

G202 Lab 4 - Introduction to Sedimentary Structures,
Sedimentary Facies, and Stratigraphy

ANSWER KEY

Part 1 - Introduction to Sedimentary Structures

Examine the samples that are located at the labeled stations in the lab. Answer the associated questions. For reference, use the attached "Sedimentology Tool Kit", and p. 95-98 in your lab manual.

Station 1 - Sedimentation Patterns

Fine "muddy" sediment was mixed with water in the jar, shaken, and left to sit for 1 week. Turn on the light / illuminator, and examine the results. Pay close attention to the subtle distribution of grain size from the bottom of the jar to the top. Answer the following questions:

1-1A. What are your initial observations of sediment size distribution?

GRADUO FROM BOTTOM → TOP
COARSE SILT → FINE SILT → CLAY

1-1B. Is the deposit graded or ungraded? (refer to p. 96 of the lab manual for help with these terms).

GRADED

1-1C. Where do you find the coarsest sediment? What is its approximate grain size? (answer in both millimeters, and with the appropriate size term)

Bottom - COARSE SILT

1-1D. Where do you find the finest sediment? What is its approximate grain size?

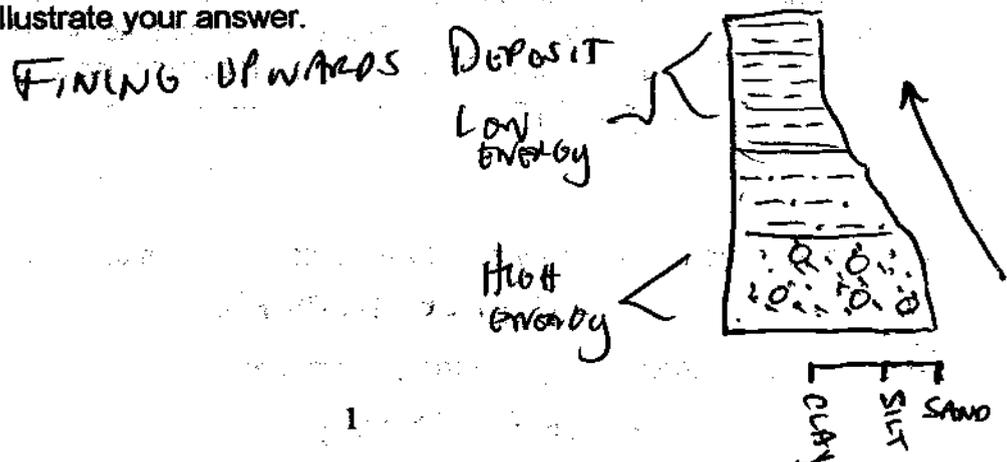
TOP - CLAY

1-1E. What is the implication for grain settling velocity vs. grain diameter? (i.e. which sediment sizes settle faster - or first? and which sizes settle slower - or last?)

LARGER DIAMETER PARTICLES SETTLE FASTER -
CLAY IS LAST TO SETTLE OUT

1-1F. Consider a natural depositional condition in which pebbles, sand, silt and clay are deposited during flood discharge in a broad river valley. What would be a likely arrangement of grain sizes that you might find in such a deposit? (based on your above observations).

Draw a diagram to illustrate your answer.



1-1G. Is the sediment sample in the jar "lithified" or "unconsolidated"?

Station 2 - Cross-Bedding

Examine the freshly broken surface of the red rock sample at Station 2A. Answer the following questions.

1-2A. What is the grain size and rock name of this sample?

FINE-MEDIUM GRAINED SANDSTONE

1-2B. Is this sample well sorted or poorly sorted?

WELL SORTED

1-2C. Is this sample graded or ungraded?

UNGRADED (MASSIVE)

1-2D. Is this sample best described as massive or cross-bedded? (massive is used where cross-bedding is not evident, see p. 96 of your lab manual for diagrams of cross-bedding)

MASSIVE

Examine the sample at Station 2B and answer the following questions.

1-2E. What is the grain size and rock name of this sample?

FINE TO MEDIUM GRAINED QUARTZOSE SANDSTONE

1-2F. Is it well sorted, moderately sorted, or poorly sorted?

WELL SORTED

1-2G. Is this sample massive or cross-bedded?

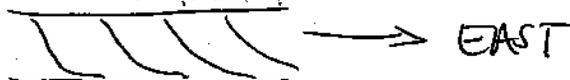
CROSS-BEDDED

1-2H. Using p. 96-97 of your lab manual for comparison, is this sample right-side up, or upside down compared to its original depositional position?

RIGHT SIDE UP

1-2I. Examine the north arrow taped to the top of the sample. Determine the general compass direction of paleocurrent that prevailed at the time of deposition. (north, east, northeast, or???; refer to p. 96-97 for help in your determination).

EAST



Station 3

1-3A. What is the sedimentary structure displayed in this sample?

RIPPLE MARKS

1-3B. Are these structures symmetric or asymmetric?

ASYMMETRIC₂

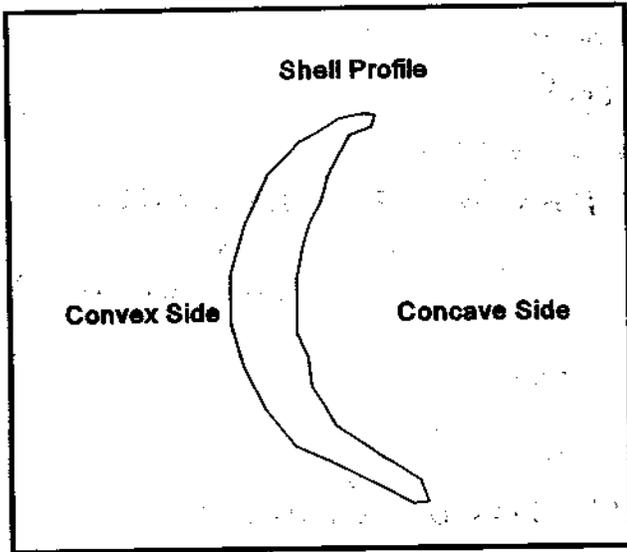
1-3C. Can you determine the paleocurrent direction at the time of deposition? If so, what is it (note north arrow on sample).

WEST

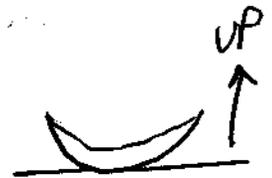


Station 4 - Sedimentary Processes and Determining "Up Orientation"

Drop the loose shells into the tub of water, repeat 10 times and tabulate your results in the table below. Place a check on the appropriate line, determining whether the shells land convex-up, or concave-up.



Trial No.	Convex Up	Concave Up
1	_____	_____/✓
2	_____	_____/✓
3	_____	_____/✓
4	_____	_____/✓
5	_____	_____/✓
6	_____	_____/✓
7	_____	_____/✓
8	_____	_____/✓
9	_____	_____/✓
10	_____	_____/✓



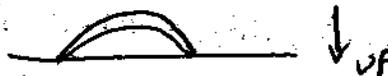
1-4A. What can you deduce about the position of a shell that is deposited on the sea floor, when the animal dies?

LOOKS LIKE IT SHOULD FALL CONCAVE UP!



1-4B. Given your experimental results, do you think the rock sample at this station is currently in a right-side up or upside-down position, relative to it's original depositional environment?

IT LOOKS UPSIDE DOWN



1-4C. The correct answer to 1-4B above is that the rock is currently in a right-side up position. Assuming that this sample was deposited in a shallow-water, near-shore marine environment, suggest a process or processes that might provide an explanation for the discrepancy between your experimental results, and the fact that this sample is in a right-side up position.

WAVE/CURRENT ACTION IN SHALLOW OCEAN
 FLIPS SHELL OVER INTO CONCAVE
 DOWN POSITION — AFTER IT FALLS
 3 CONCAVE UP TO SEA FLOOR

Station 5.

Examine the glass dish of sediment at Station 5A, complete the following observations:

- 1-5A. What is the grain size? **BODY = SILT / CLAY**
TOP = SAND / PEBBLES
- 1-5B. Is this sediment sample well, moderately or poorly sorted?
MODERATELY
- 1-5C. Is this sample graded or ungraded?
- 1-5D. What is the sedimentary structure that is evident on the sediment surface?
UNGRADED
MUD CRACKS
- 1-5E. How did this sedimentary structure form (what are the variables and the process?)?
WETTING + CLAY MINERALS + DRYING = SHRINKAGE
+ MUD CRACKS

Examine the display at Station 5B, answer the following:

- 1-5F. What is the primary sedimentary structure observable on this sample.
LITHIFIED MUD CRACKS
- 1-5G. Which of the following environments of deposition could this rock have formed in? Check all that apply, more than 1 possible. Explain your line of reasoning for each that you check.

Environment	Explanation
<u>NO</u> Deep Ocean Floor	— DOESN'T DRY OUT
<u>NO</u> Submarine Fan	— " " "
<u>YES</u> Tidal Flat	— WET / DRY + MUD
<u>YES</u> River Floodplain	— WET / DRY + MUD DURING FLOOD
<u>YES</u> Shallow Lake	— IF LAKE LEVELS CHANGE: WET / DRY MUD
<u>NO</u> Gravel-dominated mountain stream	— NO MUD HERE

Station 6.

Examine the sample under the protective glass - fragile, do not touch!!!

1-6A. What is the grain size (millimeters and term)? SILTY CLAY (<0.0625 mm)

1-6B. Note the polygonal shape of the sample fragments, what sedimentary process might result in this pattern? PART OF A MUD CRACK POLYGON

1-6C. What are your hypotheses as to the origin of the small circular patterns on the surface of the sample? RAIN DROP IMPRESSIONS

1-6D. Which of the following environments of deposition could this rock have formed in? Check all that apply, more than 1 possible. Explain your line of reasoning for each that you check.

Environment	Explanation
<u>NO</u> Deep Ocean Floor	Submerged
<u>NO</u> Submarine Fan	Submerged
<u>YES</u> Tidal Flat	NEED SUBAERIAL MUD " " "
<u>YES</u> River Floodplain	
<u>NO</u> Shallow Lake	SUBMERGED
<u>NO</u> Gravel-dominated mountain stream	NO MUD

Station 7.

Refer to the catalog of sedimentary structures shown on p. 96-97 of your lab manual.

1-7A. What type of sedimentary structure is associated with this sample?

FLUTE CAST

1-7B. Are these structures molds or casts (a mold is a form, a cast is a 3-D object made from the mold)?

CASTS

1-7C. Is this sample right-side up or upside down relative to its original depositional position? How do you know?

UPSIDE DOWN, CAST IS ON BOTTOM OF BED

1-7D. Using the north arrow, what is the paleocurrent direction represented in this sample.

NORTH WEST 

Station 8.

Note the finely layered interval between points A and B on this sample. Refer to the attached Sedimentology Tool Kit, and answer the following questions.

1-8A. Are these layers best described as bedding or laminations? What is the difference between bedding layers and lamination layers?

LAMINATIONS (THIN LAYERS)

LAMINATION < 1 cm THICK

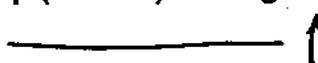
BEDDING > 1 cm THICK

1-8B. Based on your choice above, are these features thin, medium, or thick?

THIN LAMINATIONS (< 3 mm THICK)

Refer to the contact between the light gray and dark gray strata at points A and B. Answer the following:

1-8C. At contact A, is the break in strata sharp (smooth) or irregular (rough)?

SMOOTH 

1-8D. At contact B, is the break in strata sharp (smooth) or irregular (rough)?

IRREGULAR 

1-8E. Based on your observations, and considering the process of erosive scour in a sedimentary environment (erosive scour = high-energy removal of previously deposited sediments), which direction do you think is depositionally right-side up? (i.e. is A toward to top, or is B toward the top?).

I THINK A IS TO THE TOP, AND B IS A SCOUR MARK (WHICH WOULD BE TOWARD THE BOTTOM)

Station 9

Examine the stratal interval between Pt. A and Pt. B on Sample S3-39. Using your Sedimentology Tool Kit, make the following observations:

1-9A. Grain size? **PEBBLES, GRANULES, COARSE SAND**

1-9B. Sorting? **POORLY**

1-9C. Grain Rounding? **ANGULAR - SUBANGULAR**

1-9D. Graded or Ungraded? **GRADED**

1-9E. Referring to p. 96-97 of your lab manual, what sedimentary processes result in your answer to 1-9D above?

DEPOSITION BY TURBULENT, SEDIMENT-LADEN WATER / RAPID DEPOSITION

Station 10.

1-10A. What does the ring structure of this sample remind you of?

TREE RINGS

1-10B. Guess what the name of this sample is?

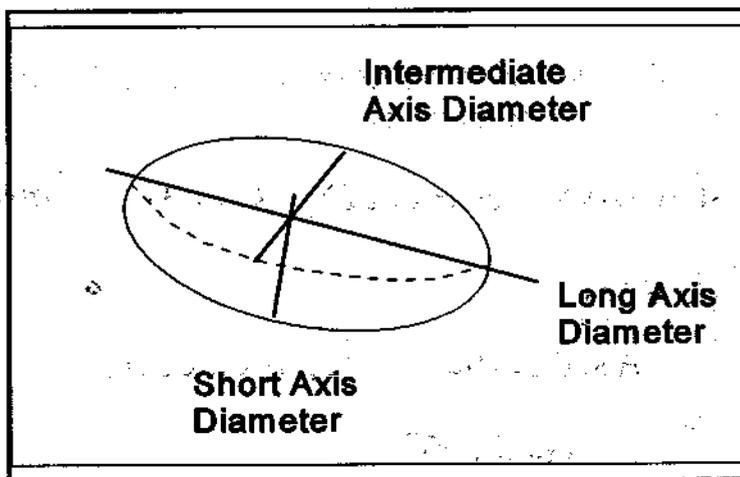
PETRIFIED WOOD

1-10C. What could such a sample in rock outcrop tell you about past climate conditions, relative to ancient Earth history?

NON MARINE DEPOSIT AND THE CLIMATE SUPPORTED TREES (NOT TOO DRY, NOT TOO WET, NOT TOO COLD)

Station 11 - Clast-Shape Measurements

This station consists of 5 black pebbles and 5 light-colored pebbles. Your job is to measure the length of 3 mutually perpendicular axes of diameter, as illustrated below.

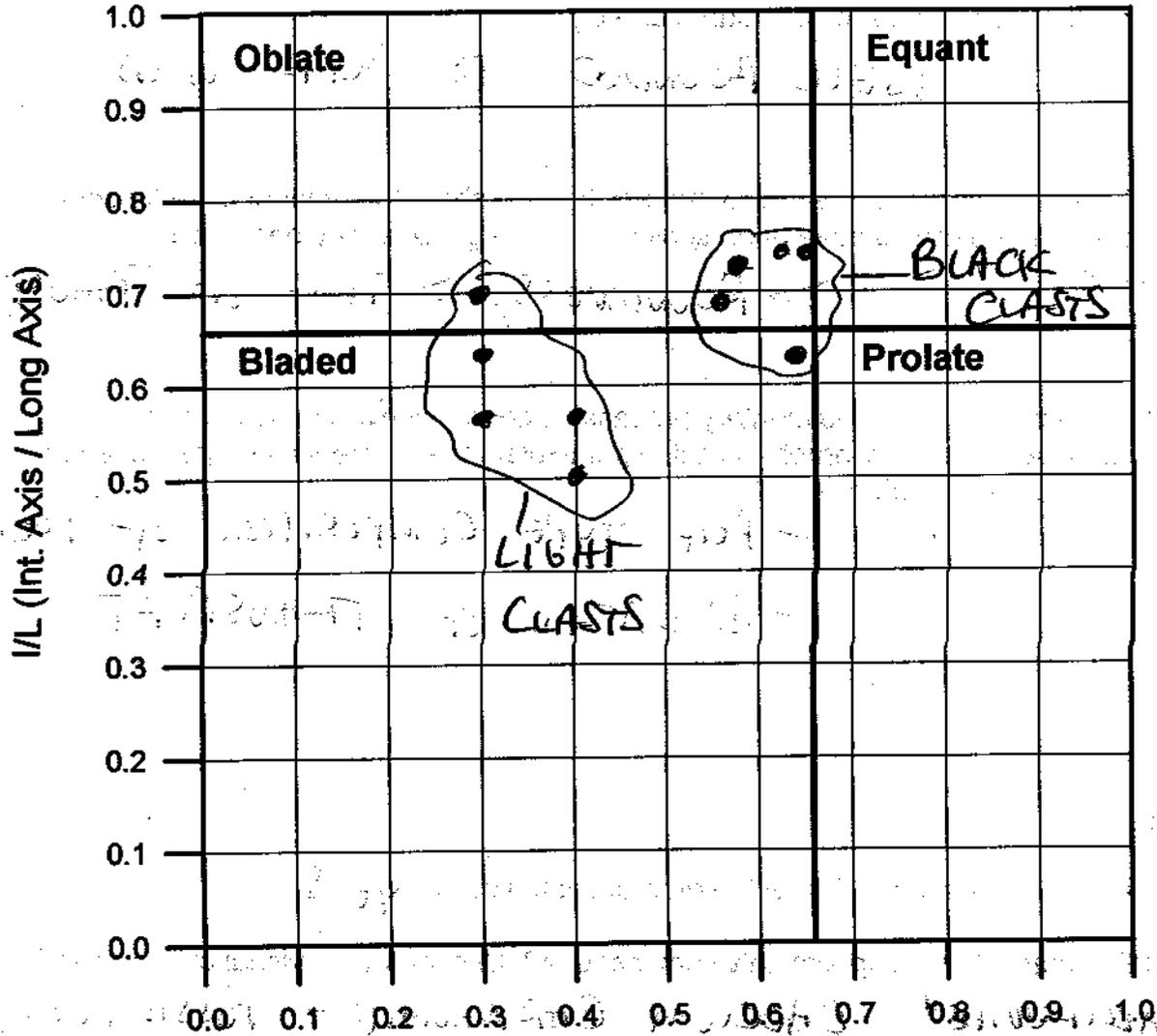


For each pebble, measure the short, intermediate, and long axis diameters in CENTIMETERS. Fill in the table below.

Pebble I.D.	Pebble Color	Short Axis (cm)	Intermed. Axis (cm)	Long Axis (cm)	S/I (divide)	I/L (divide)	Shape Type (from graph)
1	BLACK	1.3	1.6	2.5	0.63	0.64	BLADED
2	↓	1.3	2.0	2.7	0.65	0.74	OBLATE
3	↓	1.2	2.1	2.9	0.57	0.72	"
4	↓	1.0	1.8	2.6	0.56	0.69	"
5	↓	1.0	1.6	2.2	0.63	0.73	"
6	LIGHT	0.8	2.0	3.5	0.40	0.57	BLADED
7	↓	0.6	1.9	2.7	0.30	0.70	OBLATE
8	↓	0.5	1.8	3.2	0.30	0.56	BLADED
9	↓	0.6	1.9	3.0	0.30	0.63	"
10	↓	0.7	1.6	3.5	0.40	0.50	"

Now using the attached graph paper, plot each pebble with the ratio of S/I on the x-axis, and the ratio of I/L on the y-axis. Determine the shape type of the pebble from the graph, and write the type in the last column of the table above.

Grain Shape Plots for Station 12 - G202 Lab 4



S/L (Short Axis / Long Axis)

Questions

1-11A. Do the black and light pebbles plot the same or differently on the graph? How so? - explain the graph patterns that you see.

DIFFERENT -
THE BLACK ARE MORE OBLATE
WHILE THE LIGHT ARE MORE
BLADED

1-11B. What is the general grain roundness of the pebbles (use your sedimentology tool kit to determine angular, subangular, rounded, etc.).

WELL ROUNDED TO SUBROUNDED

1-11C. What does the degree of roundness tell you about the amount of sedimentary transport that the grains have been subjected to? (e.g. have they been transported... how do you know?)

> ROUNDNESS, > TIME OF TRANSPORT

1-11D. Keeping in mind sedimentary processes, construct hypotheses to explain the patterns that you observe on your graph. What might explain the differences in grain shape between the light and black pebbles?

- ROCK-TYPE COMPOSITION OF PEBBLE
- DURATION OF TRANSPORT

Station 12

1-12A. Does this sample fizz with a drop of dilute HCl? YES

1-12B. What is this sample mainly comprised of? Describe your visual observations

"CALCIPUDITE" CALCIUM CARBONATE - FOSSILIFEROUS
LIMESTONE

1-12C. Which of the following environments of deposition could this rock have formed in? Check all that apply, more than 1 possible. Explain your line of reasoning.

Environment

Explanation

Yes? No.?

<input checked="" type="checkbox"/>	Mountain River System	HAS MARINE FOSSILS
<input checked="" type="checkbox"/>	Antarctic Continental Glacier	" " "
<input checked="" type="checkbox"/>	Tropical Rainforest (nonmarine)	" " "
<input checked="" type="checkbox"/>	Shallow, tropical marine environment	" " "
<input checked="" type="checkbox"/>	Reef off the coast of Australia	" " "
<input checked="" type="checkbox"/>	The deepest depths of the ocean (e.g. ~30,000 ft below sea level)	TOO DARK, DEEP, & COLD TO SUPPORT THIS TYPE OF ANIMALS

Station 13.

Use your Sedimentology Tool Kit and lab manual to answer the following:

1-13A. What is the name of this sedimentary rock?

CHERT BRECCIA

1-13B. Grain roundness of the gravel clasts?

ANGULAR TO SUBANGULAR, SOME ROUNDED

1-13C. What is the sorting of this sample?

POORLY

1-13D. Is this sample graded or ungraded?

UNGRADED

1-13E. Do you think that this rock represents a wind-blown sedimentary deposit? Explain your answer, why or why not.

NOT WIND BLOWN — SEDIMENT IS TOO COARSE (GRAVEL-SIZED), WIND CAN ONLY TRANSPORT SILT TO SAND-SIZED PARTICLES (NOT ENOUGH ENERGY)

Station 14.

Use your lab book and tool kit to answer the following. You know what to do...

1-14A. What is the name of the primary sedimentary structure displayed in this sample?

SYMMETRICAL RIPPLES

1-14B. Are these features symmetrical or asymmetrical?

1-14C. Can you determine a paleocurrent direction in this sample? If so, use the north arrow and determine.

No — They are symmetrical

1-14D. What type of sedimentary environment does this type of structure form in?

WAVE — DOMINATED —
WAVE OSCILLATIONS

Part 2 - Introduction to Sedimentary Facies and Stratigraphy

Sedimentary facies refer to the physical, chemical and biological aspects of sedimentary rock. The type of sedimentary facies is related back to the depositional environment that led to the formation of the rock. For example, peat and coal start out as accumulations of plant matter (trees / grasses) in terrestrial bogs or swamps. We can observe this relationship directly in modern day environments. So the implication is, if one identifies coal in the rock record, then it indicates deposition in an ancient terrestrial swamp.

Stratigraphy involves the study of rock sequences both spatially and temporally (with respect to Earth history / time). Stratigraphy is a fundamental area of study in geology as it is the foundation upon which Earth history is derived. For example, stratigraphic observations of changes in fossilized animal remains in the rock record provides a critical evidence that supports Darwin's concept of evolution through time.

Stratigraphic analysis involves the study of rock sequences with respect to their spatial and temporal distribution. Since sediments are commonly deposited under the influence of gravity in a fluid medium, sedimentary rocks are commonly layered and stacked in **stratigraphic sequences**. Analysis of sedimentary facies and stratigraphic position permits the reconstruction of ancient sedimentary environments through geologic time.

Stratigraphy Exercise

The bookshelf at the front of the lab contains a stratigraphic sequence of sedimentary rock layers. The rock units are numbered from 1 to 11 and the thickness is listed on the note card (e.g. t = 30 m ... reads as "this bed is 30 m thick"). Your job is to construct a stratigraphic column of the "rock outcrop", and make interpretations of sedimentary environments and changes through time. Since the "outcrop" is spatially limited to one locality, you will be asked to analyze the changes that occurred at this site through time.

Step 1 - Starting at the bottom of the stratigraphic sequence, fill in the chart below.

Rock Unit Name	Rock Type (i.d. using your lab manual)	Thickness (meters)	Environment of Deposition (choose from list below).	List Key Evidence Used to Interpret Env. of Deposition
Unit 11	SHALE	30m	DEEP OCEAN	QUIET-WATER MUD
Unit 10	MICRITE	12m	OFFSHORE MARINE	FINE, QUIET WATER MUD
Unit 9	CALCIRUDITE (Fossiliferous LS)	15m	SHALLOW MARINE SHELF	FOSSILS / MARINE
Unit 8	COQUINA	2m	BEACH	SHELL FRAGMENTS
Unit 7	ROCK SALT	0.5m	EVAPORATING BAY	EVAPORITES
Unit 6	FINE-GRAINED SS	8m	TIDAL FLAT	MUD CRACK CASTS (FILLS DUE TO CaCO ₃ cement)
Unit 5	COAL	2m	SWAMP / TERRESTRIAL	BLACK PLANT DEBRIS
Unit 4	MUDSTONE	5m	NON MARINE FLOODPLAIN	PLANT FOSSILS
Unit 3	QUARTZOSE SS MEDIUM-GRAINED	10m	RIVER CHANNEL	NO FOSSILS / XBD
Unit 2	CONGLOMERATE	4m	NON MARINE RIVER CHANNEL	ROUNDED GRAVEL
Unit 1	VESICULAR BASALT	20m	NON MARINE VOLCANIC	BASALT + VESICLES

Key to Use in Identifying Environments of Deposition (Use in Combination with p. 98 in Lab Manual)

Environment (in no particular order)	Key Evidence
Nonmarine (terrestrial / land-derived)	Plant Fossils, Lack of Marine Fossils
Nonmarine / volcanic	Volcanic Rock
Swamp (warm, wet environment)	Coal
Evaporating Lake or Bay (warm, dry env.)	Evaporite Deposits (e.g. rock salt / gypsum)
River Channel Deposit	Cross-bedded sandstone, no marine fossils
River Channel Gravel	Conglomerate / Rounded Gravel, no marine fossils
Tidal Flat (wetting / drying)	Mudcracks, Fine-Grained Sediments
Deep Ocean	Shale (clay, no plant fossils)
River Floodplain	Fine mudstone (plant fossils)
Beach Deposit	Coquina (shell deposits)
Shallow Marine Shelf (warm ocean water)	Fossiliferous Limestone ("calcirudite")
Offshore Marine / Intermediate Water Depth (warm)	Micrite / Microcrystalline Limestone

NOTE: THIS ROCK RECORD DOCUMENTS SEA LEVEL RISE AND ¹³ FLOODING OF THIS LOCATION IN THE EARTH'S PAST!!

Questions.

2-1. What is the oldest rock unit in the stratigraphic sequence? What is the youngest rock unit?

UNIT 1 = OLDEST, UNIT 11 = YOUNGEST

2-2. Given that Unit 1 has been dated as being 60 million years old, and Unit 11 is 55 million years old. What was the sedimentation rate for this particular stratigraphic sequence (Sed. Rate = thickness of accumulation / time of accumulation). Give your answer in meters per year.

TOTAL THICKNESS = 108.5m
(UNIT 1-11)

RATE = $108.5m / 5,000,000 \text{ yr} = 2.17 \times 10^{-5} \text{ m/yr} = 21.7 \text{ m/My.}$

TOTAL TIME = 60m.y. - 55m.y. = 5m.y.

2-3. Comment on the climate change that had taken place between the time of deposition of Unit 5 and Unit 7. Give your answer in terms of relative temperature and precipitation (e.g. wetter and colder, etc.)

UNIT 5 = COAL = WARM, WET (SWAMP)

UNIT 7 = EVAPORITE = WARM, DRY (EVAPORATION)

THE CLIMATE BECAME DRIER BETWEEN TIME 5 & 7

2-4. By examining unit 4, do you think that this rock was deposited in a tundra environment that was frozen year round? Why or why not.

NO — IT HAS TEMPERATE,
DECIDUOUS LEAF
FOSSILS

2-5. Based on your stratigraphic analysis, what happened to relative sea level from the time of Unit 2 through that of Unit 11? (i.e. what happened to this area during the geologic time interval covered by the stratigraphic section?).

SEA LEVEL ROSE, (INCREASED)
↓
IT FLOODED!!

2-6. Hypothesize mechanisms that could result in the sea level relationships that you discussed in question 2-5 above.

- TECTONIC SINKING (LOWERING OF LAND)
- SEA LEVEL RISE (MELTING OF ICE CAPS??)



Current (Asymmetric) Ripples



Clast Shape Analysis



Stratigraphic Column

Current (Symmetric) Ripples (Wave Oscillation)

