Teacher Background Info - Station 6: Historical Distribution and Using Fossils to Age Sediment Layers

Tiny ocean creatures called foraminfera (forams, for short) can tell a multitude of stories about the ocean bottom – changes going on in the ocean affect foram groupings and distribution. Benthic ocean sediments contain remnants of once living organisms (in this case the test, or calcium carbonate shell, of a protist in the foraminfera group), and because foram species segregate themselves in regards to water depth, latitude, and water temperature, and because they contain chemical signatures that can indicate glacial and interglacial periods, forams are often used by geologists as a climatic indicator species (DeMarco, 2009; Wetmore, 2017). Scientists can also tell the age of sediments, reconstruct past climate, determine the feasibility of drilling for oil, and take a pretty good guess as to what ancient habitats were like in terms of food availability, salinity, water depth, water temperature, and so forth by looking at what fossil foram species are present in a given sediment layer.

Fossil assemblages are used to assign relative ages to the terrestrial rock strata in which they are found; similarly, forams also can indicate geologic time in oceanic environments. In addition, the presence of a species at a particular time or layer can indicate historical range of the species. Just like we know that Gray Wolves once roamed most of North America (from eyewitness accounts, eradication program data, and animal remains) we can figure out the historical distribution of a species based on fossil evidence. For the sampling techniques station 5 we will look at foram species present in three geologic layers to assess the age of the layer, and the species' historical distribution. Information is included to extend this to look at climate as well.

This hands-on exercise may sound familiar at first, and you have probably seen students "mining" cookies in lessons on economics or resource extraction, or you may have done cupcake geology where students investigate layers, or strata, of a cupcake Earth. I have put these geology exercises in the framework of a real-life situation, with real organisms that existed on Earth in the past, and I've used color-coded images instead of cookies to keep this station at about 30 minutes of analysis.

Using the data sheet on foram species, ask students: What is different about the layers? Which one was laid down first? Which one is newest? How can you tell? When students struggle, I ask them to look at the geologic time scale (Table 4) and consider: if you have a foram that lived from ancient times up to more modern times, over a wide range, will it be easy to use it to identify the age of the sediment sample? Why or why not? What if you had a foram that is only found in a narrow time range, say, only in the early Cenozoic (65 – 33 mya) – would you then be able to narrow down the age of the sediment sample in which that foram species was found? Could that foram species be used as an indicator of a geologic time frame? And, just because a foram could have been alive and present in a geological time period, does that mean you will necessarily find fossil evidence of it?

This may help also: using colored pencils, you can have the students overlay the colors of forams (which are color coded by species on the data sheet) that could possibly be present over the timeline – so, if you have a foram that is only found in a time corresponding to layer 1, then that sample must be from that time period (Figure 10). A foram that could be found in both layers 1 and 2 could help you exclude layer 3, but you need more information to narrow it down to one layer. *Tawitawia*, for example, in only found in the Holocene, and so a layer that has *Tawitawia* present must be the top layer, and you will find a couple of foram species that are thus good indicators, because they are present in only one of the layers.

Layer	Era	Period	Epoch
top layer	Cenozoic	Quaternary	Holocene
middle layer			Pleistocene
		Neogene	Pliocene
			Miocene
		Paleogene	Oligocene
Bottom layer			Eocene
			Paleocene
	Mesozoic	Cretaceous	
		Jurassic	
		Triassic	
	Paleozoic	Permean	

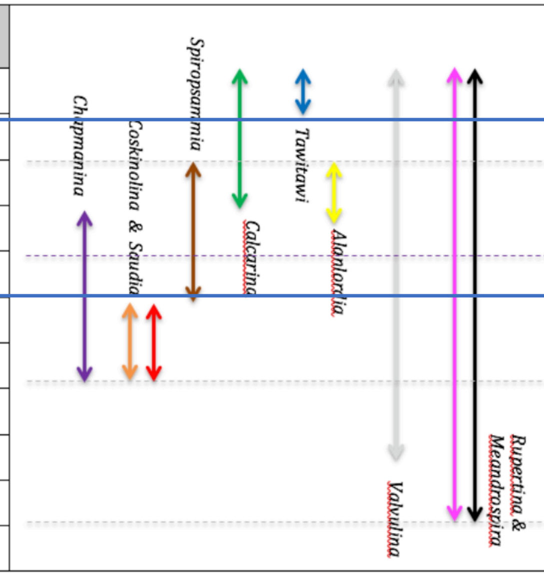
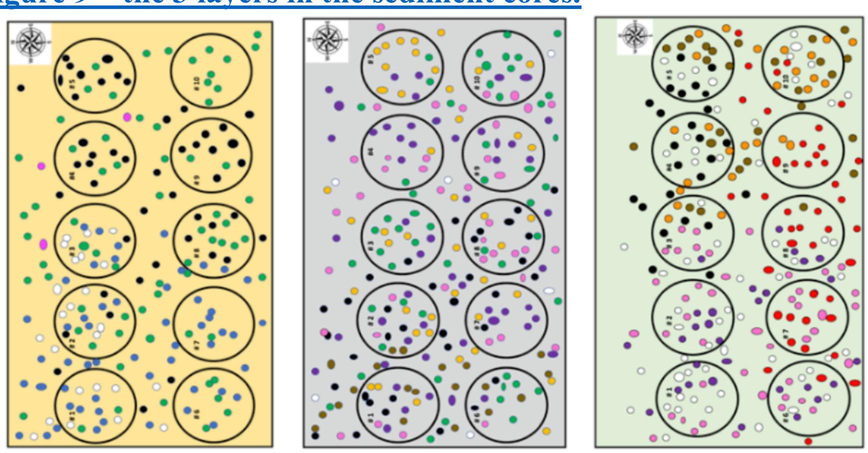


Figure 10 Using colored pencils to figure out time ranges.

At the station, each student in a group is assigned a core. The core divides into 3 layers, distinguished by sediment color (Figure 9). Students are asked to determine which layer is the oldest. Tell them: You have three sediment layers from 10 deep ocean cores – but the layers got mixed up in transit back to the lab. Put them in chronological order, then defend your claim by explaining the evidence you found that caused you to arrange the layers as you did. While 'dissecting' these layers they should note what species, and how many of each, they find. From this they can try to figure out the age of each layer and thus the order the layers belong in. Students will use group data to defend their claims about which oceanic sediment layer is the oldest and youngest (Table 5). Follow up by linking this station with station two to discuss species richness and biodiversity, which, given time, could also be calculated for each layer.

Figure 9 – the 3 layers in the sediment cores.



A representation of the deep ocean sediment cores. Each box represents a different layer, and colored dots represent foraminfera species. The black circles represent cores #1-10. Students use provided information about forams to determine which layer is the oldest, or bottom layer and which is the top, or youngest, layer.

Students will add their data to the class data, which helps them to understand why sample size is important: information from one core is often not enough to get the big picture. One core may show only 1-2 species present in a layer, where the class average of all cores gives a different picture. Students who successfully complete this station need to 1. Find those species that can indicate the age of a layer, 2. Identify which layer contains those indicator species, 3. Assign a time period to the layers, 4. Arrange the layers in chronological order, and 5. Discuss the geographical range (N, S, W, E Atlantic) of the foram species. Students then can discuss how the geographical ranges of species change with time, and what factors (often climatic) might cause that distribution change.

Era	**Period**	**Epoch**	**Time Frame (millions of years ago (ma))**	**Climate**
Cenozoic	Quaternary	Holocene	8,000 years ago - present	Interglacial (little ice age 1300 AD)
		Pleistocene	1.8 ma – 8,000 years ago	Ice age
	Neogene	Pliocene	5.3-1.8 ma	Warm, with ice age 2.5 ma
		Miocene	23.8-5.3 ma	Warm
	Paleogene	Oligocene	33.7-23.8 ma	Warm
		Eocene	55.5-33.7 ma	Warm / Cooling around 49 ma / Warm
		Paleocene	65-55.5 ma	Tropical
Mesozoic	Cretaceous		154-65 ma	Warm
	Jurassic		213-145 ma	Warm, Humid
	Triassic		248-213 ma	Warm, Dry
Paleozoic	Permean		286-248 ma	Glacial beginning, Warming towards end
	Carboniferous		360-286 ma	Shifting glacial→interglacial
	Devonian		410-360 ma	Warm

Table 4 – Geologic Ages on Earth from http://scienceviews.com/dinosaurs/geologictime.html

My Claim	**Foram species present (% of sample) e.g. *Foram One* (18%)**	**Age Range of Layer**	**Geological Era / Period**
Youngest Layer = **Top / YELLOW**	Rupertina (black) 27% Valvulina (white) 14% Tawitawia (blue) 25% Calcarina (green) 34%	8000 ya (1 ma?) – present	• Cenozoic / Holocene (maybe late Pleistocene)
Middle Layer = **Middle / GRAY**	Chapmania (purple) 24% Meandrospira (pink) 15% Rupertina (black) 12% Calcarina (green) 24% Spiropsammia (brown) 5% Alanlordia (yellow) 20%	33 ma – 1.8 ma	• Cenozoic / Oligocene, Miocene, Pliocene
Oldest Layer = **Bottom / GREEN**	Chapmania (purple) 12% Meandrospira (pink) 17% Rupertina (black) 10% Saudia(red) 15% Valvulina (white) 24% Spiropsammia (brown) 10% Coskinolina (orange) 12%	286 ma – 33 ma	• Cenozoic / Paleocene and Eocene, and • Mesozoic / Permean, Triassic, Jurassic, Cretaceous

Table 5. Students compile class data to determine which layer was the top, or youngest layer and which was the bottom, or oldest layer. Students use evidence (foram species found) to defend their claim.

Student Handout **Station 6: Historical Distribution and Using Fossils to Age Sediment Layers**

The ocean bottom has layers, like geologic rock layers on land, but the ocean layers are not as old as the rock strata (or, layers) in terrestrial environments. They also aren't rock, but are composed of sand, silt, and the calcium and/or silica-based remains of planktonic organisms; these layers are called "**oozes**". Just like fossil assemblages are used to assign relative ages to the terrestrial rock strata in which they are found, the test, or calcium carbonate shell, of protists in the **foraminfera** group also can indicate geologic time in oceanic sediments. In addition, the presence of a species at a particular time, place, or layer can indicate historical range of the species. Because foram species segregate themselves in regards to water depth, latitude, and water temperature, and because they contain chemical signatures that can indicate glacial and interglacial periods, forams are often used by geologists as a climatic **indicator species**. Basically, forams can tell a multitude of stories about the ocean bottom because changes going on in the ocean affect foram groupings and distribution.

At this station you will look at three ocean bottom (benthic) cores. Scientists obtain benthic cores with a special corer drill tool, and the cores, when pulled out, are layered – one core on top of another – so that the top layer is the youngest and the bottom layer is the oldest. But, somehow in the transport of the core back to the lab, the layers got mixed up! Your job is to use knowledge of foram species and past climates to figure out which core is the top, middle, and bottom layer, and to age the cores. You will also look at foram species distribution and range for each of the layers.

Procedure:

1. Each student in the group gets one core (divided into the three color-coded layers). Look at the three layers in your core. What is different about them? How could you tell which is the oldest layer, or which layer was laid down the most recently (what information do you need to know)?

2. Look at which eras, periods, and epochs the various foram species lived in (Data Table 1). Then, using colored pencils, draw arrows on the chart that indicates presence of each foram species versus era/period/epoch (Data Table 2). The foram *Meandrospira* was drawn in for you, in pink, as an example.

3. Next, fill in Data Table 2, using information from **Table 3 – Geologic Ages on Earth** (**http://scienceviews.com/dinosaurs/geologictime.html**)

4. If you have a foram that lived from ancient times up to more modern times, a wide range, will it be easy to use it to identify the age of the sediment sample? Why or why not? What type of foram would you look for to indicate the age of a layer?

   Identify good indicator species for the Quartenary period:
   Identify good indicator species for the Neogene and Upper Paleogene periods:
   Identify good indicator species for the Lower Paleogene and Cretaceous periods:

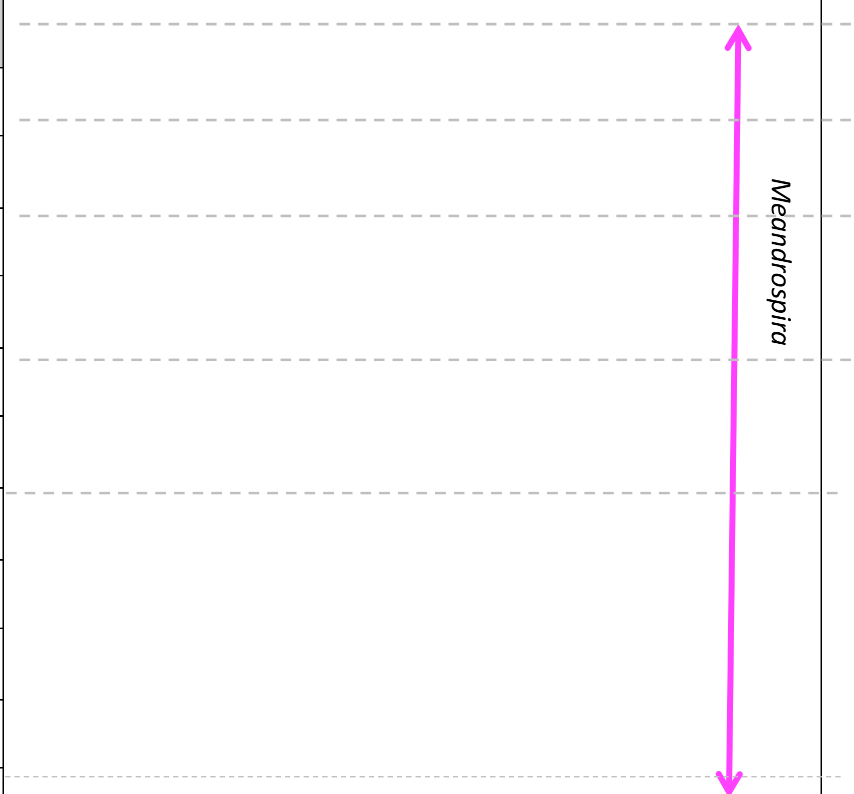
5. Draw two horizontal lines on Data Table 1 to indicate where you think the division between layers 1 and 2, and layers 2 and 3, are.

   What species are present in each core / layer? When were those species found on Earth? Use this information to make a conclusion as to the order of the 3 layers – which is the youngest (top) layer and which is the oldest (bottom) layer? Defend your group's conclusion to your classmates, who may have had different cores (and thus different information).

6. Count the number of species, or species richness (each species is a different color) and count the number of individuals for each species (if we had time we could then calculate species diversity for each layer, as you will learn how to do in station 2). Then, use your completed Data Table 2 to assemble individual and group data (Data Table 3 and 4).

Data Table 1: Use colored pencils to determine foraminferan overlap in geologic time. For each species found, draw a line representing in which time period(s) and epoch(s) it is present. A visual such as this can help you to figure out the relative age range in which your layer was deposited.

Era	**Period**	**Epoch**	
Cenozoic	Quaternary	Holocene	
		Pleistocene	
	Neogene	Pliocene	
		Miocene	
	Paleogene	Oligocene	
		Eocene	
		Paleocene	
Mesozoic	Cretaceous		
	Jurassic		
	Triassic		
Paleozoic	Permean		
	Carboniferous		
	Devonian		



Data Table 2: Fill in the chart for Time (ma) and Climate for each foram species using **Table 3 – Geologic Ages on Earth** from **http://scienceviews.com/dinosaurs/geologictime.html**

Color	Foraminifera Species (abbrev)	Era	Period	Time (millions of years ago, ma)	Climate
Blue	*Tawitawia (T)*	Cenozoic	Holocene		
Black	*Rupertina (R)*	Mesozoic→ Cenozoic	Cretaceous → Holocene		
Purple	*Chapmanina (CH)*	Cenozoic	Paleocene → Miocene		
Orange	*Coskinolina (CO)*	Cenozoic	Paleocene → Eocene		
Red	*Saudia (SA)*	Cenozoic	Paleocene → Eocene		
Yellow	*Alanlordia (AL)*	Cenozoic	Miocene→Pliocene		
Brown	*Spiropsammia (SP)*	Cenozoic	Oligocene → Pliocene		
White	*Valvulina (V)*	Mesozoic→ Cenozoic	Jurassic→Holocene		
Pink	*Meandrospira (ME)*	Paleozoic→ Cenozoic	Permean→Holocene		
Green	*Calcarina (CU)*	Cenozoic	Pliocene→Holocene		

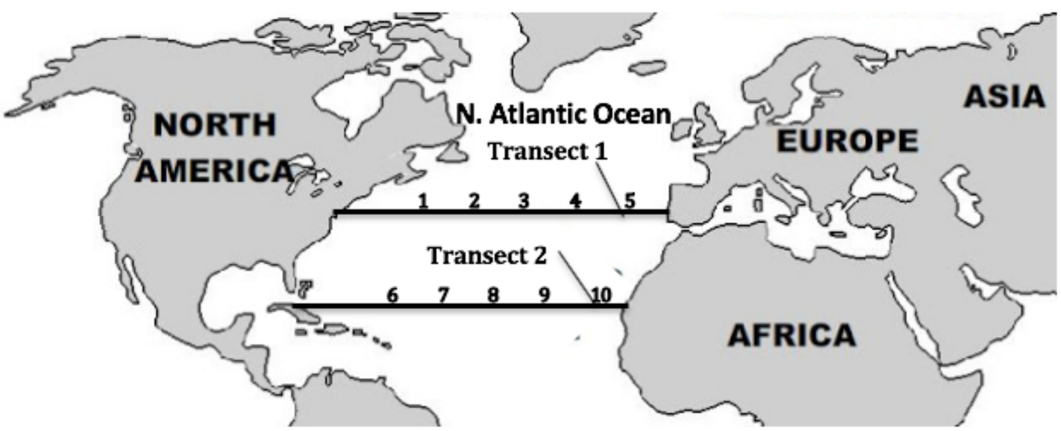


Figure 1. A map showing the Atlantic Ocean and the locations where the deep ocean cores were taken. Cores were taken along two transects with transect two in more tropical waters, and cores 1, 2, 6, and 7 in the Western North Atlantic and cores 4, 5, 9 and 10 in the Eastern North Atlantic.

Data Table 3 -
Individual data: Group # __________________ Name ______________________________

Cores 1, 2 = Northwestern N. Atlantic
Cores 6, 7 = Southwestern equatorial N. Atlantic
Cores 3 = North Central N. Atlantic
Cores 8 = Equatorial Central N. Atlantic
Cores 4, 5 = Northeastern N. Atlantic
Cores 9, 10 = Southeastern equatorial N. Atlantic

Core # ________________________

Geographical Location: ______________________

Species Present (Genus Name)	Color	# of individuals
Green Layer		
1.		
2.		
3.		
4.		
5.		
6.		
7.		
Yellow Layer		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
Gray Layer		
15.		
16.		
17.		
18.		
19.		
20.		
21.		

Circle, or Highlight, any Indicator Species (species found only in some times, but not others).

Data Table 4: Group / Class data: combine the numbers from each person (each core) in the group.

Layer	# Foram Species present	Foram Species / Color	Number of individ. of each species	% of sample (# individ. of species 'X'/ total # individuals)	Time (Era / Period)	Geographical Presence (in the North Atlantic):
Green						
		total				
Yellow						
		total				
Gray						
		total				
Total						

Reflection:

1. What is Your Claim – Which layer is the youngest (top)? Oldest (bottom)? How did you determine this?

	Foram species present (% of sample) e.g. ***Foram One* (18%)**	**Age Range of Layer**	**Geological Era / Period(s) of Layer based on forams present**
Youngest Layer =			
Middle Layer =			
Oldest Layer =			

Table 5. Compile class data to determine which layer was the top, or youngest layer and which was the bottom, or oldest layer. Use evidence (foram species found) to defend your claim.

2. Are there any forams who expanded their range from ancient to more modern times?

3. Any that restricted their range?

4. What are some reasons that an organism's range might expand or restrict?

5. Are there any foram species found predominantly in warm climates? Cool climates?

6. What was the species richness for each layer?

7. Are there any forams that you did not identify as being present (that were on the master diagram, but not included in any cores your group selected)?

8. What is an inherent issue with using a small subsample (the cores) to represent the whole area?

9. How is taking cores similar to sampling quadrats (as in Station 2)?

Teacher Notes:

Here is a two-minute video that can help students to understand what the scientists can learn from drilling: http://www.youtube.com/watch?v=n98nJ6GRLaQ

JR Core Journey from Rig Floor to Core Receiving Deck to Core Lab
http://www.youtube.com/watch?v=wC9lDPvvze0&feature=related

Answers to Reflection questions:

1. What is Your Claim – Which layer is the youngest (top)? Oldest (bottom)? How did you determine this?

   The yellow layer is the top, the gray is middle, and the green is the bottom:
   The top layer is around 8000 years ago till present (climate cool with little ice age 1300 AD)
   The middle layer is about 23 ma – 1.8 ma (climate warm, ending with an ice age about 2.5 ma)
   The bottom layer is 213 – 33 ma (climate warm moving towards tropical hot)

   I determined this by looking for indicator foram species – species that were restricted in time to a certain layer. If they were present in the layer then the layer had to be from that time. - so, if blue was present then it had to be the top, youngest layer. If red or orange was present it had to be the bottom or oldest layer and if yellow was present it had to be the middle layer.

   Absence of a species is harder to use as an indicator – your sample may just not have picked it up (esp if it was rare or uncommon). If green was absent it was probably the top or middle layer, and if brown, pink, or purple were absent it was probably the bottom or middle layer.

2. Are there any forams who expanded their range from ancient to more modern times?

   Pink and Purple expanded from bottom to the middle layer (expanded from just western to entire N. Atlantic) but both were absent in top layer. The black expanded from east to west to entire basin

3. Any that restricted their range?

   White was found everywhere in the bottom layer, absent in the middle, and restricted to the north west N. Atlantic in the youngest layer. This indicates it doesn't like colder climates.

4. What are some reasons that an organism's range might expand or restrict?

   Some organisms are adapted to warmer or cooler waters physiologically, or perhaps because their food source (forams have symbiotic algae inside them) was restricted by climate, or maybe their predators were more abundant (or less abundant) in certain climates.

5. Are there any foram species found predominantly in warm climates? Cool climates?

Blue was only found in the top, youngest, cooler layer. Red and orange were only found in the bottom hot layer. Black and white could be found in cold and warm - hot climates.

6. What was the species richness for each layer?

The top / youngest layer had a species richness of 4 species, the middle layer had 6 species, and the bottom layer had 7 species.

7. Are there any forams that you did not identify as being present (that were on the master diagram, but not included in any cores your group selected)?

Layer 1 / top layer had some of the pink species (Meandrospira) even though no pink forams were in any of the cores. And – the white species (Valvulina) – which were present in layer 2 but not present in any cores.

8. What is an inherent issue with using a small subsample (the cores) to represent the whole area?

You might miss a species – as in layer 1 / top layer which probably included the pink species (Meandrospira) even though no pink forams were in any of the cores. And – the white species (Valvulina) – which were probably present in layer 2 but not present in any cores.

9. How is taking cores similar to sampling quadrats (as in Station 2)?

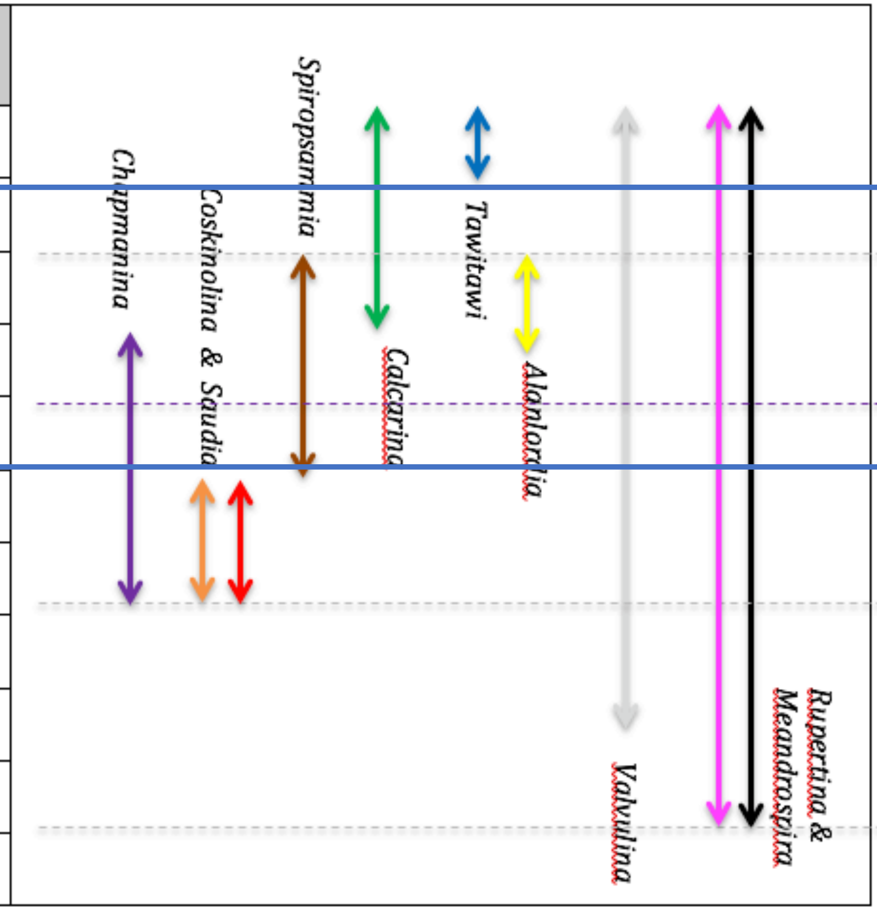
Defining quadrats to sample a larger area is the same thing – we just used circular cores instead of square quadrats because the drill used to take the core was circular – but the idea is the same – take a smaller sample to represent the whole.

top layer

middle layer

Bottom layer

Era	Period	Epoch
Cenozoic	Quaternary	Holocene
		Pleistocene
	Neogene	Pliocene
		Miocene
	Paleogene	Oligocene
		Eocene
		Paleocene
Mesozoic	Cretaceous	
	Jurassic	
	Triassic	
Paleozoic	Permean	

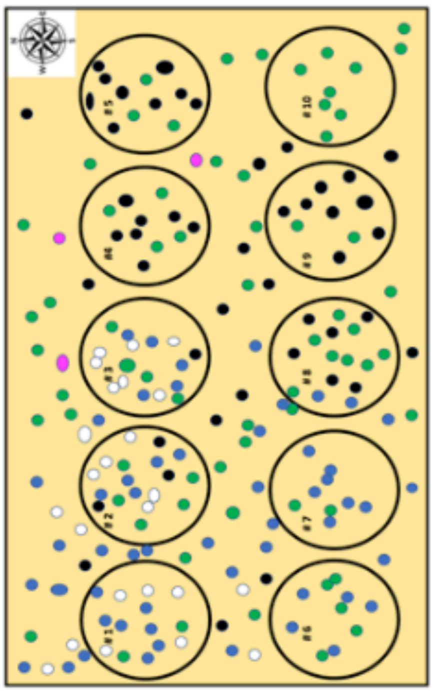


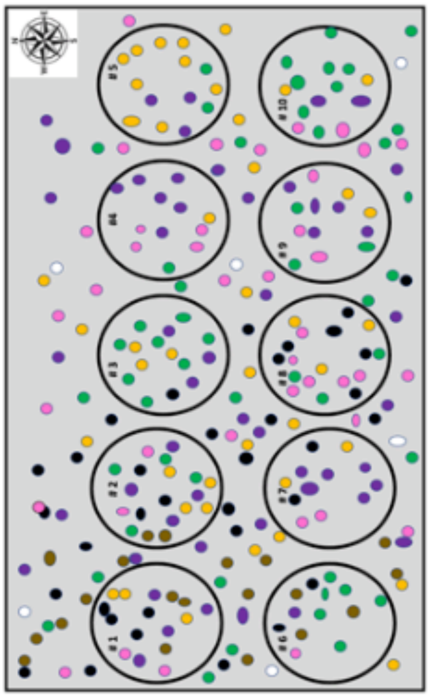
Bead Color	Foraminifera Species (abbrev)	Era	Period	Layers present in	Time (millions of years ago, ma)	Climate
Blue	*Tawitawia (T)*	Cenozoic	Holocene	1 (top)	8,000 yrs ago –pres.	Cool
Black	*Rupertina (R)*	Mesozoic→Cenozoic	Cretaceous → Holocene	1, 2, 3 (all)	155 ma - present	Hot→Warm→Cold
Purple	*Chapmanina (CH)*	Cenozoic	Paleocene → Miocene	2, 3	65 - 5 ma	Hot→ Warm
Orange	*Coskinolina (CO)*	Cenozoic	Paleocene → Eocene	3 (bottom)	65 - 33 ma	Hot → Warm
Red	*Saudia (SA)*	Cenozoic	Paleocene → Eocene	3	65 - 33 ma	Hot → Warm
Yellow	*Alanlordia (AL)*	Cenozoic	Miocene→Pliocene	2 (middle)	20 - 5 ma	Cool
Brown	*Spiropsammia (SP)*	Cenozoic	Oligocene → Pliocene	2, 3	33 - 1.8 ma	Warm → Cool
White	*Valvulina (V)*	Mesozoic→Cenozoic	Jurassic→Holocene	1, 3 (prob. 2 also, not in our sample)	200 ma - present	Warm → Cool
Pink	*Meandrospira (ME)*	Paleozoic→Cenozoic	Permean→Holocene	2, 3 (prob 1 also, not in our sample)	290 ma - present	Cold → Warm → Cool
Green	*Calcarina (CU)*	Cenozoic	Pliocene→Holocene	1, 2	5 ma - present	Warm → Cool

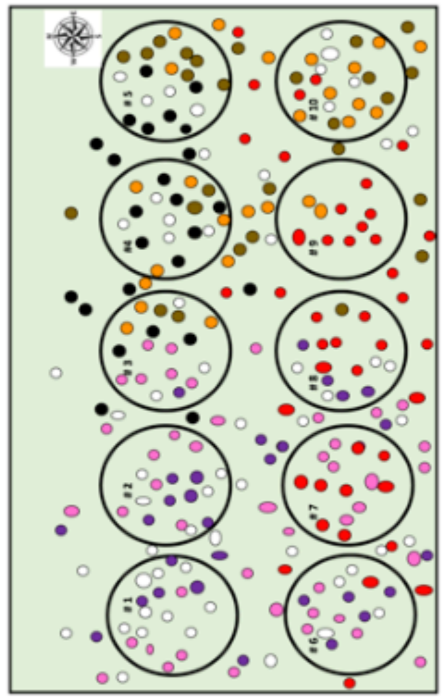
Data Table 5: <u>Group / Class</u> data: combine the numbers from each person (each core) in the group.

Layer	# Foram Species present	Foram Species / Color	Number of individ. of each species in all 10 cores	% of sample (# individ. of species 'X'/ total # individuals)	Time (Era : Period)	Time (millions of years ago, ma)	Layers Present in	Climate	Geographical Presence (in the North Atlantic):
Green **(Layer 3 = BOTTOM)** **Climate = Warm/Hot**	**7**	*Chapmanina* - purple	20	12 %	Cenozoic : Paleocene → Miocene	65 - 5 ma	2,3	Hot→ Warm	Western N. Atlantic (southwest and northwest)
		Meandrospira - pink	28	17 %	Paleozoic→Cenozoic: Permean→Holocene	290 ma - present	2,3 (prob.1 too)	Cold → Warm → Cool	Western N. Atlantic (southwest and northwest)
		Rupertina – black	16	10 %	Mesozoic→Cenozoic: Cretaceous → Holocene	155 ma - present	1,2,3	Hot→Warm→Cold	Northeastern N. Atlantic
		Saudia - red	25	15 %	Cenozoic: Paleocene → Eocene	65 - 33 ma	3	Hot → Warm	Southern equatorial N. Atlantic (west and east)
		Valvulina – white	39	24 %	Mesozoic→Cenozoic: Jurassic→Holocene	200 ma - present	1,3 (prob 2 too)	Warm → Cool	Entire N. Atlantic
		Spiropsammia - brown	17	10 %	Cenozoic: Oligocene → Pliocene	33 - 1.8 ma	2,3	Warm → Cool	Eastern N. Atlantic (north and equatorial)
		Coskinolina – orange	19	12%	Cenozoic: Paleocene → Eocene	65 - 33 ma	3	Hot → Warm	Eastern N. Atlantic (north and equatorial)
	total		**164**	100 %					
Yellow **(Layer 1 = TOP)** **Climate = Cool**	**4**	*Rupertina* – black	34	27 %	Mesozoic→Cenozoic: Cretaceous → Holocene	155 ma - present	1,2,3	Hot→Warm→Cold	entire N. Atlantic
		Valvulina – white	17	14 %	Mesozoic→Cenozoic: Jurassic→Holocene	200 ma - present	1,3 (prob 2 too)	Warm → Cool	Northwestern N. Atlantic
		Tawitawia - blue	31	25 %	Cenozoic: Holocene	8,000 yrs ago –pres.	1	Cool	Western N. Atlantic (north and equatorial)
		Calcarina - green	42	34 %	Cenozoic: Pliocene→Holocene	5 ma - present	1,2	Warm → Cool	Entire N. Atlantic
	total		**124**	100 %					

Gray **(Layer 2 = MIDDLE)** **Climate = Warm**	**6**	*Chapmanina* - purple	34	24 %	Cenozoic: Paleocene → Miocene	65 - 5 ma	2,3	Hot→ Warm	Entire N. Atlantic
		Meandrospira - pink	22	15 %	Paleozoic→Cenozoic: Permean→Holocene	290 ma - present	2,3 (prob 1 too)	Cold → Warm → Cool	Entire N. Atlantic
		Alanlordia - yellow	28	20 %	Cenozoic: Miocene→Pliocene	20 - 5 ma	2	Cool	Entire N. Atlantic
		Calcarina - green	35	24 %	Cenozoic: Pliocene→Holocene	5 ma - present	1,2	Warm → Cool	Entire N. Atlantic
		Rupertina – black	18	12 %	Mesozoic→Cenozoic: Cretaceous → Holocene	155 ma - present	1,2,3	Hot→Warm→Cold	Western N. Atlantic (north and equatorial)
		Spiropsammia - brown	8	5 %	Cenozoic: Oligocene → Pliocene	33 - 1.8 ma	2,3	Warm → Cool	Western N. Atlantic (north and equatorial)
	total		**145**	100					





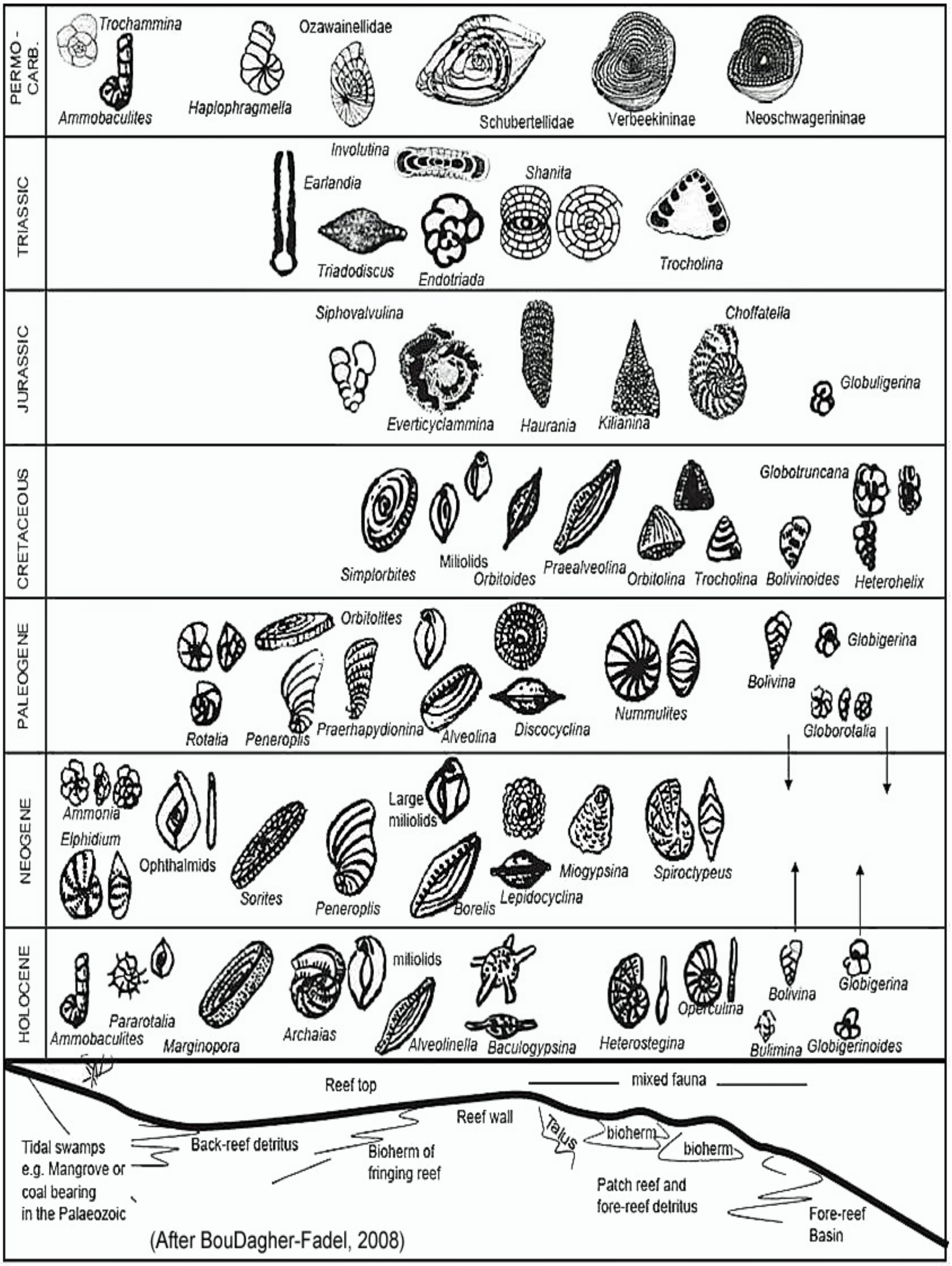


A representation of the deep ocean sediment cores. Each box represents a different layer, and colored dots represent foraminfera species. The black circles represent cores #1-10. Students use provided information about forams to determine which layer is the oldest, or bottom layer and which is the top, or youngest, layer.

What is Your Claim – Which layer is the youngest (top)? Oldest (bottom)? How did you determine this?

My Claim	**Foram species present (% of sample)** e.g. ***Foram One*** **(18%)**	**Age Range of Layer**	**Geological Era / Period**
Youngest Layer = **Top / YELLOW**	Rupertina (black) 27% Valvulina (white) 14% Tawitawia (blue) 25% Calcarina (green) 34%	8000 ya (1 ma?) – present	• Cenozoic / Holocene (maybe late Pleistocene)
Middle Layer = **Middle / GRAY**	Chapmania (purple) 24% Meandrospira (pink) 15% Rupertina (black) 12% Calcarina (green) 24% Spiropsammia (brown) 5% Alanlordia (yellow) 20%	33 ma – 1.8 ma	• Cenozoic / Oligocene, Miocene, Pliocene
Oldest Layer = **Bottom / GREEN**	Chapmania (purple) 12% Meandrospira (pink) 17% Rupertina (black) 10% Saudia(red) 15% Valvulina (white) 24% Spiropsammia (brown) 10% Coskinolina (orange) 12%	286 ma – 33 ma	• Cenozoic / Paleocene and Eocene, and • Mesozoic / Permean, Triassic, Jurassic, Cretaceous

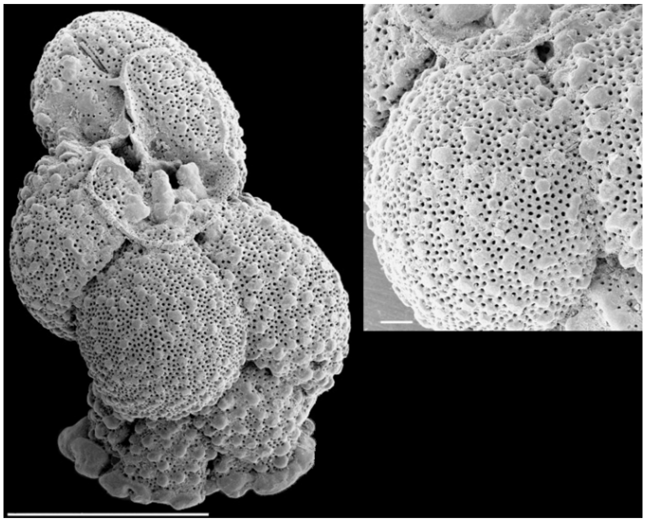
Table 5. Compile class data to determine which layer was the top, or youngest layer and which was the bottom, or oldest layer. Use evidence (foram species found) to defend your claim.



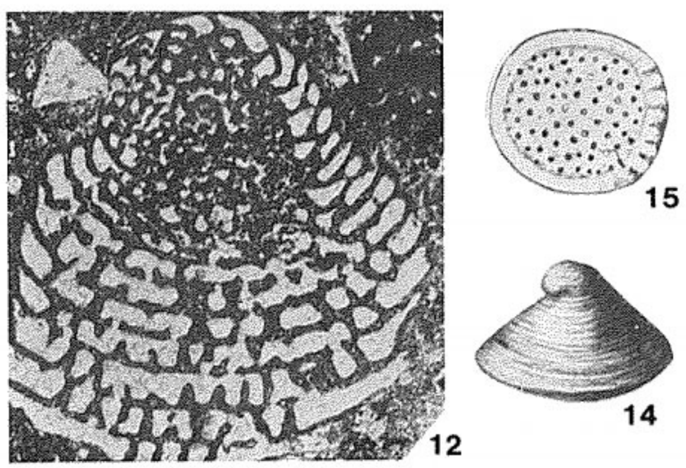
PERMO - CARB.
Trochammina
Ammobaculites
Haplophragmella
Ozawainellidae
Schubertellidae
Verbeekininae
Neoschwagerininae
TRIASSIC
Involutina
Earlandia
Shanita
Triadodiscus
Endotriada
Trocholina
JURASSIC
Siphovalvulina
Choffatella
Globuligerina
Everticyclammina
Haurania
Kilianina
CRETACEOUS
Globotruncana
Miliolids
Simplorbites
Orbitoides
Praealveolina
Orbitolina
Trocholina
Bolivinoides
Heterohelix
PALEOGENE
Orbitolites
Globigerina
Bolivina
Nummulites
Rotalia
Peneroplis
Praerhapydionina
Alveolina
Discocyclina
Globorotalia
NEOGENE
Ammonia
Elphidium
Ophthalmids
Large miliolids
Sorites
Peneroplis
Borelis
Lepidocyclina
Miogypsina
Spiroclypeus
HOLOCENE
miliolids
Pararotalia
Ammobaculites
Marginopora
Archaias
Alveolinella
Baculogypsina
Heterostegina
Operculina
Bolivina
Globigerina
Bulimina
Globigerinoides
Reef top
mixed fauna
Reef wall
Talus
bioherm
bioherm
Tidal swamps e.g. Mangrove or coal bearing in the Palaeozoic
Back-reef detritus
Bioherm of fringing reef
Patch reef and fore-reef detritus
Fore-reef Basin
(After BouDagher-Fadel, 2008)

Rupertina

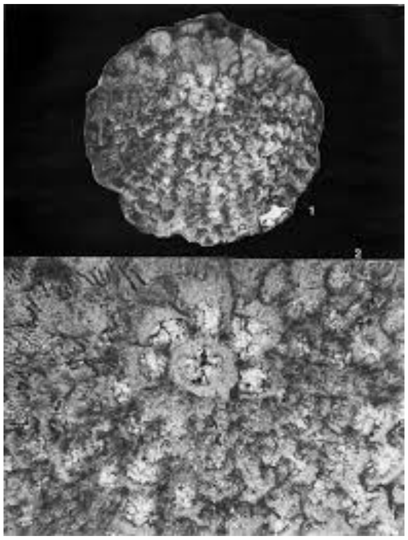
Example Forams



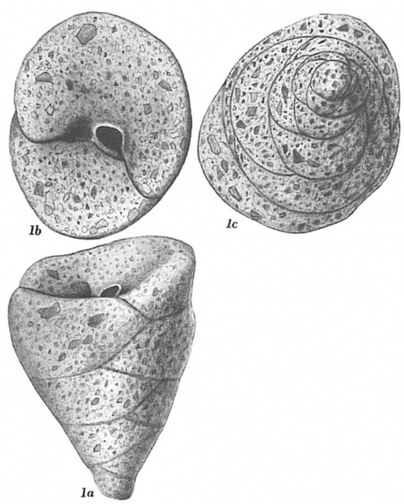
Coskinolina



Alanlordia



Valvulina



Calcarina

Assessment Ideas:

1. Research other ways to tell past climatic conditions.

2. Do the cupcake geology lab.

Resources:

- Joides Resolution. n.d. https://joidesresolution.org/

References:

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