Geology 101, Fall 2008 Name:

Lab 8: Climate change and ice ages

1. Distinguish *climate* from *weather*.

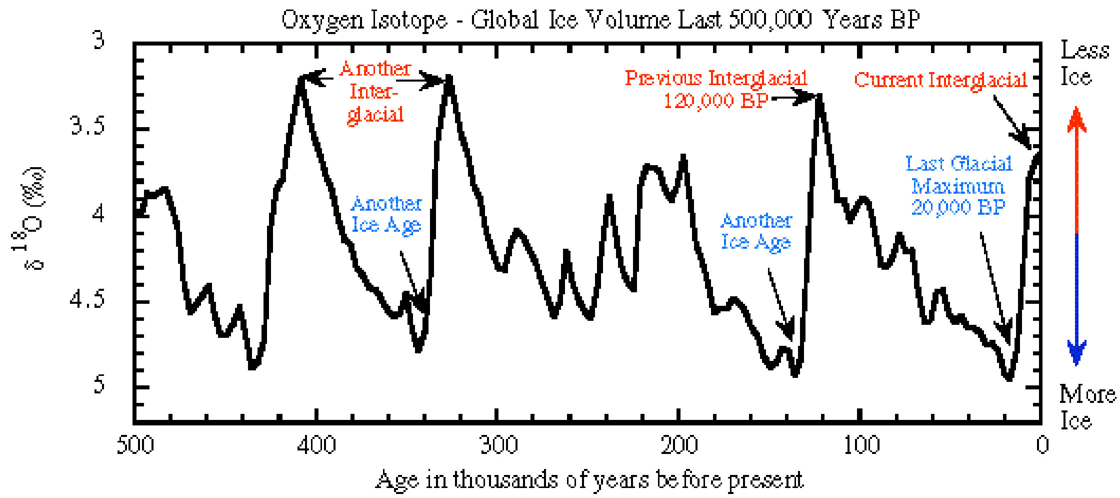
2. The controls on the Earth's climate are numerous, and operate on different **timescales** (the time needed for that particular control to affect worldwide climate). Fill in the table below:

Climate control	Brief description of how the control affects the climate	Timescale (millions of years, thousands of years, years)
Plate tectonics (positions of the continents)		
Astronomical parameters (Milankovitch controls)		
Sea surface warming or cooling (El Nino, La Nina)		

3. a. Describe the **positive climatic feedback** that the **Icehouse Earth** scenario of about 700 million years ago demonstrates (in other words, how did Icehouse Earth perpetuate itself?)?

b. How did the Earth finally free itself of the Icehouse?

4. The graph below (from the Oceanography 540 class at UW) shows the fluctuations in the **oxygen isotope** ratio ($^{18}O/^{16}O$) of ice in the Greenland and Antarctic Ice Sheets.



a. Briefly describe how the vertical axis numbers on the graph are calculated.

b. Briefly describe the mechanism of the oxygen isotope record in ice. In other words, how can the authors of the graph tell when there is more ice and therefore another ice age?

5. a. The scientific evidence for **anthropogenic** (human-induced) **global warming** are many; give **three** lines of evidence.

b. In the face of all that evidence, give **one** *plausible* argument against anthropogenic global warming.

Glacier Peak and Mount Carrie quadrangles (1950)

The **equilibrium line altitude** (ELA) of a glacier represents the elevation at which the **accumulation** zone of the glacier meets the **ablation** zone. In other words, *above* the ELA, the glacier is accumulating ice; *below* the ELA, the glacier is ablating (getting rid of) ice.

6. a. If the world enters another glacial period (ice age), what would happen to most glacial ELAs?

b. In any given time period, how will glacial ELAs compare for glaciers located on different mountains at the same latitude?

7. Fill in the table for the **latitude** of the top of Glacier Peak and the top of Mount Carrie. Don't forget that there are 60 minutes in one degree of latitude and that you need to include an "N" or an "S" after the number to indicate northern or southern hemisphere.

8. Fill in the table for the **longitude** of the top of Glacier Peak and the top of Mount Carrie. Don't forget an "E" or "W" after the number.

	Latitude	Longitude
Glacier Peak		
Mount Carrie		

Steve Porter, a geologist at the University of Washington, devised a cunningly simple method of using a topographic map to determine ELAs for different glaciers. He noted that the contour lines on glaciers bow *toward* the peak in the **accumulation zone** and bow *away from* the peak in the **ablation zone**. Thus the ELA is given by the only contour line which is roughly straight across the glacier's width. Try this with the Kennedy Glacier on the Glacier Peak quad (it's located on the northwest side of Glacier Peak) and the Carrie Glacier on the Mount Carrie quad (look on the northeast side of Mount Carrie). The Carrie Glacier contour line changes are *very* subtle.

9. Kennedy Glacier ELA:

Carrie Glacier ELA:

10. Estimate what **fraction** of the glacier is in the accumulation zone, and what **fraction** is in the ablation zone. Make these simple fractions!

11. Satisfy yourself that both glaciers are located at approximately the same latitude. How do you explain your observation in question 9? Hint: what factor besides **temperature** (which is related to latitude) governs glacial size?

Aerial Stereo Photographs Plate 17 (page 17 of the stereophoto book)

A stereophotograph is a set of two photos that are taken slightly off-center from each other so that, when placed side by side, by having your left eye focus on a feature in the left photo and your right eye focus on the same feature in the right photo, you can get depth perception. In other words, mountains will stick out towards you and valleys will drop away.

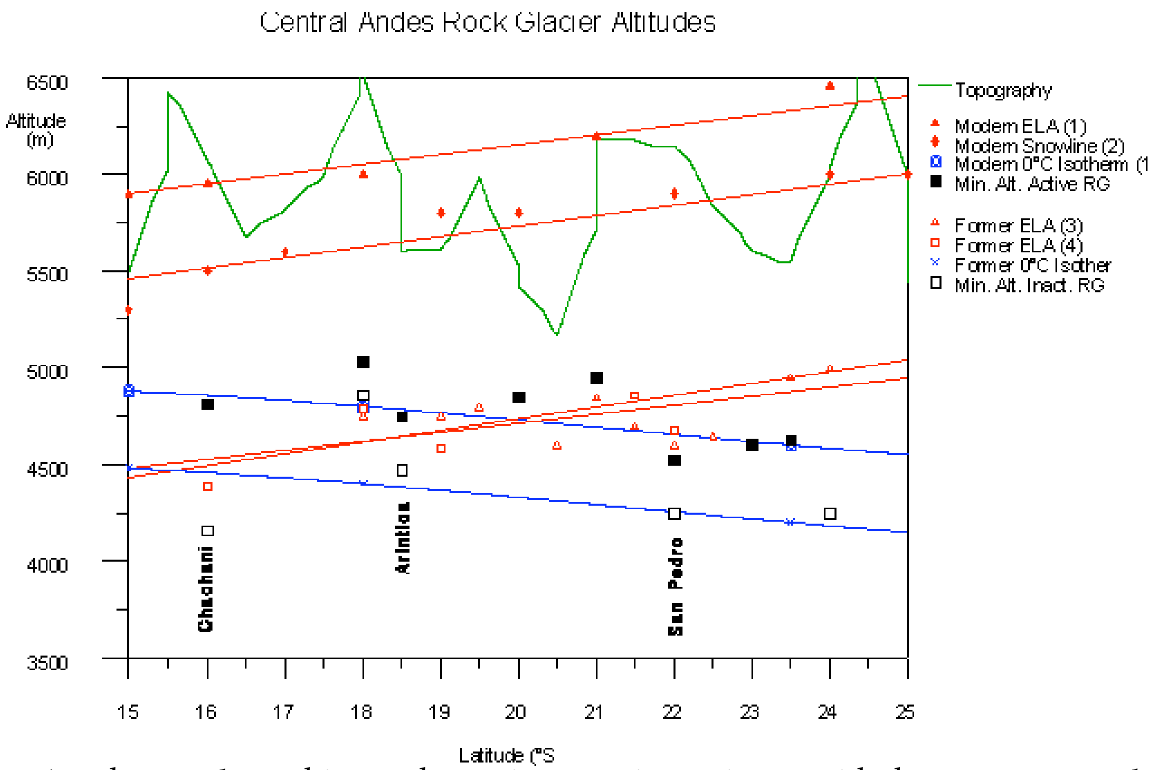
12. The outermost moraine is called the **terminal** moraine. The **cirque** is the mountain wall on which the glacier originated. If north is toward the top of the photograph, in which **compass direction** did the Walker Lake glacier flow? Hint: Figure out which way is *down* by finding the terminal moraine and the cirque.

Topographic map of the Mono Craters Quadrangle (1953) or use Google Maps to find "Bloody Canyon", then use the terrain view and zoom out until you see the moraines

13. a. Orient yourself so you can find the same glacial valley on this map as you did on the aerial stereophoto. Using the contour lines on the topo map and the result from question 10, estimate the **ELA** of the Walker Valley Glacier (in feet). Note that you are now inferring information about the last ice age.

b. Does the Walker Valley Glacier exist today? If so, estimate the ELA; if not, explain what happened to the climate. In either case, does this confirm your result in question 6a?

14. Donald Payne at the University of Aberdeen in Scotland has compiled data for ELAs of rock glaciers (that is, glaciers covered by a layer of fallen rock) in the Andes of South America, and plotted it on an altitude versus latitude graph (see next page). He has also performed the same analysis you did in the previous question to deduce the ELAs of these glaciers during the last ice age, and plotted those on the same graph. The full text and figures of this paper are available at http://ggg.qub.ac.uk/papers/full/1998/rp031998/rp03.htm



a. Are the trends on this graph consistent or inconsistent with the equator-to-pole temperature gradient?

b. Are the trends on this graph consistent or inconsistent with atmospheric warming in this area? What other factor (see question 11) could account for the trend?

Model 4: Alpine Glaciation

15. Write the **number** of the glacial **feature** on the model corresponding to the terms given below. The first one has been done as an example. Hint: The glossary of the textbook or a dictionary of geological terms will be helpful.

a. terminal (or end) moraine ___60___

b. icecap ______________

c. cirque ______________

d. cirque glacier ______________

e. moraine-impounded lake ______________

f. tarn (note: not the same as e) ____________

g. horn ____________

h. arête ____________

i. lateral moraine ____________

16. Look at the side of the model and note that there are different colored and patterned areas; these correspond to layers and areas of different **rocks**.

a. Give the number of the most **resistant** (to **erosion**, that is) rock. The pattern show for this rock is typical for **crystalline** (which are either **igneous** or **metamorphic**) rock.

b. Of 77 or 78, which is more resistant? 77 has the typical pattern for a **foliated** metamorphic rock; 78 has the pattern for **limestone**.

Continental glaciation and the glacial history of Puget Sound

Geomorphology is the science of studying present-day landforms and topography to understand the forces that shaped them.

Geomorphology in the Puget Sound area is dominated by three factors: the continental glaciation which carved and dumped the rough shapes of features here, the streams and floods that have moved that material around and the continuing action of the ocean and landslides acting to carry away what the streams have moved.

Goal: In the field trip, you will determine the **geologic history** of the Discovery Park area from the record of the sediments laid down there. To do this, you will draw a **stratigraphic column**, a sort of stylized cross-section of the rocks or sediment in an area (**locality**).

John Figge (2003) gives a summary of the major events in the late Cenozoic Era around here: “North of the Seattle Fault Zone, the northern half of the Seattle area is sculpted out of layers of sediments, sediments largely deposited during the last episode of continental glaciation. That episode spans the period from roughly 20,000 to 11,000 years ago, and is known as the Fraser (locally, “Vashon”) Glaciation. In that episode a great lobe of ice advanced south from Canada and down the Puget Sound Basin, eventually reaching all the way to Olympia. As that ice retreated some 12,000 years ago, it revealed a new landscape across much of the Puget lowland, a landscape constructed largely out of glacial sediments.

“The Fraser Glaciation was the most recent in a succession of at least four major glacial episodes over the last 2 million years of the Pleistocene. Between those glacial episodes, the landscape likely looked much as it does today, featuring extensive forests in a temperate climatic setting. Such a setting was established here after the penultimate (next to the last) glaciation, probably by 40,000 years ago. This period is known as the Olympia interglacial period. “

Getting there: Follow Northgate Way westbound as it becomes 110th St. NE and then bends around and becomes 15th Ave. NW. Cross the Ballard Bridge and turn right onto Emerson, past Fishermans' Terminal. At Gilman, turn right and continue to the east entrance of Discovery Park. Receive a parking permit from the park center building and then follow the road to West Point through Fort Lawton. Park at the small parking area near the Sewage Outfall plant; the outcrops will be to the left along the cliffs. Work in groups!

What to do: To draw the stratigraphic column, you will need to know the following formation names and descriptions:

Esperance Sand: Yellow to brown, well-sorted, cross-bedded sands. The interpretation is that these sands were deposited from meltwater streams, flowing generally southward from the sand aprons in front of the ice sheet, as it advanced into a **proglacial** lake (called Lake Russell).

Olympia Beds: Reddish, cross-bedded sands and silts with some gravel and clay layers. These beds may also contain organic material, such as tree bark. The interpretation is these beds were deposited by northward-flowing rivers.

Lawton Clay: Blue-gray clay (and some silt) interlayered with light gray clay in fine laminations called **varves**. The interpretation is that this clay settled to the bottom of Lake Russell, which was created when northward-flowing streams were blocked by the advancing ice of the Puget Lobe glacier.

Vashon Till: Unsorted deposit of cobbles, pebbles, sand and silt of varying lithologies. The interpretation is that this till was directly deposited by a retreating glacier.

17. Examine the first exposure of the cliffside on the left. Two units are exposed here — you can climb to the lower unit, but the upper unit may be too difficult to attempt; it can be identified by careful observation from where you are. Using the list of formation names above, name the upper and lower unit.

UPPER UNIT A: name ______________________
notable features:

LOWER UNIT A: name ________________________
notable features:

Walk along the path on the raised marine platform, until you must descend to the beach by crossing a driftwood deposit. Once on the beach, walk to the exposure is being eroded away by the waves. Examine the unit at eye level closely, and go around the headland to examine the unit immediately above the eye-level one (some lumps of the upper unit here may have fallen down to the beach). Again, name the upper and lower unit.

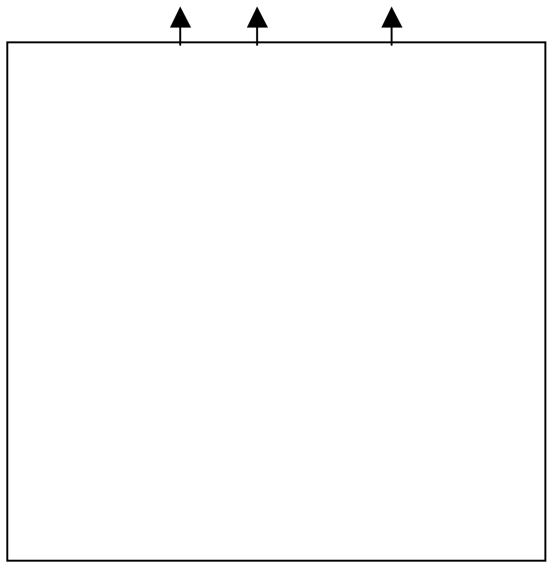
UPPER UNIT B: name ______________________
notable features:

LOWER UNIT B: name _______________________
notable features:

18. Clearly, there is some sort of unconformity here; in the earlier stop, unit A was at eye level or above and in this stop, unit B is at eye level or above. Unless one wants to evoke huge local faults (of which there is no evidence here), the simple explanation is that either unit A slid off of unit B or unit B slid off of unit A. In either case, the unit that slid off came away as a cohesive units, so much so that the layers are still basically horizontal.

From this stop, looking high above, it should be evident which unit was originally on top and which was below. **Draw** a sketch of the whole Cliffside and indicate where you see unit B and where you see unit A, and what allows you to tell which unit you're seeing. **Why** did the sliding occur at this boundary?

19. Complete the **stratigraphic column** of the Discovery Park sediments, using a dotted pattern to represent sandy units, an open circle pattern to represent glacial till, a dash pattern for clayey units and a dash-and-dot pattern for silty units. Remember Steno's principles and place the oldest unit at the bottom and the youngest unit at the top. Draw horizontal lines (which represent unconformities) between units to separate the different sediment and rock types. Finally label the units with their names to the right of the column.



20. Now you have the information to write a **brief** event by event **geologic history** of this area during the period 22000 to 14000 years ago. Begin with the oldest event and work your way up to the youngest event. In this history, you should mention whether the local climate was glacial (cold) or interglacial (warm); and also, what kind of **depositional environment** is represented by each unit. Hint: you should have **four** events.