Assignment pgs. 259 - 264

Data (p263)

Equation (p259)

Planktonic Foraminifera and Late Pleistocene Climate Change

Introduction:

Planktonic foraminifera are a very diverse group of single-celled marine microorganisms that are widely used in stratigraphy, geochronology, and paleoenvironmental studies. This is largely because they:

1. are extremely abundant in most marine sediments
2. are distinct and easily recognizable
3. are globally distributed (planktonic foraminifera)
4. have evolved rapidly to produce numerous "index" taxa
5. are well preserved
6. are sensitive to temperature, salinity, and nutrients in the water column

In this lab, we will focus specifically on the ecology and morphology of a particular planktonic foraminiferal species, and then draw paleoclimatic inferences based on its fossil record in the North Atlantic.

Globorotalia truncatulinoides (d'Orbigny) shown in Plate 1 is a subtropical to subpolar planktonic foraminiferal species that is present in the upper water column (0-100m) during winter conditions (Dec.-April, July-August in southern hemisphere).

The size and shape of individuals of a species are often affected by the ecological conditions of their environment. For example, well-nourished children tend to be larger as adults than malnourished children, although genetics may also play a certain role. *Globorotalia truncatulinoides* has been shown to exhibit size differences depending on the latitude where modern specimens were collected (Kennett, 1968). In Kennett's study, the width and height (Figure 1) was measured for specimens collected from 50 sea bed sediment samples around the globe. Kennett found that the width:height ratio was strongly correlated to temperature of the overlying surface water (Figure 3).

Plate 1. *Globorotalia truncatulinoides*, scale bar = 0.10 mm.
http://rin.hiroba.org/foraminifera/truncatulinoides.html

This lab was adapted and greatly expanded from Pipkin, 2000. Exercise 23: Micropaleontology and Paleoceanography, Laboratory Exercises in Oceanography, W.H. Freeman and Co., New York, NY.

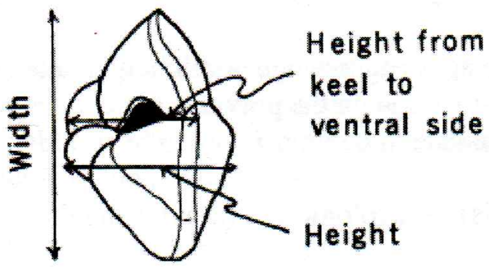

Figure 1. Side view of a specimen of *G. truncatulinoides* showing the measured parameters. This is a biconvex morphology typical of subantarctic waters. (Taken from Kennett, 1968)

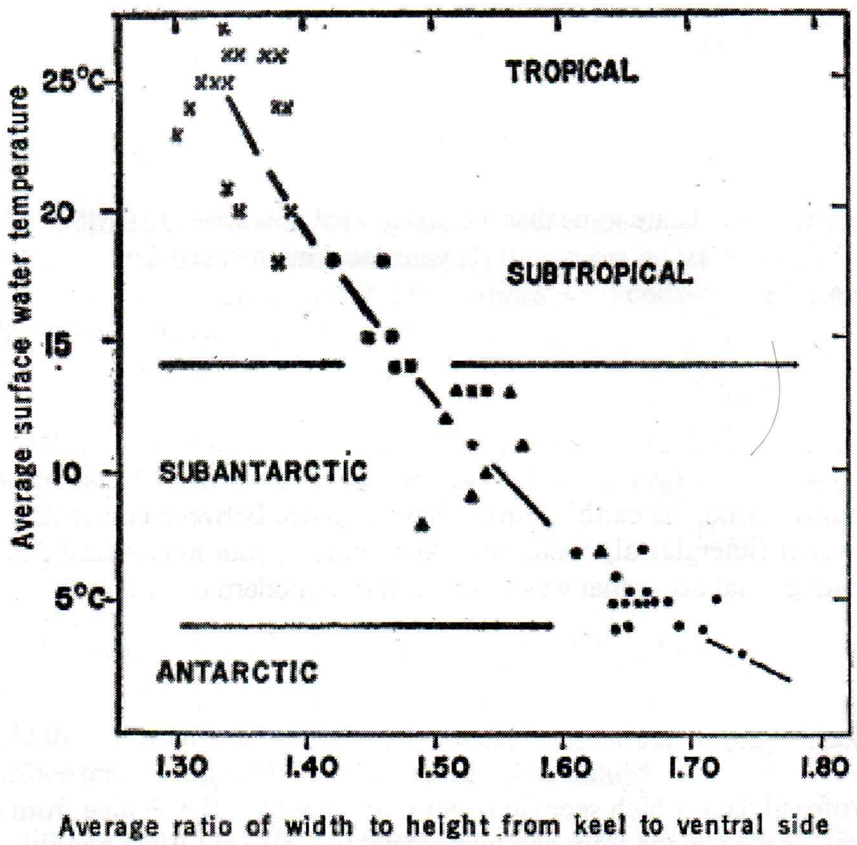

Figure 2. This is a graph showing that as average water temperatures decrease, the average width:height of *G. truncatulinoides* increases. (Taken from Kennett, 1968)

The empirical formula relating the two parameters is as follows:

$$WaterTemperature(^{\circ}C) = -55.9 \times (Avg.Width : Height) + 97.9$$

Reference: Kennett, J.P. 1968. *Globorotalia truncatulinoides* as a paleo-oceanographic index. *Science* 159 (3822): 1461-1463.

Part 1:

1. In Table 1, you are given a summary of geologic ages and average width:height data from a core taken in the North Atlantic. Using the Equation on the previous page, calculate the temperature for each age and fill in the data in column 3.

2. Plot a graph showing average temperature (y-axis) vs. geologic age (x-axis) and then answer the questions below.

Questions:

1. When do sea surface temperatures in the North Atlantic appear to have been the warmest in the region?

2. Numerous lines of evidence indicate to us that the last glacial maximum (LGM) occurred during ~25-18 kya (thousand years ago). Is your local microfossil data consistent with this general observation?

3. Over the past 1.8 million years, the earth's climate has oscillated between cooler/drier (glacial) and warmer/wetter (interglacial) conditions. According to your microfossil data, when (in kya) did an interglacial occur that was most similar to modern conditions?

4. Based on your microfossil data, which seem to occur more rapidly – the change from a glacial to an interglacial, or the change from and interglacial to a glacial? What possible explanations can you think of for this difference?

Part 2:

1. Now add another y-axis to your graph and plot the "ice rafted detritus" (IRD) data with another color, ask your instructor if you need help doing this. **IRD** is coarse sand to cobble sized particles that are transported out into muddy open ocean sediments by ice bergs in the Polar Regions.

Questions:

1. What, if any, is the general relationship between sea surface temperature and IRD abundances? What does this suggest about linkages between continental climates and surface ocean conditions?

Part 3:

1. Finally, let's add some data from the Vostok ice-core taken in Antarctica; this will give us a more global as well as continental perspective on climate change during the time interval we are investigating. Add two more y-axes to your original graph and plot the atmospheric dust and carbon dioxide data.

1. During what time intervals do carbon dioxide levels in Antarctica appear to have been the greatest? What were the average glacial and interglacial levels (in ppm)?

2. Is there any correlation between atmospheric carbon dioxide concentrations and sea surface temperatures? If so, what is the relationship?

3. What, if any, is the general relationship between atmospheric dust levels and carbon dioxide? What does this suggest about the continental climates during times of high dust levels?

4. A graduate student has lost the data for modern dust levels. Based on the relationship between dust and CO_2 extrapolate the amount of dust expected to be found in the modern on your graph.

5. Based on the relationship of the following curves, what predictions can be made about temperature in Earth's future?

Age, ka BP	Avg Width:Height	Temperature	IRD (#/10cc)	Dust (ppm)	CO_2 (ppm)
0	1.5		2	X	395
2	1.51		6	0.03	285
9	1.55		10	0.04	260
13	1.6		12	0.08	236
19	1.64		16	1.21	189
27	1.62		15	1.35	192
32	1.61		14	0.60	205
41	1.61		18	0.20	189
53	1.59		15	0.17	190
59	1.6		16	0.65	210
64	1.61		20	0.84	195
70	1.58		14	0.21	227
81	1.54		2	0.24	222
85	1.56		3	0.07	239
92	1.56		4	0.19	226
99	1.54		3	0.09	228
104	1.55		4	0.15	237
109	1.56		6	0.07	242
110	1.56		6	0.04	251
115	1.53		5	0.05	268
122	1.5		2	0.08	274
127	1.55		4	0.09	269
130	1.59		6	0.07	259
146	1.62		10	0.53	197

Table 1. Data used in this lab to investigate climate change during the Latest Pleistocene. IRD = ice rafted detritus, in total number of particles per 10 cubic centimeters of sediment. Dust and CO_2 were measured from melted ice core samples and air bubbles trapped in the ice; they are reported in ppm or parts per million.

Part 4.

1. What are the causes of the "big five" mass extinctions in Earth's history?

2. How do organisms respond to climate change? Can any generalizations be made about those who survive versus those who do not?

3. What do you think will happen to class *Mammalia* (to which humans belong) if the current climate change trends continue?