10

Sedimentary Rocks

adley Deline

10.1 INTRODUCTION

We are particularly interested in the history and events that occur on the surface of the Earth both because it is easier to directly observe and test, and has direct relevance to our lives and our own history. Sedimentary rocks are the pages in which history is written, since they contain powerful environmental indicators, traces of life, and chemical signatures that can inform us about a wealth of subjects from the occurrence of ancient catastrophes to the productivity of life.

The identification of sedimentary rocks is more than applying names, since each name is a loaded term that conveys information regarding its history, where it was formed, potentially when it was formed, and the processes that lead to its formation. Each sedimentary rock is a puzzle and by identifying a set of rocks, how they are layered, the fossils within, and patterns in the rocks a geologist can reconstruct an entire environment and ecosystem. Solving these puzzles is both an academic exercise to better understand the world around us as well as a tool for finding the resources that are important to our lives. In particular, fossil fuels as well as many other natural resources are, or are contained within, sedimentary rocks such as coal, natural gas, petroleum, salt, and the materials that go into wallboard or in the making of cement. Therefore, a better understanding of sedimentary rocks and how and where they are formed directly influences your everyday life.

10.1.1 Learning Outcomes

After completing this chapter, you should be able to:

- Describe how erosion and weathering relate to the formation of sedimentary rocks
- Identify sedimentary rocks and their features
- Describe the formation and history of different types of sedimentary rocks

- Describe the formation of different sedimentary structures
- Discuss the distribution of sedimentary rocks, sedimentary structures, and types of weathering in varying sedimentary environments

10.1.2 Key

Beach Depositional Environments	Glacial Depositional Environments
Biochemical Sedimentary Rocks	Lacustrine Depositional Environments
Chemical Sedimentary Rocks	Marine Environments
Chemical Weathering	Maturity
Clastic Sedimentary Rocks	Mechanical Weathering
Continental Environments	Organic Sedimentary Rocks
Deep Marine Depositional	Reef Depositional Environments
Deltas	Sedimentary Structures
Aolian Depositional Environments	Shallow Marine Depositional Environments
Erosion	Tidal Mudflat Depositional
Fluuvial Depositional	Transitional Environments

10.2 WEATHERING AND EROSION

Sedimentary rocks are formed by the weathering, erosion, deposition, and lithification of sediments. Basically, sedimentary rocks are composed of the broken pieces of other rocks. The obvious place to start this chapter is a discussion of how rocks are broken down, which is a process called weathering. There are two basic ways that weathering occurs in nature. First, rocks can be physically broken into smaller pieces (imagine hitting a rock with a hammer), which is called **mechanical weathering**. Alternatively, rocks can be broken down and altered at the atomic level (imagine dissolving salt in a glass of water), which is called c**hemical weathering**. There are multiple ways each type of weathering can occur and, therefore, both the rate that rock breaks down and how it breaks down vary dramatically depending on the area and environment.

The most prevalent type of mechanical weathering is the collision, breaking, and grinding of rock by the movement of a fluid, either water or air. The size of the carried sediment depends on the type of fluid and speed of the movement. A fast fluid (like a rapid flowing river) can carry large particles and cause immense amounts of weathering while a slow fluid (like a calm stream) would hardly cause any weathering. The density of the fluid also controls the size of particle that can be transported, for instance denser fluid (like water) can carry larger particles than less dense fluid (like air). Another common method of mechanical weathering is called frost wedging, which occurs when water seeps into a crack in the rock and freezes. Water has a unique property in that it expands when frozen, which puts pressure on the rock and can potentially split boulders. The addition and subtraction of heat or pressure can also cause rock to break, for instance spilling cold water on a hot light bulb will cause it to shatter. This breakage can also occur with rocks when they cool very quickly or immense pressure is released. Finally, plants, animals, and humans can cause significant amounts of weathering. These sediments then undergo **erosion**, which is the transport of sediment from where it is weathered to where it will be deposited and turned into a rock.

Rocks can also be chemically weathered, most commonly by one of three processes. The first, which you are probably familiar with, is called dissolution. In this case, a mineral or rock is completely broken apart in water into individual atoms or molecules. These individual ions can then be transport with the water and then re-deposited as the concentration of ions increases, normally because of evaporation. Chemical weathering can also change the mineralogy and weaken the original material, which again is caused by water. A mineral can undergo hydrolysis, which occurs when a hydrogen atom from the water molecule replaces the cation in a mineral; this normally alters minerals like feldspar into a softer clay mineral. A mineral can also undergo oxidation, which is when oxygen atoms alter the valence state of a cation, this normally occurs on a metal and is commonly known as rusting.

Chemical and mechanical weathering can work together to increase the overall rate of weathering. Chemical weathering weakens rocks making them more prone to breaking physically, while mechanical weathering increases the surface area of the sediment, which increases the surface area that is exposed to chemical weathering. Therefore, environments with multiple types of weathering can erode very quickly. As you go through the following sections (on rocks and environments) think about the types of weathering required to make the sediment that will then make up different types of sedimentary rocks as well as what types of weathering you would expect to occur in different environments.

10.3 IDENTIFYING SEDIMENTARY ROCKS

The classification of sedimentary rocks is largely based on differentiating the processes that lead to their formation. The biggest division in types of sedimentary rocks types is based on the primary type of weathering that leads to the material building the sedimentary rock. If the rock is largely made from broken pieces (called clasts) of rock that have been mechanically weathered the rocks are referred to as Detrital or **Clastic Sedimentary Rocks**. Simply put, these are rocks that are composed of the broken pieces of other rocks. In this case, the mineralogy of the clasts is not important, but instead we need to note the properties of the sediment itself. Alternatively if the rock is largely the product of chemical weathering the classification is then based on the composition of the material as well as the processes involved in the materials precipitation from solution. **Chemical Sedimentary Rocks** form from the inorganic precipitation of minerals from a fluid. If the ions present within a fluid (water) become very concentrated either by the addition of more ions or the removal of water (by freezing or evaporation), then crystals begin to form. In this case the identification of the type of sedimentary rocks is based on the minerals present. If organisms facilitate the precipitation of these minerals from water we refer to the rocks as **Biochemical Sedimentary Rocks.** An example of biochemical precipitation is the formation of skeletal minerals in many organisms: from starfish and clams that grow calcite, to sponges that grow silica-based material, to humans that have bones made of hydroxyapatite. In many cases it is hard to differentiate whether a mineral was formed organically or inorganically, so in the current lab we will mostly group these two types of sedimentary rocks together. Rocks can also be formed from the carbon-based organic material produced by ancient life and are called **Organic Sedimentary Rocks**. Now we can discuss the identification and formation of particular sedimentary rocks.

10.3.1 Clastic Sedimentary Rocks

Weathering and erosion occur normally in areas that are at high elevation, such as mountains, while deposition occurs in lower areas such as valleys, lakes, or the ocean. The sediment is transported from the area of erosion to area of deposition by ice, water, or air. Not surprisingly, the sediment changes during its journey and we can recognize the amount of change and the distance the material has traveled, and the transport mechanism, by looking at its maturity (Figure 10.1). **Maturity** is defined as the texture and composition of a sedimentary rock resulting from varying amounts of erosion or sedimentary transport. Imagine a mountain composed of the igneous rock granite and let us explore how the sediment from this mountain changes as it makes the long distance trek via river to the ocean. The first process is just breaking the rock down into smaller pieces mechanically, which creates sediment that has large and small pieces, the pieces are jagged, and all of the minerals remain. The sizes of clasts in these rocks can range from large boulders, to cobbles, to pebbles, to the smallest particles, clay. As this sediment is transported in the river the pebbles collide with other pebbles and the rocks get smaller and the sharp edges are broken off. Also, as the slope of the land decreases the river slows leaving behind the large boulders and cobbles while carrying away the smaller particles. This results in sediments further from the source to be more uniform in size, which is a process called sorting. Chemical weathering also occurs, altering the feldspars into clay-sized particles. The end result of this process is the granite reduced from boulders and cobbles close to the mountain, to pebbles in the rivers, and finally to pure and uniform quartz sand at the beach and miniscule clay grains on the ocean floor. Therefore, different clastic rocks are found in different areas and have traveled different distances.

In this lab, we will look at three types of clastic rocks (Figure 10.1, Table 10.1), conglomerate, sandstone, and shale. Conglomerate is an immature sedimentary rock (rock that has been transported a short distance) that is a poorly sorted mixture of clay, sand, and rounded pebbles. The mineralogy of the sand and pebbles (also called clasts) can vary depending on its source. These rocks would be found on the continent in a several types of deposits such as ancient landslides or pebble beds in rivers. Sandstone is defined as a clastic sedimentary rock that consists of sand-sized clasts. These clasts can vary from jagged to rounded as well as containing many minerals or just quartz. Therefore, sandstone ranges from being relatively immature to mature which makes sense because we can find layers of sand associated with mountain rivers to pure white quartz beaches. Last we have shale, which is composed of clay particles and has a finely layered or fissile appearance. This extremely mature sedimentary rock is made from the smallest particles that can be carried by wind or barely moving water and can be found thousands of miles away from the original source.

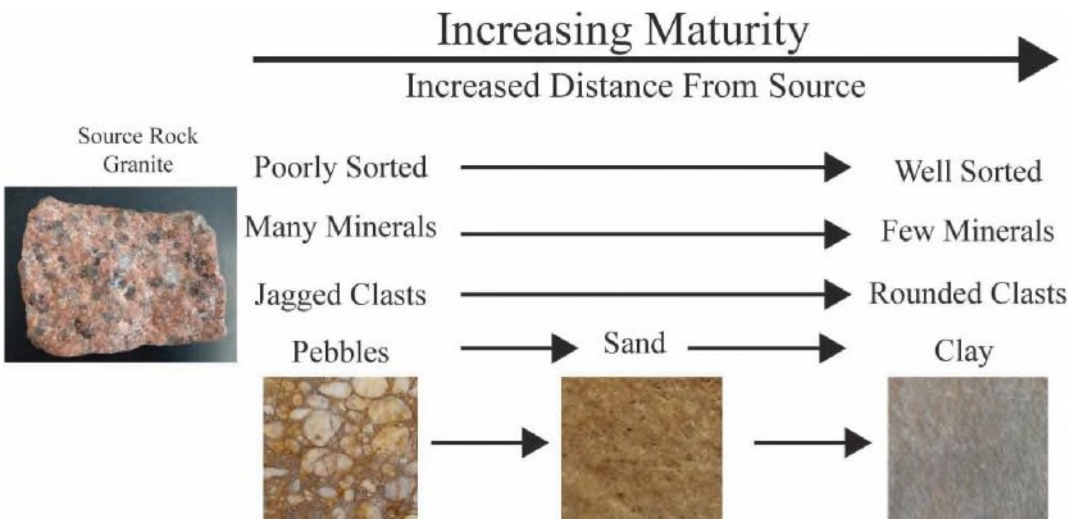


Figure 10.1 | Maturity in clastic sedimentary rocks showing how the sediments change as they are eroded further from their source.
Author: Bradley Deline
Source: Original Work

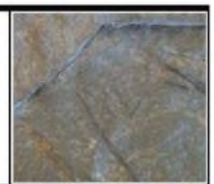
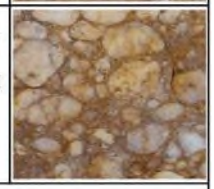
	Composition	Texture and Properties	
Detrital Sedimentary Rocks			
Shale	Rock fragments smaller than 1/16 mm	Clay-sized particles that cannot be differentiated by the naked eye. May be fissile, splits into distinctive layers.	
Sandstone	Rock fragments between 1/16 - 2mm	Composed of sand-sized rock fragments. The fragments can vary in mineralogy including mainly quartz, along with feldspar, and clay	
Conglomerate	Rock fragments ranging in size with the largest >2mm	Poorly sorted mixture of rock fragments including subround or rounded pebbles.	
Chemical and Biochemical Sedimentary Rocks			
Crystalline Limestone	Calcite crystals or microcrystalline calcite	Masses of large interlocking calcite crystals or microscopic crystals not visiable with the naked eye. Effervesces in dilute HCl.	
Coquina	Calcareous skeletal fragments of coral or shells	Consisting of gravel-sized shell or coral fragments composed of calcite or aragonite. Effervesces in dilute HCl.	
Dolostone	Microcrystalline dolomite	Masses of large interlocking dolomite crystals or microscopic crystals not visiable with the naked eye. Effervesces in dilute HCl.	
Chert	Microcrystalline polymorphs of quartz	Microcrystalline varieties of quartz. Scratches glass and may show conchoidal fracturing.	
Organic Sedimentary Rocks			
Coal	Plant fragments and carbonized organic material	Black brittle rock with possible plant fragments. Light in weight with a sooty or shiny appearance. Dark gray streak.	

Table 10.1 | Classification of Sedimentary rocks.
Author: Bradley Deline
Source: Original Work

10.3.2 Biochemical and Chemical Sedimentary Rocks

As mentioned before, biochemical and chemical sedimentary rocks either precipitated directly from water or by organisms. The most recognizable chemical sedimentary rocks are evaporites. These are minerals that are formed by the precipitation of minerals from the evaporation of water. You have already examined multiple examples of these minerals/rocks in a previous lab, such as halite and gypsum. In this current lab, we will focus on siliceous and carbonate biochemical sedimentary rocks. Chert is a rock composed of microcrystalline varieties of quartz, and thus it has properties that are associated with quartz itself, such as conchoidal fracturing and hardness greater than glass. Chert is often formed deep in the ocean from silicious material that is either inorganic (silica clay) or biologic (skeletons of sponges and single-celled organisms) in origin. Carbonates are one of the most important groups of sedimentary rocks and as you have previously learned (Chapter 5), can result in distinctive landscapes (karst) and human hazards (sinkholes). Limestone is a sedimentary rock composed of the carbonate mineral calcite and can vary greatly in its appearance depending on how it is formed, but can easily be identified by its chemical weathering. Limestone composed of the mineral calcite undergoes dissolution in acids, in other words it effervesces dramatically when we apply dilute HCl. As with chert, limestone can be formed inorganically from a supersaturation of calcium and carbonate ions in water in varying environments from caves to tropical beaches. Limestone that consists of crystals of calcite or microcrystalline masses of calcite is called crystalline limestone. Alternatively, limestone can be formed biologically with the most striking example called a coquina, which are rocks made exclusively of fragmented carbonate (calcite or its polymorph aragonite) shells or coral. Lastly, we have dolostones, which are made from crystals (large or microscopic) of the mineral dolomite and are a carbonate that only weakly reacts to dilute HCl; you can scratch and powder dolostone to increase the surface area to see the reaction with acid. Dolostone is formed by the inorganic chemical alteration of limestones, therefore they are classified as chemical rather than biochemical sedimentary rocks.

10.3.3 Organic Sedimentary Rocks

Organic compounds are materials that contain a significant amount of the element carbon and are often associated with life. Organic sedimentary rocks are, therefore, rocks that consist mostly of carbon and are associated with significant biological activity. Other sedimentary rocks such as limestone and shale can contain carbon, but at much lower concentration (though shale can appear black from their carbon content). The most common organic sedimentary rock is coal, which is a very low density (light) black rock that has a dusty (sooty) or shiny appearance. It also produces a dark gray streak that can be seen both on a streak plate or a piece of paper. Coal is formed from the preservation and compaction of abundant plant material often in areas where oxygen is lacking, such as a swamp.

10.4 LAB EXERCISE

Materials

Unpack your HOL Sedimentary Rock bag with rocks labeled S1-S8 following what you see in Figure 10.2. In addition to these samples you will need the following from your HOL Rock Kit: 1) your glass plate, 2) your streak plate, 3) your hand lens, and 4) your bottle of diluted HCl.

Using Table 10.1, start identifying the rocks by separating out the organic sedimentary rocks from the chemical and biological sedimentary rocks from the clas-tic sedimentary rocks. Make sure to use all of the tools available including the glass plate and the diluted HCl to identify the chemical and biochemical sedimentary rocks (chert will be harder than glass, limestone will strongly react with dilute HCl, and dolostone will weakly react with dilute HCl when powdered). The streak plate can be helpful in identifying coal, which will easily produce a dark gray streak. Finally, use the hand lens to closely examine the size of the grains in the clastic sedimentary rocks. Once you are confident of your identifications, answer the following questions.

Figure 10.2 | The eight rocks (S1- S8) in the Sedimentary Rocks Bag in the HOL kit.
Author: Bradley Deline
Source: Original Work
License: CC BY-SA 3.0

Part A – Identifying Sedimentary Rocks

1. Sample S1 is called ________________.

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale
e. Coquina f. Chert g. Dolostone h. Sandstone

2. Sample S1. is an example of a_______________ .

a. Clastic Sedimentary Rock

b. Organic Sedimentary Rock

c. Chemical or Biochemical Sedimentary Rock

3. Sample S1. has the following characteristic:

a. effervesces in diluted HCl acid

b. weakly effervesces in diluted HCl acid if powdered

c. contains fossil shells and effervesces in diluted HCl acid

d. contains pebbles and finer sediments

e. a sooty or shiny appearance

4. The formation of Sample S1. includes:_____________ .

a. chemical weathering, transport of ions, precipitation of minerals, lithification

b. mechanical weathering, transport of sediment a short distance, deposition of sediment, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transport of ions, precipitation of minerals as shells by organisms, deposition, lithification

5. Sample S2 is called ________________ .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

6. Sample S2 is composed of _______________.

a. clastic sediments b. calcite crystals c. dolomite crystals

d. organic material e. calcite shells

7. Closely examine the individual grains in Sample S2. Which of the following is true about its maturity?

a. It is mature because it contains a variety of different minerals.

b. It is immature because it is poorly sorted.

c. It is mature because it contains mostly rounded quartz grains.

d. It is immature because the grains are jagged.

8. The formation of Sample S2 includes: ____________ .

a. chemical weathering, transport of ions, precipitation of minerals, lithification

b. mechanical weathering, transport of sediment a long distance, deposition of sediment, lithification

c. mechanical weathering, transport of sediment a very short distance, deposition of sediment, lithification

d. photosynthesis, growth of organic material, deposition of organic materials, lithification

e. chemical weathering, transport of ions, precipitation of minerals as shells by organisms, deposition, lithification

9. Sample S3 is called .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

10. Sample S3 is an example of a __________________ .

a. Clastic Sedimentary Rock b. Organic Sedimentary Rock

c. Chemical Sedimentary Rock d. Biochemical Sedimentary Rock

11. Sample S3 has the following characteristic:

a. effervesces in diluted HCl acid

b. weakly effervesces in diluted HCl acid if powdered

c. contains fossil shells and effervesces in diluted HCl acid

d. contains pebbles and finer sediments

e. has a sooty or shiny appearance

12. The formation of Sample S3 includes:____________ .

a. chemical weathering, transport of ions, precipitation of minerals, lithification

b. mechanical weathering, transport of sediment a short distance, deposition of sediment, lithification

c. chemical weathering, transport of ions, precipitation of minerals, lithification, chemical alteration

d. photosynthesis, growth of organic material, deposition of organic materials, lithification

e. chemical weathering, transport of ions, precipitation of minerals as shells by organisms, deposition, lithification

13. Sample S4 is called .

a. Conglomerate	b. Crystalline Limestone	c. Coal	d. Shale
e. Coquina	f. Chert	g. Dolostone	h. Sandstone

14. Sample S4 is an example of a________________.

a. Clastic Sedimentary Rock	b. Organic Sedimentary Rock
c. Chemical Sedimentary Rock	d. Biochemical Sedimentary Rock

15. Closely examine the individual grains in Sample S4. Which of the following is true about its maturity?

a. It is immature because it is poorly sorted.

b. It is mature because it is poorly sorted.

c. It is mature because it contains mostly rounded grains.

d. It is immature because it contains mostly rounded grains.

e. It is immature because it has clay-sized particles.

16. The formation of Sample S4 includes:____________ .

a. chemical weathering, transportation of ions, precipitation of minerals, lithification

b. mechanical weathering, transportation of sediment a short distance, deposition of sediments, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

17. Sample S5 is called _______________.

a. Conglomerate	b. Crystalline Limestone	c. Coal	d. Shale
e. Coquina	f. Chert	g. Dolostone	h. Sandstone

18. Sample S5 is an example of a________________.

a. Clastic Sedimentary Rock

b. Organic Sedimentary Rock

c. Chemical or Biochemical Sedimentary Rock

19. The history of formation of Sample S5 includes:_____________ .

a. chemical weathering, transportation of ions, precipitation of minerals, lithification

b. mechanical weathering, transportation of sediment a short distance, deposition of sediments, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

20. Sample S5 has the following characteristic:

a. effervesces in diluted HCl acid

b. weakly effervesces in diluted HCl acid if powdered

c. contains fossil shells and effervesces in diluted HCl acid

d. contains pebbles and finer sediments

e. a sooty or shiny appearance

21. Sample S6 is called _____________ .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

22. The history of formation of Sample S6 includes: __________ .

a. chemical weathering, transportation of ions, precipitation of minerals either biologically or inorganically, lithification

b. mechanical weathering, transportation of sediments a short distance, deposition of sediments, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

23. Sample S6 is composed of __________.

a. clastic sediments b. microcrystalline calcite crystals

c. microcrystalline dolomite crystals d. microcrystalline quartz crystals

e. organic material

24. Sample S6 can be easily recognized by which of the following properties?

a. conchoidal fracturing

b. weakly effervesces in diluted HCl acid if powdered

c. fissule appearance

d. a sandpaper texture

e. a sooty or shiny appearance

25. Sample S7 is called .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

26. Compared to Sample S2, how mature is Sample S7?

a. more mature   b. less mature   c. same level of maturity

27. Sample S7 consists of_______________.

a. fragments of calcite shells   b. clay-sized sediments

c. sand-sized sediments   d. organic material

e. dolomite crystals

28. Sample S7 can be easily recognized by which of the following properties?

a. conchoidal fracturing

b. weakly effervesces in diluted HCl acid if powdered

c. fissile appearance

d. a sandpaper texture

e. a sooty or shiny appearance

29. Sample S8 is called _______________.

a. Conglomerate   b. Crystalline Limestone   c. Coal   d. Shale

e. Coquina   f. Chert   g. Dolostone   h. Sandstone

30. Sample S8 is an example of a _______________.

a. Clastic Sedimentary Rock   b. Organic Sedimentary Rock

c. Chemical Sedimentary Rock   d. Biochemical Sedimentary Rock

31. Sample S8 is most likely to weather by which of the following processes?

a. Dissolution   b. Frost Wedging

c. Oxidation   d. Hydrolysis

e. The addition and subtraction of heat

32. The history of formation of Sample S8 includes: __________ .

a. chemical weathering, transportation of ions, precipitation of minerals, lithification

b. mechanical weathering, transportation of sediments a long distance, deposition of sediments, lithification

c. mechanical weathering, transportation of sediments a very short distance, deposition of sediments, lithification

d. photosynthesis, growth of organic material, deposition of organic materials, lithification

e. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

10.5 SEDIMENTARY STRUCTURES

Sedimentary rocks often show distinctive patterns that are unrelated to their type of rock, yet reflect events or conditions during deposition and are called **sedimentary structures**. These patterns in the rocks can be very informative to geologists attempting to reconstruct the environment in which a sedimentary rock was formed. Imagine wind blowing steadily along a beach; this wind pushes the sand into dunes that can be preserved in the rock record, informing us about the strength and direction of the wind along with the rock type.

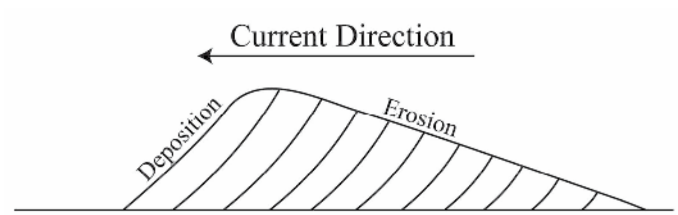


Figure 10.3 | Cross-section of a ripple showing the area of erosion and deposition.
Author: Bradley Deline
Source: Original Work
License: CC BY-SA 3.0

Examples of sedimentary structures are given in Table 10.2, but let us discuss them in more detail. The sedimentary structures that most students are familiar with are ripples and dunes. We are familiar with seeing dunes at the beach or in deserts or smaller ripples in mud puddles. In each case, these ripples are formed from either a wind or water current. Ripples form by the current pushing sediment into a pile; on the down-current side the sediment is shadowed and protected from the wind or water current. This means that there is erosion on the up-current side making a shallow slope and deposition on the steeper, down-current side. Therefore, if you cut a ripple in half and look at it in prospect you can see inclined layers of sediment building up on the steep down current side of the ripple. We can often see multiple layers of beds consisting of these inclined layers, which represent multiple generations of migrating ripples or dunes that are called cross-beds. Both ripples and cross-beds can indicate the presence and direction of the current in an environment.

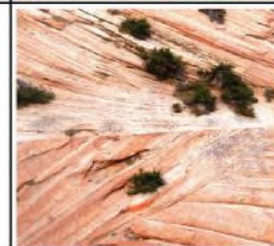
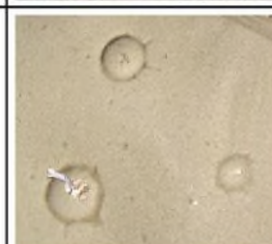
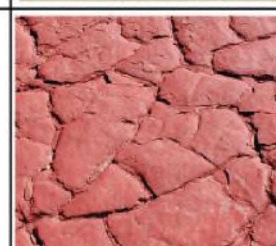
Sedimentary Structure	Description	Required conditions	
Ripple Marks	Either symmetrical or asymetrical ripples present on bedding surfaces.	Water or air currents. Asymetrical ripples indicate unidirectional currents with the steep slope facing down current and the shallow slope facing up current. Symmetrical ripples indicate bidirectional currents.	
Cross-bedding	Layers of inclined beds often altering directions from bed to bed.	Water or air currents.	
Graded Beds	Beds of sedimentary rocks with a change in sediment size through the layer with smaller grains at the top of the bed and larger grains on the bottom.	A turbulent water current carrying sediment loses energy and slows.	
Raindrop impressions	Small indentations on a bedding plane from the impact of raindrops.	Soft muddy substrate that is exposed and subsequently buried with sediment.	
Mudcrack casts	Muddy cast infills of a polygonal pattern of cracks formed in mud as it drys.	Alternating wet and dry conditions create cracks in mud, which are then buried by sediment and preserved.	
Trace fossils	Tracks, burrows, or other traces left by the activity of plants or animals.	The presence of animals or plants. These traces occur where the organism lives and more specific information can be obtained based on the identity of the tracemaker.	

Table 10.2 | Descriptions of common sedimentary structures. Images provided by (from top to bottom) Grand Canyon National Park, Zion National Park, B. Deline, James St. John, Grand Canyon National Park, and B. Deline.
Author: Bradley Deline
Source: Original Work

We can also see structures that indicate changes in the strength of a current. Imagine a fast moving current carrying a variety of sediment sizes; if the current slows it will no longer be able to carry the largest particles and they will be deposited first. Then as the current continues to slow progressively smaller particles are deposited on top of the bigger particles, forming a sedimentary deposit called a graded bed. This graded bed is a sedimentary layer with larger clasts on the bottom and smaller clasts on the top. These types of beds can be the result of floods in a river or storms in the ocean. We can also observe features that are pretty self-explanatory such as casts of mud cracks (covered and preserved cracks that are the result of the drying of wet mud), and rain drop impressions (covered and preserved impacts of rain drops in soft mud). In both of these cases, the sedimentary structure tells us about the sediment, the water content, and its exposure at the surface above water level.

Related to sedimentary structures are trace fossils, which are patterns in the rocks that are caused by the activity of organisms. These can occur in many different ways and can indicate many different aspects about the environment depending on the trace and the identity of the tracemaker. Traces can be terrestrial such as footprints, burrows or dens, or the traces of roots, which can inform us about the climate, ecosystem, and the development of soils. Traces can also be found in freshwater and marine environments, such as burrows, borings, footprints, or feeding traces, which tell us about the sediment, chemistry of the poor water, and the life that lived within it.

10.6 DEPOSITIONAL ENVIRONMENTS

A depositional environment is the accumulation of chemical, biological, and physical properties and processes associated with the deposition of sediments that lead to a distinctive suite of sedimentary rocks. Sedimentary environments are interpreted by geologists based on clues within such as rock types, sedimentary structures, trace fossils, and fossils. We can then compare these clues to modern environments to reconstruct ancient environments. We can break up the numerous depositional environments found on earth into common environments we find on land **(continental environments)**, in the ocean **(marine environments)**, and at the interface between the two **(transitional environments**). As each of the environments is briefly described, think about and fill in Table 3 with the following information: 1) select the image that best depicts the depositional environment in Figure 10.4 and put the corresponding letter (from Figure 10.4) in the first column, 2) the types of sediments and sedimentary rocks most likely to occur in that environment, 3) the maturity of those sediments if clastic, and 4) the types of sedimentary structures that may be present.

10.6.1 Continental Environments

There are many different environments on the continents, but again we are limited to those that are dominated by the deposition rather than the erosion of sediments. Erosion occurs in high altitude areas and although continents are overall topographically elevated compared to the oceans, there are several different areas on the continent where we get distinctive depositional properties. Continental depositional environments are dominated by clastic sedimentary rocks, largely because of their proximity to the source of the sediments.

Glacial depositional environments are controlled mostly by the weathering and erosion by glaciers and glacial meltwater. Glaciers most commonly occur in areas that are both high elevation and/or high latitudes. Glaciers are fairly slow moving (centimeters a day) and normally travel short distances from their source, but they can cause immense mechanical weathering. Glaciers grind and bulldoze rock and create piles of poorly sorted sediment called moraines. Glaciers also produce a significant though fluctuating amount of melt water, which flows through the moraines building a system of braided rivers. These rivers carry the small sediments further from the end of the glaciers into an area called the outwash plain, which consists of poorly sorted sediment.

We have spent a significant amount of time in chapter five discussing rivers and how they erode, transport, and deposit sediment. Sediments that are deposited through the action of rivers are referred to as **fluvial depositional environments**. The gradient and discharge of a river can greatly control the shape of the river, how it flows, and how it deposits sediment. Rivers alter sediment both chemically and physically as well as sort the sediment since there is a limit to the size or particles a river can carry. Within a meandering river we see several different types of sediments, from the pebbles and stones within the river channel to sandy point bars along the outer edge of the meander where the water slows. In addition, we see multiple types of sedimentary structures related to the flow of the river as well as those related to flood events.

We also have sediments deposited within lakes, which are called **lacustrine depositional environments**. Unlike rivers, lakes do not have rapidly flowing water and thus there is significantly less movement of sediment. The sediment that accumulates in lakes can come from several sources including rainwater carrying sediment into the lake from the shores, rivers that flow into the lake, and sediment that is transported by the wind. Once the sediment reaches the lake it remains undisturbed so we see thin layers of fine sediment, with varying amounts of trace fossil.

Lastly, there are **eolian depositional environment**, which are dominated by currents of wind rather than water. Since air is less dense than water, only smaller particles can be transported. In addition, wind is not restrained within distinctive channels like water and, therefore, the features of eolian deposits are more widespread than those of fluvial deposits. Certain areas have predominant wind patterns, such that the wind is fairly consistent in direction and strength, which can generate significant sedimentary structures. When water is present within these environments it is often in the form of seasonal lakes that undergo significant evaporation and sometimes leaving behind chemical sedimentary rocks (evaporite deposits).

10.6.2 Transitional Environments

The interface between the continents and oceans are complicated areas that can be influenced by rivers, ocean currents, winds, waves, and tides. In addition, the sediments that are present in these areas are a mixture of materials derived from the continents (clastic and organic) and those from the ocean (chemical and biochemical). Finally, with the abundant currents (both air and water), sediments influenced by the elements, and abundant life these areas, which results in abundant sedimentary structures and trace fossils. However, we can distinguish transitional areas that are dominated by different forces such as tides, ocean currents, and rivers.

Shorelines that are influenced by strong daily tidal currents are called **tidal mudflat depositional environments**. Tides are currents that are the result of the gravitational forces exerted by the moon and the rotation of the earth. Shorelines that have strong tidal currents as well as seafloors with low gradients can have large areas that are submerged during high tide and exposed to air during low tide. These areas often have smaller particles than a normal shoreline since the tidal currents can pull marine sediments into the area. In addition, the strong bidirectional currents, daily drying out, exposure to the elements, and abundant life create abundant indicators of these environments.

Shorelines that are dominated by ocean currents are called **beach depositional environments**. Shorelines have constant wind on and off shore that are the result of the difference in the way the land and water heat and cool through the day. These winds produce the waves that are iconic at the beach, but as these waves move onto shore they curve, mimicking the shape of the shore and result in a current that runs parallel to the shore itself. This current carries and deposits sand along the beach. In addition, the wind can also produce dunes, which promote a diverse and complicated ecosystem. Within beach depositional environments there are areas where rivers flow into the ocean, which are called **Deltas**. As a river that is carrying material empties into the ocean the water slows and deposits sediment. Most of the sediment is deposited at the mouth of the river with some spilling out into the surrounding areas building a distinctive fan of sediment. Since the sediment is coming from the river, the delta is largely a thick sequence of clastic sediment showing indications of the strong flow of the river.

10.6.3 Marine Environments

Marine depositional environments differ in multiple ways, but the controlling factors in the rocks that are produced is related to the proximity and supply of continental sediment, the water depth, and the community of organisms that live in the area. The further an environment is from the shore the less clastic sediment will be present and the area will have a higher concentration of the chemical and biological sedimentary rocks that are formed within the ocean. In addition, some organisms in the right environmental conditions can produce huge amounts of skeletal material.

Shallow marine depositional environments are areas that are close to shore, but always submerged. These areas have a significant amount of mature clastic sediment along with marine algae (like sea grass) as well as skeletal material from animals like coral, echinoderms (sea urchins and sand dollars), and mollusks (clams and snails). These areas can have a significant difference in their energy level from very shallow areas influenced by waves to deeper areas only influenced by large storms. A better understanding of the relative depth can often be determined based on the sedimentary structures as well as the community of organisms and types of trace fossils, which can be very sensitive to depth.

In warm tropical shallow water area we often find **reef depositional environments**. Reefs are formed through the growth of coral colonies building a large three-dimensional structure built from calcite skeletons. Corals can grow in many different marine environments, but they can only produce reefs when their symbiotic algae that live within their tentacles can photosynthesize effectively, resulting in more energy for the coral to grow faster. Reefs also create a barrier between shallow water environments and ocean currents producing shallow, low-energy environment called lagoons. Lagoons can have thin layers of fine sediment that we would expect in quiet water along with chemical sedimentary deposits that are the result of evaporation.

Most of the ocean consists of **deep marine depositional environments**. These areas are beyond the reach of most clastic sediment other than the dust carried by the wind. Therefore, the sediment is being produced chemically and biologically within the ocean. The largest source of sediment in these deep settings is skeletal material from some of the smallest marine organisms. Multiple types of single-celled organisms can produce shells composed of either silica or calcite. These shells are mostly produced in the surface waters that are bathed in sunlight permitting photosynthesis. When the organism dies, these shells then rain down into deeper water; this slow accumulation of sediment produces fine layers of biochemical sedimentary rocks. In some cases, these shells are dissolved or altered before they reach the bottom (which can be miles away) and are precipitated as chemical sedimentary rocks. Obviously, there is not a clear boundary between shallow and deep-water environments given the gradient of the ocean floor. The deep marine depositional environment is normally thousands of feet deep and beyond the influence of even large storms.

10.6.4 Depositional Environments

Based on the descriptions of the different sedimentary environments along with your understanding of weathering, sedimentary rocks, and sedimentary structures please fill out the following table, which can then be used as a guide for answering the following questions on depositional environments.

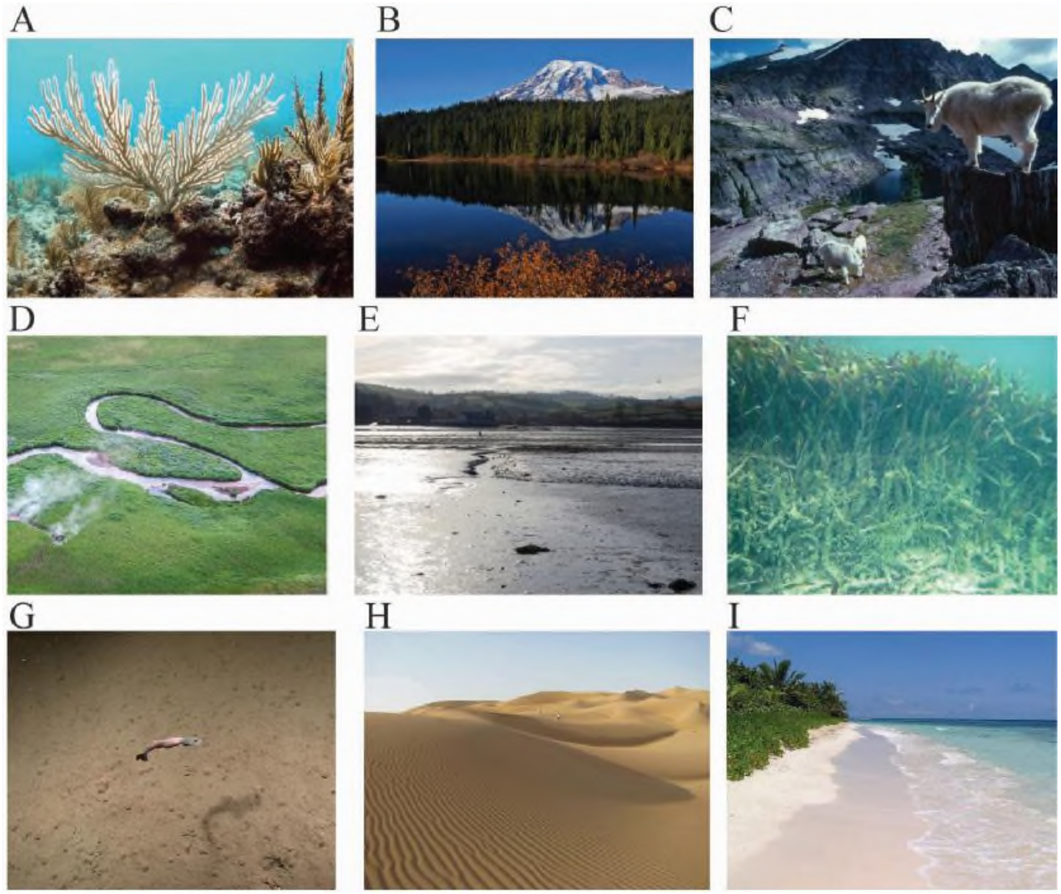


Figure 10.4 | Modern examples of the discussed depositional environments.

Photo A
Author: Kelsey Roberts, USGS
Source: Flickr
License: Public Domain

Photo B
Author: Alan Cressler
Source: Flickr
License: CC BY 2.0

Photo C
Author: Kim Keating, USGS
Source: Flickr
License: Public Domain

Photo D
Author: Deborah Bergfeld, USGS
Source: Flickr
License: Public Domain

Photo E
Author: Paul Hutchinson **Source:** Wikimedia Commons **License:** CC BY-SA 2.0

Photo F
Author: James St. John **Source:** Wikimedia Commons **License:** CC BY 2.0

Photo G
Author: NOAA
Source: Wikimedia Commons
License: CC BY 2.0

Photo H
Author: Peter Dowley **Source:** Wikimedia Commons **License:** CC BY 2.0

Photo I
Author: Diueine Monteiro **Source:** Wikimedia Commons **License:** CC BY-NC-SA 2.0

Example from Figure 4	Depositional Environment	Description	Clastic Rock Maturity, distance from source, and type	Other sedimentary Rocks	Sedimentary Structures
ntinental					
	vial				
	custrine				
	cial				
	lian				
ansitional					
	ach				
	dflats				
arine					
	allow Marine				
	efs				
	ep Marine				

Table 10.3
Author: Bradley Deline
Source: Original Work

10.7 LAB EXERCISE

Part B – Depositional Environments

The following exercises use Google Earth to explore the depositional environments that are the source for sedimentary rocks. For each locality think about the types of sediments that are accumulating, the types of weathering that would occur, as well as the presence of any sedimentary structures.

33. Search for 39 05 52.46N 84 30 56.16E and zoom out to an eye altitude of ~30,000 ft. The large-scale structures in this sedimentary environment are asymmetrical ripples (known as dunes at this size). Zoom in and out and examine the sedimentary environment. What type of sedimentary environment is this?

a. Lacustrine b. Fluvial c. Eolian d. Glacial

34. What type of weathering do you think is most prominent in this sedimentary environment?

a. Mechanical weathering from a current b. Dissolution

c. Frost Wedging d. Hydrolysis

35. Study the large dunes in this image (zoom out to an eye altitude of ~25,000 feet). These structures can indicate the direction that the wind is blowing. What is the predominant wind direction in this area? (Hint: it is easier to see these features if we exaggerate the vertical scale to do this go to Tools, options, and on the 3D view tab change the Elevation Exaggeration to 3. To do this on a Mac go to Google Earth then Preferences)

a. north to south b. south to north c. east to west d. west to east

36. Search for 64 01 03.61N 16 52 56.63W and zoom out to an eye altitude of ~25,000 ft. What type of sedimentary environment is this?

a. Lacustrine b. Fluvial c. Eolian d. Glacial

37. What type of weathering do you think is most prominent in this sedimentary environment? (Make sure you evaluate all choices.)

a. Mechanical weathering from ice b. Dissolution

c. Frost Wedging d.

Hydrolysis e. Both a and c are correct

38. When the sediment you see today lithifies, what type of sedimentary rock would you expect to be most abundant in this area and how mature is this rock type?

a. Shale, Mature
b. Shale, Immature
c. Sandstone, Immature
d. Sandstone, Mature
e. Conglomerate, Immature
f. Conglomerate, Mature

39. Search for 44 42 16.98N 1 05 23.88W and zoom out to an eye altitude of -17 miles. Notice the depth of this shallow bay (Arcachon Bay, France). This bay dries out at times and later greatly expands in size daily. What sedimentary structure would you likely find in this area because of this?

a. graded beds
b. finely layered beds
c. cross beds
d. mud cracks

40. What type of sedimentary environment is this?

a. lacustrine
b. tidal mudflats
c. deep marine
d. beach

41. Search for 20 20 23.94S 150 38 29.14E and zoom out to an eye altitude of -25 miles (also zoom far out to notice where you are in the world). What type of sedimentary environment is this?

a. shallow marine
b. deep marine
c. delta
d. reef

42. Think about the origin of this marine formation and consider the latitude to assess climatic conditions. What is the most abundant type of rock you would expect to form in this sedimentary environment?

a. Limestone
b. Sandstone
c. Coal
d. Shale

43. If the sea level dropped 1,000 feet and this sedimentary environment stopped being built and began to break down, what type of weathering would be most likely to occur on these rocks?

a. Fracturing from the addition or subtraction of pressure
b. Dissolution
c. Frost Wedging
d. Hydrolysis

44. Search for 31 00 43.61N 81 25 40.92W and zoom out to an eye altitude of 1,500 ft. What type of sedimentary environment is this?

a. shallow marine b. reef c. fluvial d. each e. tidal mudflat

45. What type of sediment would you expect to find in this depositional environment?

a. Mostly mature clastic sediments with some biochemical and chemical sedimentary sediments

b. Mostly biochemical and chemical sedimentary sediments with some mature clastic sediments

c. Exclusively organic sediments

d. Exclusively biochemical sediments

e. Exclusively immature clastic sediments

10.8 STUDENT RESPONSES

1. Sample S1 is called .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

2. Sample S1 is an example of a __________________ .

a. Clastic Sedimentary Rock

b. Organic Sedimentary Rock

c. Chemical or Biochemical Sedimentary Rock

3. Sample S1 has the following characteristic:

a. effervesces in diluted HCl acid

b. weakly effervesces in diluted HCl acid if powdered

c. contains fossil shells and effervesces in diluted HCl acid

d. contains pebbles and finer sediments

e. a sooty or shiny appearance

4. The formation of Sample S1 includes:______________ .

a. chemical weathering, transport of ions, precipitation of minerals, lithification

b. mechanical weathering, transport of sediment a short distance, deposition of sediment, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transport of ions, precipitation of minerals as shells by organisms, deposition, lithification

5. Sample S2 is called ________________ .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

6. Sample S2 is composed of ______________.

a. clastic sediments
b. calcite crystals
c. dolomite crystals
d. organic material
e. calcite shells

7. Closely examine the individual grains in Sample S2. Which of the following is true about its maturity?

a. It is mature because it contains a variety of different minerals.

b. It is immature because it is poorly sorted.

c. It is mature because it contains mostly rounded quartz grains.

d. It is immature because the grains are jagged.

8. The formation of Sample S2 includes: ____________ .

a. chemical weathering, transport of ions, precipitation of minerals, lithification

b. mechanical weathering, transport of sediment a long distance, deposition of sediment, lithification

c. mechanical weathering, transport of sediment a very short distance, deposition of sediment, lithification

d. photosynthesis, growth of organic material, deposition of organic materials, lithification

e. chemical weathering, transport of ions, precipitation of minerals as shells by organisms, deposition, lithification

9. Sample S3 is called .

a. Conglomerate
b. Crystalline Limestone
c. Coal
d. Shale
e. Coquina
f. Chert
g. Dolostone
h. Sandstone

10. Sample S3 is an example of a __________________ .

a. Clastic Sedimentary Rock
b. Organic Sedimentary Rock
c. Chemical Sedimentary Rock
d. Biochemical Sedimentary Rock

11. Sample S3 has the following characteristic:

a. effervesces in diluted HCl acid

b. weakly effervesces in diluted HCl acid if powdered

c. contains fossil shells and effervesces in diluted HCl acid

d. contains pebbles and finer sediments

e. has a sooty or shiny appearance

12. The formation of Sample S3 includes:____________ .

a. chemical weathering, transport of ions, precipitation of minerals, lithification

b. mechanical weathering, transport of sediment a short distance, deposition of sediment, lithification

c. chemical weathering, transport of ions, precipitation of minerals, lithification, chemical alteration

d. photosynthesis, growth of organic material, deposition of organic materials, lithification

e. chemical weathering, transport of ions, precipitation of minerals as shells by organisms, deposition, lithification

13. Sample S4 is called .

a. Conglomerate	b. Crystalline Limestone	c. Coal	d. Shale
e. Coquina	f. Chert	g. Dolostone	h. Sandstone

14. Sample S4 is an example of a________________.

a. Clastic Sedimentary Rock	b. Organic Sedimentary Rock
c. Chemical Sedimentary Rock	d. Biochemical Sedimentary Rock

15. Closely examine the individual grains in Sample S4. Which of the following is true about its maturity?

a. It is immature because it is poorly sorted.

b. It is mature because it is poorly sorted.

c. It is mature because it contains mostly rounded grains.

d. It is immature because it contains mostly rounded grains.

e. It is immature because it has clay-sized particles.

16. The formation of Sample S4 includes:____________ .

a. chemical weathering, transportation of ions, precipitation of minerals, lithification

b. mechanical weathering, transportation of sediment a short distance, deposition of sediments, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

17. Sample S5 is called _______________.

a. Conglomerate	b. Crystalline Limestone	c. Coal	d. Shale
e. Coquina	f. Chert	g. Dolostone	h. Sandstone

18. Sample S5 is an example of a________________.

a. Clastic Sedimentary Rock

b. Organic Sedimentary Rock

c. Chemical or Biochemical Sedimentary Rock

19. The history of formation of Sample S5 includes: ____________ .

a. chemical weathering, transportation of ions, precipitation of minerals, lithification

b. mechanical weathering, transportation of sediment a short distance, deposition of sediments, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

20. Sample S5 has the following characteristic:

a. effervesces in diluted HCl acid

b. weakly effervesces in diluted HCl acid if powdered

c. contains fossil shells and effervesces in diluted HCl acid

d. contains pebbles and finer sediments

e. a sooty or shiny appearance

21. Sample S6 is called _______________ .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

22. The history of formation of Sample S6 includes: ____________ .

a. chemical weathering, transportation of ions, precipitation of minerals either biologically or inorganically, lithification

b. mechanical weathering, transportation of sediments a short distance, deposition of sediments, lithification

c. photosynthesis, growth of organic material, deposition of organic materials, lithification

d. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

23. Sample S6 is composed of ___________.

a. clastic sediments
b. microcrystalline calcite crystals
c. microcrystalline dolomite crystals
d. microcrystalline quartz crystals
e. organic material

24. Sample S6 can be easily recognized by which of the following properties?

a. conchoidal fracturing
b. weakly effervesces in diluted HCl acid if powdered
c. fissule appearance
d. a sandpaper texture
e. a sooty or shiny appearance

25. Sample S7 is called .

a. Conglomerate
b. Crystalline Limestone
c. Coal
d. Shale
e. Coquina
f. Chert
g. Dolostone
h. Sandstone

26. Compared to Sample S2, how mature is Sample S7?

a. more mature
b. less mature
c. same level of maturity

27. Sample S7 consists of_______________.

a. fragments of calcite shells
b. clay-sized sediments
c. sand-sized sediments
d. organic material
e. dolomite crystals

28. Sample S7 can be easily recognized by which of the following properties?

a. conchoidal fracturing
b. weakly effervesces in diluted HCl acid if powdered
c. fissile appearance
d. a sandpaper texture
e. a sooty or shiny appearance

29. Sample S8 is called _______________ .

a. Conglomerate b. Crystalline Limestone c. Coal d. Shale

e. Coquina f. Chert g. Dolostone h. Sandstone

30. Sample S8 is an example of a _______________.

a. Clastic Sedimentary Rock b. Organic Sedimentary Rock

c. Chemical Sedimentary Rock d. Biochemical Sedimentary Rock

31. Sample S8 is most likely to weather by which of the following processes?

a. Dissolution b. Frost Wedging

c. Oxidation d. Hydrolysis

e. The addition and subtraction of heat

32. The history of formation of Sample S8 includes: ______________ .

a. chemical weathering, transportation of ions, precipitation of minerals, lithification

b. mechanical weathering, transportation of sediments a long distance, deposition of sediments, lithification

c. mechanical weathering, transportation of sediments a very short distance, deposition of sediments, lithification

d. photosynthesis, growth of organic material, deposition of organic materials, lithification

e. chemical weathering, transportation of ions, precipitation of minerals as shells by organisms, deposition, lithification

33. Search for 39 05 52.46N 84 30 56.16E and zoom out to an eye altitude of ~30,000 ft. The large-scale structures in this sedimentary environment are asymmetrical ripples (known as dunes at this size). Zoom in and out and examine the sedimentary environment. What type of sedimentary environment is this?

a. Lacustrine b. Fluvial c. Eolian d. Glacial

34. What type of weathering do you think is most prominent in this sedimentary environment?

a. Mechanical weathering from a current b. Dissolution

c. Frost Wedging d. Hydrolysis

35. Study the large dunes in this image (zoom out to an eye altitude of -25,000 feet). These structures can indicate the direction that the wind is blowing. What is the predominant wind direction in this area? (Hint: it is easier to see these features if we exaggerate the vertical scale to do this go to Tools, options, and on the 3D view tab change the Elevation Exaggeration to 3. To do this on a Mac go to Google Earth then Preferences)

a. north to south b. south to north c. east to west d. west to east

36. Search for 64 01 03.61N 16 52 56.63W and zoom out to an eye altitude of -25,000 ft. What type of sedimentary environment is this?

a. Lacustrine b. Fluvial c. Eolian d. Glacial

37. What type of weathering do you think is most prominent in this sedimentary environment? (Make sure you evaluate all choices.)

a. Mechanical weathering from ice b. Dissolution

c. Frost Wedging d. Hydrolysis

e. Both a and c are correct

38. When the sediment you see today lithifies, what type of sedimentary rock would you expect to be most abundant in this area and how mature is this rock type?

a. Shale, Mature b. Shale, Immature c. Sandstone, Immature

d. Sandstone, Mature e. Conglomerate, Immature f. Conglomerate, Mature

39. Search for 44 42 16.98N 1 05 23.88W and zoom out to an eye altitude of -17 miles. Notice the depth of this shallow bay (Arcachon Bay, France). This bay dries out at times and later greatly expands in size daily. What sedimentary structure would you likely find in this area because of this?

a. graded beds b. finely layered beds

c. cross beds d. mud cracks

40. What type of sedimentary environment is this?

a. lacustrine b. tidal mudflats

c. deep marine d. beach

41. Search for 20 20 23.94S 150 38 29.14E and zoom out to an eye altitude of ~25 miles (also zoom far out to notice where you are in the world). What type of sedimentary environment is this?

a. shallow marine b. deep marine c. delta d. reef

42. Think about the origin of this marine formation and consider the latitude to assess climatic conditions. What is the most abundant type of rock you would expect to form in this sedimentary environment?

a. Limestone b. Sandstone c. Coal d. Shale

43. If the sea level dropped 1,000 feet and this sedimentary environment stopped being built and began to break down, what type of weathering would be most likely to occur on these rocks?

a. Fracturing from the addition or subtraction of pressure

b. Dissolution

c. Frost Wedging

d. Hydrolysis

44. Search for 31 00 43.61N 81 25 40.92W and zoom out to an eye altitude of 1,500 ft. What type of sedimentary environment is this?

a. shallow marine b. reef c. fluvial d. each e. tidal mudflat

45. What type of sediment would you expect to find in this depositional environment?

a. Mostly mature clastic sediments with some biochemical and chemical sedimentary sediments

b. Mostly biochemical and chemical sedimentary sediments with some mature clastic sediments

c. Exclusively organic sediments

d. Exclusively biochemical sediments

e. Exclusively immature clastic sediments