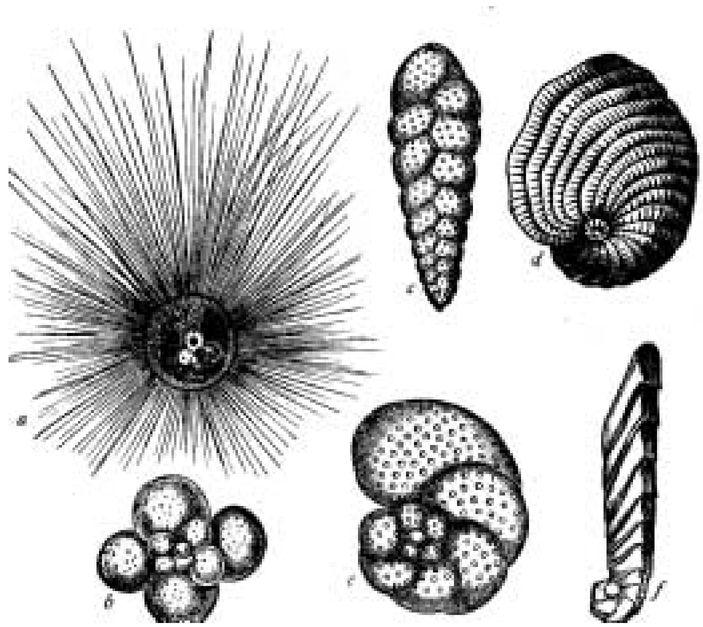

Week Six
Biostratigraphy

Background: We have spent considerable time discussing the importance of fossils in unraveling Earth history and you should recall that they are particularly useful in establishing stratigraphic relationships between rocks in different areas. This component of geology is known as **biostratigraphy.** Many fossils can be used in biostratigraphy, but one of the most important groups is the **foraminifera.** Commonly referred to as "**forams"**, these beasties are usually tiny (frequently smaller than 0.1 mm) and hence, can really only be studied with the aid of a microscope. For this reason, they are considered to be **microfossils.**

Whether you use microfossils or **macrofossils** or even **nannofossils** (really tiny beasties best studied with an electron microscope), the procedures required to establish biostratigraphic relationships are relatively straight-forward. You must first identify the types and names of beasties (usually down to genus and species levels) that are contained in the rocks. Then you need to determine the age range of each of those beasties. Unless the fossil(s) you identify are new species, there is a good chance that someone has already determined when they lived and they preferred environment. For example, the large gastropod *Struthiolaria frazeri* (Figure 6-1), has been studied by many different paleontologists and they have determined that it lived

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Tests of living (Modern) foraminifera. Figure from Le Conte, J., 1905. Elements of Geology. D. Appleton & Co. New York, 667p.

from the late Pliocene to the early Pleistocene in sandy marine environments less than 50 m deep. Since its age and environment of deposition is rather restricted, you can be pretty certain that if you find strata containing *Struthiolaria frazeri,* the strata must be late Pliocene-early Pleistocene in age and must have been deposited in a shallow ocean. If you find a new fossil, there is a bit more work required to resolve its age and paleoenvironment, but at least you get to name the beastie.

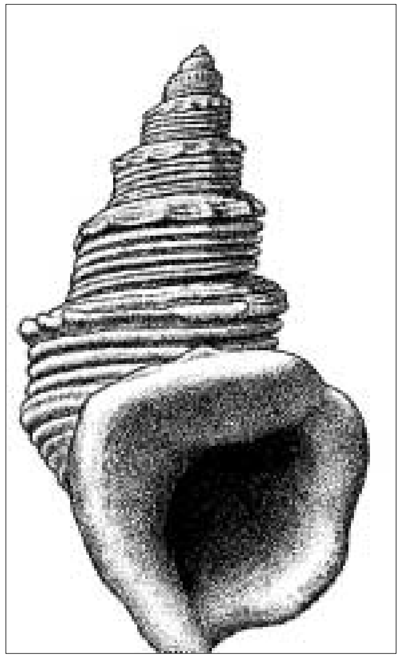


Figure 6-1*: Strutiolaria frazeri (approximately 6 cm long).*

From Beu and Maxwell, 1990. Cenozoic Mollusca of New Zealand. NZGS Paleo. Bull. 58

In most cases, one fossil is insufficient to accurately age a particular sedimentary layer. If a sandstone contained *Struthiolaria frazeri,* all you can safely conclude is that the sandstone formed sometime between the late Pliocene and early Pleistocene. What you really need is a bunch of fossils with overlapping age ranges. If you are lucky, you will be able to establish the age of strata within a very narrow time range (e.g., upper Pliocene, lower Miocene etc.).

The majority of this lab is designed to introduce you to the principles of biostratigraphy and bio-stratigraphic correlation using a fictitious series of stratigraphic sections. Be warned; this component of the lab frequently causes problems for students.

Since some of the correlations you will be doing involve foraminifera, we thought that it would be a good idea to introduce you to this group of beasties during this lab. Important background information about the forams follows. From this lab exercise onward, every GY 112 lab will include important new fossil groups.

Phylum Protozoa

Foraminifera belong to the phylum **Protozoa** and all protozoans share one common characteristic. They are all organisms that consist of only a single cell. That one cell performs all of the necessary bodily functions including locomotion, digestion and reproduction. Protozoans are generally very small (they are after all, single-celled), and most require a powerful hand lens if you are going to study them (I hope you brought yours today!). Some are so small that electron microscopes are necessary in order to effectively study them.

There are four **classes** of Protozoa and they are distinguished from one another based upon modes of locomotion. The most important Protozoans in geology belong to the class **Sarcodina** which consist of beasties that move and feed via long thread-like extensions called **pseudopodia.** Two **orders,** Foraminifera and **Radiolaria** belong to the class Sarcodina. Both are characterized by beautiful **tests** (a kind of exoskeleton; see inset figure on the first page of this weeks lab) composed of either calcium carbonate (the forams) or opaline silica (radiolarians). The former are important components of **chalk**. The latter, of deep sea **chert**.

In GY 112, we do not examine radiolarians. They are exceptionally small nannofossils and hence, hard to study in a class room setting. However, some foraminifera (including the **Family** Fusulinidae) were huge, some up to 1 cm across! (remember, foraminifera are single-celled organisms). You will get to see an example of **fusulinid** foraminifera in this week's lab exercise.

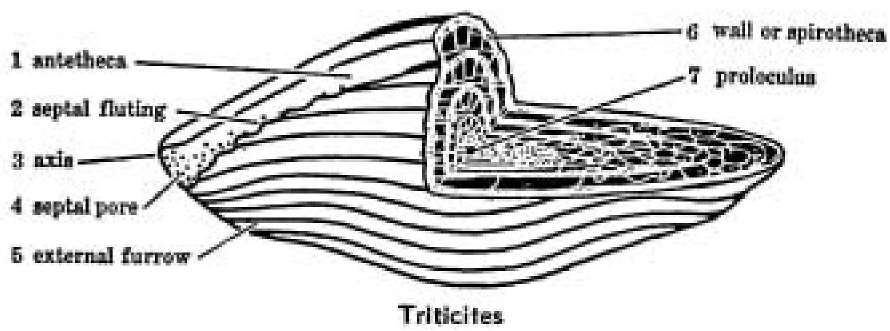


Figure 6-2: *Diagram of a fusulinid foraminifera showing important structural features. From, Moore R..C., Lalicker,C.G. and Fischer, A.G., 1952. Invertebrate Fossils., McGraw-Hill, New York, p60.*

Notes

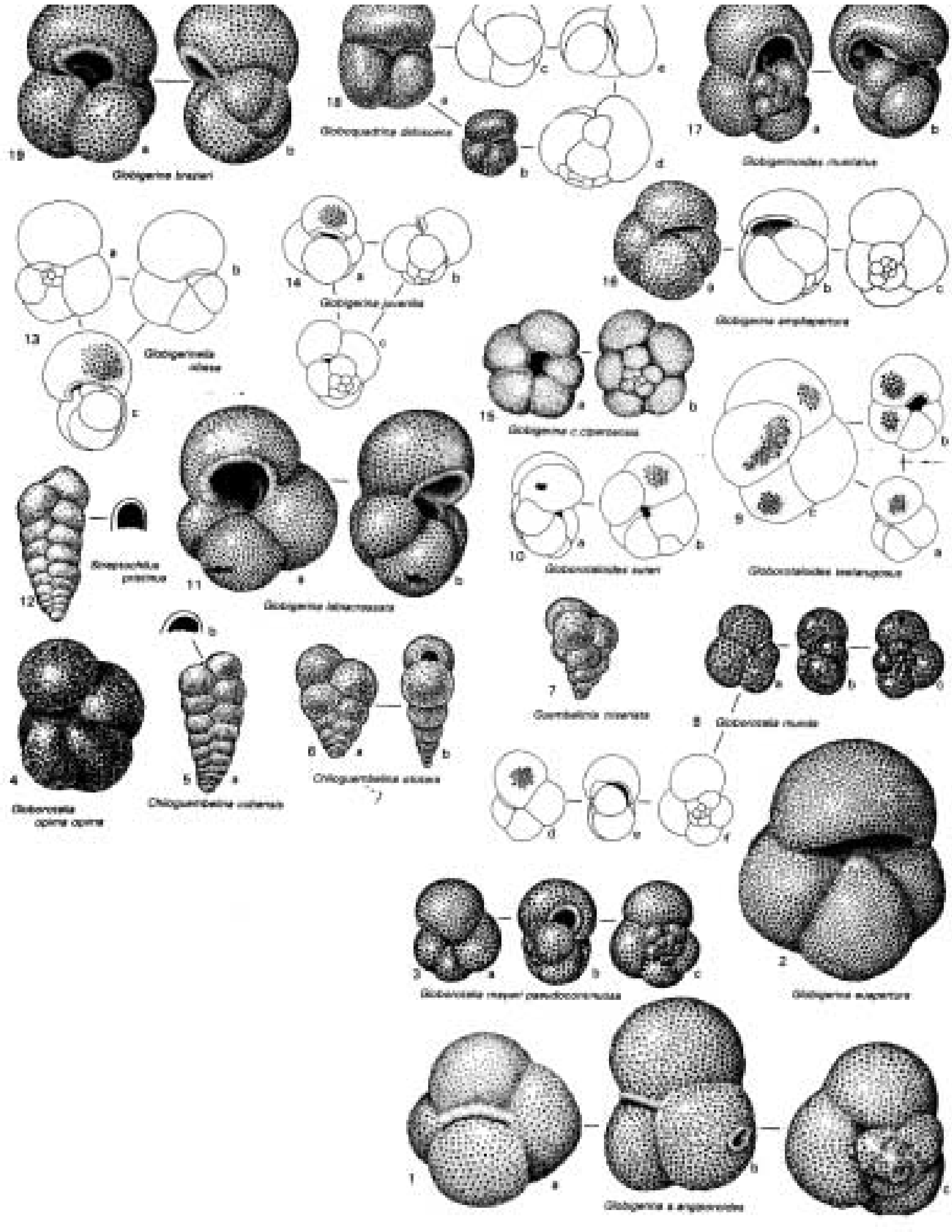


Figure 6-3: *Some important planktonic foraminifera. From, Hornibrook, N.de, Brazier, R.C. and Strong, C.P., 1989. Manual of New Zealand Permian to Pleistocene Foraminiferal Biostratigraphy. NZGS Palaeontological Bulletin 56., 175p.*

Name: ________________________ Grade ____/100 (+2 bonus) Percent: _____

GY 112 Lab Assignment 6

Biostratigraphy and Foraminifera

Note: We want you to become familiar with these beasties and one of the most effective ways to do this is to draw them. In this lab, you will be asked for the first time to draw one of the fossil specimens. We know that most of you are not art majors, nevertheless, we ask that you try to do the best job that you can. Use pencil, add shading where possible, and add scales (You will be told about this in class). Part of your mark will be based upon quality. Also, please try to label significant features of the beasties you draw. Your text book will also help you here.

You will find pages 125 to 129 and 137 in your textbook helpful in answering the questions in this lab. You will also want to refer to the notes you (should) have taken in class.

Part One

The Problem: You are a budding young geologist and have spent an entire summer field session examining (in detail) several Tertiary-aged outcrops in western Nevada. In total you measured 6 sections (Good Job!). They were spectacular cycles of sandstone and shale with lesser amounts of siltstone and volcanic ash. Everything was unconformably underlain by Cretaceous-aged limestone.

Unfortunately, the outcrops were many miles apart, and as is frequently the case, you were left unsure about lateral correlations between sections. You realize that different lithologies can come and go due to facies changes, pinch outs, unconformities etc. So you decide to hire a pseudo-paleontologist to help you sort out the stratigraphy. (The person you hire is really a biologist pretending to be a real scientist, but luckily for you, this person actually knows something about Tertiary fossils). You admit defeat and opt to correlate the rock layers with the help of biostratigraphy.

The paleontologist that you hired collected samples from many locations at each section. Fortunately, there were only 3 different types of fossils (bivalves, gastropods and foraminifera) and only 6 or 7 different species of each. In another area, you might have seen many hundreds of different fossils. The beasties that the pseudo-paleontologist found are listed in Table 6-1.

Just when you thought things were starting to take a turn for the better, disaster! The pseudo-paleontologist was offered a much more lucrative job than he was used to as a biologist (a greeter at the nearest Walmart) and leaves your employment before helping you to do the biostratigraphic correlation. So you are now on your own. However, being the cleaver geologist that you are, you stole all of his notes (and his wallet) before he left your employment. You have everything you need to do the correlation (and money for popcorn).

Table 6-1: Fossils found in your sections by the paleontologist/biologist.

Gastropods	Bivalves	Foraminifera
0 *Yokelthoe lei*	**7** *Eumaricia plana*	**14** *Sebastiana dabossus*
1 *Pelicaria convexa*	**8** *Tawera subsulcata*	**15** *Uvigerina maynei*
2 *Pelicaria acuminata*	**9** *Tawera spissa*	**16** *Ammonia beccarii*
3 *Taniella sp.*	**10** *Stephaniae capellea*	**17** *Virgulopsis davisae*
4 *Alcithoe mariea*	**11** *Clarki miniae*	**18** *Anomalinoides sp.*
5 *Cominella hamiltoni*	**12** *Ostrea sp.*	**19** *Zeafloris parri*
6 *Charlynia girlyi*	**13** *Jasonella hurelli*	**20** *Allisani davidania*

The Data: The pseudo-paleontologist examined fossils from several levels in each section. He identified which beasties were in each site via number (e.g., #1 refers to the gastropod *Pelicaria convex*, # 10 to the bivalve *Stephaniae capellea* etc.). In addition, you have background data about the age ranges and water depths for each of the beasties that the paleontologist identified. An ash bed that occurs near the top of the section has been radiometrically dated and serves as the **datum** by which the sections are tentatively correlated. Think you can complete the correlation? Just remember that not all fossils were **cosmopolitan**. Some lived in different environments (e.g., shallower water) than others. Take this into account when you are correlating rock units. Figure 6-4 shows a sample biostratigraphic correlation. Your section will be different, but it might give you a bit of guidance to finish it.

Table 6-2: Fossil content at each section. See columns for locations of each site. BARREN: no fossils

Site	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
A	0,15,19	Barren	Barren	Barren	Barren	Barren
B	1,2,15,20	11,17,20	0,8,11,17	8,11,13,17	0,8,11,13	4,8,10,13
C	1,3,14,19,20	0,2,4,15	4,8,10,17	0,2,4,13	0,4,8,10	2,3,9,10
D	2,10,14,19	1,13,15,19	0,2,4,15	2,13,19	0,2,4,10	2,3,7,9
E	3,18,20	1,3,14,19	1,2,13,19	1,2,3,19	1,2,13,19	2,7,9,12
F	2,12,14,18	14,19,20	1,2,3,19	2,3,10,19	2,3,10,19	5,7,9
G	5,9,16,18	3,14,18,20	3,10,14	2,3,7,9	2,3,7,9	
H	6,12,16,18	12,14,18	2,10, 14	2,12,14	2,12,18	
I		5,9,16,18	2,3,7,20	5,7,9,16	2,7,9,12	
J		5,9,16	2,12,18	5,6,16	5,7,9,12	
K		5,6,16,18	5,7, 9,18			
L			5,6,7,18			

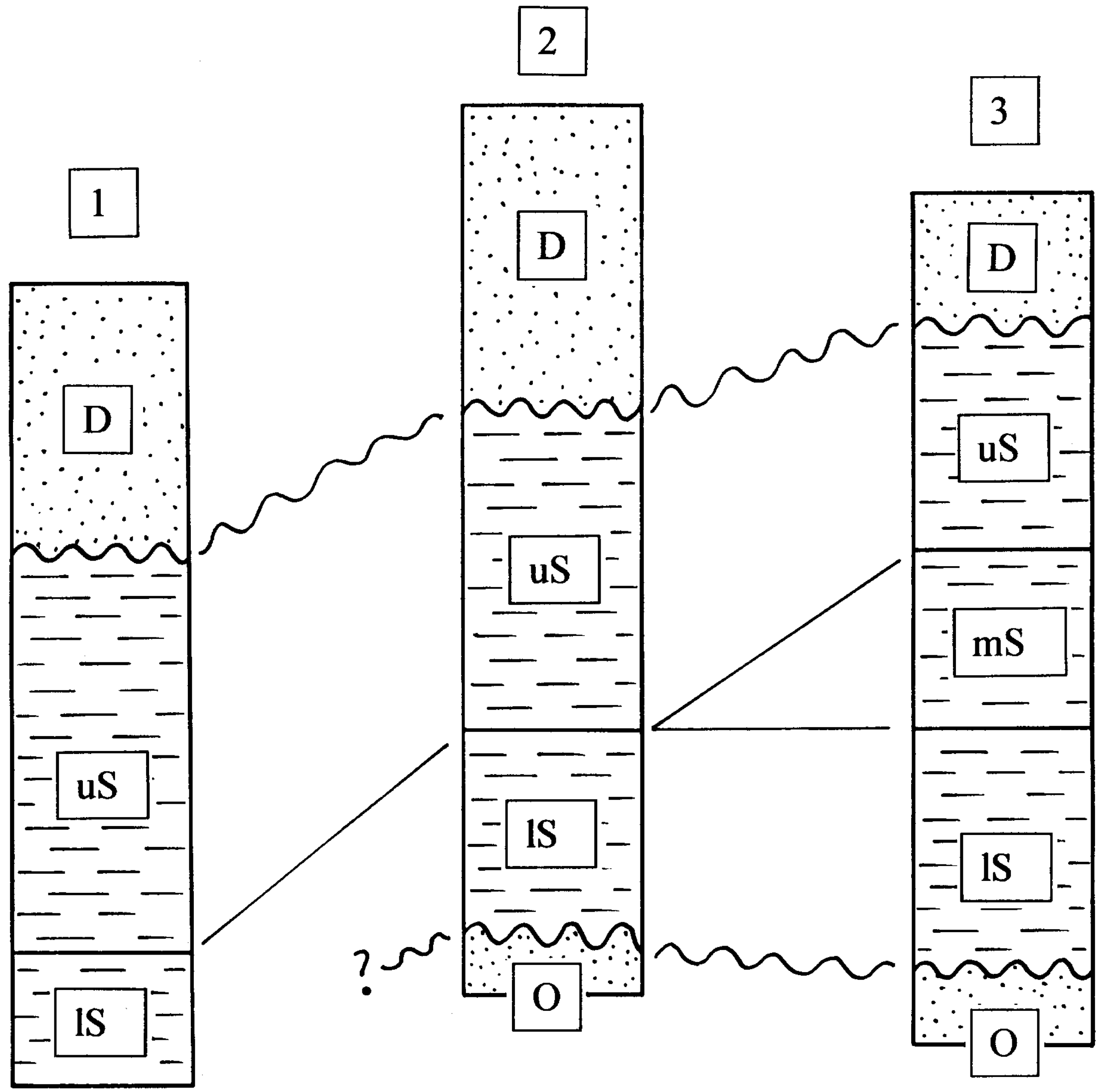
Table 6-3: Depth and age data of fossil species as provided by the Paleontologist.
(u) - upper; (l) – lower

Gastropods	Age	Depth*
0 *Yokelthoe lei*	Cretaceous – (l) Eocene	75 – 150 m
1 *Pelicaria convexa*	(u) Eocene- (l) Oligocene	100 - 200 m
2 *Pelecaria acuminata*	Eocene - Miocene	25 – 200 m
3 *Taniella sp.*	Oligocene- Miocene	25 -100 m
4 *Alcithoe mariea*	(u) Paleocene-Eocene	25 - 200 m
5 *Cominella hamiltoni*	Pliocene-Pleistocene	25 - 100 m
6 *Charlynia girlyi*	(u) Pliocene - Pleistocene	75 - 150 m

Bivalves	Age	Depth*
7 *Eumaricia plana*	Miocene - Pliocene	0 - 25 m
8 *Tawera subsulcata*	Paleocene	75 – 150 m
9 *Tawera spissa*	(u) Oligocene- Pliocene	0 - 50 m
10 *Stephaniae capellea*	(u) Paleocene -Oligocene	25 – 100 m
11 *Clarki miniae*	(l) Paleocene	150 – 200 m
12 *Ostrea sp.*	(u) Miocene-Pleistocene	25 – 200 m
13 *Jasonella hurelli*	Paleocene-Eocene	25 – 200 m

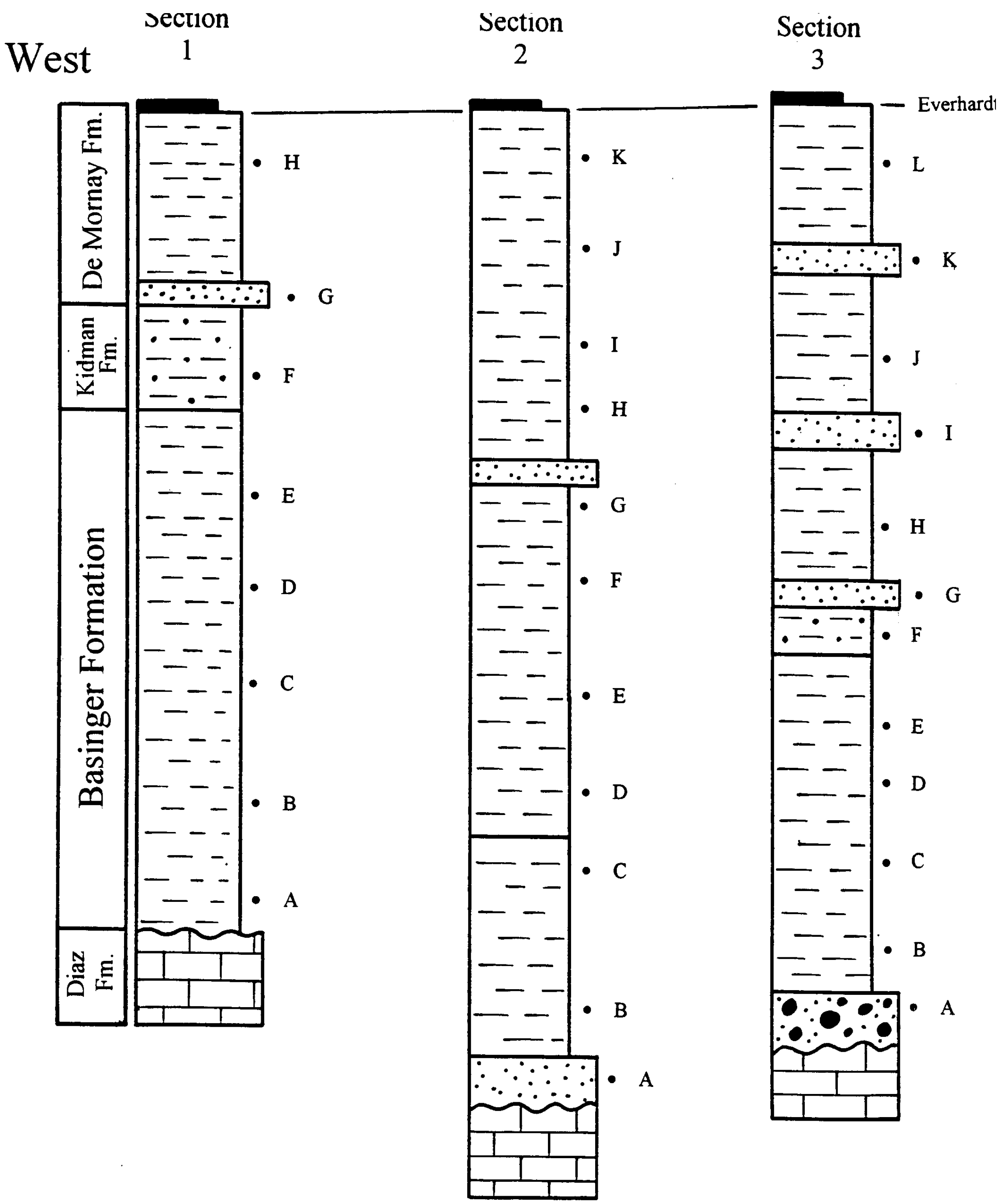
Foraminifera	Age	Depth*
14 *Sebastiana dabossus*	Oligocene-Miocene	75 – 150 m
15 *Uvigerina maynei*	Eocene	150 – 500 m
16 *Ammonia beccarii*	Pliocene	25 – 2000 m
17 *Virgulopsis davisae*	Paleocene	100 – 500 m
18 *Anomalinoides sp.*	Miocene-Pliocene	25 – 200 m
19 *Zeafloris parri*	Eocene-Oligocene	25 –100 m
20 *Allisani davidania*	Paleocene- Miocene	25 – 200 m

* Most common range of depth. Occasionally, some organisms may be found in shallower and/or deeper water environments.



Legend
D- Devonian
uS- upper Silurian
mS- middle Silurian
lS- lower Silurian
O- Ordovician

Figure 6-4:
Sample correlation of sedimentary units on the basis of ages determined through biostratigraphy. Although the Silurian-aged strata are all the same lithology (shale), it is still possible to trace distinct units on the basis of ages. Note that the middle Silurian shale bed pinches out between sections 2 and 3.


West
Section 1
Section 2
Section 3
Everhardt
De Mornay Fm.
Kidman Fm.
Basinger Formation
Diaz Fm.
H
G
F
E
D
C
B
A
K
J
I
H
G
F
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D
C
B
A
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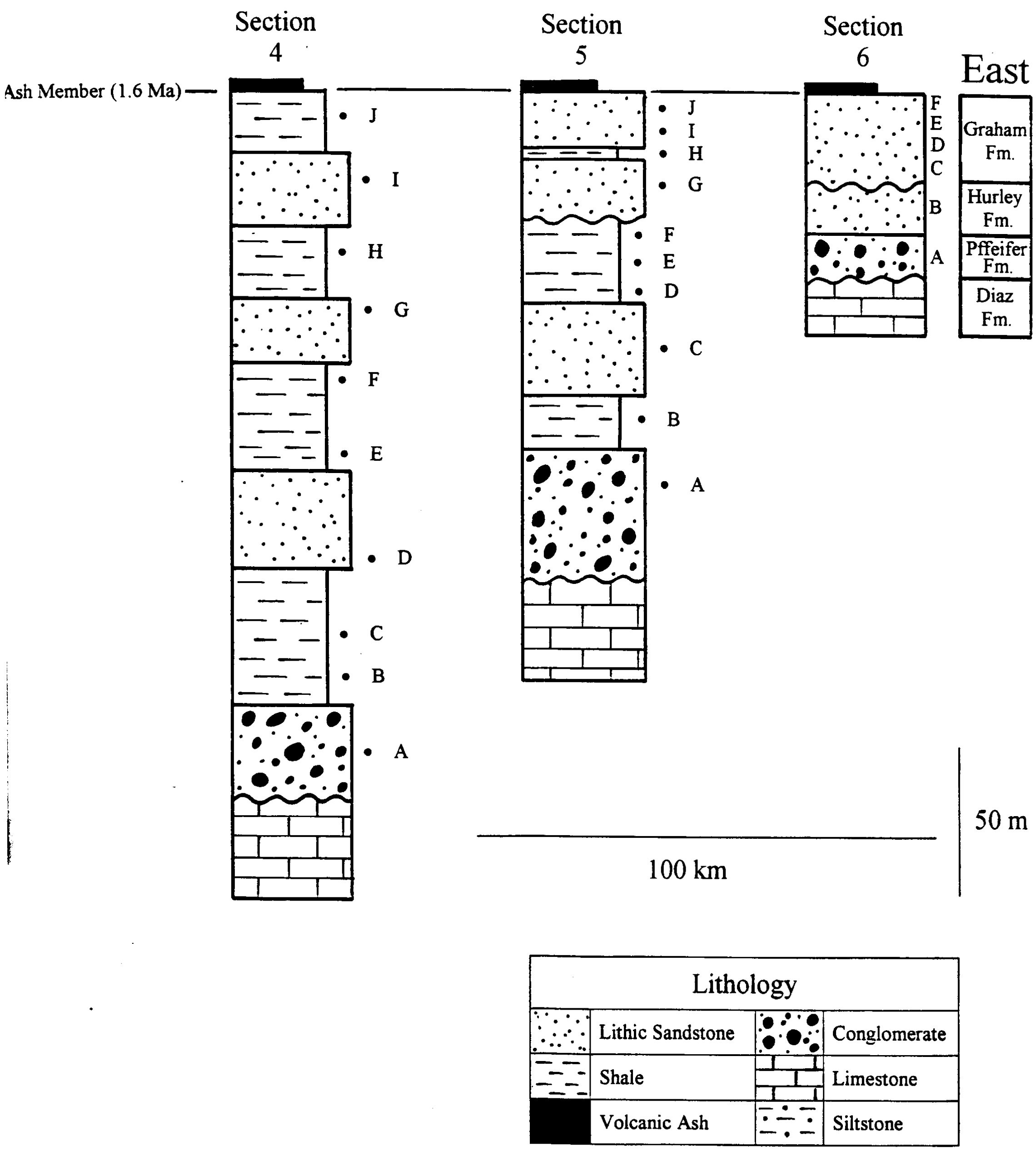
E
D
C
B
A


Section 4
Section 5
Section 6
East
Ash Member (1.6 Ma)
J
I
H
G
F
E
D
C
B
A
Graham Fm.
Hurley Fm.
Pffeifer Fm.
Diaz Fm.
50 m
100 km
Lithology
Lithic Sandstone
Conglomerate
Shale
Limestone
Volcanic Ash
Siltstone

Exercise 1: Here is where you start to earn your points for this laboratory assignment. The first thing you need to do is to establish the age ranges of each of the gastropods, bivalves and foraminifera found in the rocks. To do this, fill in the appropriate field in Tables 6-4, 6-5 and 6-6 below. I have done *Cominella hamiltoni* (gastropod #5) for you as an example.

Table 6-4: Age ranges of gastropods found in the stratigraphic sections **[5 points]**

Gastropods	Tertiary				
	Paleocene	Eocene	Oligocene	Miocene	Pliocene
0 *Yokelthoe lei*					
1 *Pelicaria convexa*					
2 *Pelecaria acuminata*					
3 *Taniella sp.*					
4 *Alcithoe mariea*					
5 *Cominella hamiltoni*					■
6 *Charlynia girlyi*					

Table 6-5: Age ranges of bivalves found in the stratigraphic sections **[5 points]**

Bivalves	Tertiary				
	Paleocene	Eocene	Oligocene	Miocene	Pliocene
7 *Eumaricia plana*					
8 *Tawera subsulcata*					
9 *Tawera spissa*					
10 *Stephaniae capellea*					
11 *Clarki miniae*					
12 *Ostrea sp.*					
13 *Jasonella hurelli*					

Table 6-6: Age ranges of foraminifera found in the stratigraphic sections **[5 points]**

Foraminifera	Tertiary				
	Paleocene	Eocene	Oligocene	Miocene	Pliocene
14 *Sebastiana dabossus*					
15 *Uvigerina maynei*					
16 *Ammonia beccarii*					
17 *Virgulopsis davisae*					
18 *Anomalinoides sp.*					
19 *Zeafloris parri*					
20 *Allisani davidania*					

Exercise 2: Now that you have established the age range of the various beasties in your sections, it's time to use these data to establish the biostratigraphy of strata. The fold out in this chapter shows the locations of all of the samples in each of the sections. Using the age range data in Tables 6-4, 6-5, and 6-6, determine the age of each sample site and then correlate the major epoch boundaries from section to section. **[50 points]**

Short Answer Questions: Once you have completed the correlations, answer the following short written questions about your interpretation.

1) What happens to the Pffeifer Formation from east to west?

____

____ **[2 points]**

2) What happens to the Eocene aged strata from east to west?

____

____ **[2 points]**

3) Paleo-water depths can also be determined from fossil data, but it is trickier because you frequently get mixtures of shallow water planktic beasties and deeper water benthic beasties (or visa versa). Some beasties also live over very wide depth ranges. Despite these limitations, useful data can often be obtained. In the data you have here, fossils 1, 11, 15 and 17 are generally found in deeper water (>100m) while fossils 7 and 9 are found in shallower water (<50m). Given their distribution in the sections studied, were the sandstones deposited in deeper or shallower water than the shales?

____ **[5 points]**

4) Was the paleoshoreline to the east or west of the sections?

____________________________________ **[2 points]**

5) For what reason(s) can you conclude this? (refers to question 4)

____

____ **[3 points]**

Part 2: Phylum Protozoa.
Specimen 6-1a: *Tricicities* sp. (a Fusilinid foraminifera; Penn – Perm).
Specimen 6-1b: Various modern foraminifera.
Note: Both beasties are best viewed under a binocular microscope or with your hand lens.

Fusilinids are important Paleozoic animals. To which class do they belong?

_______________________________**[1 point]**

Discuss one of 2 ways that foraminifera build their shells? ______________________

____

____

____

____ **[5 points]**

Why are forams useful in paleogeographic reconstructions? ________________________

____

____

____

____ **[5 points]**

Draw a representative example of a single fusulinid foraminifera or a single modern foraminifera **[10 points]**

Scale:

Name: ______________________________

Bonus: The direction that foraminiferal tests coil may be controlled by environmental factors. What example(s) of environmental control does your text book cite?

____ **[2 points]**