Geology 350

LAB 4: FIELD TRIP TO McKINLEYVILLE – TRINIDAD AREA

OBJECTIVES:

a. to look at geomorphic and geologic evidence for large scale thrust-faulting of young sediments in the Humboldt Bay region
b. to look at topographic and geologic evidence for uplifted marine terraces in the McKinleyville-Trinidad area
c. to use soils and topography to determine the relative ages of uplifted terraces
d. to use geomorphic techniques to assess the seismic hazard of a major thrust fault

MATERIALS:

soft dark (2H) pencil
eraser
field notebook
colored pencils (red,blue, green, yellow)

MAPS:

xerox maps of McKinleyville-Trinidad area
Crannell 7.5' quad
Trinidad 7.5" quad

ROAD LOG AND FIELD TRIP GUIDE

1. **Mad River Fault Zone:** Proceed north on Highway 101 from HSU; follow along on Map #1 when we get onto it near the Mad River bridge. As we approach the Mad River, note the steep hillslope forming the north margin of the valley. This slope is cut by a series of thrust faults which dip about 30° to the north. These faults, which continue inland to the SE for at least 50 km, are part of the Mad River Fault Zone (MRFZ). The MRFZ is about 15 km wide and contains five principal thrusts (Trinidad, Blue Lake, McKinleyville, Mad River, and Fickle Hill faults) and three folds (the Fickle Hill and Blue Lake anticlines, and the Jacoby Creek syncline).

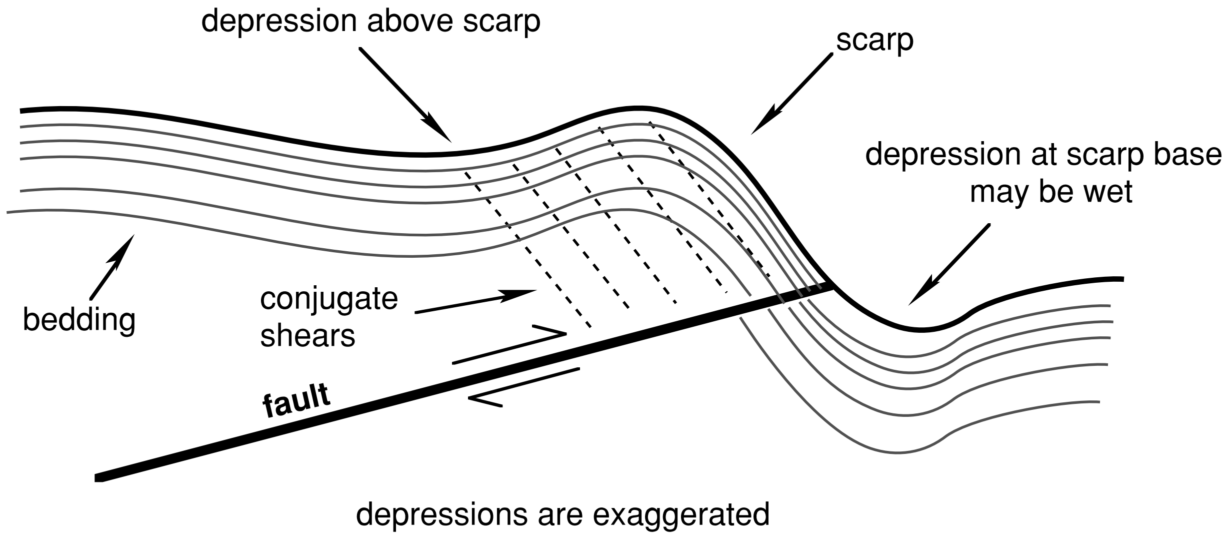
   When Highway 101 turns NW after crossing the Mad River, we will be roughly paralleling the fault scarp. The faults cross the highway just north of School Road. As we travel from Mad River to School Road, try to pick out these linear features--they form NW-SE trending steps which range in height from 3-15 meters.

2. **Stop 1: School Road Fault**

   a. Locate yourself on the map; then look around and try to pick out the scarps. The School Road fault consists of two main traces here, one above the other. The yellow house to the NE sits at the top of the uppermost scarp. The Baptist church is near the base of the lowermost scarp. Do your best to draw in the fault traces on the topographic map. Each fault should be a line running along the base of its scarp.

      The flat surface that is offset here is part of the 83,000 year-old Savage Creek terrace, the lowest marine terrace in this area. Across the highway, the faults flatten out and become nearly horizontal; hence they do not form obvious scarps.

   b. The topographic expression of thrust fault scarps in this region is very distinctive. A broad depression typically occurs in the flat just above the scarp, and a sharper depression occurs below the scarp base. This basal depression is commonly wet, and may contain ponds or hydrophilic vegetation. The diagram on the next page shows these features schematically.



c. As we proceed north on Highway 101, we cross another fault along the N side of Widow White Creek. If you look east just before reaching the Airport turnoff, you can see the scarp of the McKinleyville fault forming a rise behind the daffodil fields. We will turn off and stop before we reach the airport.

2. **Stop 2: McKinleyville Fault (Airport Road)**
   a. Locate yourself. The linear feature running NW-SE here is the scarp of the McKinleyville fault., one of the five major thrusts in the Mad River Fault Zone. It offsets the 83,000 year-old Savage Creek terrace. At the airport, the fault includes two main traces defined as scarps and sharp warps of the terrace. To the east, these traces converge to form a single steeper scarp.
   b. To the best of your ability, draw in the trace of the McKinleyville fault on your map. Extend it as far as you can see it.
   c. As we proceed east along Airport Road to Central Ave., much of the way we will be running along the top edge of the fault scarp.

3. **Stop 3: McKinleyville Fault (Central Ave.)**
   a. The hill that Central Ave. climbs to the north is the scarp of the McKinleyville Fault. If you look east along Norton Ave., you can see where it climbs up the scarp face also. Draw in the fault trace on your map.
   b. From this point, use topography to trace the McKinleyville fault SE on the map as far as you can recognize it.

4. **Central Ave En Route to Highway 101**
   a. As we go north on Central Ave., note the dip in the highway behind the crest of the scarp; this is an example of the broad sag typically found behind the scarp.
   b. Look west, and note the gentle warps of the terrace near the airport. Small fault scarps run right next to the terminal.
   c. As we cross Dows Prairie, look for fault scarps east of Central Ave.
   d. As the road dips down into the valley of Strawberry Creek, we run along another fault scarp. Sandy rocks cropping out in roadcuts here are the Crannell sands, marine sediments about 400,000? years old. The much younger McKinleyville Terrace is bevelled across them.

5. **Highway 101 En Route to Trinidad**
   a. As we head north along Highway 101 toward Little River, the Savage Creek terrace lies at the top of the abandoned sea cliff to our right. Note the great width of Clam Beach on the left. It is a late Holocene marine terrace, which has been uplifted by several meters over the last 1200 years. This uplift probably occurred in association with large earthquakes on the Little Salmon Fault south of Eureka.
   b. The valley of Little River probably has a thrust fault along the northern side.
   c. As we travel from Moonstone north to Trinidad, note the ups and downs of the highway. Some of these are associated with stream valleys that the road crosses, but others are due either to faulting, or to climbing (or dropping) from one marine terrace to the next.

6. **En Route Trinidad to Elk Head**
   a. As we proceed north along Patricks Point Road from Trinidad to Anderson Road, we are travelling on the surface of the 63,000 year-old Patricks Point Terrace.
   b. As we go west along Anderson Road, note the gentle dip in the road midway between Patricks Point Road and Stagecoach Road. You have just crossed the scarp of a major thrust, the Trinidad Fault. The scarp is not very high here because the dip of the fault is low. The scarp can barely be glimpsed through the trees to south just before we reach Stagecoach Road. From here the scarp runs to the northwest, roughly paralleling Stagecoach Road. (It lies a couple of hundred feet east of the road.) The fault forms a 60 ft high scarp on Anderson Ranch, and offset sands are evident in the sea cliff there.
   c. On the topographic map note the abrupt hill just east of Stagecoach Road. This is an old sea stack--further evidence that we are on an uplifted marine terrace.

7. **Stop 4: Elk Head**
   a. At this stop we are on the 63,000 year-old Patricks Point terrace. Look SW toward Omenoku Point.

      Starting at sea level, the lowest rocks exposed are greenstones and greywacke of the late Jurassic-Cretaceous Franciscan Formation. These are old deep-sea/trench rocks, welded to the continent by subduction and subsequently uplifted. An old (circa 400,000?yr) abrasion platform is cut across them. Sitting on this platform are the mid-Pleistocene Elk Head sands (probably equivalent to the Crannell and Moonstone sands.) Based on one fossil date, the base of these sands is >370,000 yr. An abrasion platform was later developed on these older sands, and the sands of the Patricks Point terrace were deposited across them. The contact between these two units can be seen a few meters below the top of the cliff. The terrace has subsequently been uplifted, and the prominent brownish soil has developed on it.
   b. Drop over the cliff edge using the trail at the north end and look carefully at the exposure of soil at the cliff-top.

      Make a sketch of the soil profile, and on it describe the soil as well as you can -- texture, color, thickness, structure at different depths (see hints below).

      To determine soil texture, examine it with a hand lens. Then wet it and roll it in your fingers. Is it sandy feeling? Finely gritty (silty)? Smooth and/or sticky (clayey)? Do this at various depths, wherever you see a change.

      Be sure to record the colors of the soil at different depths, and of the sandy parent beneath it.
   c. The dark brown soil in the cliff-top is probably a relatively recent soil with a strong aeolian (wind-blown) component. Note its "fluffy" silty texture -- this is typical of aeolian soils. According to Bud Burke, this material overlies the truncated B-horizon of a soil developed on the Patricks Point Terrace.

8. **En Route to Fox Farm Road**
   a. We cross the trace of the Trinidad fault when we go under the freeway at Trinidad and head uphill.
   b. As we climb uphill, we leave the Trinidad (Patricks Point) terrace and move up onto the Savage Creek terrace. The Savage Creek terrace is not very wide here, and not too obvious. As we head south, we later drop back down onto the Trinidad terrace.

9. **Fox Farm Road**
   Fox Farm Road provides a transect up the flight of raised terraces on the flank of the Trinidad Anticline. At least 12 terraces are preserved on the flank of the anticline, the highest standing about 350 m above present sea level.
   a. The road climbs quickly uphill from the Trinidad terrace onto the Savage Creek terrace.
   b. Further uphill, the road flattens out onto the Westhaven terrace, then climbs again onto the Fox Farm terrace.
   c. Continuing uphill, we ascend to the higher, much wider Sky Horse terrace.

10. **Stop 5: Sky Horse Terrace**
   The Sky Horse terrace is probably about 133,000 years old. It is the most prominent high terrace on the Trinidad anticline.
   a. Locate yourself on the map. Then walk slowly downhill, looking carefully at the soils exposed in the roadcut. **WATCH FOR CARS--THIS IS A DANGEROUS SPOT!**
   b. Make a sketch of the soil profile, and on it describe the soil as well as you can -- texture, color, thickness, structure at different depths. In what ways does this soil differ from the one you saw at Elk Head? What soil characteristics suggest that the Sky Horse terrace soil is older?
   c. Look at the map and draw the approximate back and front edges of the Sky Horse and Westhaven terraces. What criteria can you use to distinguish them topographically? (i.e., how does their topography differ?) What does this say about their relative ages? How does this tie in with what we've seen in the roadcuts, that is, do the map and roadcut inferences support each other?

LAB EXERCISE TO ACCOMPANY FIELD TRIP

please put answers on the accompanying answer sheet

I. ASSESSING RATES OF UPLIFT AND LOCAL DEFORMATION

You will need a copy of the Trinidad and Crannell 7.5' quads for this exercise

Accompanying this exercise is a composite topographic cross section constructed from the Crannell and Trinidad 7.5' quadrangles. The lower part of the cross-section (A-A') runs along a line extending NE from the coast near the east boundary of the Trinidad Indian Reservation (Trinidad quad) through the corner of sections 17, 18, 19, and 20 to the corner of sections 8, 9, 16, and 17 on the Crannell quad. This part of the cross-section stops at the 1000 ft contour. The higher part of the cross-section (B-B') was constructed along a line extending from the 1400 ft contour on the middle of the hilltop between stations "Maple" and "Stump" (in Sec 7 and 8 on the Crannell quad), down through "Stump" to the 1000 ft contour.

The vertical scale on the cross-section is 1"=400 ft, so it has 5X vertical exaggeration.

Six different terraces have been given names in the Trinidad-Patricks Point area. They are, in order from lowest to highest: Patricks Point (Trinidad), Savage Creek, Westhaven, Sky Horse, A-Line, and Maple Stump terraces.

a. **Terrace recognition:** How many terraces can you recognize in the cross section? Label them with the appropriate names. Note: the Savage Creek terrace is absent in this cross-section.

b. **Terrace elevations:** From the cross-section, determine the elevations of the front and back edges of each terrace flat. Give the elevations in both feet and meters.

c. **Spatial consistency of uplift:** Using these elevations as a guide, try to trace the terraces north and south from the cross-section. Do the terraces stay at the same elevation, or have they been deformed? Based on the map, has the rate of uplift been constant over the Trinidad-Patricks Point area, or have some areas been uplifted more than others? Cite specific evidence for your conclusions.

d. **Terrace uplift rates:** Compute the rate of uplift in mm/yr and m/1000 yr for the Patricks Point and Sky Horse terraces. Use 83,000 yr for the age of the Patricks Point surface and 133,000 yr for the Sky Horse surface. *Assume* that when the terraces formed sea level was approximately where it is today. How consistent are the two rates?

e. **Estimated terrace age:** Assuming a constant rate of uplift, what would the age of the Maple Stump terrace be?

f. **Assumptions about uplift rates:** What do you think of the assumption that rate of uplift has been constant with time? What sort of evidence would you need in the field to assess this assumption? Is there any evidence from the map that might support or refute the assumption?

g. **Validity of uplift rates:** How valid or meaningful do you think these uplift rates are? What problems do you see in determining them? Are there possible errors in our assumptions?

II. ANALYSIS OF TECTONICS AND SEISMIC HAZARD OF THE MCKINLEYVILLE FAULT

a. **Elevations of terrace:** Determine the *average elevation* of the Savage Creek terrace in the vicinity of the airport in both feet and meters:

   i. on the upper plate of the fault (above the scarp)
   ii. below the fault scarp

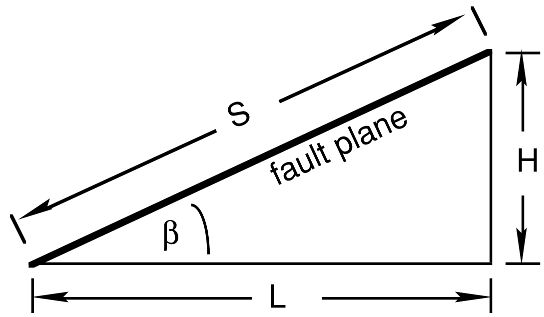
b. **Terrace uplift rates:** If we assume that the Savage Creek terrace is 83,000 yr old, *and* that when it formed sea level was approximately where it is today, what is the uplift rate in mm/yr and meters/1000 yr:

   i. above the fault (i.e., with the fault present)
   ii. below the fault scarp (i.e., with the fault absent)

c. **Vertical offset on fault:** From your measurements on the map, how much *vertical* offset has occurred along the fault where it crosses Central Ave (Redwood Highway on the map)?

d. **Total slip on fault:** Trenches dug across the fault west of the airport show that the fault plane dips NE at 17° to 25°. If the fault dips NE at 25°, how much *slip (offset) along the fault plane* must have occurred to yield a scarp as high as the one that we observed on Central Ave?

The diagram below shows how to determine the slip (S) on the fault:



$$\sin\beta = \frac{H}{S}$$

e. **Mean slip rate:** Using this offset and the age of the terrace, calculate the mean *slip rate* on the fault in mm/yr and m/1000 yr.

f. **Fault trace length:** Use your mapping of the McKinleyville fault to determine the minimum probable length of surface expression of the fault in feet and km The fault starts at the coast and runs SE. You will have to decide where you think the fault trace ends. (Note: this is a minimum length because the fault *does* extend offshore; however, we cannot determine its length there.)

g. **Magnitudes of probable earthquakes:** *Assume* that if an earthquake occurs on the McKinleyville fault, that rupture will take place along the entire length of the fault. Use lines BB' and EE' in the graph of magnitude vs. rupture length to determine the *most probable* and *maximum probable* magnitudes associated with such an earthquake. (Note: the data in the graph is for strike-slip faults; it is possible that the same relation does not hold for thrust faults. However, it's all we've got, so we will use it as a first approximation.)

h. **Probable slip:** Use the magnitude-displacement graph to estimate the probable amount of slip (in meters) on the fault that would be associated with each of these earthquakes.

i. **Number of earthquakes:** Use the total slip (from part d) together with the probable slip per event (from part h) to estimate the *number* of earthquakes of each magnitude that would have been needed to give the observed slip.

j. **Earthquake recurrence intervals:** Use your estimates of the number of earthquakes together with the 83,000 yr age of the terrace to calculate the likely recurrence intervals for the most probable and maximum probable earthquakes.

k. **Assumptions:** List the essential *assumptions*, both explicit and implicit, that were made in steps f through j. Which assumptions do you think are most risky? Which are most solid?

Name: ________________

LAB 4 ANSWER SHEET

I. ASSESSING RATES OF UPLIFT AND LOCAL DEFORMATION

a. (3) Number of terraces recognized in cross-section: ________

(5) Attach cross-section with labeled terraces

b. (12) Elevations of front and back edges of terraces, from cross-section and maps near line of cross-section:

terrace	front edge		back edge	
	ft	m	ft	m
Maple Stump	________	________	________	________
A-Line	________	________	________	________
Sky Horse	________	________	________	________
Westhaven	________	________	________	________
Savage Creek	________	________	________	________
Patricks Point	________	________	________	________

c. (5) Discussion of spatial consistency of uplift, citing map evidence:

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____
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____

d. (10) Uplift rates for Patricks Point and Sky Horse terraces (show calculations on back of page):

Patricks Point: _______ mm/yr __________ m/1000 yr

Sky Horse: ________ mm/yr __________ m/1000 yr

Discussion of consistency of rates:

____
____
____

e. (2) Estimated age of Maple Stump terrace (show calculations on back of page)

Maple Stump age: _____________ yr

f. (8) Critical assessment of assumptions about uplift rates, and appropriate evidence:

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g. (7) Assessment of validity of uplift rate calculations and possible errors:

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II. ANALYSIS OF TECTONICS AND SEISMIC HAZARD OF THE MCKINLEYVILLE FAULT

a. (4) Mean elevation of Savage Creek Terrace near airport

upper plate: ____________ ft __________ m

lower plate: ____________ ft __________ m

b. (4) Terrace uplift rates (show calculations on back of page)

above fault: ____________ mm/yr ______ m/1000 yr

below fault: ____________ mm/yr ______ m/1000 yr

c. (4) Vertical offset on fault: ___________ ft ___________ m

d. (5) Total slip on fault: _____________ m (show calculations on back of page)

e. (4) Mean slip rate: _____________ mm/yr ___________ m/1000 yr

f. (5) Length of fault trace: ____________ feet ___________ km g-j. (24) Fill in table below

	most probable earthquake	maximum probable earthquake
earthquake magnitude		
probable slip, m		
number of earthquakes		
recurrence interval, yr		

k. (10) Listing and critical assessment of assumptions made in the above procedures:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________