Geology 101, Fall 2007

UPPER YAKIMA RIVER VALLEY FIELD TRIP

The evolution of Washington's Southern Cascade Mountains over the last 55 million years can be divided into four distinct stages.

0. The base on which all of the following events were to occur are the original west edge of the North American **craton**, which consisted of Jurassic and Cretaceous age metamorphic rocks, similar to those in the North Cascades.

1. The coast of Washington 55 to 40 million years ago (my) was oriented northwest/southeast and, like today, was a convergent margin. This view is somewhat controversial, in that there is much rock evidence which does not fit the "classic" convergent margin model. Assuming the convergent story, a **continental volcanic arc**, called the Challis Arc, existed inland of the convergent margin's **subduction zone** (east of the present Cascades). Numerous volcanic and sedimentary rocks were deposited during this time. Sedimentation occurred in numerous basins which probably were related to strike-slip faulting. Sometime around 52 my, movement along the Straight Creek Fault began and continued until, at the latest, 35 my.

2. After the **accretion** of the Olympic Mountains Block (and a coincident reconfiguration of plate motion), the subduction zone moved to its current location and north-south orientation off the coast of modern-day Washington. From 35 to 20 my, a continental volcanic arc existed where the Cascades are today. Evidence for this arc is preserved in the form of numerous volcanic and plutonic rocks. These rocks are referred to as the "West Cascades" because they are often but not *always* found to the west of the modern High Cascades. At the same time, sedimentary rocks were forming along the coast; these rocks would later make up the Blakeley and Renton **Formations** near Seattle (a formation is a group of age- or composition-related rocks found in a geographic location).

3. The eruption of the Columbia River Basalts, which began about 17 my, may have corresponded with a lull in Cascade volcanism. During this time, the Cascades were eroding, resulting in sedimentary rock such as that found in the Ellensburg Formation. The Cascades were probably lower in elevation, allowing more moisture to pass into eastern Washington. There is some evidence that *some* of the Cascadian volcanoes were active at this time.

4. Since 2 my, Cascade volcanism has again become active, resulting in the formation of the "High Cascades", such as Mt. Rainier, Mt. St. Helens, etc.

Based on this history, we will examine various outcrops to show that there is evidence for some of the story. Though the geological history is not crucial for understanding and writing about the topics for the teaching module (see back of handout for the assignment), the maps and the history are included to flesh out an interesting time in Washington's geological record.

Take I-90 east to exit 80 (Roslyn-Salmon La Sac). Turn left under the highway and continue for about 4.5 miles and make a left onto State Route 903 towards Roslyn and Salmon La Sac. Follow the road about 12 miles and pull off to the left (along the lake) and examine the outcrops on the right.

Stop 1: Swauk Formation/Teanaway Formation (52 to 47 my)

Sketch the outcrop and identify and label the whitish rock. Include a **scale**!

Identify and label the black rock surrounding it. What type of rock is it? How did this rock get here?

What is the **age relationship** between the white rock and the black rock? What relative dating **principle** is invoked here?

Is the white rock **altered** by the presence of the black rock (look at the white rock at stop 2, then look at the white rock near the contact)? So what type of rock is the white rock, technically?

From the white rock, derive a rough **paleocurrent** (compass) **direction** of the black rock.

Turn around and drive 1.7 miles, pulling off into a turnout on the right. The outcrop is across the road.

Stop 2: Swauk Formation (55 – 51 my)

How do the Swauk Formation rocks here differ from the Swauk Formation rocks in the previous stop? What is the rock type and name?

Identify the **clasts** visible in the outcrop. Identify the **fossils**, if any, in the outcrop. **Sketch** examples of the fossils (include a scale).

Have the rocks of the Swauk Formation been **tectonically affected** since they were deposited? If so, **sketch** evidence of this deformation.

As you drive back down the road toward I-90, look at the overlying Teanaway Formation. Has it been tilted like the Swauk Formation? What kind of **contact** (**conformable** or unconformable) exists between the Teanaway and Swauk Formations?

Return to Cle Elum and continue on SR 970 through town. At the intersection with SR 10, take SR 10 along the Yakima River. After about 5 miles, pull off the road at a turnout; the outcrop will be across the road.

Stop 3: Manastash Ridge Member of the Ellensburg Formation (17 - 16 my)
These rocks represent fluvial (river) and **lahar** (volcanic mudflow) deposits.

What kind of rock(s) are these? Hint: it's at least two different rocks (as indicated by the sources listed above). **Sketch** part of the outcrop that has these two rocks and label the sketch with the rock names. Note that the **grain size** of these rocks will be key in identifying the rocks.

What was the **source** of the sediment in these deposits? In other words, from what geographical feature did the sediment originate? Hint: identify the bigger clasts!

Does the variation in grain size between the rocks tell you anything about the **energy** of the transport agent that brought the sediment here? In other words, was there a variation in the stream (or whatever) flow rate?

Are there any **faults** in this outcrop? **Sketch** an example (you may have to walk up or down the road to find one). Are these faults **younger** or **older** than the rocks? What dating principle is illustrated here? As usual, include a scale.

What kind of **tectonic stress** did these rocks experience (hint: you can tell from what type of faults these are)?

Besides the faulting, what evidence is there for the type of deformation seen in the Swauk Formation (a much *older* formation)?

Continue east on SR 10 for several miles, until you see some yellow in the rocks on the roadcut to the left. Pull over at a convenient turnout overlooking the Yakima River.

Stop 4: Grande Ronde Formation (17 my)

What is the name of the dark rock here?

The dark rock forms shapes. Sketch part of the outcrop, showing some of the structures which will allow you to answer the questions below. Include a **scale**.

The yellow-brown material is *palagonite*, which is a mixture of clay and iron oxides formed when the dark rock reacts with water. Even though you can't see it, what kind of rock would you expect underlies the basalt? What was the environment like in this area before the dark rock flowed into it?

Continue east on SR 10. Turn right onto Hayward Rd. (aka Thorp Highway). Turn right again at Taneum Road and continue until you cross I-90 (the road will now be called Taneum Canyon Road). Reset the trip meter. At 2.7 miles, pull off to the right, on the shoulder of the gravel road at the base of some large cliffs.

Stop 5: Grande Ronde Formation and an unknown member of the Ellensburg Formation (20 - 15 my)

How many rock types are present here? Identify the types. Again, sketch and label the two formations. The Grande Ronde is the upper formation and the Ellensburg is the lower formation. Which is older? What geological principle did you use here to determine that order?

What kind of **contact** (conformable or unconformable) exists between these two units?

Is there any indication of **paleocurrent** direction in the Grande Ronde formation? Before you give up, look carefully in the rocks themselves (make sure you look at a fresh surface).

Identify some clasts in the lower formation. What does their **composition** tell you about its source? Can you conclude that this member is the Manastash Ridge member of the Ellensberg? Why or why not?

Is there much evidence of widespread **tectonic deformation** in either of these two formations?

Continue on Taneum Canyon Road (Forest Road 33) to 5.7 miles. Pull off to the right.

Stop 6: Manashtash Formation (50 my) — Note the name (and age) is different from Stop 3's formation!

Name the rock. In what **depositional environment** did it form?

Identify and sketch any **fossils**. What do these fossils tell you about the depositional environment?

How does the Manashtash depositional environment compare with the Ellensburg depositional environment (stop 3 or 5) in terms of the **water energy**?

Is the **tectonic deformation** here more like the Swauk or the Ellensberg/Grande Ronde?

Continue on FR 33 (follow signs to Cle Elum). At 8.9 miles, stop at the inter-section of FR 33 and FR 133. Walk about 100 feet up the right fork in the road.

Stop 7: Cascade Basement Rocks (Jurassic/Cretaceous)

Identify the minerals present in the rock, then name the rock.

This is a **metamorphic** rock. Do you suppose that this was a low-grade (not very high temperature and pressure) form of metamorphism, or a high-grade form? How can you tell? Hint: consider how tough the major mineral would be at extremely high temperatures.

What is the **protolith** (the original rock prior to metamorphosis) of this rock and what kind of environment did the protolith come from? Hint: what's the origin of the shiny gray mineral?

By the age given above, this is the **oldest** rock in this area. Give a justification why by **just looking at the rock** you would have known that it was the oldest of the rocks seen so far.

Return to the intersection with the road to Cle Elum. Follow this road to Reservoir Canyon Road and take a right. Eventually, you will join 4th St., which will return you to Cle Elum and I-90. Take I-90 west to exit 54 (Hyak) and take a right at the end of the off-ramp. Make a right on the frontage road along the north side of the freeway and stop 0.5 miles down the road, along a large gray cliff on the left side of the road

Stop 8: Mt. Catherine Member of the Naches Formation (44 to 40 my)

What distinctive features are in the rock?

What coarse-grained **minerals** are present?

Name the **rock** and describe a possible **origin** of this rock. What type of rock is it?

Sketch the portion of the outcrop that shows that there was more than one **emplacement event** (in this case, more than one flow). What is the big vertical feature called? What relative dating principle is illustrated here?

Is there much evidence of widespread **tectonic deformation** in this formation?

The assignment

You are a curriculum developer for a local educational outreach group, such as the Pacific Science Center or the North Cascades Institute. Most of your clients are high school earth science teachers, who have taken some geology courses. Write a **two or three page "module"** for these teachers. "Module" is short for "modular lesson plan"; this particular module will assume that the teacher can lead a field trip. For your module, you will choose **one** of the following titles:

- Older or Younger? Illustrations of the Principles of Relative Dating
- Meet Three Rock Groups! (Igneous, Sedimentary, Metamorphic)
- Rolling on the River: How Ancient and Varying Water Speeds are Recorded in Rock

For any of these titles (you can modify the titles but keep the same topic!), use the following format:

The **first** paragraph should state the purpose of the module; in other words, what geological lessons are to be learned.

The **next** section of the module should lay out background information for the teacher, including technical term definitions that occur in this handout but probably won't be transmitted to the teacher's students (clearly, you are doing

this to help the teacher) and what the teacher should talk about in class *prior* to the trip. This may include having students examine rock samples, for instance.

The **next** section of the module should explain where to go to see real-life illustrations of these geological lessons (at least *three* field trip stops should be mentioned) and what should be seen at these sites. You should also include examples of "hands-on" sorts of activities the students could do at these places (for instance, breaking open one of the rocks to find a fossil), as well as questions the teacher should anticipate from the students (with answers!).

The **final** section of the module should suggest a post-field trip exercise that will reinforce the lessons taught during the field trip. This may include classifying various rocks, for instance.

Put yourself in the place of the children who will be experiencing this module. Were there any "hard" words the teacher said that you did not know what they meant? Were the differences in the rocks the teacher was pointing out obvious? The great thing about this report is that if you are a teacher or have friends who are teachers (or other educational professionals), you have a ready-made gift for them!

Please **type** or **word-process** this report (**double-spaced**) and **proofread** for the usual spelling and grammar errors. The best way to accomplish this is to have someone else read your report (the **Loft** on the second floor of the library will do this for free!). Remember, don't include field trip stops or other information which is *irrelevant* to the topic you are illustrating.

A **draft** of this report is due either by e-mail or in my mailbox in the Math/Science/Social Science division office, no later than **4:00 p.m**. on Friday, **October 26, 2007**.