle, home soil testing activity, and "How the Marines Build" soil activity.

Conflict: Environment

One of the opponents that the United States Marine Corps encounters during a conflict is the environment. The terrain and weather can have a huge impact on how the Marines can deploy their forces, how they can fight, and understand how native insurgents use the land for their advantage. During Operations Desert Shield and Desert Storm, the desert region of the Arabian Peninsula became an adversary to overcome for the Marines, just like the forces of Saddam Hussein's military.

The sandy soil of the Arabian Peninsula became an ever present reminder of the harsh, dry, and severe climate the Marines were facing. Infiltrating food, water, tents, uniforms, and machines, the blowing sands caused vehicle and machine parts to freeze up and wear down faster, fouled engines and clogged rifles, caused electricity outages, and often times stopped operations all together.

The soils of the Arabian Peninsula reflect the dryness of the desert climate. Most are sandy and rocky areas that make up sand dunes, hills, and other geologic features. The soils are usually shallow, or have substances like lime, gypsum, or salts in them, which makes it hard for things to grow so vegetation is sparse.

Marines from Company D, 2d Tank Battalion, drive their M60A1 main battle tank during a breach exercise in Operation Desert Storm in 1991. The tank is fitted with reactive armor and an M-9 bulldozer kit. (USMC Photo)

Because so much of the soil is light and sandy, and there is little rain, windstorms can cause haboobs, where the sand kicks up and makes it hard to see. During these storms, helicopters cannot take off and Marines' tents can be blown over.

While Marines can't get rid of the sandy soil, they can adapt to it. One group of Marines, Combat Engineers, are sent in Marine Air-Ground Task Forces (MAGTFs) to assess the environment and create infrastructure and clear areas of hazards to allow operations to move forward. Combat Engineers may be assigned to support ground troops in order to construct roads, buildings, and other infrastructure needs, or to support an air wing, which build air fields and support air operations. Combat Engineers can also be part of front line breaching detachments: which is the removal of obstacles in the path of the infantry. The first line of defense for the Iraqi army were a series of sand berms, anti-tank ditches, and mind fields. It was up to the Combat Engineers to use bulldozers and explosives to clear the path of these obstacles.

Marines from 3rd CEB dispose of mines in a berm during the Gulf War ground campaign. (USMC Photo)

In Operations Desert Shield and Storm, all three groups needed to understand the geology of the region to understand how to complete their mission. For example, when building airfields, Air Wing Support Engineers needed to reinforce the sand with marl, a type of sedimentary rock composed of clay and lime to stabilize the soil in order to support the weight of the landing air craft. At the end of this packet, you can test the weight of your own soil!

GSG-2 engineers dig and transport marl to stabilize the soil at Jubayl Naval Air Facility. (Photo by LtGen James A. Brabham, Jr.)

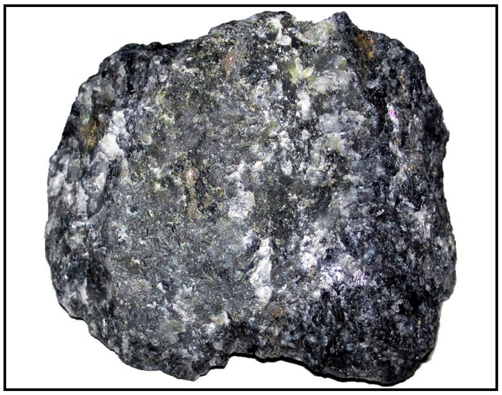
To learn more about MAGTFs, please see our resource guide and game about Operation Provide Comfort [LINK].

Identifying and Classifying Rocks

Instructions:

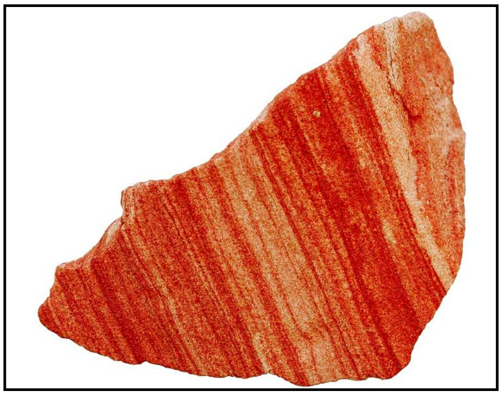
Read through the rock descriptions below and then complete the “What Type” fill-in questions.

IGNEOUS



Igneous rocks are formed from molten rock. Magma-produced igneous rocks have large mineral crystals that formed inside the earth. Lava-produced igneous rocks can have gas bubbles or tiny crystals that formed outside on the Earth’s surface.

SEDIMENTARY



Sedimentary rocks are composed of rounded grains or fragments of other rocks cemented together in layers. Many sedimentary rocks contain fossils of plants or animals. Sedimentary rocks usually form in a water environment like an ocean, lake, or stream.

METAMORPHIC

Metamorphic rocks are formed inside the Earth from heat and pressure. Although metamorphic rocks are not liquid, the intense heat and pressure makes them change into a metamorphic rock. Visible layers may be bent or distorted.

“What Type” Questions:

1. What type of rock might contain evidence of past life? ____________________

2. What type of rock contains large crystals? ____________________

3. What type of rock might contain holes from gases? ____________________

4. What type of rock has visible flat layers? ____________________

5. What type of rock changes by intense heat/pressure? ____________________

6. What type of rock contains rounded grains? ____________________

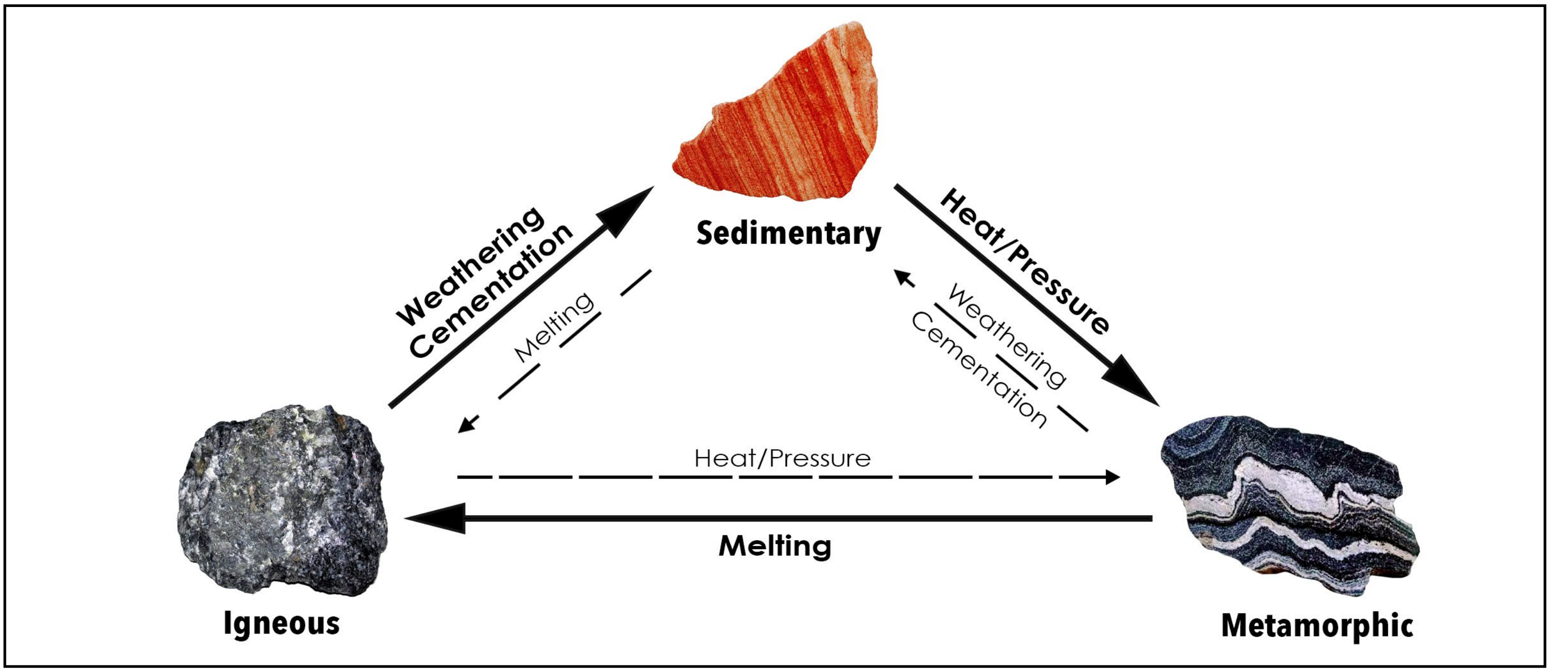
7. What type of rock comes from liquit rock material? ____________________

8. What type of rock has wavy banding layers? ____________________

The Rock Cycle

Instructions:

Look at the Rock Cycle diagram below, and read the description. Then complete the activity at the bottom of the page.



The **Rock Cycle** is the process of recycling and changing rocks from one type of rock into another by Earth's geologic processes. The three main forms of rock; *Igneous*, *Sedimentary*, and *Metamorphic*, all can be changed into each other by a variety of ways. Rock that has melted can become Igneous rock. Rock that has been weathered down and cemented together can become Sedimentary rock. Rock that has been under great heat and pressure can change into Metamorphic rock. Even though it is called the Rock Cycle, any type of rock can change into any other depending on geologic events.

Complete the statements below by using one of the three choices shown here:

Weathering/Cementation **Melting** **Heat/Pressure**

1. To turn Igenous into Metamorphic, you need: ____________________

2. To turn Metamorphic into Sedimentary, you need: ____________________

3. To turn Sedimentary into Igneous, you need: ____________________

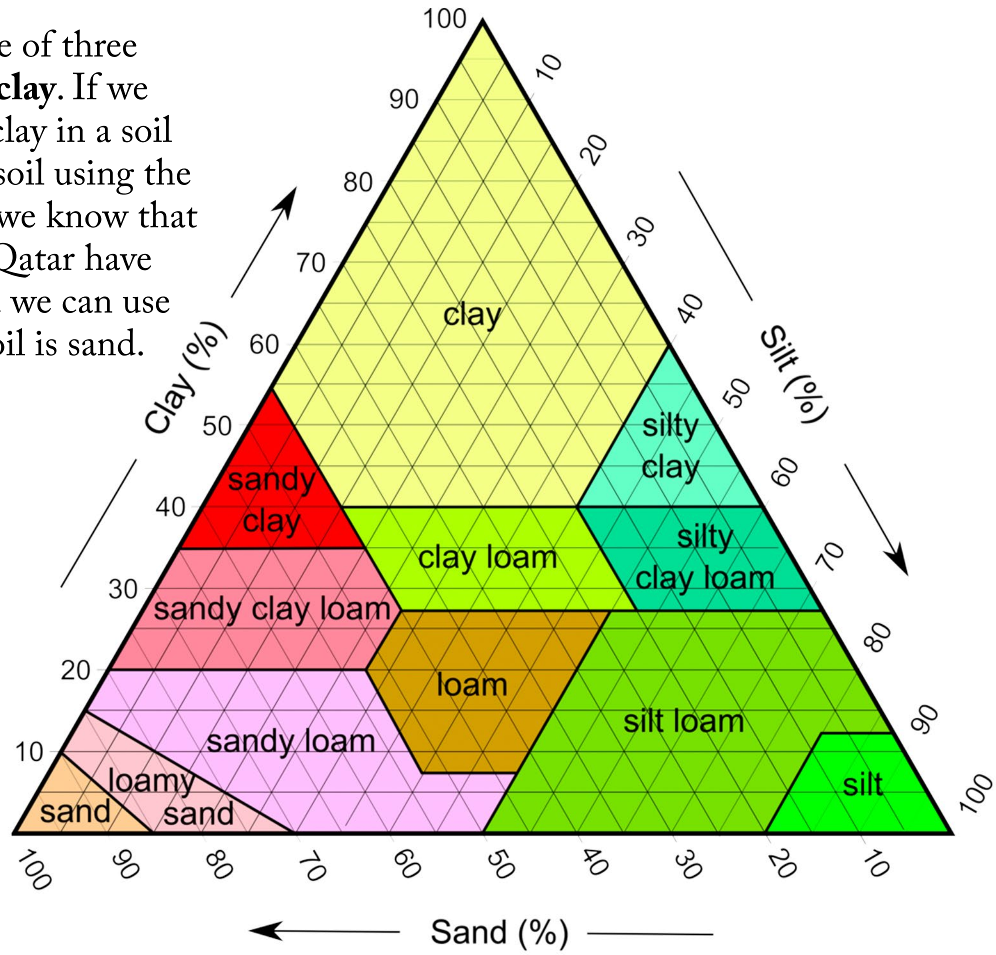
4. To turn Metamorphic into Igneous, you need: ____________________

5. To turn Igneous into Sedimentary, you need: ____________________

6. To turn Sedimentary into Metamorphic, you need: ____________________

Soil Top Layers

All soils are made up of a percentage of three different substances: **sand**, **silt**, and **clay**. If we know the amount of sand, silt, and clay in a soil we can determine the exact type of soil using the soil triangle (right). For example, if we know that the coastal flats (called sabkhas) in Qatar have 2.5% clay, 1.0% silt, and 96.5% sand we can use the triangle to determine that the soil is sand.



Directions:

Use the soil percentages below and determine what kind of soil it is using the graph above.

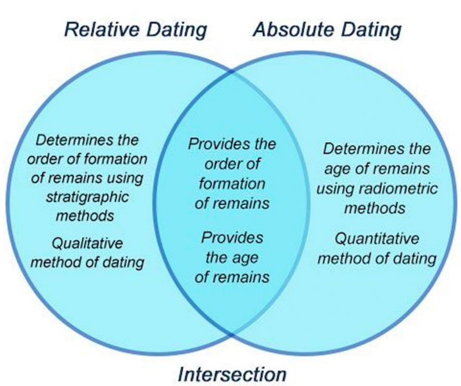
Place	% Clay	% Silt	% Sand	Type of Soil
Qatar (sabkas)	2.5%	1.0%	96.5%	SAND
Qater (rocky hammades)	10.48%	8.18%	81.4%	
London, England	35%	30%	35%	
Eastern Virginia	23%	25%	52%	
Yellowstone National Park	40%	53%	7%	
Cierva Point, Antarctica	15%	25%	61%	
Victoria, Australia	51%	35%	14%	

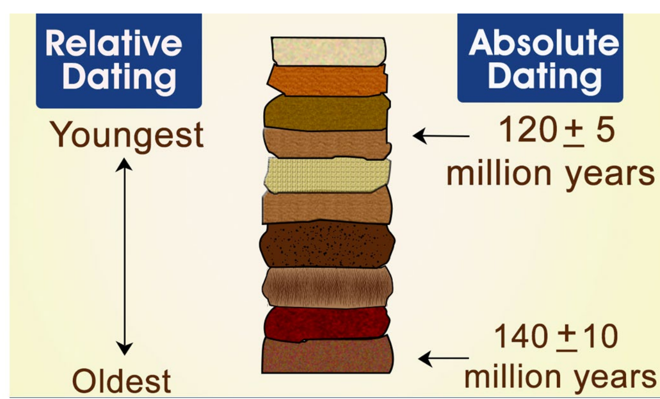
Sedimentary Layers

Over time soils can turn into Sedimentary rock. Sedimentary rocks are made when sand, silt, clay, and/or pebbles get laid down in layers. Over time, these layers are squashed under more and more layers. Eventually, the layers are lithified – turned to rock. Sedimentary rocks can be formed in deserts, lakes, rivers and seas. The layers in Sedimentary rock can tell us a lot about the past. Scientists can look at the rock and know if an area used to be a sea millions of years ago, or if there was an ice age, or if the desert used to be a forest!

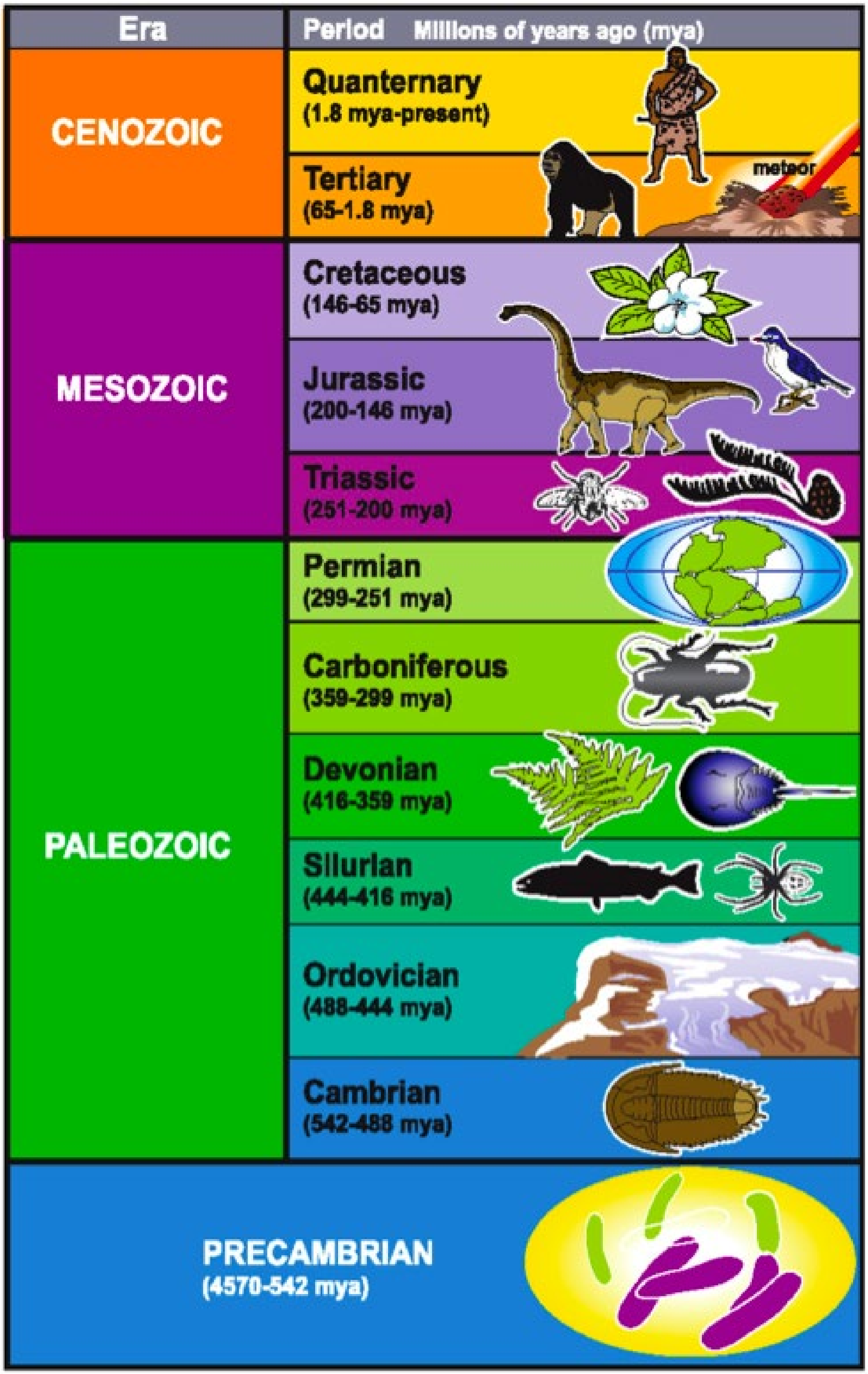
Sometimes, the Sedimentary layers have fossils in them. The fossils can tell us about what plants and animals lived there in the past. If a trilobite fossil like the one here (right) is found, that means the area was once under water because trilobites were ocean animals.

Our study of soil and rock layers over time has taught us about different periods in geology going back millions of years! We measure geologic time in m.y.a., which stands for million years ago. When geologists study rocks and fossils from millions of years ago they sometimes focus on the relative date, or how old something is compared to something else, rather than worry about the exact age of an artifact.

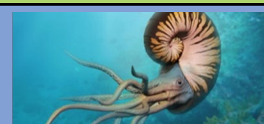
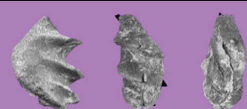
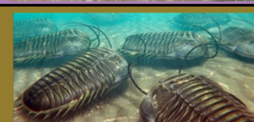




Geologic History

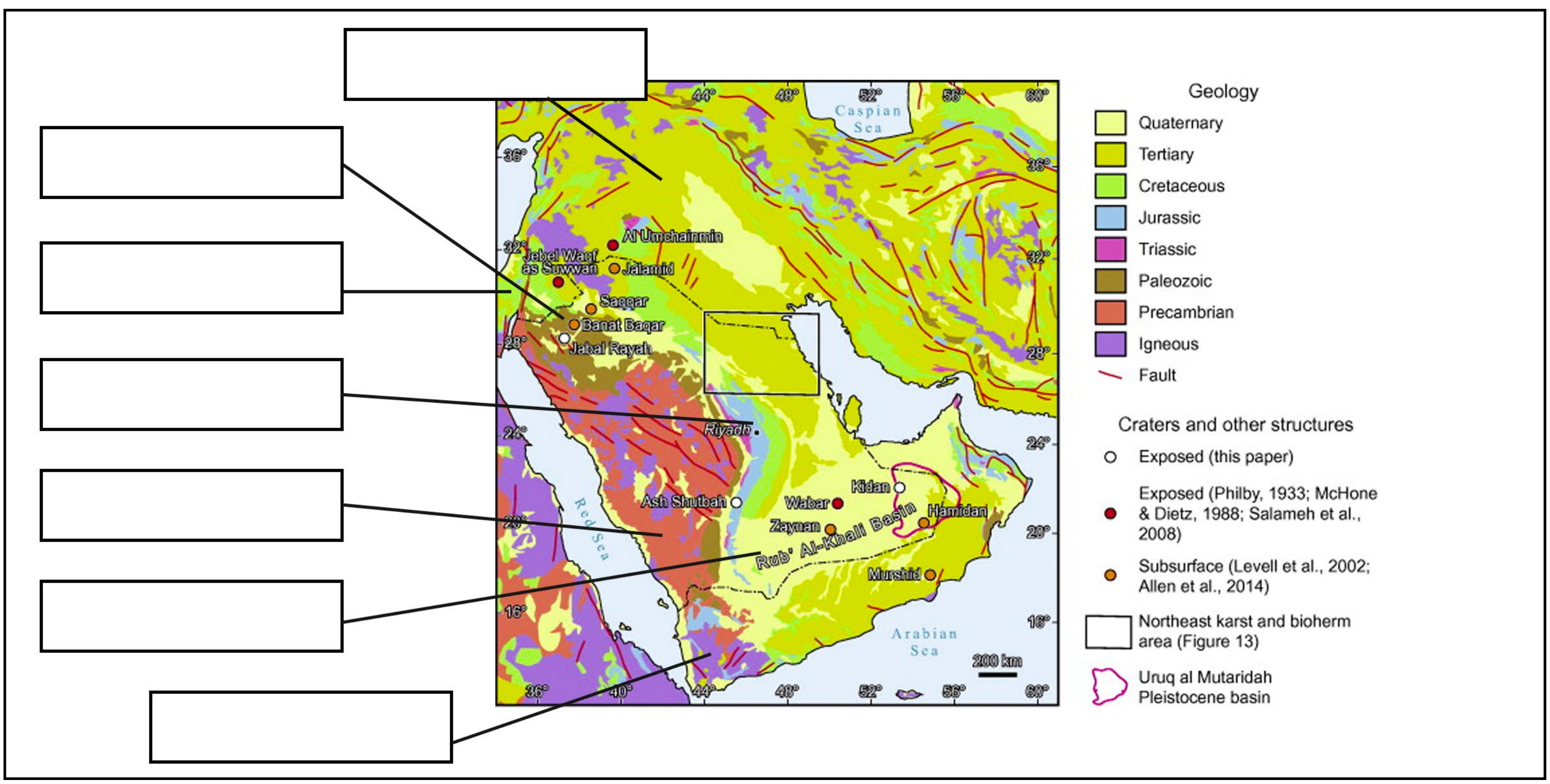


Fossils of the Arabian Peninsula

Identification	Fossil	Alive	Geologic Time Period
Golden Jackal			Cenozoic Quaternary 0.75 m.y.a.
Arsinoitherium			Cenozoic Tertiary
Titanosaur			Mesozoic Cretaceous
Ammonite			Mesozoic Jurassic
Lungfish			Mesozoic Triassic 245 m.y.a.
Trilobite			Paleozoic Cambrian
Sea Pen			Late Precambrian

Directions:

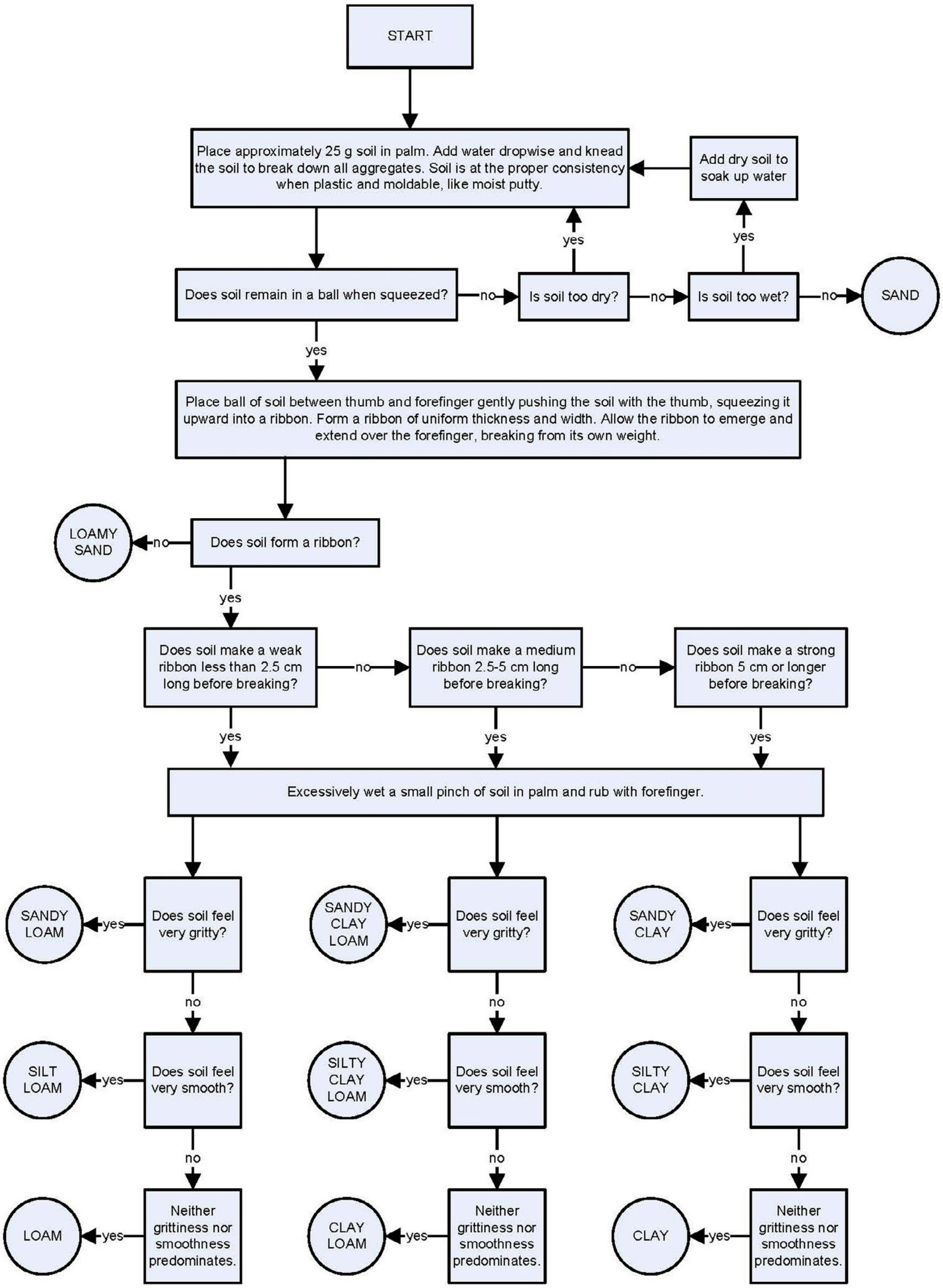
Label the fossils in the proper geologic time period on this map of the Arabian Peninsula.



Test Your Soil at Home Activity

Directions:

Gather 25 g of soil of your choosing outside and follow these steps to see what type it is by following the guided arrows. Write what type of soil yours is at the bottom of the page. *(Graph adapted from the U.S Department of Agriculture)*



My soil is: ______________________________

How the Marine Corps Builds

Marines and other service members used a knowledge of geology every day during Middle East operations to stay safe from sandstorms, know where to build facilities and roads, and to determine where to dig wells for fresh water.

The bearing capacity of soil is an important consideration in construction projects. Dams, bridges, and buildings are all examples of structures that can be supported by underlying soil.

How do military engineers know how much weight soil can support? Is the amount of weight different for different types of soil? How does the size of the area in contact with the soil affect bearing capacity? How does the presence of water in the soil affect bearing capacity? Do you think sand or clay would have a higher bearing capacity? Why? These are the kinds of questions you can begin to answer with this project.

Materials and Equipment:

- Large plastic tub (container for soil)
- 1-inch diameter dowel (length approximately equal to height of tub
- Ruler
- Marker
- Small pieces of wood or hardboard for platform and jig
- Drill with 1-inch spade bit or hole saw
- File
- 1/4-inch diameter dowel for legs of jig
- Different types of soil (play sand, mason's sand, topsoil, subsoil)
- Shovel or garden trowel
- Weight for platform (e.g., bucket with water)
- An adult helper

Experimental Procedure:

1. You can make a simple experimental apparatus for measuring soil bearing capacity in a plastic tub. You'll need a piece of 1-inch diameter dowel, about as long as your tub is high. Mark off 1-cm increments along the length of the dowel, as shown in Figure 1.

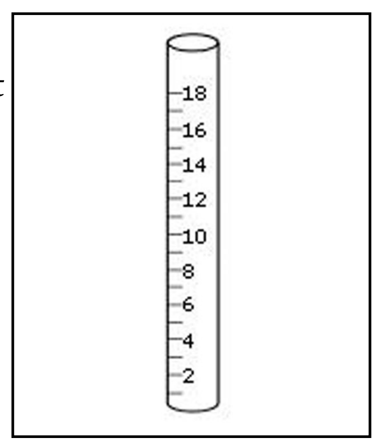


Figure 1. 1-inch diameter dowel, marked off in 1-cm increments (not to scale).

2. With an adult helper, make a platform from a small piece of wood or hardboard and attach it firmly to the top of the dowel with a wood screw and glue (Figure 2). It's a good idea to drill a pilot hole for the wood screw, so the dowel doesn't split. Your platform should be large enough to support the weight you'll be using.

   Make a jig to hold the dowel vertically over the soil surface. (Figure 3). The dowel should be able to slide freely, so the hole needs to be slightly larger than the diameter of the dowel. You can drill it.

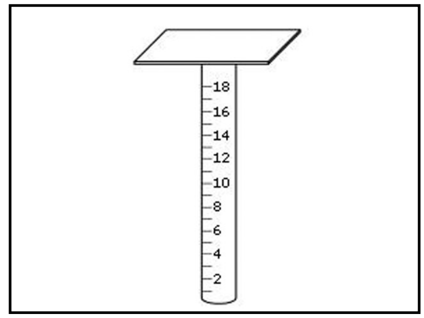


Figure 2. Dowel with platform attached (not to scale).

3. Continuing to use your adult helper, use a 1-inch spade bit, or a 1-inch hole saw, and then file out the hole to enlarge it enough for the dowel to slide freely. Make the legs from thinner dowels, and glue them to the bottom. You'll push these into the soil, so they need to be a bit longer than your tub is high (tall enough to hold the dowel upright).

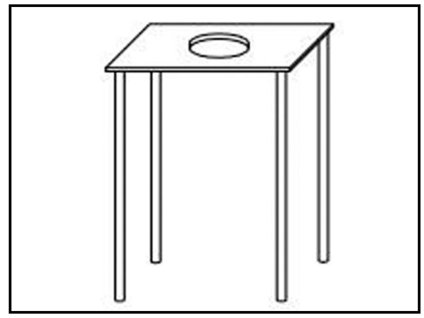


Figure 3. Jig for holding the dowel upright. The hole should be slightly larger than the dowel, allowing it to slide freely, but still supporting it. The legs should reach the bottom of the tub and leave the platform high enough above the soil to keep the dowel from tipping over (not to scale).

4. Fill the plastic tub with the sand or soil you want to test.

5. Push the legs of the jig firmly down into the soil and set the dowel so that it rests on the surface of the soil (see Figure 4).

6. Load the platform with weight (e.g., container + 500 ml water), and record how far the dowel penetrates into the soil. Keep track of the results in your lab notebook.

7. Add an increment of weight and record how far the dowel penetrates into the soil. Repeat until the dowel does not penetrate further. Repeat the measurement at least three times, in different locations in the tub. Calculate the average penetration depth for each weight and soil type tested.

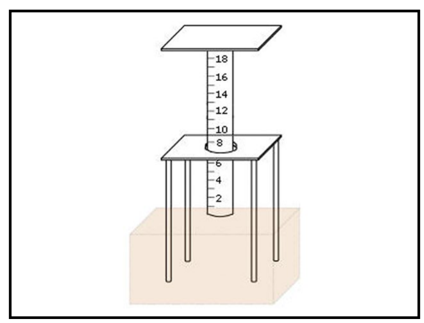


Figure 4. The dowel supported in the jig. Push the legs of the jig firmly down into the soil and set the dowel so that it rests on the surface of the soil (not to scale).

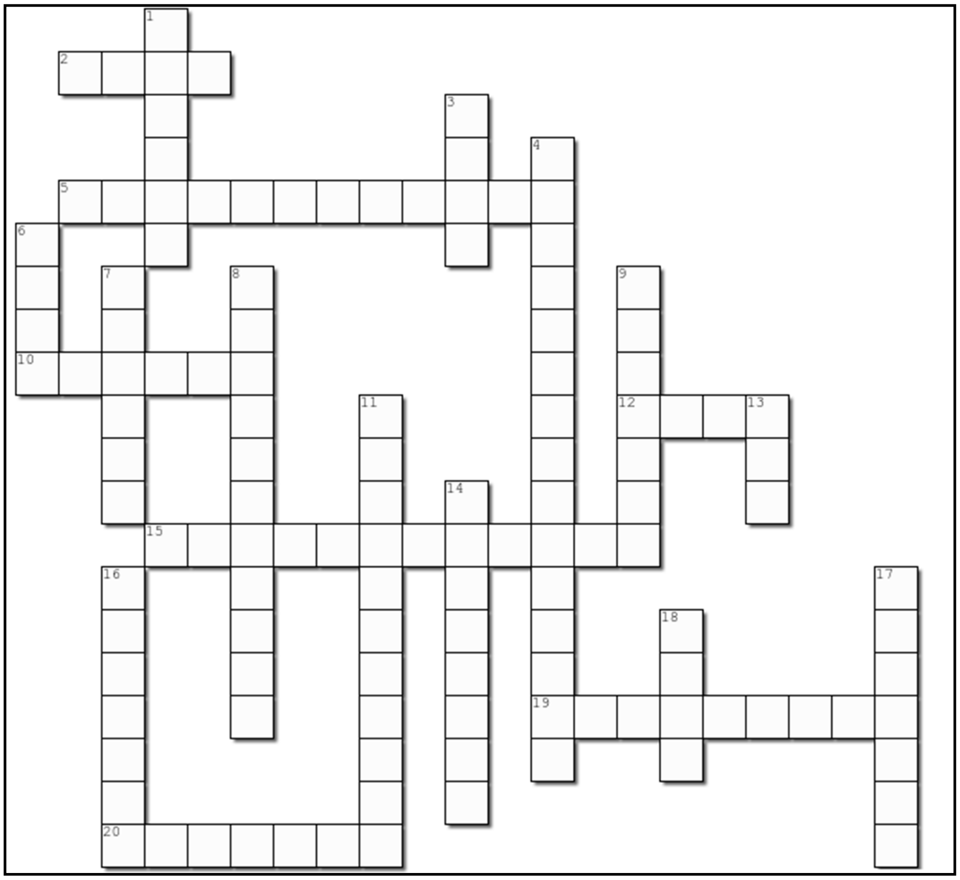
8. For each soil type, make a graph of the penetration depth vs. weight.

9. What happens to the soil underneath the dowel? If you add more weight to the dowel, does it descend by the same amount for each additional (equal) increment in weight?

Geology Definitions Crossword

Instructions:

Apply what you have learned so far about soil and stratigraphy to complete this crossword puzzle!



Word Bank

- Geology
- Stratigraphy
- Soil
- Haboob
- Sedimentary
- Metamorphic
- Igneous
- Desert
- Geologic Time
- Sand
- Silt
- Clay
- Fossil
- Lithify
- Trilobite
- Triassic
- Loam
- Topsoil
- Bearing Capacity
- MYA

ACROSS

2. A wet, smooth, and sticky soil made from tiny particles of rock
5. The billions of years since the planet Earth began developing (2 words)
10. Any large region that gets very little rain each year where very few animals and plants live
12. Soil with roughly equal proportions of sand, silt, and clay
15. A branch of geology that studies rock formations called strata
19. Extinct ocean animals that were very numerous during the early Paleozoic era
20. The process by which sediments and soil, under intense pressure, become rock

DOWN

1. A violent dust storm or sandstorm, especially in the middle east
3. The loose upper layer of the Earth's surface where plants grow
4. The maximum pressure a structure can sustain without failure of rock and soil (2 words)
6. Rough soil made up of small, loose pieces of rock, minerals, and even gemstones
7. The preserved remains or impressions of a living organism such as a plant, animal, or insect
8. Rocks that are a result of a transformation of a pre-existing rock
9. The study of the Earth's origin, structure, composition, and history
11. Rocks that are made when sand, mud, and pebbles get laid down in layers
13. Stands for "million years ago"
14. A period in time that began 251.9 million years ago, and ended 201.3 million years ago
16. The rich upper layer of soil in which plants have most of their roots
17. Rocks that have formed by the cooling and hardening of molten lava or magma
18. Smooth soil made up of tiny particles of sediment in water

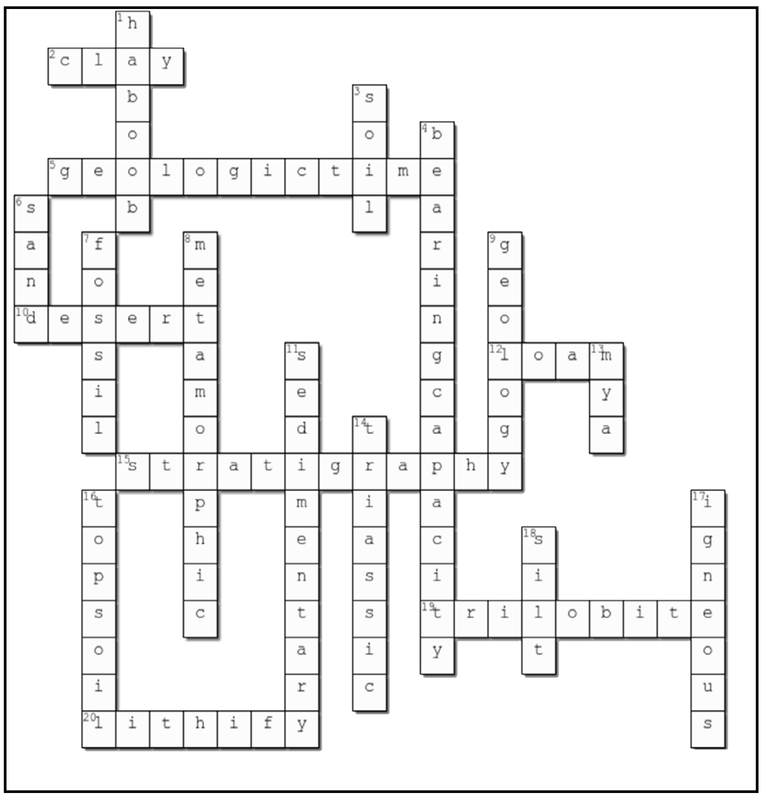
Answer Sheet

Identifying and Classifying Rocks
(Page 6)
1. Sedimentary
2. Igneous
3. Igneous
4. Sedimentary
5. Metamorphic
6. Sedimentary
7. Metamorphic
8. Metamorphic

The Rock Cycle
(Page 7)
1. Heat/Pressure
2. Weathering/Cementation
3. Melting
4. Melting
5. Weathering/Cementation
6. Heat/Pressure

Soil Top Layers
(Page 8)
Qatar (rock hammades): Loamy Sand
London: Silty Clay Loam
Eastern Virginia: Silty Loam
Yellowstone: Silty Clay Loam
Cierva Point: Sandy Loam
Victoria: Clay

Geography Definitions Crossword



Fossils of the Arabian Peninsula