Deschutes Basin Geomorphology
Applied Field Problems and Question Set

Part 1 - Paulina Lake Geomophology and Hydrology

We will be making two field stops at Paulina Lake, one on the eastern side of the lake at Little Cone Camp Ground and one on the western side where the resort access road crosses the Paulina Creek outlet (refer to base map on p. 161 of the field guide).

A. At Little Cone Campground, observe the present day lake level and compare it to the flat topographic bench upon which the campground is located. Are these two features at equal elevation or different? If different, measure/estimate the relief (in meters) between the modern lake level and the campground "bench".

B. Observe the present-day wave action of Paulina Lake, as waves approach shore. Based on your coastal experience with water waves, are they erosional or depositional in nature?

C. What type of vegetation is growing on the bench upon which the campground is located.

D. Using the surficial mapping protocol listed on p. 116 of the field, identify the landform upon which the campground is located.

E. At Paulina Lake Outlet, observe the present day lake level and compare it to the flat areas surrounding the lake shore. Are these two features at equal elevation or different?

F. What type of vegetation is growing on the flat areas surrounding the lake shore at Paulina Outlet?

G. Considering the mechanics of gravitational pull on standing bodies of water, how does the present-day lake elevation compare between that at Little Cone Campground and Paulina Outlet? Are the lake levels at equal elevation or different?

H. Compare and describe your observations of the shoreline topography between the west and east ends of Paulina lake (refer to map on p. 161 for geographic frame of reference).

I. Now relate you answer in "H" above to Figure 6 shown on p. 149 of your field guide. Given all of the data and observations, provide at least two hypotheses to explain lake and/or geologic processes that could result in the lake terrace relationships between the east and west ends of Paulina Lake.

Paulina Lake is approximately circular in outline, with an average diameter of 2.8 km and an average depth of 50 m.

J. Calculate the area of Paulina Lake in acres AND hectares. Show all math work and unit algebra.

K. Calculate the average volume of water contained in Paulina Lake in ac-ft AND m^3. Show all math work and unit algebra.

L. Using your field guide, determine the elevation of Paulina Lake outlet at the west end of the lake, where the resort road crosses Paulina Creek.

M. What is the lake level elevation, as compared to the outlet elevation?

N. Given that the average annual discharge of Paulina Creek is 18 cubic feet per second, how long would it take to totally drain Paulina Lake if all inflows were eliminated. Answer in days AND years, show all of your math work and unit algebra.

Part 2 - Paulina Falls Knickpoint Problem

Stream gradient is the measure of the amount of vertical drop per unit horizontal distance (i.e. "rise / run", as measured along a stream channel. Gradient is essentially a measure of the gravitational shear force oriented parallel to the longitudinal profile of the stream channel, i.e. the higher the gradient, the higher the shear force associated with flowing water. The power of the flowing water (energy expenditure per unit time) is directly proportional to the discharge (volume / time) and the gradient (ft/ft) of the river; the higher the discharge and gradient, the higher the stream power and energy available to do geomorphic work (erosion and transportation).

A. Figure 2 on p. 149 of the field guide is a longitudinal profile of Paulina Creek, extending from the outlet at Paulina Lake to the confluence with the Deschutes River. Calculate the average gradient of Paulina Creek between the Paulina Lake outlet and Ogden Group Camp. Answer BOTH in ft / mi and ft/ft (i.e. a dimensionless ratio of ft elevation drop divided by ft horizontal distance). Show all of your math work and unit algebra.

B. We will be visiting the overlook at Paulina Falls, hopefully you are looking at Paulina Falls presently. Geomorphically, the technical term for a water fall is "knickpoint", hence you are looking at the "Paulina Knickpoint". Using the available field tools provided by your professor and the trigonometric functions illustrated on p. 129 of the field guide, determine the height of Paulina Falls in meters. Draw a sketch of the trigonometric relations and show all of your math work, with unit algebra.

C. Using the longitudinal profile on p. 149 of the field guide, and your own direct observations, draw a scaled field sketch of Paulina Falls. Include observations on bedrock geology, channel configuration, and relief.

D. As described in 2A above, calculate the gradient of Paulina Creek at Paulina Falls, answer in ft/mi and ft/ft (dimensionless ratio). Show all of your math work, with unit algebra.

E. Based on your observations and gradient calculations along Paulina Creek, write your own definition of the term "knickpoint" as applied to stream channels. Once completed, compare your answer to the notes listed on p. 24 of your field guide.

F. Examine Fig. 6.42 on p. 101 of the field guide and relate it to Paulina Falls. Are knickpoints erosional or depositional landforms? List and briefly discuss three hypotheses as to what geologic processes or features could result in knickpoint development along a river channel. What will happen to the Paulina Falls knickpoint over time – is it mobile or stationary? How will it evolve in terms of form and position over time?

G. If you were a steelhead, salmon, or trout living in the Deschutes River basin, what would be the significance of channel knickpoints in terms of your aquatic ecosystem? How do knickpoints affect your life and the place where you live in the basin?

Part 3 – Incision Rate Problem

Two 10-m thick deposits of rounded gravels are located at points A and B on Figure 3A, p.235 of the field guide (profile showing Deschutes Geology and Topography vs. Elevation). Basaltic lava flows capping the respective gravel layers were isotopically dated at 4 m.y. old (Pliocene). Assuming that the gravels are deposits of the Deschutes River, answer the following questions:

A. What is the likely depositional origin of the rounded gravel layers?

B. What is the youngest age that can be applied to the gravel deposit, meaning how long ago was it deposited? What is your line of evidence?

C. What is the name used to define the flat surface upon which the rounded gravels are deposited.

D. Using Figure 3A on p. 235, calculate the minimum incision rate at which the Deschutes River has been down-cutting it's canyon since 4 m.y. ago. Answer in mm / t.y. and cm / t.y. (hint t.y. = "thousand years")

E. Compare your answer to published, long-term average incision rates shown on Table 1, p. 99 of the field guide.

- What are the highest average incision rates listed on p. 99 (cm / t.y.)?
- Where are the highest rates located?
- What type of bedrock (lithology) are the highest rates associated with?
- What are the lowest average incision rates listed on p. 99 (cm / t.y.)?
- Where are the lowest rates located?
- What type of bedrock (lithology) are the lowest rates associated with?
- Do all rocks and rivers erode at the same rate? Explain your answer.
- What is the total drainage area of the Deschutes River basin? (sq. km)
- What is the long-term average incision rate that you calculated in 1D above (in cm/t.y.)?
- In comparing Deschutes drainage area and average incision rate to those listed on p. 99, which locations are most similar? What is the age of the rocks at those similar locations listed on p. 99? What is the rock type at those similar locations listed on p. 99?

- Comment and discuss whether the Deschutes River is associated with average, below average, or above average incision rates compared to other published studies?

- List and discuss the variables that control the incision rate of any given drainage basin?

Part 4 - Deschutes Basin Water Budget Analysis

Refer to the location map of the Deschutes River basin on p. 232 of the field guide. The total drainage area of the basin is 27,200 sq. km. The Deschutes is climatically and physiographically divided into two distinct sub-regions, the wetter western portion comprised of the High Cascades (covering about 10% of the total basin area), and the drier eastern portion comprised of the Ochoco Mountains, Newberry Volcano, and High Lava Plains (covering about 90% of the total basin area). The western (Cascades) portion receives an annual average precipitation of 1500 mm/yr, while the eastern area receives approximately 250 mm/yr. In addition, the average annual discharge of the Deschutes River at its outlet near the Columbia River gorge is on the order of 175 m^3/sec. Your task is to conduct a cursory hydrologic analysis of the Deschutes watershed, based on the following questions:

A. Calculate the hydrologic parameters listed in the table below (show all of your math work and unit algebra):

Sub-area of western portion (sq. km) ______________ sq. m ______________

Sub-area of eastern portion (sq. km) ______________ sq. m ______________

Average annual precipitation western (in/yr) ____________

Average annual precipitation – eastern (in/yr) ___________

Average annual precipitation – western (m/yr) ___________

Average annual precipitation – eastern (m/yr) ____________

Total Precipitation Input Volume for Year – Eastern (cu. m) __________________

Total Precipitation Input Volume for Year – Western (cu. m) _________________

Total River Discharge Output Volume for Year – at Outlet (cu. m) ______________

Total Annual Precipitation Input – Total Discharge Output (cu. m) __________________

Total Annual Percent Loss of Precipitation During Drainage Process (cu. m) ___________

B. Compare the total annual precipitation input volume to the discharge output volume for the Deschutes basin. Provide a hypothesis and explanation to account for the differences.

C. Examine the stream hydrographs on Figure 6, p. 240 of the field guide. Compare the annual stream hydrograph of the North Fork of the Crooked River (east side drainage in Ochoco Mtns) to that of the Metolius River (west side drainage in Cascades).

Critical questions: are there significant seasonal discharge variations? If so, when are the "wet months", when are the "dry". Compare each river.

Now compare the Metolius and N. Fork Crooked River hydrographs to those of the main stem of the Deschutes near Madras and at Moody. Are the main-stem Deschutes hydrographs more seasonally similar to the west-side Metolius record of the east side Crooked R. record? Is the overall Deschutes more "west side" or "east side" in character?

D. Examine Figure 3 on p. 233 of the field guide, generalized geologic map of the Deschutes basin. Compare and contrast the bedrock geology from the west-Cascade side of the basin, to the east-Ochoco side. What are the primary rock types? How old are they?

E. Based on your above analysis, provide hypotheses to explain the seasonal hydrograph variations between the west and east sides, and how they compare to the main stem of the Deschutes. What geologic and climatic factors could explain the seasonal differences and/or similarities? (hint: figures on p. 241 will get you heading in the right direction).

ES458/558 River Environments – Geologic Timeline Exercise

Introduction

Studying the Earth involves systematic application of the scientific method via observation, analysis and interpretation. Characteristics of geoscience that set it apart from other physical sciences include that of large-scale (planetary) spatial dimensions and extensive amounts of "deep time". Through systematic observation of rock material over the past century, geologists have arrived at the conclusion that Earth history extends back to over 4 billion years. Whereas physicists or chemists conduct "bench-scale" experiments on time periods of seconds-minutes-hours-days-weeks; geologists commonly make observations at the planetary scale involving Earth processes that have been operating for 100's of thousands to millions of years. The large dimensions of space and time make study of the Earth the ultimate "CSI" investigation that utilizes rapidly emerging technologies such as satellite observation systems and isotopic chemistry. Hence, the science of geology involves reconstructing events that operate at slow rates over long periods of time, extending well beyond the observational lifetime of any given scientist, generations of scientists, or even life spans of species.

Throughout the "River Environments" field trip, we will be making stops that involve observation of Earth materials and landforms that have developed over 1000's to 100's of thousands to millions of years. In terms of materials, there are two broad types that occur at the Earth's surface: (1) "regolith" or "unconsolidated sediment" (any material that can be excavated with a shovel) and (2) "bedrock" ("lithified" or "indurated" brittle materials that require blasting or a hammer to break apart). Both sediment and bedrock are products of the "rock cycle" involving igneous, sedimentary, and metamorphic processes. With respect to landforms, there are also two broad categories: (1) depositional and (2) erosional. Depositional landforms result from accumulation of sediment or other mineral-based materials at the Earth's surface. Examples include wind-blown sand dunes at the beach or volcanic cinder cones from magmatic eruptions. Erosional landforms result from removal of Earth material by processes that exert force (push or pull action) at the Earth's surface. Force-based "agents of erosion" include wind (moving atmospheric gas), water (flowing rivers), ice (flowing glaciers), gravitational pull (e.g. rock fall or landslides), and/or human activity (e.g. back-hoe and dump truck). A good example of a complex erosional landform is the Grand Canyon which has been formed primarily by a combination of river erosion and mass wasting (e.g. "landsliding") over millions of years. In sum, erosion results in mass transfer of Earth materials from one place to another, deposition is the end result of transportation.

Objectives and Directions

The objective of this exercise is to place the materials and landforms that we visit at each field stop in the context of geologic time. As you will quickly observe, the landscape represents a telescoping patchwork of time recorded in the bedrock, sediment, and landforms. This is an ongoing exercise that is to be completed throughout the field trip, as we visit each field locality.

Task 1 – Identify, label, and record your location at each field stop on the base map provided on the next page.

Task 2 – Key each located field stop to the "geologic timeline" tables that follow. The tables show geologic time and the epoch name in the columns at left, with spaces to record the range of geologic events that you will observe on the field trip. For each stop, provide a location ID (keyed to the base map), the geologic events recorded at the stop, and observations pertaining to the type of geologic phenomena that records the event (i.e. bedrock, sediment deposit, or landform record). For bedrock and sediment records, make observations on composition, texture, and stratigraphic patterns. For landforms, record observations on the type of feature and whether it is the result of erosion or deposition.

You will systematically complete your timeline tables on each day of the field trip. By the end of the class, you will have a comprehensive temporal summary of geologic events that we have observed in the field. This timeline summary will help you to organize your final field trip report, and will be included as one of your final portfolio products.

Time - Years Before Present	Geologic Epoch	Field Stop / Location ID:		Field Stop / Location ID:	
		Geologic Event	Geologic Record / Observations (bedrock, sediment, and/or landform)	Geologic Event	Geologic Record / Observations (bedrock, sediment, and/or landform)
0	Today				
0-200	Historic				
200-1000	Historic - Prehistoric				
1000-5000	Late Holocene				
5000-10,000	Early Holocene				
10,000-15,000	Late Pleistocene				
15,000-20,000	Late Pleistocene				
20,000-100,000	Late Pleistocene				
100,000-200,000	Middle Pleistocene				
200,000-500,000	Middle Pleistocene				
500,000-1 m.y.	Early Pleistocene				
1 m.y. - 1.8 m.y.	Early Pleistocene				
1.8 m.y.- 5 m.y.	Pliocene				
5 m.y. - 24 m.y.	Miocene				
24 m.y.-37 m.y.	Oligocene				
37 m.y.- 57 m.y.	Eocene				
57 m.y.- 66 m.y.	Paleocene				

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ES458/558 Small Group Worksheet
Landscape Analysis Harpham Flat to Maupin City Park

You will experience the last leg of your raft excursion on the Deschutes River this afternoon, floating from Harpham Flats to Maupin City Park. The objective of this worksheet is to make observations of the river landscape around you, and place those observations in the context of rafting dynamics.

Examine the two topographic map sheets that cover the Deschutes River reach from Harpham Flat to Maupin (pages 173C and 173D). You will be floating through Wapinitia and Boxcar rapids on this stretch. Working in small groups, use the attached topographic maps and your own field observations to answer the following questions.

1. Standing at Harpam Flats, make landscape observations, before boarding the rafts:
    a. In which direction is the Deschutes River flowing?

    b. Do you see layers of bedrock exposed on the hillslopes of the canyon walls, look both to river left (west) and river right (east).

    c. Are the hillslopes on river left and river right equally as steep? Are they equally as high from the valley floor to the observable canyon rim? Which side would be easier to hike up to the canyon rim?

    d. Is there abundantly thick soil and vegetative cover on the hillslopes? Or are they sparse and thin?

    e. What is your general sense of the climate in this region? Dry or wet? What are your indicators?

    f. What type of earth material are you standing on at Harpam Flats: hard bedrock or loose unconsolidated sediment? If the latter, what is the dominant size: sand? Pebbles? Cobbles? Boulders?

    g. How wide is the valley-bottom of the Deschutes River in this area? Greater than 1 mi? Between 2000 and 3000 feet? Between 1000 and 2000 feet? Less than 1000 feet?

    h. How deep is the river channel? Which of the following best describes the river hydraulics you observe: highly turbulent white water, flat “lake water”, swiftly flowing pools and riffles?

    i. What is the flow volume (i.e. “Discharge”) of the Deschutes like today? Almost dry? Low? Medium? High? Flood stage?

   j. What is the water temperature like today? Hot tub? Warm? Cold and refreshing?\

   k. It is now late July in central Oregon, the dry fire season. Given this fact and your answers in 1e, 1i, and 1j above, does the river discharge seem like it matches what you might expect given the climate and season in central Oregon? Explain your reasoning.

2. Floating through Wapinitia and Boxcar rapids:

   a. Note the hillslopes on river left and river right. Do you see traceable layers of bedrock exposed on the hillslopes of the canyon walls on each side? If not what type of material do you see?

   b. Looking at the topographic map, what do you observe about the contour line patterns and river left? Even and parallel or wavy and irregular?

   c. Are the hillslopes on river left and river right equally as steep? Are they equally as high from the valley floor to the observable canyon rim? Which side would be easier to hike up to the canyon rim?

   d. When floating through the rapids, what types of physical barriers caused the whitewater turbulence that you experienced? Rock-layer water falls? Large boulders? Large log jams?

   e. Which of the following best describes the river hydraulics you observe: highly turbulent white water, flat “lake water”, swiftly flowing pools and riffles?

3. Floating from Boxcar back to Maupin City Park:

   a. Note the hillslopes on river left and river right. Do you see traceable layers of bedrock exposed on the hillslopes of the canyon walls on each side? If not what type of material do you see?

   b. Looking at the topographic map, what do you observe about the contour line patterns and river left? Even and parallel or wavy and irregular?

   c. Are the hillslopes on river left and river right equally as steep? Are they equally as high from the valley floor to the observable canyon rim? Which side would be easier to hike up to the canyon rim?

   d. How deep is the river in this stretch? Which of the following best describes the river hydraulics you observe: highly turbulent white water, flat “lake water”, swiftly flowing pools and riffles?

4. Based on your observations above, write a two-paragraph summary hypothesizing what geologic materials and processes are controlling the hillslope morphology on this river stretch, and what processes have resulted in the creation of Boxcar and Wapanitia rapids.