2009-2010 PROJECTS

SE ALASKA - EXHUMATION OF THE COAST MOUNTAINS BATHOLITH DURING THE GREENHOUSE TO ICEHOUSE TRANSITION IN SOUTHEAST ALASKA: A MULTIDISCIPLINARY STUDY OF THE PALEOGENE KOOTZNAHOO FM.
Faculty: Cameron Davidson (Carleton College), Karl Wirth (Macalester College), Tim White (Penn State University)
Students: Lenny Ancuta, Jordan Epstein, Nathan Evenson, Samantha Falcon, Alexander Gonzalez, Tiffany Henderson, Conor McNally, Julia Nave, Maria Princen

COLORADO – INTERDISCIPLINARY STUDIES IN THE CRITICAL ZONE, BOULDER CREEK CATCHMENT, FRONT RANGE, COLORADO.
Faculty: David Dethier (Williams) Students: Elizabeth Dengler, Evan Riddle, James Trotta

WISCONSIN - THE GEOLOGY AND ECOTHERMOMETRY OF SPRINGS IN THE DRIFTLESS AREA OF SOUTHWEST WISCONSIN.
Faculty: Sue Swanson (Beloit) and Maureen Muldoon (UW-Oshkosh)
Students: Hannah Doherty, Elizabeth Forbes, Ashley Krutko, Mary Liang, Ethan Mamer, Miles Reed

OREGON - SOURCE TO SINK – WEATHERING OF VOLCANIC ROCKS AND THEIR INFLUENCE ON SOIL AND WATER CHEMISTRY IN CENTRAL OREGON.
Faculty: Holli Frey (Union) and Kathryn Szramek (Drake U.)
Students: Livia Capaldi, Matthew Harward, Matthew Kissane, Ashley Melendez, Julia Schwarz, Lauren Werckenthien

MONGOLIA - PALEOZOIC PALEOENVIRONMENTAL RECONSTRUCTION OF THE GOBI-ALTAI TERRANE, MONGOLIA.
Faculty: Connie Soja (Colgate), Paul Myrow (Colorado College), Jeff Over (SUNY-Geneeseo), Chuluan Minjin (Mongolian University of Science and Technology)
Students: Uyanga Bold, Bilguun Dalaibat, Timothy Gibson, Badral Khurelbaatar, Madelyn Mette, Sara Oser, Adam Pellegrini, Jennifer Peteya, Munkh-Od Purevtsuren, Nadine Reitman, Nicholas Sullivan, Zoe Vulgaropulos

KENAI - THE GEOMORPHOLOGY AND DATING OF HOLOCENE HIGH-WATER LEVELS ON THE KENAI PENINSULA, ALASKA
Faculty: Greg Wiles (The College of Wooster), Tom Lowell, (U. Cincinnati), Ed Berg (Kenai National Wildlife Refuge, Soldotna AK)
Students: Alena Giesche, Jessica Moser, Terry Workman

SVALBARD - HOLOCENE AND MODERN CLIMATE CHANGE IN THE HIGH ARCTIC, SVALBARD, NORWAY.
Faculty: Al Werner (Mount Holyoke College), Steve Roof (Hampshire College), Mike Retelle (Bates College)
Students: Travis Brown, Chris Coleman, Franklin Dekker, Jacalyn Gorczynski, Alice Nelson, Alexander Neser, David Vallencourt

UNALASKA - LATE CENOZOIC VOLCANISM IN THE ALEUTIAN ARC: EXAMINING THE PRE-HOLOCENE RECORD ON UNALASKA ISLAND, AK.
Faculty: Kirsten Nicolaysen (Whitman College) and Rick Hazlett (Pomona College)
Students: Adam Curry, Allison Goldberg, Lauren Idleman, Allan Lerner, Max Siegrist, Clare Tochilin

Funding Provided by: Keck Geology Consortium Member Institutions and NSF (NSF-REU: 0648782) and ExxonMobil
WEATHERING OF A VOLCANIC LANDSCAPE: THE GEOCHEMISTRY OF THE DESCHUTES RIVER WATERSHED, CENTRAL OREGON.

Project Faculty: **HOLLI FREY**, Union College & **KATHRYN SZRAMEK**, Drake University

CHEMICAL WEATHERING IN THE DESCHUTES BASIN: HOW WATERSHED FEATURES EFFECT CATION CONCENTRATIONS IN WATER CHEMISTRY

**LIVIA CAPALDI**: Oberlin College
Research Advisor: Steven Wojtal

SPATIAL VARIABILITY OF TEPHRA SOIL ON DIFFERING GEOMORPHIC SURFACES WITHIN THE HEADWATERS OF THE DESCHUTES RIVER, OREGON

**MATTHEW HARWARD**: University of North Carolina at Charlotte
Research Advisor: Dr. Martha C. Eppes

INCIPIENT WEATHERING IN SILICIC ROCKS INDICATED BY ENRICHMENT OF REE AND TRACE ELEMENT CONCENTRATIONS: THE HIGH CASCADES, OREGON

**MATTHEW KISSANE**: Union College
Research Advisor: Holli Frey

PLAGIOCLASE WEATHERING WITH DISTANCE FROM VOIDS IN VOLCANIC ROCKS OF THE DESCHUTES BASIN, CENTRAL OREGON

**ASHLEY MELENDEZ**: California State University, Fullerton
Research Advisor: Brandon Browne
INFLUENCE OF CLIMATE AND LITHOLOGY ON SPRING CHEMISTRY IN
THE UPPER DESCHUTES RIVER, OREGON

JULIA SCHWARZ: Carleton College
Research Advisor: Cameron Davidson

ALKALINITY AND DISSOLVED ORGANIC CARBON IN SURFACE WATERS
OF THE DESCHUTES DRAINAGE BASIN, OREGON

LAUREN WERCKENTHIEN: DePauw University
Research Advisor: Dr. James G. Mills, Jr.

Funding provided by: Keck Geology Consortium Member Institutions and NSF (NSF-REU: 0648782)

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CHEMICAL WEATHERING IN THE DESCHUTES BASIN: HOW WATERSHED FEATURES EFFECT CATION CONCENTRATIONS IN WATER CHEMISTRY

INTRODUCTION

One of the most important factors controlling stream chemistry is the bedrock geology of the region; however there is not a quantitative way to predict chemistry based on geology alone (O’brien et al. 1997). There are many factors that can affect the constituents in the water chemistry such as geology, slope, rainfall, and land use. In the Deschutes Basin in central Oregon there is a range in all of the factors listed. The western part of the basin drains the eastern side of the Cascade Mountains, and is largely covered in federally managed forests, with less commercial agriculture and more precipitation than the eastern regions of the basin which mainly drain areas with irrigated crop and grazing land with an overall drier climate. Do these factors contribute to the chemical difference in the east and west equally or are there some factors that should be weighted more heavily when predicting the water chemistry of a region. This is very important in determining the effect that rock chemistry and other factors will have on water chemistry, and it can also give some insight into how water chemistry can affect rock weathering.

The Deschutes Basin is mostly comprised of volcanic material and unconsolidated silicate sediments (Ludington et al. 2006). The water travels through all of these areas, but the groundwater can have different residence times due to climate and slope of the region (Tanaka and Suzuki 2008). The average annual rainfall for most of the Crooked River catchment is less than 40 inches per year, while the lower part of the Deschutes basin receives over 50 inches a year in most places and some regions in the mountains exceed 150 inches per year.

METHODOLOGY

The study area provides an excellent location to compare the weathering of silicate rocks in two different climatic and land use settings. As seen in previous studies when there are carbonate rocks in a system they tend to dominate the chemical weathering and a good signal cannot be gathered from the silicate weathering (Douglas 2006).

Samples were collected at 52 stream samples around the Deschutes basin (fig. 1). These samples were analyzed for major and minor element chemistry. Conductivity and pH were tested on site and alkalinity was calculated using titrations in the field. Assessing the differences between the two regions was done using GIS to map and compare the topography, precipitation, watershed size, and stream length. The regions can be easily split based on the separation between the Deschutes River catchment and the Crooked River catchment, a major tributary to the Deschutes River that drains the eastern part of the basin. Due to distance and access the eastern region was sampled less and there are only six samples from the Crooked River catchment, but they are statistically different from the forty-seven samples taken in the western region. There was little to no rain for the entirety of the sampling dates so it is unlikely that a particular stream was extremely diluted or concentrated on any one day.

The Deschutes watershed was broken down into over 300 smaller watersheds, based on state specifications to more accurately assess the contribution of watershed size to the water chemistry. Using this data the area draining to each sample was calculated. These watersheds were further broken down
into geologic units to determine the total area of a single unit that was draining to a sample and also the percentage of the total watershed that a particular unit represents. The stream length leading to a sample location was also calculated.

**RESULTS**

The watersheds of the six Crooked River samples average an annual rainfall of 42.91 inches per year, whereas the Deschutes River watershed samples average 92.9 inches per year. The elevation in the west is generally higher, with an average elevation of 1377 m, and the Crooked River catchments have an average elevation of 1150 m. The average slope of the western watersheds is less than the eastern watersheds, with averages of 32 and 43 degrees respectively. Based on numerous studies climate and topography are the major secondary controls on how rocks weather, the rates are largely based on temperature, precipitation, elevation, slope, and runoff (Gislason et al. 2008 and Noh et al. 2009).

Chemical analysis showed that the samples in the east had significantly higher cation concentrations. The least abundant is potassium. The cation concentration distribution shows a clear increase in calcium concentration in the samples in the eastern region (fig 3). The magnesium distribution also shows a clear trend of much higher concentrations in the east. The samples tend to reflect each other in cation concentrations, so that a sample with high levels of one cation will tend to have high levels of the other cations as well.

Combining these small watersheds and raster data, the correlation of annual precipitation to cation concentrations is a weak negative relationship for all cations, except for Mg, which has a weak positive correlation. The correlation is strongest for calcium, but still only with an $r^2$ value of less than 0.15. Despite previous studies (Tanaka and Suzuki 2009) observing a strong correlation between both mean elevation and slope within a watershed and cation concentration, this data exhibits only very weak trends (see fig. 4). The elevation and slope related to cation concentrations both have a very weak correlation with a trend line that has a slope close to 0.

The only relatively strong correlation between a physical characteristic and the cation concentration is to the area of the watershed. The relationship of
the sodium calcium ratio to total watershed area is a relatively strong positive correlation (see fig. 5), greater areas yield higher ratios. There is also some correlation between the individual cation concentrations and stream length but the trendlines for these relationships are nearly horizontal and just show that the concentrations of potassium, magnesium, and sodium do not vary much as stream length changes.

**DISCUSSION AND CONCLUSION**

All of the cations respond to the difference in physical properties in a similar way, with the eastern regions experiencing an increase in concentration across all of the cations, although there is an extreme increase in calcium in the South Fork Crooked River sample. This probably means that there is not an outside source input, such as agriculture because
there is no one cation that is generally more abundant in the east. Another possibility is that there is a constant pollution source across the entire Deschutes watershed that is affecting everything equally. The total concentrations are what is changing, not the relative abundances, which could be a result of less precipitation, greater evaporation, an increase in weathering rates, or some other factor. The lack of direct correlations of one characteristic to any of the cations among the data shows that none of the factors considered have a dominant control over the water chemistry in the Deschutes Basin. The data does not show a predictable trend for water chemistries within a watershed. It is clear that the conditions in the east and west are quite different in terms of climate and topography; however there is no conclusive evidence that either of these things is driving the difference in cation concentrations. The most significant predictor of the relationship between the water chemistries within the watershed is the total area that is draining to that point. This makes sense since there is more time for interaction between the water and rock to allow for chemical weathering. In general the cation concentration increased with watershed area, the major anomaly in this correlation is Paulina Creek, which has a similar cation concentration to the samples from the east. Paulina Creek watershed has a similar lithology to the watersheds of the east, which could be the reason that it more closely resembles those samples.

Factors that could also be affecting the way the rock weather and changes water chemistry are vegetation, rock fracturing, and residence time. Although residence time is a major consideration in how slope effects weathering there are hydrogeologic factors such as porosity, and biologic factors such as vegetation cover.

Comparing the east and west of the Deschutes Basin shows that there is no clear cut recipe that can be followed to determine water chemistry. Trends that were expected based on studies in small volcanic watersheds in different places did not prove true in the study area, the mean slope of the watershed did not yield a correlation similar to that found by Tanaka and Suzuki (2009) and precipitation did not give a strong correlation either.

REFERENCES


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