DATING MASS WASTING WITHIN THE SWAUK WATERSHED, WASHINGTON

By

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Abstract

The ultimate goal of this project was to gather 6 sediment samples that contained enough organic matter for a ^{14}C date. Dr. Lillquist had previously relative age dated all of the mass wasting features throughout the Swauk Watershed. Getting 14C dates of selected mass wasting features throughout the Swauk Watershed would allow us to compare the relative age dated features that Dr. Lillquist (2002) had assigned to each mass wasting feature with the more accurate scientific meathods of ^{14}C dating.

Of the 6 samples used for dating, one was a tephra (site #4) that was sent to Washington State University for Electron Microbeam Analysis. This gave us a minimum age for mass wasting feature #151. Sediment sample #'s 1,2,3,5 and 6 all contained enough organics for ^{14}C dates at Beta Analytic. Sample #1, mass wasting feature #170 was the only ^{14}C date that was consistant with the relative age dates assigned by Dr. lillquist (2002). Sample #'s 2,3,and 5 were inconsistant with Dr. Lillquists (2002) relative age dates but were within 900 years which is still fairly accurate. Sample #6, from mass wasting feature #476 had a large descrepancy in the relative age date (Lillquist,2002) and the ^{14}C date. Since all the other comparisons of the other 4 ^{14}C were fairly accurate I attribute this difference to contamination of the sag pond due to newer sediments being washed down the slope into the sag pond over the years.

Overall our objectives of retrieving 6 samples to be scientifically dated so that we could compare them to the relative age dates (Lillquist) so that we could see how accurate the relative dates were have been met. The relative dates seem to be accurate throughout the watershed.

Introduction

This project was conducted in conjunction with Dr. Karl Lillquist, geography professor at Central Washington University. The project commenced in October of 2000 and consisted of examining and dating the mass wasting features within the Swauk Watershed (Figure 1) of Central Washington. Dating these features, which cover approximately 38% of the area has proven difficult in the past (Lillquist, 2002). A relative age has been assigned to each mass wasting feature, but we did not know how accurate these dates were.

The purpose of the research was to date six landslides, chosen by Dr. Lillquist, to serve as a model for dating the mass wasting features throughout the entire watershed. Sampling involved the retrieval of sediment samples that contained organic matter and tephra, from sag ponds, for radio carbon dating. The purpose of sampling was to date selected slides from each of the various mass wasting categories and compare them to the already assigned relative age dated landslide features in Lillquist (2002). The secondary purpose was to find the best and most accurate techniques and procedures that can be used in the future to typify all the mass wasting features within a single watershed by using a selected sample.

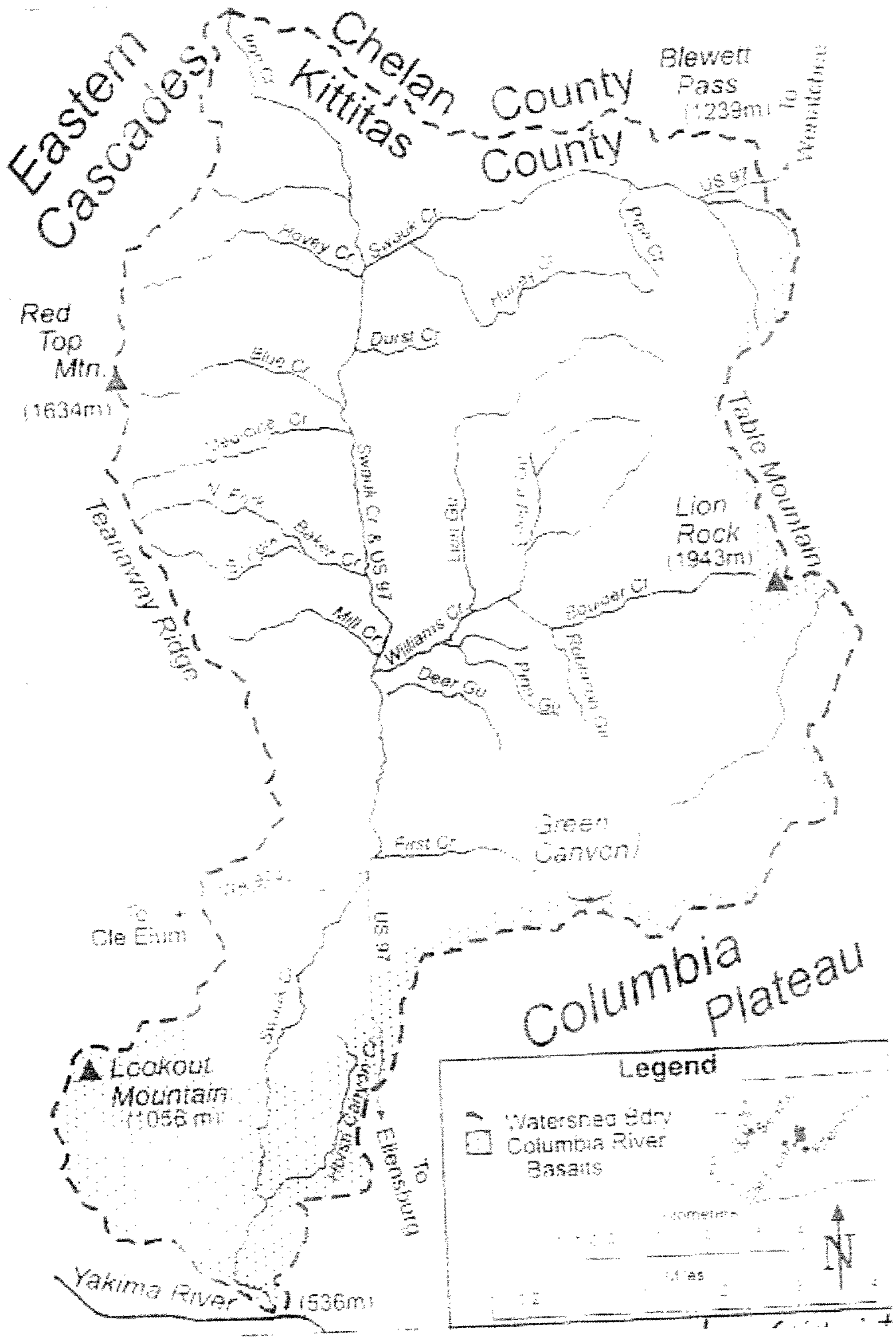
With a detailed analysis of all the temporal data that had been collected, one is now able to define the chronological order of mass wasting events in the Swauk Watershed. The Swauk Watershed temporal data tells more about the processes and factors that may have influenced these events. This same information will also be available to assist other interested parties with their research. When this project is complete, scientists will have access to the results of this study and hopefully the information contained within will assist them when conducting their own research projects either within the Swauk Watershed or outside of it. This report can assist other research projects by means of explaining how to conduct a reasearch project or the data itself will be useful to these scientists.

Study Area

Location

The Swauk Watershed is a part of the Yakima River Watershed, located in north central Kittitas County in central Washington. The study area is approximately two and a half hours east of Seattle, one hour north-northwest of Yakima and ten minutes northwest of Ellensburg (Figure 1). The western border of our study area lies within the eastern portion of the Cascade Range and the northern section is within the southern part of the Wenatchee Range. The watershed is a 250km^2, teardrop shaped polygon and ranges in elevation from 1634m at Red Top Mountain to 1943m at Lion Rock. The lowest elevation in the watershed is at the confluence of Swauk Creek and the Yakima River, which is at an elevation of 536m (Lillquist,2002).

Lion Rock is located at the western edge of the watershed while Red Top Mountain is located in the northwest part of the watershed. Bordering the eastern boundary of the watershed is Table Mountain. The Kittitas-Chelan county border defines the northern border of the watershed while the Yakima River outlines the south and southwest border of the watershed (Cle Elum ranger District, 1997). The



Swauk Watershed, Washington (Lillquist,2002) Figure 1

Swauk Watershed is a part of six different United States Geological Survey (USGS) Quadrangles (Figure 2).

Climate

The paleoenvironment has been classified in three general periods: The Anathermal, a post-glacial climate, cooler and moister than present; the Altithermal, a much warmer and dryer climate of extreme proportions; and the Midthermal, when conditions were cooler and moister (Bundy,1998).

The modern climate for the lower elevations can be given a general description as generally arid to semiarid with low precipitation, hot and dry summers, and cold winters (Bundy,1998). The past cool and moist climatic conditions are a large factor in the current state of mass wasting within the Swauk Watershed. Moisture, through saturation, erosion and movement of sediment contribute greatly to mass wasting. Cooler conditions of the past also are a major contributor to mass wasting. Freeze-thaw and moist conditions combined are ideal conditions for processes of mass wasting.

Vegetation

Between the highest points in the watershed at Lion Rock down to the lowest point at the confluence of the Swauk Creek and the Yakima River exists five different vegetation zones. The lower elevations are shrub steppe (*Artemesia tridentata/Agropyan)*, Ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menseizii*), grand fir (*Abis grandis*) and at the highest elevations are the subalpine fir (*Abis lasiocar*) (Franklin and Dyrness, 1973; Schneider, 1971).

The 6 USGS Quadrangles that contain the Swauk Watershed

Red Top Mountain USGS Quadrangle	Liberty USGS Quadrangle	Blewett Pass USGS Quadrangle
Teanaway USGS Quadrangles	Swauk Prairie USGS Quadrangle	Reecer Canyon USGS Quadrangle

Fig 2

Geology

During the Tertiary Period the two main geologic groups within the Swauk Watershed were formed. The youngest were formed during the Quaternary are the Columbia River Basalts, which are believed to have covered much, if not all, of the watershed at one time, is one of these geologic features. Due to mass wasting over a period of tens of thousands of years, the Columbia River Basalts are now located mainly in the eastern portion of the watershed. Table Mountain now represents the western edge of these basalt flows (Cle Elum Ranger District, 1997).

The Swauk Formation, which formed during the Tertiary, represents the oldest geologic group that helps to comprise the Swauk watershed.

The central and the eastern parts of the watershed are made up of mainly sedimentary Swauk rocks which are a part of the Swauk Formation. The Swauk Formation which is composed of folded inter-bedded relatively fine grained, weakly cemented sandstone with some shale beds (Cle Elum Ranger District, 1997). The landslides of this area more than likely began at the outer edges of the basalt flows and through headward erosion worked their way inwards. This was made easier by the probable percolation of water into the weakly cemented sedimentary flows of the Swauk Formation. As the water accumulated, large slip planes developed within the interbed and the Swauk Formation and the results were landslides (Cle Elum Ranger District, 1997).

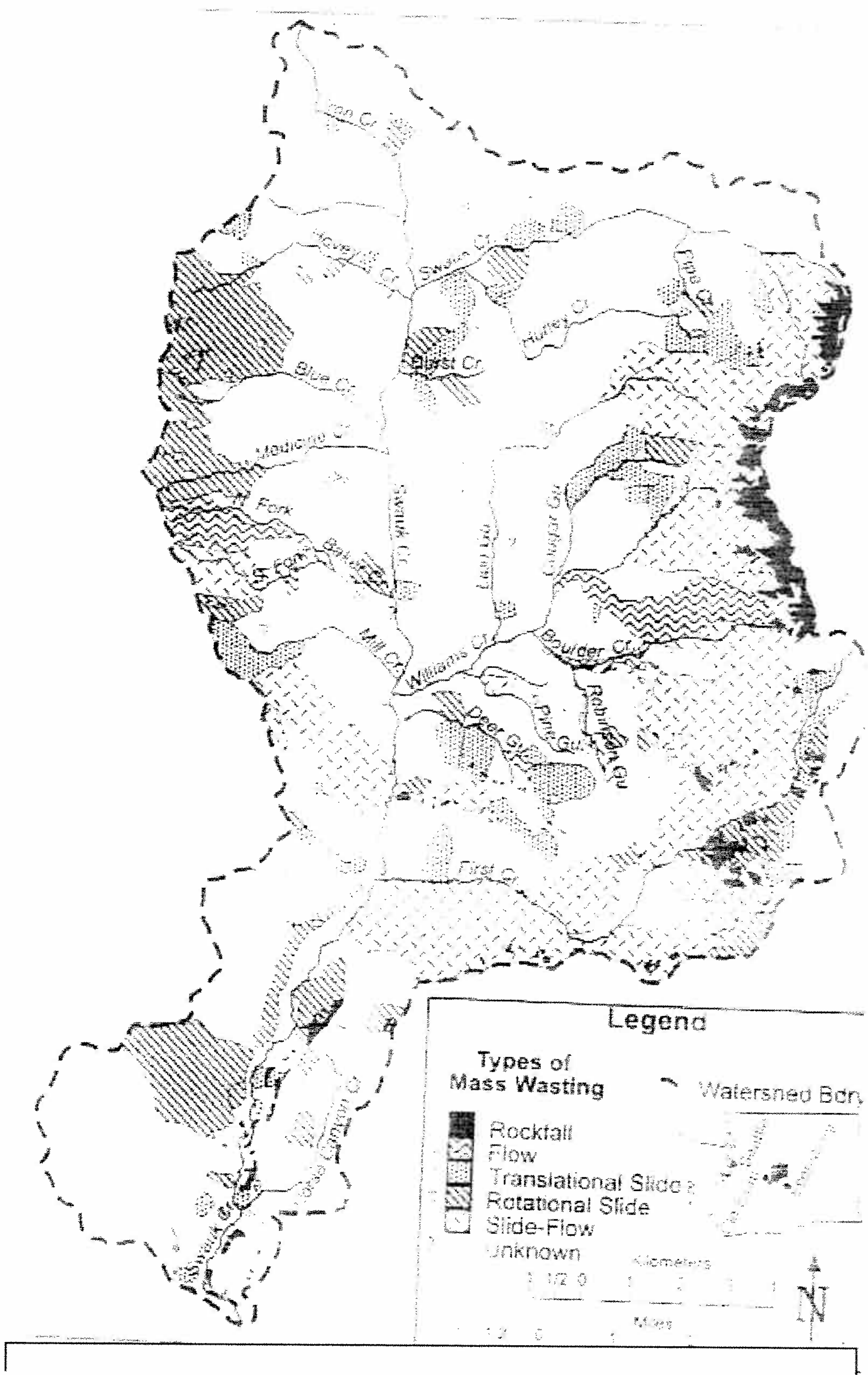
Land Use

A wide variety of land use exists within the Swauk watershed. Mining, particularly placer mining, has played a large role in the development and the destruction of the watershed. Gold was discovered in 1868 along Swauk Creek including wire gold, a rarer form and therefore more valuable than placer mining (Cle Elum Ranger District, 1997). Other forms of resource extraction include, but are not limited to, silver mining, coal mining, the mining of natural gas, and the harvesting of timber. Approximately 60% of the entire watershed is covered with timber.

The building of railroads and roads, recreation, grazing, ranching and farming have also contributed to the development and the processes of mass wasting. The price of these "modern" achievements is destruction to the landscape. Mining, harvesting of timber, grazing of livestock, railroad and road building which often undercuts slopes, and recreation all contribute to the process of mass wasting.

Methods

Lillquist (2002) had previously identified and mapped all of the landslides within the watershed (figure 3). He then attempted to identify the types of mass wasting. This was accomplished with the assistance of Cruden and Varnes (1996) categories for slides. Each slide was placed into a category of a fall, a rotational slide, a translational slide, a flow, or a complex slide flow. Lillquist also made an effort to differentiate between the composition of the different mass wasting features and each was placed into a category rock fall, debris (mostly course



Types of mass wasting features
Swauk Watershed, Washington (Lillquist, 2002)

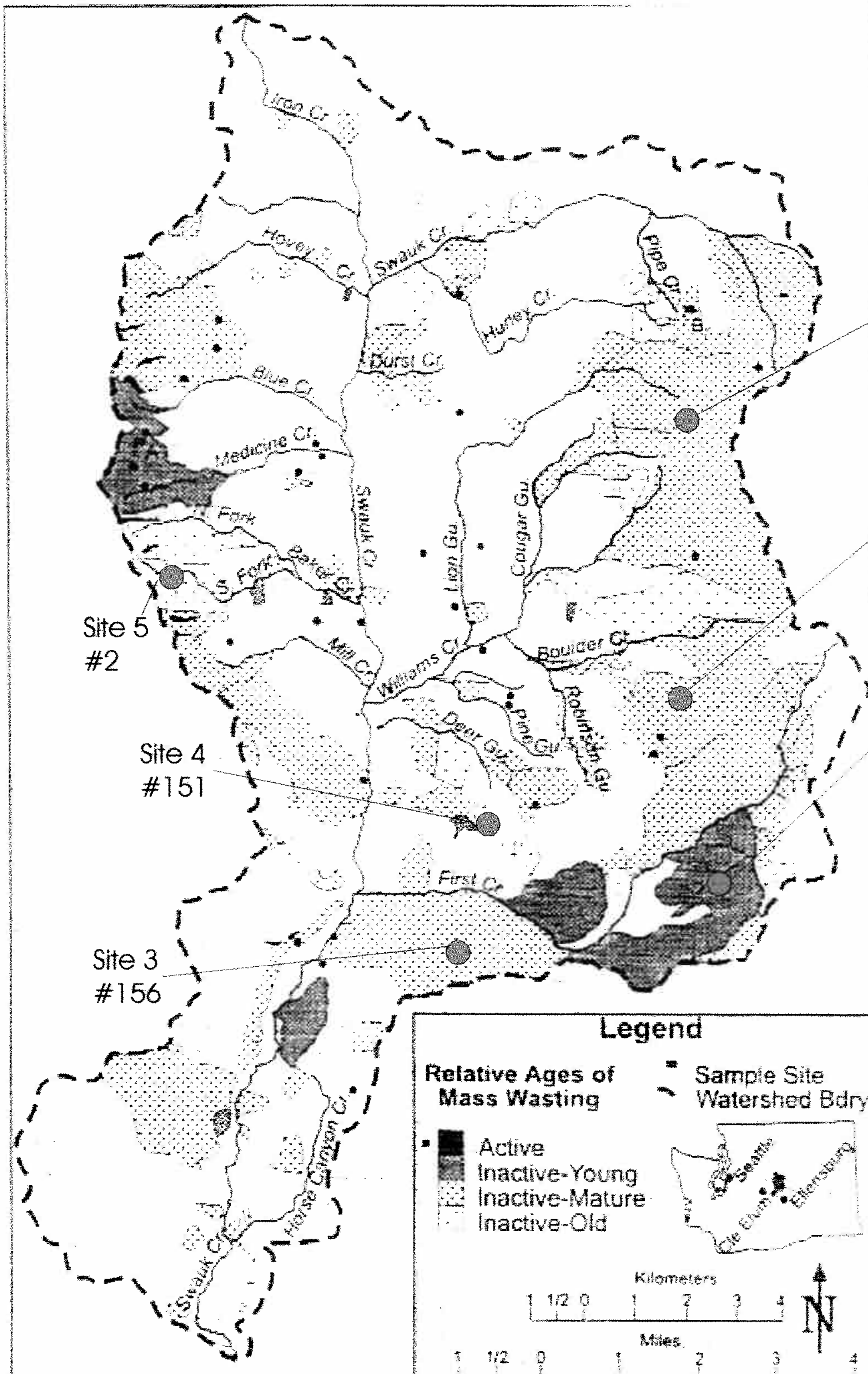
Fig 3

sediment), or earth (mostly fine sediment) (Cruden and Varnes 1996)(figure3). After full assessment of the main scarps, lateral flanks, internal morphology, vegetation cover and toe relationships, Lillquist (2002) then assigned a relative age to each of the slides (figure 4). Each slide was assigned to one of four age categories; active, <100 years, inactive young, between 100-5,000 years, inactive mature, between 5,000-10,000 years, inactive old, >10,000 years (Table 1).

In this study, every effort was made to get sediment samples from each relative age category of mass wasting feature evenly distributed throughout the Swauk Watershed. Younger slides are easier to identify, and easier to collect sediment samples. Locating sag ponds on the older slides was more difficult than locating them on the younger slides due to dense vegetation growth and erosion of the original slide features. I used 1992, 1:16000 United States Forest Service airphotos and 1984, 1:12000 Washington Department of Natural Resources natural color photos along with six USGS Quadrangles (Liberty, Blewitt Pass, Reecer Canyon, Swauk Prairie, Teanaway, and Red Top Mountain)(figure2) to identify and locate landslides. For the geologic data, the USGS 1:100000 Geologic Map of the Wenatchee Quadrangle were used to become familiar with the geology of the area.

The airphotos were used to locate sag ponds and hummocky terrain. The sag ponds show up as small open meadows, usually with dense plant life, in the middle of the hummocky, wooded landscape. The USGS quadrangles were helpful when determining which airphotos to use to optimize the chances of locating a sag pond.

Once located in the air photos, sag ponds were investigated in the field. We



Sites of sediment samples used for 14C dating
Swauk Watershed, Washington (Lillquist, 2002)

Fig 4

identified what we thought was the deepest part of each sag pond. Using a 11/8 AMS soil probe with extensions we retrieved cores from as deep as possible to get the oldest datable sediments. We often cored 2 or more cores to ensure we recovered enough organics that were datable. Equipment used included coring equipment, Munsel color chart, shovels and field guides. Coring gave deeper samples than hand dug soil pits and was less time consuming. Deeper cores, up to 18 feet deep, from within the slides gave a more accurate date of the slide.

These cores provided the first four samples. Sediment samples came from as close to the base of the core as possible.

The radiocarbon dating services of Beta Analytic of Miami, Florida were utilized to date the organic rich samples. Each sediment sample was processed and dated through a standard dating process or through an AMS dating process. The process used to date each sediment sample depended on the quanity of carbon each sediment sample contained. Standard Service is for samples containing at least 1.0 to 4.0 grams of final carbon (carbon remaining after all necessary pretreatments and chemical syntheses have been performed). Much less material is necessary for AMS analysis. The AMS technique is uniquely suited for small samples containing 0.00025 to 0.3 grams of final carbon (Beta Analytic). The tephra sample, from site number four, was sent to Washington State University for Electron Microbeam Analysis. This information tells when and where this sample originated, giving us a minimum age for this particular mass wasting feature.

I described the color and texture of each layer in each core using a Munsel color chart and a texture chart.

Results and Discussion

I dated six mass wasting features in the Swauk Watershed. The sites of the mass wasting features and the results of the mass wasting features are discussed below.

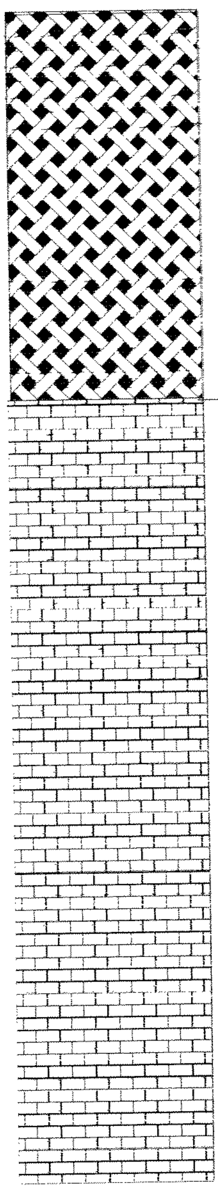
Site 1

Three sediment samples from mass wasting feature #170, an inactive young rotaional slide from the First Creek drainage was examined on October 24th, 2000. Of the 3 samples collected, it was determined that sample #2, a core that was 335 cm deep, had the largest amount of organics for ^{14}C dating. The organics used for ^{14}C dating came from an inorganic layer with a color of 10 YR 3/2, (Very Dark Grayish Brown) and the texture was loamy sand. Through AMS ^{14}C, (Beta #153220) dating methods at Beta Analytic, it was determined that mass wasting feature #170 is 4550+/-50 BP. The relative age assigned to this feature was as an inactive young slide which is between 100-5000 BP (Lillquist,2002). The relative age assigned to this slide is consistent with the ^{14}C date of this slide (fig 5).

The objective of this research project is to retrieve sediment samples from every age classification of mass wasting feature, inactive young, inactive mature, and inactive old. This project relied on Dr. Lillquists (2002) relative age dating of mass wasting features as it was the map used when deciding which age categorie and location of each mass wasting feature to retrieve sediment samples from.

The objective of retrieving a ^{14}C date from an inactive young slide, 167, was achieved.

Landslide # 170 First Creek Drainage
UTM Coordinates:530825mN, 681675mE, elevation: 1055m
Type: inactive young rotational slide
Area: .47 km2
Sample: WASWRECA24100001
Collected :October 24, 2000
Age: 4550 +/- 50 BP (Beta #153220)



Organic rich silt
O cm - 122 cm
10YR 2/1 Black
Silt Loam

Light inorganic layer w/some tephra mixed
throughout and also charcoal throughout
the core (sediment sample was taken from 156.7 cm
123cm - 366cm
10YR 3/2 Very Dark Grayish Brown
Loamy Sand

Fig 5

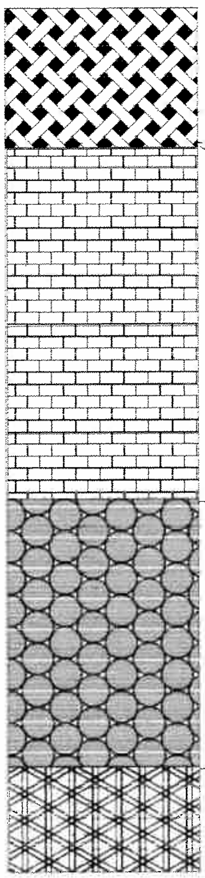
Site 2

Our second sample to be dated was collected in upper Swauk Creek and came from an inactive mature slide/flow, mass wasting feature #476 and covers an area of 22.63 km^2. A total of 3 samples were collected from this feature. Sample #3 has an organic layer that contained enough organics for ^{14}C dating. Sediment sample #3 is a core that is 259cm deep. The color is a 10YR 5/2 (Grayish Brown) with a texture of loamy sand. This inactive mature feature, #476, was given a relative age of 5000-10,000 BP (Lillquist, 2002). An AMS ^{14}C (Beta #153221) determined that this mass wasting feature was actually an inactive young feature with a date of 4160+/- 40 BP (fig 6).

Different factors contribute to the difference of the relative age date and the ^{14}C date. One must take into consideration wether the relative age assigned to mass wasting feature was as accurate as possible. Another factor that may play a significant role in the reclassification of mass wasting feature was the possibility of contamination of the sediment sample used for ^{14}C dating. According to Beta Analytic plenty of carbon was available for AMS ^{14}C dating. We must also take into consideration the physical attributes of the location from where this sediment sample was gathered. Was the sample gathered from the base of the sag pond or was it mistakenly gathered from a younger, more shallow layer? Nonetheless, since physical proof of age is available this feature will be recategorized from an inactive mature feature into an inactive young one.

The objective of obtaining a ^{14}C date of an inactive mature feature from a unique area of the Swuak Watershed was met.

Landslide # 476 Upper Swauk Creek
UTM Coordinates: 5234900mN, 680975mE, elevation: 1439m
Type: inactive young slide/flow
Sample: WASWRECA1110002
Area: 22.63 km2
Collected: November 1, 2000
Age: 4160 +/- 40 BP (Beta #153221)



Organic rich layer with traces of tephra and ash at 59.69 cm through 63.5 cm
0 cm - 71 cm
10YR 4/2 Dark Grayish Brown
Sandy Loam

Clean tephra from the Mt. Mazama eruption
72 cm - 152 cm
10YR 5/2 Grayish Brown
Loamy Sand

Non-organic layer w/traces of wood and charcoal throughout
153 cm - 229 cm
Color; 10YR 5/2 Grayish Brown
Loamy Sand

Non-organic layer
230 cm - 259 cm
10YR 3/2 Very Dark Grayish Brown
Sand Clay Loam

Fig 6

Site 3

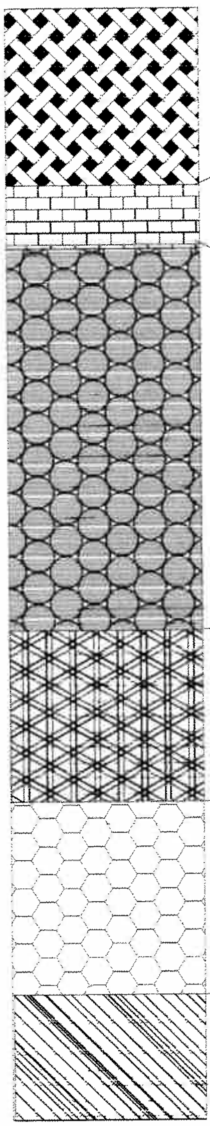
We collected 3 sediment samples from slide #156, a slide/flow that covers an area of approximately 7.12 km^2 and is an inactive old mass wasting feature from Upper First Creek. Of the 3 sediment samples that were collected at this site, core sample #2 was chosen for ^{14}C dating. This particular core was 488 cm deep. The sediment sample that was used for ^{14}C dating had a color 10YR 2/1 (Black) with a texture of a peat. The age of this feature was determined by AMS dating to be 10,560+/-70 BP (Beta #153222). The relative age of this slide was estimated to be an inactive mature feature with an estimated age range between 5,000-10,000 BP (Lillquist, 2002)(fig 7).

Mass wasting feature #156 will be reassigned from a relative age dated inactive mature to an inactive old slide/flow. The relative age assigned by Dr. Lillquist (2002) is at a minimum 560+/-70 years younger than the ^{14}C date from Beta Analytic.

Factors that may contribute to the difference is misclassification by Dr. Lillquist or contamination of the sediment sample used for dating. Beta Analytic noted that there was plenty of organics for an accurate measurement and that all analysis went normally.

Overall the objective of obtaining a ^{14}C date from an inactive old feature from a unique area of the Swauk Watershed was met.

Landslide # 156 Upper First Creek
UTM coordinates: 5229500mN, 676925mE, elevation: 951m
Type: inactive mature slide flow
Area covered; 7.12 km2
Sample; WASWPR14110003
Collected on November 14, 2000
Age of slide; 10,560 +/- 70 BP (Beta #153222)



Undiiferentiated organics
0 cm - 61 cm
10YR 2/1 Black
Silt Loam

Red sandy layer
62 cm - 66 cm
10YR 4/3 Brown
Silt Loam

Clay sediment w/traces of charcoal
67 cm - 168 cm
7.5YR 2.5/1 Black
Silt Loam w/ traces of charcoal

Tephra, possibly Mt. Mazama
169 cm - 213 cm
7.5YR 7/1 Light Gray
Loamy Sand Ash

Non-organic sediment
214 cm - 274 cm
7.5YR 2.5/1 Black
Silty Clay

Organic rich sedimentary deposit
275 cm - 320 cm
10YR 2/1 Black
Peat

Fig 7

Site 4

We collected 3 sediment samples from mass wasting feature #151, a relative age dated inactive old, rotationional mass wasting feature located near an Upper First Creek tributary. This feature covers an area of 0.33km^2. Of the 3 cores that were gathered, the first #1-A, is the sample that was use to date a tephra. The tephra was collected from a depth of 183cm. The color of the tephra is a 10 YR 7/1 (Light Gray) with a texture of a clay loam. The Electron Microbeam Analysis (#WA-SwPr-06-07-01-01) gave us a minimum age of 6,900 ^{14}C BP. These tephra are from the Mount Mazama eruption. Since the date retrieved from this sample is a minimum age we have no way of accurately comparing to the relative age date of >10,000 BP(Lillquist, 2002)(fig 8).

Since the Electron Microbeam Analysis is a minimum age it is known that this feature is at least6,900BP. Did this sediment sample come from the base of the sag pond is a question that must be considered. If the sediment sample did not come from the base of the sag pond then undoubtably the mass wasting feature in question will be older. As to how much older is a question that can be answered only with further research.

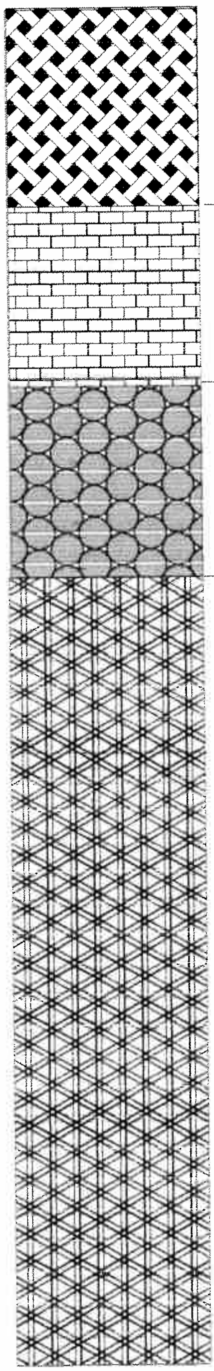
Until more research is done mass wasting feature #161 will remain categorized as an inactive old rotational slide.

The objective of collecting a sediment sample from a mass wasting feature #161 in order to get an accurate date to compare to the relative age assigned by Dr. Lillquist was not met.

Landslide #151 Upper North First Creek
UTM Coordinates:5231925mN, 677250mE, elevation: 1091m
Type: inactive mature rotaional slide
Area: .39 km2
Sample: WASWPR06070101

This tephra sample was analyzed via Electron Microbeam Analysis at Washington State University and not date by Beta Analytical of Miami Florida

Collected: June 7, 2001
Age: 6900 BP



Interbed w/ organics mixed throughout
0 cm - 11 cm
10YR 2/1 Black
Loamy Sand

Undifferentiated organic matter
12 cm - 24 cm
10YR 2/1 Black
Loamy Sand

Tefra (sample for dating)
25 cm - 36 cm
10YR 7/1 Light Gray
Sand/Tefra

A clay layer
37 cm - 86 cm
5 GY 4/1 Dark Greenish Gray
Clay Loam

Fig 8

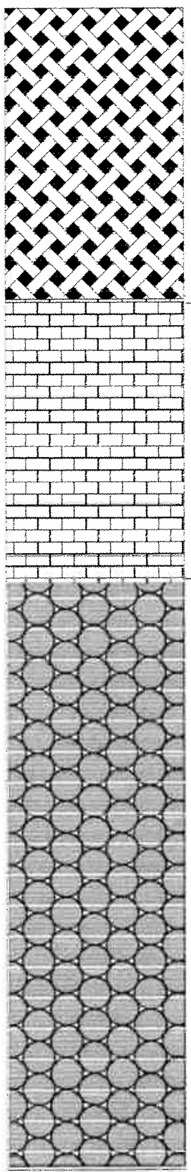
Site 5

A sediment sample was collected from mas wasting feature #2 in upper Baker Creek. This particular feature covers an area of approximately 1.51 km^2 and is relative age dated as an inactive old slide/flow. The organics, pieces of charcoal, that were used for the ^{14}C date were collected from a depth of 305cm and was mixed throughout a highly oxidized layer of iron rich sediments. The AMS ^{14}C age date of this slide is 9590 +/-60 BP (Beta #161396). The original relative age date of >10,000 BP (Lillquist) is close but this slide will have to be recategorized as an inactive mature slide/flow. The color of this layer is a 10YR 3/4 (Dark Yellowish Brown). The texture is a sandy clay loam (fig 9).

When the ^{14}C date is younger than the relative age date assigned by Dr. Lillquist (2002), the question "did the sediment sample come from the base of the sag pond ?" must be considered. The depth that the sample came from, 305cm, is deep but by no means does that maen it was the base. Did Dr. Lillquist relative age date this slide correctly? Beta Analytic conficonfirmed that the sample used had plenty of carbon matter for an accurate measurement and all anlysis went normally.

Whether or not mass wasting feature #2 was originally categorized correctly is unimportant because a objective of getting a ^{14}C date from an inactive mature feature from a unique area of the Swauk Watershed was met.

Landslide #2 Upper Baker Creek
UTM Coordinate:5239800mN, 669800mE, elevation 1353m
Type; Inactive young feature
Area 1.51 km2
Sample: WARETO07280101
Collected; June 28, 2001
Age of slide: 1790 +/- 40 BP (Beta #161396)



Oorganic rich sediment layer
0 cm - 74 cm
7.5 YR 2.5/2 Very Dark Brown
Loamy Sand

Iron rich non-organic sediment
75 cm - 152 cm
10YR 3/4 Dark Yellowish Brown
Sandy Loam

An organic rich, highly oxidized layer
w/traces of charcoal throughout (Sample used for dating)
153 cm - 305 cm
10YR 3/4 Dark Yellowish Brown
Sandy Clay Loam

Fig 9

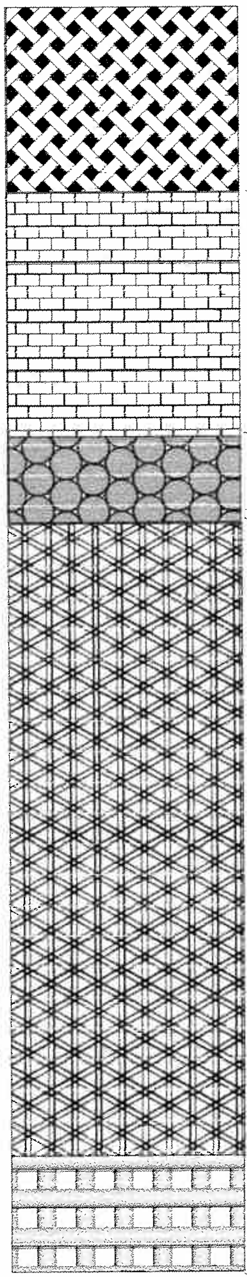
Site 6

The last slide from which a sample was retrieved was from slide/flow #476 and was relative age dated as an inactive mature, which is 5,000-10,000 BP. Slide/flow #476 covers an area of approximately 22.63 km^2. The original organics used for 14C dating was a small amount of charcoal that was mixed in with a dark organic rich layer that had traces of tefra mixed throughout the layer. The organics used came from a depth of 289cm. The color of this sample is 10YR 2/1 (Black) and has a texture of silty clay loam. The ^{14}C date from Beta Analytic (Beta #161397) is not compatible with the relative age date of 5,000-10,000 BP. The AMS ^{14}C date gives us an age of 1,790+/-40 BP which catigorizes this slide/flow as an inactive young slide/flow (fig 10).

Once again the question of whether or not the sediment sample used to retrieve the organic matter from came from the base of the sag pond. So far Dr. Lillquists relative age dates have been close, to within 900 years of the ^{14}C dates. The difference in the relative age assigned by Dr. Lillquist, >10,000 BP (2002) and the ^{14}C date of 1,790^{+}/-40 of feature #476 is a large difference. Beta Analytic once again states that plenty of carbon for an accurate measurement was provided and that all analysis went normally. Dr. Lillquists deductions have been close so far, therefore one must deduce that the sediment sample was not collected from an optimal location. For reasons unknown the sediment sample from mass wasting feature #476 must not have been collected from the base of the sag pond. This would be one reason for such a young ^{14}C date. Also younger sediments could have been washed into the sag pond over the years thus contaminating our sample. Until further research is done the ^{14}C date age of an inactive young feature will have to be assigned.

The objective of retrieving a sediment sample and getting a ^{14}C date from mass wasting feature #476 has beeen achieved. There is also a need for further research.

Landslide # 476 Hurley Creek
UTM Coordinates:5240600mN, 681350mE, elevation 1561m
Type: Inactive mature slide flow
Area; aproximately 22.63 km2
Sample:WABIPA09230101
Collected: September 23, 2001
Age: 9590 +/- 60 BP (Beta #161397)



Organic rich layer
0 - 43 cm
10YR 3/4 Dark Yellowish Brown
Peat

A clean tephra/ash
44 cm - 104 cm
10YR 5/2 Grayish Brown
Sandy Loam

Organics and tephra mixed
105 cm - 122 cm
10YR 5/2 Grayish Brown
Sandy Loam w/ some organics

Light colored tefra mixed w/organics
123 cm - 259 cm
10YR 5/2 Grayish Brown
Sandy Loam

A dark organic rich sediment w/traces of tephra (Sample to be dated)
260 cm - 290 cm
10YR 2/1 Black
Silty Clay Loam

Fig 10

Conclusion

The purpose of the ^{14}C dating of sediment samples from various slides throughout the Swauk Watershed was to compare actual dates of mass wasting features to the relative age dates previously assigned to each feature by Lillquist (2002). The relative age dates assigned by Dr. Lillquist (2002) are fairly accurate according to the C^{14} dates from Beta Analytic and the Electron Microbeam Analysis of the tephra from site #4.

The relative age date from site #1 is consistant with the ^{14}C date. The 14C dates of sites # 2,3, and 5 are not consistant with the relative age dates assigned by Dr. Lillquist (2002) but in the same sense are not that far off. Site #4 was sent to washington State University for Electron Microbeam Analysis and gave us a minimum age of 6,900 BP. Further research is needed to get a more accurate date for this feature. Site #6 has a large descrepancy, the relative age assigned by Dr. Lillquist was >10,000 BP but the ^{14}C date gave us a young age of $1,790^{+}/\text{-}40$. This is a large enough difference to cause concern. Further research will be needed to get a more accurate date.

We acquired our results through the gathering of sediment samples by coring to the base of the sag pond. We then gathered the deepest samples of organic matter and had these samples sent off to Beta Analytic for more accurate dating. Site 4, Upper North First Creek was a tephra sample that we sent to Washington State University for Electron Microbeam Analysis

We also learned that coring was a more efficient method of gathering sediment samples as opposed to digging for samples. Coring saved time, energy and allowed us to get deeper sediment samples from the sag pond.

Overall our objective to gather sediment samples from each category of mass wasting feature, inactive young 100-5,000 BP, inactive mature 5,000-10,000 BP, and inactive old >10,000 BP and to gather these samples from as widely a disperesed area throughout the Swauk Watershed as possible has been met. These objectives allow us to compare the relative age dates assigned by Dr. Lillquist (2002), to the ^{14}C, and the Electron Microbeam Analysis dates to confirm that the overall relative age dates (Lillquist, 2002) are fairly accurate and reliable throughout the entire Swauk Watershed.

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