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This McNair Journal is the official journal of the Ronald E. McNair Post-Baccalaureate Achievement Program at the University of Wyoming. The University of Wyoming’s McNair Scholars Program is 100% federally funded by the U.S. Department of Education at $288,000 annually.

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The McNair Scholars Program

Background
The University of Wyoming McNair Scholars Program was established in September 1992 and is one of the only 150 programs in the nation. The University of Wyoming and the United States Department of Education jointly support the program named for an accomplished scholar of physics and an astronaut on the Challenger space shuttle, Ronald E. McNair. Prospective scholars represent a wide range of disciplines. These students share the common desire to pursue graduate studies, attain the doctorate, and join the ranks of the next generation of faculty members.

Program Components
The McNair Scholars Program provides exciting opportunities for undergraduate students at the junior and senior levels to prepare for acceptance into quality graduate programs of their choice. Program participants are provided services in academic skills, individual counseling support, and funded summer research internships. During the academic year a series of seminars provides information on graduate school financial aid, research skills and technical writing, the graduate school admission process, graduate school entrance exams, portfolio preparation, and more. Student concerns in financial, personal, and academic realms are addressed through individual counseling support services. Finally, the program offers participants site and mentors, provide workshops on research skills, help with report preparation, and assist as otherwise needed on an individual basis. At completion of the internship experience, McNair Scholars make formal presentations of their research to faculty and peers at the McNair Scholars Conference and submit papers summarizing their work. Opportunities to attend national research and graduate recruitment conferences and visits to other graduate campuses are encouraged and provided.

Funded Internships
Research internships are offered to those Scholars who have earned at least 60 credits by the beginning of the internship period. Stipends for internships are awarded for an eight week summer session. During the eight week internship, students work 40 hours per week under the supervision of a faculty mentor and a graduate student advisor. Students seeking involvement submit an internship application to the program.
Eligibility and Selection

First generation students (neither parent has received a bachelor’s degree) and income eligible Or Black (non-Hispanic), Hispanic, American Indian, Alaskan Native, Native Hawaiian and Native American Pacific Islander

Have at least 50 credit hours Meet GPA requirements U.S. Citizen or permanent U.S. resident
Commit to attaining their Ph.D.

Prospective participants are encouraged to contact the project staff for information and application materials at any time during the year. Participants are selected from undergraduate applications attending the University of Wyoming on the Laramie campus. Participation in the program is limited to 33 students.

Forward

As the McNair staff has grown in experience over the years, so have the faculty, graduate students, and McNair interns. Each year I am struck by the increased level of sophistication I see in both the projects and the presentations, oral and written.

This continuous improvement can be attributed to the hard work and dedication of the McNair Scholars, and the faculty members and graduate students without whose help their success would have been impossible. One of the greatest joys of being a McNair staff member is the opportunity to work with such terrific colleagues as the students, faculty members, and graduate students represented in this journal.

The McNair Scholars featured in this journal can be rightfully proud of what they have achieved. We wish them well and look forward to the great things they will achieve.

Zackie Salmon, Director
UW McNair Scholars Program, Summer 2012
Ronald Ervin McNair: The Man with a Mission

Ronald E. McNair, the second African American to fly in space, was born on October 21, 1950 in Lake City, South Carolina. While in junior high school, Ronald McNair was inspired by a teacher who recognized his science potential and believed in him. He graduated as valedictorian from Carver High School in 1967. In 1971, he received his Bachelor’s Degree Magna Cum Laude in Physics from North Carolina A & T State University (Greensboro). In 1976, at the age of 26, McNair earned a Ph.D. from the Massachusetts Institute of Technology (MIT).

While working with the Hughes Research Laboratory as a staff physicist, McNair soon became an acknowledged expert in laser physics. NASA selected him for the 1978 space shuttle program and in 1984, McNair became the mission specialist aboard the flight of the shuttle Challenger. In addition, he received three honorary doctorate degrees as well as numerous fellowships and commendations.

Dr. McNair’s life ended tragically on January 28, 1986 when the Challenger space shuttle exploded and crashed into the ocean, taking the lives of six other astronauts. After his death, Congress approved funding for the Ronald E. McNair Post-baccalaureate Achievement Program, which is dedicated to the support and promotion of the high standard achievement exemplified by McNair. The University of Wyoming McNair Scholars Program is dedicated to preserving his legacy of scholarship and accomplishments.
Jeremy Adkins

Faculty Mentor: Jon Gardzeleski
Graduate Student Mentor: Mahdokht Soltania

Research Topic: Feasibility of a Net Zero Energy Home in the Cold Climate of Laramie, WY

Problem Statement
This study looks at the feasibility of designing and engineering a prototype Net-Zero Energy Home (NZEH) in Laramie, Wyoming using the International Energy Conservation Code 2012 (IECC 2012) standards as a starting point.

Introduction
The U.S. department of Energy Building Technologies Program defines a NZEH as a home that produces as much energy as it uses over the duration of a year.

Laramie, Wyoming was chosen as the location to investigate because the research is taking place in Laramie. Laramie has a few unique characteristics that make it an interesting place to engineer a net zero energy home (NZEH). In cold climates, such as Laramie, the major energy use is the heating loads. Laramie has 8406 heating degree days and only 77 cooling degree days. A heating degree day is computed by taking the difference between the base temperature of 65 degrees and the average daily temperature.4&5 The influence of this on the design is that the cooling needs become negligible, therefore, all efforts can be devoted to decreasing the heating loads. Laramie is unique here because in most locations there is a greater need for cooling, where the design concentrates more on decreasing cooling loads. Since only the heating loads needs to be decreased the design can take advantage of solar heat gains. Solar heat gains are the heat energy that is transferred through windows from sun. These heat gains add heat to the inside of a home.

The traditional engineering process for a NZEH is to focus on passive design techniques that include high levels of roof, wall, and slab insulation, as well as, highly efficient windows. This is followed by a careful design of heating and cooling systems that minimize heat loss. Finally, onsite energy production, such as solar photovoltaic and solar thermal panels are used to run the home.
The IECC 2012 standards are often used when engineering a low energy home. IECC 2012 is a set of codes address energy efficiency by looking at cost savings, reduced energy usage, conservation of natural resources, and the impact of energy use on the environment. In the IECC 2012 there are suggestions of how to decrease energy loads. High levels of insulation and efficient windows are used to decrease the heat load of the house. Once the heating loads are decreased, the design of efficient heating systems decrease the total energy use. One example of a highly efficient heating and cooling system is a ground source heat pump (GSHP). A ground source heat pump takes advantage of the difference in temperature between the air and the earth’s crust. The ground is warmer than the air in the winter, and cooler than the air in the summer. To harness this difference, heat is pumped into the home in the winter, and out of the home in the summer. The ground source heat pump uses the renewable energy collected by the PV panels.

After heating loads are decreased, solar photovoltaic panels are used to power the heat
pumps, along with all other electricity needs of the home. In addition to PV panels, solar thermal panels are mounted on the roof which collect heat to warm the hot water needed for faucets and showers. The heated water is stored in a domestic hot water heater.

This electricity is used to run everything from heating systems to wall plug ins. The excess electricity is pumped into the grid.

**Methodology**

**Floor Plan**

The primary goal for the floor plan is to decrease the heating loads. This was achieved by decreasing the volume, increasing the south wall to window ratio, and using a simple shape. The decrease in volume was achieved by decreasing the square footage of the home, which allows for less space to be heated. To decrease the square footage the rooms are designed to be closer together than you would typically find, which minimizes hallways and circulation areas. The south wall to window ratio is increased to take advantage of the solar heat gains. In the Northern Hemisphere, the sun hits the building primarily on the south facade. By increasing the percentage of windows on this wall, more solar heat comes in and decreases the heat load. A simple shape, here a rectangle, is used to decrease air leakage at corner. A secondary design goal is to make a home that is aesthetically desirable. One method to achieve this goal was to create a double-height space with high ceilings for the living room.

**Simulations**

DesignBuilder (DB) Energy Simulation Software was used to predict the homes annual heating and cooling loads. Prior to running simulations, the first step was to recreate the floor plan with the appropriate construction material.
defaults. For this study, the base defaults were those outlined by IECC 2012:

<table>
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<th>Insulation Value</th>
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<td>Window R-Value</td>
<td>3.125</td>
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<tr>
<td>Wall R-Value</td>
<td>20</td>
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<td>Slab R-Value</td>
<td>30</td>
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<tr>
<td>Roof R-Value</td>
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After the construction materials are set, each room has to be designated as a certain zone type. These zone types include bedroom, bathroom, kitchen, etc.. Each zone type has its own internal gain values, thermostat settings, and schedule. The internal gains take into account the heat put off by people and appliances in the space. The schedule identifies when the room is primarily in use. Some rooms are used during the day, such as the kitchen, while others are used at night, such as the bedrooms.

After the floor plan, materials, and zone types are set, the final step before running simulations is to assign the building materials for each construction type. The four variables tested in this study are wall R-value, window R-value, window solar transmission, and south wall to window ratio. The R-value is the value that identifies how well the material is at insulating. The solar transmission is the amount of solar radiation that passes through the window and into the home.

The south wall to window ratio is the percentage of the south wall that is composed of glazing.

For each material created for the different variables, all constraints are the same, except for the one property that is being analyzed. The wall R-values investigated were 10 through 60 with an interval of ten. The window R-values were 2.5 through 10 with intervals of .5. The solar transmission values were 30% to 70% with intervals of 10%. Finally, the south wall to window ratio values are 10% to 70% with intervals of 10%.
methodology produced a total of 35 simulations: one simulation for the default values, followed by a simulation for each modified variable.

**Results**

The first variable changed in the simulations was the wall R-value. Our results show a nonlinear decrease in total heat load as the wall R-value is increased.

The second variable we changed in simulations was (etc) the window R-value. The results show a linear decrease in total heat load as the window R-value is increased.

The third variable to change in simulations is the window solar transmission. The results show a linear decrease in total heat load as the window solar transmission is increased.

The final variable to change in simulations is the south wall to window ratio. The results show a nonlinear decrease in total heat load as the wall to window ratio is increased.

![Graphs and images related to results and simulations.](image-url)
Conclusion
Based off of our simulation data, we can conclude that it is easily feasible to design and engineer a Net-Zero Energy Home in Laramie, Wyoming. The heat load values are small enough that all of the energy required to heat and run the home could be generated through a modest amount of solar thermal and solar photovoltaic panels.

Further Research
The next question to investigate is the economic feasibility of a NZEH in Laramie, Wyoming, with a cost comparison to a standard home. I predict that there will be a point where the cost of high performance materials outweights the savings on energy, but through additional PV energy collection the design could remain economically feasible.

References


4. *Period of Record General Climate Summary - Cooling Degree Days (2012).* Western Regional Climate Center. http://www.wrcc.dri.edu/cgi-bin/cliGCStC.pl?wy5410


1.0 Abstract

Water is a vital resource and its abundance is affected by climate change. Severe drought brought on by climate change affects water availability in the western U.S. Recent studies suggest El Nino-Southern Oscillation (ENSO) as a possible driver for latitudinal shifts in western storm tracks producing a north-south precipitation dipole anomaly in the western U.S. This anti-phase behavior could exist due to variations in intensities and frequencies of ENSO, which affects snowpack and causes change in water availability. Here, we generate a lake-level record for Little Molas Lake (LML) in Southern Colorado using various lakebed sediment analyses. To evaluate this anti-phased behavior we will examine lakes in a north-south transect, where LML will provide the southern extent of the transect and Lake of the Woods, WY, will provide the northern extent of the transect.

Accelerated Mass Spectroscopy (AMS) radiocarbon dating, grain size, and loss-on-ignition analyses were conducted on a near-shore core from LML to establish age constraints on sandy intervals and percent organic content, respectively. Percent sand and organic content data from LML were compared with an existing lake-level reconstruction for Lake of the Woods, to determine moisture availability trends during the Holocene. Evidence for the N-S precipitation dipole anomaly was observed at ca. 5.5 ka.

Ocean core data suggests ENSO frequencies began to increase after ca. 6.0 ka, possibly contributing to the initial anti-phased relationship between water-levels ca. 5.5 ka. This supports the existence of a N-S precipitation dipole; however, analysis of the remaining LML cores and different sites will clarify this relationship. Analyzing Holocene water-level responses to climate change may provide suggestions for water resource managers.
2.0 Introduction

Water is a vital resource and climate change affects its abundance. The south-central Rocky Mountain region receives most of its water from spring and summer snowmelt, which support agriculture, energy production, and urban growth (Shinker et al., 2010). In the past few decades, warming temperatures have triggered earlier snowmelt, causing major consequences for water availability in the western U.S. (Shinker et al., 2010). The recent drought and warming temperatures has also caused regional ecosystem changes including ecotone shifts, increased tree mortality, insect outbreaks, and extended fire seasons (Minckley et al., 2012). A prime example of climate change and water availability responses in the west is the pine bark beetle and the extensive wildfire outbreaks early this summer, 2012. As a result of climate change, current water management methods are becoming outdated (Milly et al., 2008). To help reduce these problems and properly prepare water management systems for future hydrologic changes, it is critical to examine Holocene water availability and climate trends for this area.

Dendrochronological data identifies moisture availability trends in south-central U.S. (Shinker et al., 2010), providing evidence for “megadroughs” (Shuman et al., 2010), and displaying evidence for a north-south variability in moisture on annual-to-decadal timescales (Shuman et al., submitted). However, these records are unable to provide a long-term moisture-balance record for use in future planning (Shinker et al., 2010), and sedimentary records provide a longer hydroclimatic record (Shuman et al., 2010). Lake-level reconstructions, produced from sedimentary and stratigraphic analysis of lakebed sediments, provide examination of Holocene moisture availability and hydrologic trends in the Rocky mountain region (Digerfeldt, 1986; Shuman et al., 2009, 2010, submitted; and Marsicek et al., submitted) and offers insight to current and future moisture variability and hydrologic responses to climate change in the western U.S. (Pribyl and Shuman, submitted).

A current lake level study on Emerald Lake, CO, also provides support for a millennial-scale moisture dipole anomaly across the western U.S. during the late Holocene, similar to the effects of El Nino-Southern Oscillations (ENSO) on decadal timescales seen today (Shuman et al., submitted). If this is true, then there is potential that Colorado would be dry when Wyoming is wet, a north-south precipitation dipole anomaly, during periods of frequent ENSO events (Shuman et al., submitted).

One potential driver for moisture variability considered is the tropical Pacific, an important control of the modern north-south precipitation variability, on annual-to-decadal timescales. Thus, the tropical Pacific could have been a driver of moisture variability during the Holocene on millennial-to-centennial timescales (Brown and Comrie, 2004; and Dettinger et al., 1998). The western U.S is a key study site to determine if the ENSO is a potential driver of moisture variability because ENSO can cause latitudinal shifts in storm tracts, which can produce a N-S
precipitation dipole anomaly in western North America (Brown and Comrie, 2004; and Dettinger et al., 1998). Ocean core data suggests ENSO frequencies increase after ca. 6.0 ka (Sandweiss et al., 2011), therefore the sedimentary analyses, rather than dendrochronological studies, will best examine if the moisture variability in the western U.S. was affected by ENSO during the Holocene.

Lakes whose water level is only controlled by surface water (precipitation and evaporation) should accumulate sediments that represent the actual precipitation variability for a given time during the Holocene (Shuman et al., 2010). Essentially, the lake will act as a large precipitation gage recording the lake’s history. Little Molas Lake (LML), in southern Colorado was analyzed using sedimentary and stratigraphic analysis established by Digerfeldt (1986) and Shuman et al. (2009; 2010), to provide a southern site constraint in a N-S transect of lakes spanning from northern Wyoming to southern Colorado (Shuman et al., 2010; submitted).

Accelerated Mass Spectroscopy (AMS) radiocarbon dating, grain size analysis, and loss-on-ignition (LOI) was conducted on a near-shore core from LML to establish age constraints on sand intervals and percent organic content, respectively. The LML sediment data will then be compared to an existing lake-level record for the northern most lake in the N-S transect, (Lake of the Woods [LOW], WY) to determine Holocene trends in moisture availability in the south-central Rocky Mountains and therefore determine if a N-S precipitation dipole anomaly existed.

3.0 Methods

Lake-level reconstructions help determine the moisture availability of a region during the Holocene because lake-level changes create distinctive sedimentary units and respond predictably to climate change (Dearing 1997). However, there are many factors to consider before selecting a lake to use for lake-level reconstructions.

3.1 Site Selection

When choosing a site there are many factors to consider to ensure that the cores extracted represent actual hydrologic changes. Wind introduces more energy into the water column and affects the settling rates of sediment (Dearing and Foster 1986). Factors that determine how the wind affects the sediment are particle size and shape, direction of the wind, topographical features, and duration (Dearing 1997). The influences of the wind will also be contingent on the surface area of the lake (Dearing 1997). The presence of wind and therefore wave energy, allows larger grains to remain entrained in the water column affecting sedimentation rates.

Storm events, similar to the effects of wind, impact the rate of deposition and amount and type of sediment inputs (Dearing 1997). For larger bodies of water, storms have great affects but in smaller lakes storms are less likely to cause sediment disturbances. Due to a smaller surface area, smaller lakes are less inclined to get large waves or currents from a storm. However, if a
small lake is affected by a storm it can rework and redistribute sediment (Dearing 1997). Deforestation will leave the lake area more susceptible to wind and increased erosion rates (Dearing 1997). Since deforested areas are more vulnerable to erosion, it does not take as much overland flow to wash sediments into the lake as it would if the area was vegetated. An increase in sediment accumulation, due to increased erosion, could be misinterpreted as a slumping event or a drought if not carefully analyzed. Type of vegetation can have similar effects; a grassy environment will have different effects on erosion then a forested environment.

Topographic features need to be surveyed because different features affect surface run-off and groundwater in various ways. It is important to consider the catchment area of the lake, which will determine how regional or localized the water source is and what lake-level responses might be due to the size of the catchment area (Digerfeldt 1986). A valley and a flat plain will each have different effects on the lake level and sedimentation rates.

Bedrock type and faulting near a lake can cause seepage of water from the lake into the underlying strata and tilting of the lake, due to uplift, can shift the lake basin (Dearing and Foster 1986), ultimately affecting the lake level. This will result in an inaccurate representation of the lake level and by association, the hydroclimatic history. The sediment type can indicate past hydroclimate, i.e. carbonate or evaporite deposits present in the core could indicate a time of high evaporation and low lake levels. The abundance or lack of organic sediment can indicate lake levels, also. A higher lake level provides an environment suitable for organic accumulation and deposition, but low lake levels keep fine organics suspended in the water column.

Lake-level reconstruction should be conducted on lakes with a surface area of 100ha (10,000 m2) or less (Dearing 1986; and Digerfeldt 1986). For these lakes, past lake level fluctuations are distinctly recorded and easily reconstructed, due to more regular sedimentation and hydrologic processes (Digerfeldt 1986).

Inflow brings sediment from other areas, introduces more energy into the water column, and increases the water level. Outflow removes sediment from the lake, disrupts deposition, and decreases the water level. An increase or decrease in water level due to inflow or outflow, rather than precipitation influences, will lead to an inaccurate representation of the regions hydroclimate. Sediment is also introduced to the lake from atmospheric fallout, surface erosion, and lakebed erosion (Dearing 1986). Sediment from distal locations complicate the record; old sediment could be deposited onto younger sediment creating a complex lake-level record.

The gradient of the lakebed is also examined. Small lakes with a gradual slopped profile are good site candidates because erosion or reworking of the lake sediments are more likely to be due to water-level fluctuations rather than slumping that occurs on steep slopes (Digerfeldt 1986). Steep lakebed slopes result in a more complicated record and will not accurately represent factors due to hydroclimate alone (Digerfeldt 1986).
Water depth, lakebed slope, and sediment properties (cohesion, viscosity, etc.), are factors that control settling rates, sliding, and/or slumping of sediment. These factors influence the distribution and deposition of the sediments, which will cause a concentration or absence of sediment (Dearing 1997). Slope gradient determines the effectiveness of gravity on sediments. A gradual slope is less affected than a steep slope, thus indicating the importance of using small lakes with gradual slopes for lake-level reconstruction (Dearing 1997). Small lakes with gradual slopes typically have fewer slumping events. Figure 1 provides a summary diagram of the factors just discussed.

![Diagram of factors affecting lake level]

A small tectonically stable lake with a gradual lakebed and no inlet or outlet flow allows for a lake-level reconstruction that is based on hydroclimatic factors.

### 3.2 Coring

Rather than use one core to reconstruct a lake-level history, Digerfeldt (1986) noted that a transect of cores would provide a more complete and reliable lake-level reconstruction. Core extraction, distance from core to core, and the number of cores extracted depend on stratigraphic changes and the slope characteristics. The analyses being conducted determines the type of corer used. For grain size, the corer should be big enough for macrofossils and sediment to be collected (Digerfeldt 1986).

A transect should be positioned in an area with a gradual slope, represent major facies changes, avoid slumps, and span from near-shore to deep offshore (Digerfeldt 1986) to ensure that both high and low stand events are examined. For these reasons, the location of the transect
– as well as the study lake – should be carefully chosen based on preliminary site reconnaissance. Digerfeldt (1986) claims, “selection of a suitable lake should always be based on reconnaissance stratigraphy studies to ensure the availability of useful records of past lake-level fluctuations”. Geophysical tools, such as ground-penetrating radar (GPR), facilitate such reconnaissance (Shuman et al., 2009; 2010). GPR provides a bathymetric cross section of the lake indicating, if and where slumping occurred and helps identify major sediment units (Figure 2, Shuman et al., 2001). GPR can also show the slope of the lakebed, any historic inflow or outflow channels (Shuman et al., 2001), and ultimately help determine the optimum transect for core extraction.

3.3 Field Work

Keeping these issues in mind, Bryan Shuman and colleagues (2009), identified Little Molas Lake (37.74° N, 107.71° W, 3,330 m elevation, 5 ha surface area) as a suitable lake for generating a lake-level record, Figure 3 and 6. LML is a “small glacially-scoured bedrock basin in subalpine forest in the San Juan Mountains of Colorado” Shuman et al., (2009). Shuman and colleagues also collected GPR and core samples in the summer of 2005.

Figure 2 shows how each core at LML was extracted at major facies changes to capture past hydrologic events that occurred at this lake, from the middle of the lake toward the shore, B, C, D, E, and F (Shuman et al., 009).

![Fig 2. Sub-surface profile of Little Molas Lake. Core locations (white lines) and their water depths are shown (Shuman et al., 2009).](image-url)

Core E is approximately 13 meters from the northeastern shore (Fig. 2 and Fig. 3) and was selected for this research project because it includes major sediment units and has no evidence of slump deposits. Additionally there are variations in sediment type, indicating lake-level changes most likely took place. The cores were extracted using a modified Livingstone piston corer (Shuman et al., 2009). Core E has 3 Drives, three segments of core in three different tubes, with Drive 1 being the uppermost section and Drive 3 being the bottommost section of sediment.
3.4 Lab Analyses

Core samples are cut in half (lengthwise), and then scanned with a GeoTek Multi Sensor Core Logger. This machine is used to produce a picture of the halved core, termed the working half, and to obtain bulk density, thickness and magnetic susceptibility data (presence of iron-bearing minerals in the sediments) using gamma rays, core thickness and magnetic susceptibility sensors, respectfully. These data will be used to substantiate data collected from the grain size and loss-on-ignition (LOI) analyses.

After collecting GeoTek data, subsampling was the next step. For this project the core was subsampled at contiguous one centimeter intervals (0-1cm, 1-2cm, etc.). Each centimeter interval was cut into three 1 cm³ samples: one 1 cm³ was used for grain size analysis, two 1 cm³ subsamples for radiocarbon dating, and the remainder was placed in a bag labeled ‘rind’. The rind acts as back-up mud in case there is a need to rerun tests, run new tests, or supplement the designated amount in the event of deficient material. The three segments of Core E provide an approximate total of 270-290 subsamples for each grain size, radiocarbon date samples, and rind.

Dating is an extremely important analysis because it provides age brackets for areas of interest and determines if sediment was reworked, slumping occurred, and the sedimentation rates. Dates bracketing a sandy interval can indicate how long the event lasted and could help determine what type of event it was, i.e. slumping or a drought period. Hiatuses and reworking of sediments can occur when lake level drops (Dearing 1997).

High organic content and sudden shifts in sediment type within the core were selected for dating (Shuman et al., 2009). For example, sections of dark sediment that show a rapid change to light sediment and back to dark sediment are prime targets with the objective to obtain dates above and below the light horizon. The ages provide a date bracket for the light colored interval (possibly a low water depth, i.e. a dry period) and help delimit the duration of the event.

Each subsample used for procuring radiocarbon dates was washed with water through a 125-micron sieve, rinsed into a petri dish and examined under a microscope for charcoal extraction. Charcoal is the source of carbon used for AMS radiocarbon dating and needs to be greater than 125-microns to ensure the charcoal was due to proximal fires. There needs to be one milligram of charcoal from the 2 cm³ subsample to provide enough carbon. When we obtained an adequate amount of charcoal from the intervals of interest, the charcoal was dated at the UC-Irvine Keck AMS Facility.
The last physical sediment analysis was grain size and LOI. Grain size and LOI will determine the fraction of sand and organic sediment, respectfully. LOI was already conducted on Core E by Shuman and colleagues. Every other sample was selected for grain size analysis. The procedure for LOI as described by Heiri et al. (2001) is listed below:

- **Step 1.** Weigh crucibles for a baseline weight
- **Step 2.** Place one cubic centimeter subsample in a crucible
- **Step 3.** Weigh the grain size subsamples as is (termed ‘wet weight’)
- **Step 4.** Place wet samples in a drying oven at 105 °C overnight to drive off water content
- **Step 5.** Weigh the dry samples (% water content)
- **Step 6.** Burn samples at 550°C in a muffle furnace for four hours to burn off organic matter
- **Step 7.** Weigh the burned subsamples (% organic matter)

Note: After removing samples from the oven and furnace, they were placed in a desiccator to cool to room temperature.

The grain size procedure is the same with the addition of several steps between 5 and 6: Soak samples in deionized water for 16-24 hours to disaggregate, sieve samples with a 63 micron sieve to gather the sand fraction, dry overnight at 105 °C, and weigh to determine percent sand.

### 3.5 Comparison of data

The grain size and LOI data for Core E were plotted on a calendar age scale (determined from linear interpolation between radiocarbon dates; dates are since 1950 AD) so we could compare LML to other lakes in the region. These data provide enough information to infer past lake levels; however, processing the other cores from LML will provide a more precise lake-level record. Core F is currently being processed and upon completion will be integrated with the LML lake-level reconstruction. These cores will provide us a more detailed account of the sediment limit over time. The final step was to plot the data with the lake-level reconstruction for Lake of the Woods, WY (LOW). Important local and regional moisture histories were examined to determine whether a N-S moisture dipole exists during the Holocene (approximately the last 13,000 years).

### 4.0 Results

The GPR profile and core extraction locations (Fig. 4) allow for sediment unit interpretation and provide the first indication of lake-level change at LML. The basement high along the south-central part of the lake (Fig. 4) highlights the different effects of sedimentation and deposition due to lake-level change. After conducting the various sediment analyses, the resulting information (from Fig. 5) was investigated to evaluate the initial GPR profile interpretations of the lake level (Fig 4 B). The data allows us to make a comparative analysis to establish lake level trends.
5.0 Discussion

The basement high along the south-central part of the lake in Figure 4 A and B, show how a uniform sediment drape will get truncated, reworked and redeposited with a drop in lake level. During this time of low lake level, sediment units will onlap the truncated unit and could ultimately pinch out depending on the lake level. If lake level increases, onlapping can occur. Unit 1, the most recent unit, shows uniform sedimentation along the whole lake basin indicating rising lake levels up to present. Variations in deposition and redeposition/reworking will occur considering it is directly affected by the turbulent upper layer of water.

High densities, high sand, and low organic content in Unit 5 (Fig. 5) support low lake levels. The dark reflector at the bottom of Core E (Fig. 4) further supports this correlation, because denser sediment shows up as a darker reflector. The uniform sediment drape (Unit 1; Fig. 4B), which indicates a high stand is corroborated by the core’s low bulk density, low sand content, and high organic content (Fig. 5). Units labeled in Figure 5 correspond to GPR units in Figure 4B. The AMS radiocarbon dates provide age brackets and sedimentation rates.
Fig. 5. Different analyses for Core E that corroborate high sand areas. Gamma-ray attenuation bulk density represents the sediment density. Percent sand and percent LOI have a mirror image relationship because high sand fractions correspond to low organic matter. High density intervals match high sand intervals. High sand intervals and areas of abrupt change were bracketed with dates in order to constrain the timing and magnitude of the event and to establish a chronology (dates run through Behren, Parnell et al., 2008, age model far right) to evaluate synchronicity of events across the N-S transect. Bulk density is from Shuman et al., 2009.

Fig. 6. Snowpack anomalies in the western U.S. showing a N-S variation in snowpack with the 0 line or transition zone running through CO, UT, NV, and CA (Cayan, 1996).
Existing lake-level reconstructions provide evidence for the N-S precipitation dipole anomaly (Fig. 6). Figure 6 shows snowpack anomalies in the Rocky Mountain west, and that when it is wet north of the zero line, it tends to be dry south of the zero line. LOW provides the northern limit of the N-S transect of lakes in the central Rockies and LML provides the southern limit. By comparing the data from the two lakes, the magnitude and timing of water variability can be established.

The lake-level reconstruction for LOW is compared to the LML bulk density, percent organics, and percent sand to view spatial trends and to examine the N-S precipitation dipole anomaly in Figure 7.

Fig. 7. LML grain size, LOI, and bulk density data are plotted with the lake-level reconstruction for Lake of the Woods, WY, the northernmost lake in the transect. After 5.5 ka there is a shift to the lakes being anti-phased. These are shown with $a -$ (high lake level) and $a -$ (low lake level). LOW data is from Przybyl and Shuman, submitted; and Shuman et al., 2010.

From the early to mid-Holocene (13.0-5.5ka) lake levels at LOW and LML are generally in phase with each other. There is century-scale variability across the sites after ca 5.5 ka showing a shift between dry and wet periods, providing support for the N-S precipitation dipole
anomaly. The anti-phased behavior is possibly due to increased ENSO variability (shown to increase after ca 6.0 ka; Sandweiss et al., 2001).

Core E from LML provides a good representation of Holocene lake-level variations at LML. Comparisons with the LOW reconstruction highlight spatial variations in moisture variability. This study suggests that ENSO is a major driver of the anti-phase behavior from ca 5.5 ka to present. More northern and southern lake sites will determine the north and south extremes of this N-S precipitation dipole anomaly. Furthermore, examination of the lakes near the zero line will determine if the zero line has shifted, when, and possible drivers. It is also important to finish analyses on all LML cores and obtain more AMS radiocarbon dates to provide a more complete Holocene water-availability record with tighter age constraints for Southern Colorado.

6.0 Conclusion

Water availability is a critical issue in the Rocky Mountain region and for the rivers that are fed from Rocky Mountain watersheds. Understanding past trends in water availability and possibly what drove them will help identify potential future water availability and assist in implementing proper water management systems. This study suggests ENSO may be a major driver of an anti-phased relationship in watersheds across a N-S gradient in the Rocky Mountain region, and this relationship needs to be considered when modeling water availability in this region in the future.

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8.0 Literature Cited


Marsicek, J.P., Shuman, B.N., Brewer, S., Foster, D.R., and Oswald, W.W. Submitted. Quantifying climatic changes associated with the mid-Holocene Tsuga decline at ca. 5.5 ka in the northeastern United States. Submitted to Quaternary Science Reviews.


Introduction

The criminal justice system has played a strong role in the lives of women of color. Before the 20th century, women of color were not found in the criminal justice system at a high rate. However, over time, the rate of women in the system has increased. Since 1989, the number of women in prison has doubled (Reynolds, 2004). There are various elements that have played a part in the increase of women in the criminal justice system. This review will study the elements that affect women in the criminal justice system such as the war on drugs, drug use, sentencing, women of color, and family issues.

War on Drugs

Tonry (1994) stated that in the 1980s racial disparities were seen across the criminal justice system from arrests, to jail, imprisonment and sentencing. These racial disparities are increasing as laws are being implemented. These laws call for harsher punishment of crime control and drug policies. “… The worsening disparities since 1980 are not primarily the result of racial differences in offending but were foreseeable effects of the War on Drugs and the movement toward increased use of incarceration” (Tonry, 1994, p. 480).

In 1980, President Ronald Reagan announced that the War on Drugs would be a high government priority (Mauer, 2004). The War on Drugs refers to a set of policies on how people are arrested and sentenced for drug related crimes. There are two drug policies that affected women of color the most. The first policy is mandatory sentencing, instituted in 1986 (Mauer, 2004). The second policy put in place 1989, was federal sentencing guidelines (Mauer, 2004). With these policies, law enforcement has been able to crack down on people who could be drug violators (Mauer, 2004). The new laws changed how law enforcement investigated and arrested suspected drug violators. “It has also expanded the criminalization of people by race and gender, leading to sharp increases in the numbers of incarcerated African American women and Latinas” (Sudbury, 2010, p. 14).
The exposure for all women with drugs is multifaceted. “Women come into contact with the War on Drugs both as consumers of criminalized drugs and as low-level dealers and couriers or family members of participants in the drug industry” (Sudbury, 2010, p. 14). The new policies enacted in the 1980’s for the War on Drugs disproportionately affected and specifically targeted low-income women and people of color. The women were systematically profiled as drug users and couriers, and received longer prison sentences (Bloom, 2004). The mandatory sentencing policy affected women of color the most because they required people who committed a drug crime to be sentenced for a certain amount of time (Mauer, 2004). Under mandatory sentencing laws, women who would have received community sanctions are now being incarcerated (Covington & Bloom, 2003). “Increasingly, women of color who are struggling with drug addiction are processed through the criminal punishment system rather than through drug rehabilitation programs or services that offer support for underlying issues, such as mental illness and trauma” (Sudbury, 2010, p. 14). The War on Drugs has increased the number of African American women and Latinas in the criminal justice system because of the stereotypes. African Americans are stereotyped as being the dealers and distributors in their communities. Latino/as are stereotyped as traffickers that bring drugs across the U.S. border (Sudbury, 2010).

The mandatory sentencing policy requires people who committed a drug crime to be sentenced for a certain amount of time (Mauer, 2004). Many states have introduced mandatory sentencing for drug offenses, which have made judges give lengthy sentences regardless of the situation or circumstances of the case. For example, a woman in possession of only five grams of meth receives the same sentence as one who possesses five hundred grams (Sudbury, 2010). Women of color with drug addiction or drug users are more likely to be incarcerated instead of going to drug treatment programs (Sudbury, 2010). With this act, prison time is determined by the amount of drugs a person is caught with at the time of arrest. To determine this, drugs seized during an arrest have to be weighed. Guidelines were put in place for prison sentencing for a certain amount of drugs a person might be carrying (Covington, 2003). Under these guidelines parole has been taken out as a sentencing option after a person has completed half of his or her sentence. Judges no longer have judicial discretion to sentence offenders as they wished. Lighter sentences are only implemented to offenders who have become informants for prosecutors against other drug dealers or bosses (Covington, 2003).

A change in “policies that sent nonviolent drug offenders to prison for lengthy periods of time would assist these negative consequences placed on women of color” (Reynolds, 2004, p 255). According to Reynolds (2004), the War on Drugs has impacted women of color because of the incarceration rates that have increased due to the new policies. Not only are women of color being affected by longer sentences, but also, by “ancillary consequences of their imprisonment” (Reynolds, 2004, p 250). The ancillary consequences are the “loss of civil
rights, and the denial of welfare benefits, food stamps, housing, student loans and employment” (Reynolds, 2004, p 252).

Sudbury (2010) stated that in order to support the new efforts of the War on Drugs government officials cut funding that supported low income families, which led women to “turn to survival strategies that are increasingly criminalized” (p. 110). Women have turned to “street economy, sex work, petty theft, welfare fraud or other economic survival strategies in the face of declining incomes, and few economic opportunities are frequently caught up in the revolving door of initially short and then lengthier jail times” (Sudbury, 2010, p. 13).

**Sentencing**

Women face sentencing disparities in many different ways. Some of these disparities are a result of arrest, courtroom procedures and prison. Women and men have different experience in the criminal justice system. In many situations, women do not receive the same amount of service that male offenders receive. After women are sentenced to prison, they still face inequality in prison. Research has shown that women in prison receive fewer services than males who are in prison (Grella, 2011). Some programs that female prisons are less like to receive are health care, pre-natal care, education, job training and treatment for alcohol and drug abuse (Covington, 1998). They do not have many services that appeal to their needs (Grella, 2011). Women of color face additional disparities because of their ethnicity.

Women of color are stereotyped by law enforcement to be international drug couriers and are disproportionately targeted by law enforcement (Bloom, 2004). Demuth and Steffensmeier (2004) found that African American and Hispanic offenders have a disadvantage in the criminal justice system because they are more likely to be sentenced to prison or jail compared to white offenders. Racial disparities in sentencing are because of focal concerns in the courtroom work group. “Judges and other court actors are guided by the three focal concerns in reaching sentencing decisions: blame worthiness, protection of the community, and practical constraints and consequences” (Demuth and Steffensmeier, 2004 p. 997). Demuth and Steffensmeier (2004) say that these focal concerns are influence by social structure that contributes to sentencing disparities.

**Stereotypes**

African American poor communities are mostly affected by the drugs laws related to crack cocaine when compared to the middle class drug users of meth, heroin and powder cocaine (Sudbury, 2010). Crack cocaine is cheaper and easier to access for people on the streets (Sudbury, 2010). African American women are often stopped as suspects for delivering drugs in the United States. Law enforcement views them as the people distributing and dealing drugs for their boyfriends (Barbara, 2004). Tonry stated that the problem is not that African Americans
are selling drugs at disproportionate rates than other ethnic groups, but that the locations where drug selling occurs places them in situations where they are more likely to be caught by police (1994). According to Tonry, it is easier for law enforcement to arrest African Americans than it is to arrest whites (1994). Disorganized inner city communities with minority populations often make it easier for law enforcement to come in and make arrests (Tonry, 1994). African American drug dealers sell drugs on the street, where they are more likely to be spotted, or be caught selling to an undercover police officer (Tonry 1994). In many instances, white drug dealers sell drugs in closed rooms, such as homes or offices and most likely are not subjected to undercover police officers (Tonry 1994).

Media stereotypes often portray Latin communities as places where there are a lot of narco-traffickers (Sudbury, 2010). Latinas are stereotyped by police as taking drugs across the border of the United States and Mexico (Sudbury, 2010). These women are in special situations where they carry drugs across the borders to take care of their families. “Once they cross into the United States and are interdicted at the border or in the airport, these women are treated as traffickers and consequently receive lengthy sentences disproportionate to their low-level involvement in the illegal drug industry” (Sudbury, 2010, p. 16). When crossing borders they are stopped more often and are subject to more policing, random stops for suspicious behavior and immigration violations (Sudbury, 2010). “Latinas are sometimes caught in law enforcement efforts to intercept their male family members and may be encouraged to take full responsibility for a crime in order to protect their menfolk” (Sudbury, 2010, p. 15). This causes an increase in mothers in the prison system.

**Effects on Family**

Most of the parents who are in prison are men but the rates of females are increasing (Clopton, 2008). When parents go to prison, they come across a host of family problems. Women in prison have a lot of family issues that are caused by their being in the prison system. Sudbury (2010) stated that the family problems often existed before the women were caught in the criminal justice system. In an effort by the government to reduce the crime rate, they took funding and programs away from family services and put them into the criminal justice system. Sudbury said that the government decrease in support, resources and services has caused women to find a different method to support their needs (2010). Crimes committed by women are linked to the disadvantages they face economically in society rather than the danger they pose in society (Luke, 2002). “Incarcerated mothers and their children experience pain and loss due to enforced separation” (Luke, 2002, p. 930). Many families with mothers who are incarcerated are more likely to be in poverty before, during, and after the mothers’ incarceration time (Luke, 2002). Most of the women who are in prisons are more than 100 miles from their children (Mauer,
The distance between the children and their mothers creates a break in their relationships (2004). “Phillips and colleagues found children whose mother had been involved with the criminal justice system were significantly more likely to have experienced four or more moves in a 5 year period than those children whose mother had not experienced involvement with the criminal justice system” (Clopton, 2008 p. 195). Often when a mother is in prison the child is more likely to live with another relative compared to when the father is in prison. When the father is in prison the child lives with the mother (Clopton, 2008). Relatives who take care of children with parents in prison are often not prepared to take care of the child. “Caretakers often experience stress associated with caring for children when the parent is incarcerated and children may be aware of their caretakers’ emotions” (Clopton, 2008, p.195).

Children face a lot of issues when it comes to their relationship with their incarcerated parent. One of the problems that some children face is talking about their parent’s incarceration. “Some children may find visits frustrating, awkward, or frightening” (Clopton, 2008, p. 196). Some parents do not want their children to talk about their imprisonment, and some children struggle with the information and do not want their friends to find out (Clopton, 2008). School is a challenge for these children because they are not allowed to talk about their families, or it is difficult for them to talk about their families (Clopton, 2008). Some of these children feel that they do not have anyone to talk to about their problem or feelings about their parent incarceration (Clopton, 2008).

Children can have emotional and psychological problems when their mothers and fathers are incarcerated (Luke, 2002). Children of incarcerated mothers are more likely to have personal and socially destructive outcomes. Luck (2002) indicates that regarding behavioral and emotional problems children face, “school problems, fear, anxiety, anger, sadness, and guilt are within the normal range of experiences for children of incarcerated parents, as are abuse of chemicals at a young age, early sexual activity, teen pregnancy, truancy, and juvenile delinquency” (Luke, 2002, p. 933). If children take the lead from their parents’ behavior, many can end up in the system like their parents. “Children of incarcerated parents are up to six times more likely to be incarcerated at some time in their lives than are children of parents not involved in the criminal justice system” (Luke, 2002, p. 930).

Mothers that are incarcerated feel a separation from their children, which causes most of the pain that they feel while in prison. Mothers fear losing custody of their children (Luke, 2002). “Mothers experience extreme guilt, anxiety, and sadness while they are incarcerated” (Luke, 2002, p. 934)."

Women with children and who are pregnant fear custody challenges while incarcerated (Mauer, 2004). For pregnant women, once they give birth their children are taken from them. If the pregnant offender has family members that are willing and able to take care of the child, then the baby is handed over to the family members. By giving a child to a family member, it does not
necessarily allow for the mother to see her child. In many of these cases some family members will not bring the child to visit their mother. If the pregnant woman does not have family members, then the child is given to family services for care. Once in family services, the child most likely will not see their mother while she is in prison. In many of these cases, when the mother completes her prison sentence, it is harder for her to regain custody of her child.

Latinas’ families can face different challenges when a mother goes to prison. Latinas who are not U.S. citizens are subject to deportation that affects their family. Some of these women are deported and their families are still in the United States. “On completing their prison time, these women are deported to their countries of origin, with few resources to survive, and are thus forced back into the cycle of poverty and criminalization” (Sudbury, 2010, p. 16).

**Method Section**

The method to collect data in this study will involve in-depth interviews at drug treatment facilities. There are four interviews that will take between one hour to one hour and a half. The first two interviews will be rehabilitation program directors and the last two will be meth drug officers. Contact has been made with drug treatment facilities directors, in Casper and in Cheyenne, Wyoming. This study may include an interview with the head of the Wyoming Meth Task Force. The four interviews will focus on the topic of women of color who have been incarcerated in the criminal justice system for meth use. This study will use semi-structured questions in the interviews with the participants who have volunteered, and have been approved to participate in the study. Each participant will be provided with a consent form to review and sign as a requirement for their participation. The data will be collected by using a recorder and by note taking during the interviews. A qualitative method of in-depth interviews will be used. The interviews will capture the observations and views of individuals who come in contact and work with women of color and have been in the criminal justice system for the use of meth. The data collected will provide insight into the experiences of women of color in the criminal justice system because of meth-related crimes. The participants will provide information about the struggles of women of color because of meth crimes and how sentencing has impacted their lives.

**Limitations**

Throughout this research there were various limitations. One limitation was, not being able to interviews of women of color that has been though the criminal justice system for meth related crimes. Another limitation was the number of participants, there were only three in this study. In future studies of this research the method that will be used to conducting the research will be conducting focus groups of women of color that have gone growth the criminal justice system. The will be at least three to four focus group with at least eight to ten participants.
Conclusion

Over the last few decades women have faced an increase in their placement in the prison system. New laws and policies have contributed to this increase in women who are incarcerated. The policies have directly affected women of color and their families. The War on Drugs and mandatory sentencing laws are two changes that have played a role in the increased incarceration rates of women of color. Children of parents in prison have also faced a number of emotional, psychological and social issues. Drug laws that have increased prison sentences, including for non-violent drug crimes, continue to disproportionately affect women of color. However, more needs to be done to move beyond incarceration to also look at alternatives such as rehabilitation, education and training.

Appendix 1

Sample questions that will be asked include:

1. Give me your name and professional title?
2. Describe what you do in your position and how long you have worked in this field?
3. What do you know about the War on Drugs that started in the 1980s?
4. How has the War on Drugs affected women in the criminal justice system?
5. How do you believe it has affected women of color?
6. Have you seen a change in sentencing since the War on Drug started? What changes have you seen?
7. What was your first experience with women that have been in the criminal justice system for Meth?
8. What type of sentencing have you seen for women who have been arrested for meth crimes?
9. Do you see more women sentenced to drug treatment programs or to prison?
10. What do you see as the difference between drug treatment programs and prison?
11. Do you believe the personal circumstances of the individuals as well as the crime should be considered when weighing treatment or prison? Why?
12. What might be some of the factors to consider when considering a sentence of treatment or prison?
13. Have you noticed a difference in women being sentenced for meth crimes compared to men? What are some of the differences you noticed?
14. Have you seen an adverse effect in sentencing on women of color for meth crimes, if so, how?
15. Do you believe that drug sentencing laws are harsher for women of color? Explain why or why not?
16. Can you think of any factors that are not taken into consideration when women of color are sentenced?
17. Are families taken into consideration with sentencing for meth crimes?
18. How do you believe these women’s families have been affected by prison sentencing? Drug treatment?
19. What are some of the first steps taken at your facility when women come for treatment?
20. Are there mandatory and/or optional requirements at your facility?
21. Can you speak generally, without using names, of some success stories as well as some failures?
22. What types of changes in drug sentencing might be more effective for women coming through your program?

References
Section 1: Introduction

In the long catalogue of large-scale human indecency and criminality, the Holocaust holds a singular place. Though genocide is unfortunately a recurrent phenomenon from the earliest days of recorded human history up to today, the events of the Holocaust are unique. Between 1941 and 1945 over six million European Jews were murdered at the hands of the Nazi regime. In only this example was the business of mass murder made so mechanical and systematized, most notably in the creation of distinct death camps in Poland and the transfer of Jews from across Europe to these camps. It is in knowledge of this mechanization that history can lose sight of how the Holocaust began. The Holocaust in Eastern Europe has its beginnings, in 1941 and 1942, in mass shootings carried out by the various formations of Germany’s military and Nazi party forces. Specially designed killing squads made up of SS men called Einsatzgruppen were a major part of these actions. Perhaps less known by individuals who do not study the Holocaust are the contributions to these murderous efforts by the German Wehrmacht and police. These organizations were unlike the Einsatzgruppen in that they were not composed exclusively of devoted Nazi Party members. All told, these groups were responsible for an estimated 1.5 million deaths in the Holocaust before the camp system was fully implemented.¹

How could such raw violence take place on the scale it did, well before the camps and gas chambers we often associate with the Holocaust were created? Christopher R. Browning’s Ordinary Men analyzes Holocaust participation by members of Reserve Police Battalion 101 of the German Ordnungs Polizei (the police force for occupied Poland and USSR).² In this work, Browning comes to the conclusion that many different motivations and levels of adherence in Holocaust perpetration were possible among the ranks of this one unit as a case study. Daniel Goldhagen interestingly analyzes the same unit in his Hitler’s Willing Executioners and comes to completely different conclusions.³ Goldhagen’s thesis is that the single factor of a commonly
held “eliminationist antisemitism” explains participation in Holocaust atrocities by not only the men of Reserve Police Battalion 101, but also all Germans in general. The question of motivation in this early stage of the Holocaust, the Holocaust by bullets, is an important one for anyone interested in understanding how genocide occurs.

If Goldhagen’s thesis holds true, the SS Einsatzgruppen, perpetrators of the early Holocaust in the East, should be the perfect example of motivation by ideology. Members of the Einsatzgruppen were uniform in their membership of the SS and the Nazi Party. In other words, we can assume that this meant they were more ideologically motivated than those individuals who were not party members. Goldhagen and Browning disagree on the percentage of members of Reserve Police Battalion 101 holding Nazi Party membership, though each believes the number to be less than fifty percent. In SS formations there can be no such disagreement. All members of the SS are party members. As such all members of the Einsatzgruppen, as a part of the SS, are therefore party members.

Utilizing the Einsatzgruppen as a case study, this research will step into the debate on perpetrator motivation and assess the level to which ideology was the controlling factor. Using the Einsatzgruppen as a focus allows a pair of interesting opportunities. As party and SS members this group should offer the best possible opportunity to prove Goldhagen’s thesis. The men of this group are, almost to a man, members of what Michael Wildt has called the Uncompromising Generation. They were mostly younger Germans, who spent a good deal of their formative years under the Nazi regime. Since this group was comprised completely of Nazi Party members, common sense dictates that the Einsatzgruppen should share a common ideology. Conversely, if it can be shown that even the Einsatzgruppen brought differing levels of adherence to Nazi ideology and differing reasons for participation in the Holocaust to the Eastern Front, this would support Browning’s more open ended interpretation of perpetrator motivations.

This research will utilize the transcripts of the subsequent International Military Tribunals at Nuremberg as a record in order to assess Einsatzgruppen perpetrators using their own words. Case IX, entitled The United States of America vs. Otto Ohlendorf, et al (better known as the Einsatzgruppen Case), deals exclusively with the trial of twenty-four members of the Einsatzgruppen brought forth by the occupying Allied Powers in the immediate aftermath of World War II. This was one of twelve trials held in 1947 and 1948, known as the subsequent IMT because they followed the initial Nuremberg Trial of 1945-6.

Utilizing trial transcripts as a primary source for this project has its strengths and weaknesses. The twenty-four men on trial in the wake of World War II knew the possible punishment for the crimes they stood accused of, and it included the death penalty. Admittedly, their answers may be tempered by the realization that they are on trial for their lives. Interestingly, however, it will be demonstrated that this knowledge did not stop the accused (especially in the case of Otto Ohlen-
from giving candid statements to the court that at times even include unvarnished admissions of guilt. As one of the only sources we have for perpetrators speaking in their own words, these transcripts cannot be ignored. Another limitation of trial transcripts is their scope. The transcript has only the answers of the accused to questions which they were asked. Frustratingly at times the defense of the prosecution will come so close to simply asking the question ‘why did you do it,’ only to back away again. Still, even with their incumbent faults, the trial transcript offers the best possible resource for hearing the accused members of the Einsatzgruppen in their own words. The trial took place immediately after World War II and is therefore a record of the Holocaust in the East recorded as close to the actual date of events as can be obtained.

A great many scholars have already contended with the issue of Holocaust perpetrator motivations. Previously mentioned authors Christopher Browning and Daniel Goldhagen have debated the motivations of perpetrators both in their written works and in person at the United States Holocaust Memorial Museum. Their debate represents an important part of the study of the Holocaust. Further historians such as Omer Bartov have added works to the historiography of Holocaust perpetration that also explain participant motivations and ideology. This research will begin with a review of the relevant historiography in two parts. The first section will focus on the debate between Browning’s more open ended explanation of Holocaust perpetration and Goldhagen’s singular explanation of exterminationist antisemitism. Following this debate the paper will consider the works of other historians who have offered still more possible reasons for Holocaust perpetration. This research will address the question of motivation among SS – Einsatzgruppen members who personally took part in the execution of thousands behind the lines on the Eastern Front. What compels individuals to commit the atrocities of the Holocaust? Does the answer lie simply in ideology or were there other contributing or even competing motivations? The paper will then turn to the case study in question and offer its own analysis of motivation using the Einsatzgruppen case transcripts as evidence.

Of utmost importance throughout the progress of any work analyzing the motives of criminal groups, is the goal of the work in question. Here, as with any reputable work on this topic, the goal is not at any time to provide justification for the actions of participants in the mass murder of innocent people. From here forward if the word justification is used, it will only be in order to repeat the stated or implied feelings of those responsible. It should by no means be construed as agreement with or acceptance of any possible attempts to justify participation in the actions of the Holocaust. Among the goals of any good research is objectivity. In one respect, this research will happily fail to remain objective. No comfort will come from these pages for those who have committed the criminal atrocities of the Holocaust. Though this research seeks an understanding of their personal reasons for participation, any understanding gained will not seek to disabuse them of the guilt that is eternally theirs alone to bear.
Section 2: The Debate.

Almost all who know something of the history of the Holocaust know the story of concentration camps and ghettos. What may remain less understood by the casual observer are the events that preceded the death camps. The Holocaust took its first victims from among the disabled and mentally handicapped. Those least able to defend themselves were swept up in what was known as Aktion T4. This code name simply refers to the program’s street address at Tiergartenstrasse 4 in Berlin. This state-sponsored ‘euthanasia’ of those considered a drain on society by eugenicists and Social Darwinists was Nazi Germany’s first foray into mass murder. Though camps existed from the outset of the Nazi regime, it was not until 1942 that these camps became exterminationist in purpose. Prior to that most camps were in Germany and most held political prisoners of the regime. Only from 1942 were specific death camps so designated, and those were entirely in occupied Poland. Between T4 and the formation of death camps comes one of the Holocaust’s most forgotten phases and its least understood.

From the invasion of Poland in 1939 and accelerating after Germany’s invasion of Russia in 1941, the Holocaust claimed most of its victims by rifle rather than gas. The wholesale execution of masses of people in the death camps of Sobibor, Treblinka and others does not go into full swing until 1942. From June 22, 1941 onwards, the Einsatzgruppen mobile killing squads took thousands of lives in Eastern Europe. What history continues to wrestle with and debate most recently are the motivations of individual perpetrators. Germans and Americans alike have long clung to the idea that the SS were Hitler’s criminals. In this tidy understanding of history, it was easier for Germans to live with the legacy of World War II and for Americans to live with Germans as allies in the Cold War. The truth, however, as is so often the case, is messier. Far more Germans took part in this “Holocaust by bullets,” to borrow the title of Father Patrick Desbois’ powerful book, than simply those who were members of the Einsatzgruppen. Between 1939 and the end of the war the SS, the Wehrmacht and police all took part in the execution of over 1.5 million Eastern European Jews, Gypsies and suspected communists. These victims were neither transported to camps nor worked to death in German factories. Some were concentrated in ghettos before their eventual murder but for many more their experience of the Holocaust was simply to be lead from their homes and shot in the fields and forests surrounding their towns and cities.

Daniel J. Goldhagen is not exclusively a historian by training, as a holder of advanced degrees in political science it may seem only reasonable that he comes to conclusions with which historians may differ. His website touts the debate and impact that his Hitler’s Willing Executioners: Ordinary Germans and the Holocaust has had on perpetrator studies since first published in 1996. On the home page of his website, Goldhagen proclaims that his book “told buried truths about the tens upon tens of thousands who carried out Hitler’s plan to exterminate
the Jews: these perpetrators were willing executioners, willing because they were antisemites who believed that exterminating Jews was right and necessary.”9 This short quote actually contains the central thesis of his book. Goldhagen goes to great lengths to convince his audience that the only necessity for Holocaust perpetration was a singular antisemitism driven model. Of previous (and following) treatments of perpetrator actions, Goldhagen has the following to say:

“The conventional explanations cannot account for the findings of this study, for the evidence from the cases presented here. They are belied by the actions of the perpetrators, glaringly and irrefutably. The notions that the perpetrators contributed to genocide because they were coerced, because they were unthinking, obedient executors of state orders, because of social psychological pressure, because of the prospects of personal advancement, or because they did not comprehend or feel responsible for what they were doing, owing to the putative fragmentation of tasks, can each be demonstrated in quick order to be untenable.”10

The author’s certainty in, and ambition for his point of view are undeniable. Goldhagen leaves no room for explanations of perpetrator actions based on personal gain, uncaring tunnel vision or peer pressure. His disregard of peer pressure related motivations for perpetration is very interesting considering the military style social structure that these acts were committed in whether the perpetrators in question are SS, police or Wehrmacht.

In stark contrast to Goldhagen’s thesis lies the work and ideas of Christopher R. Browning. As mentioned previously, Browning’s book *Ordinary Men: Reserve Police Battalion 101 and the Final Solution in Poland* offers several explanations of perpetrator actions. The differing points of view on perpetrator motivations are made even more interesting by the previously mentioned fact that both authors use Reserve Police Battalion 101 as their case study. In his conclusion regarding the actions of these “ordinary men,” Browning states the following about motivations:

“The collective behavior of Reserve Police Battalion 101 has deeply disturbing implications. There are many societies afflicted by traditions of racism and caught in the siege mentality of war or the threat of war. Everywhere society conditions people to respect and defer to authority, and indeed could scarcely function otherwise. Everywhere people seek career advancement. In every modern society, the complexity of life and the resulting bureaucratization and specialization attenuate the sense of personal responsibility of those implementing official policy. Within virtually every social collective, the peer group exerts tremendous pressures on behavior and sets social norms. If the men of Reserve Police Battalion 101 could become killers under such circumstances, what group of men cannot?”11
Browning’s emphasis is that there were many ways in which the men of this battalion were led along paths that resulted in the same end: mass murder. In this understanding of Holocaust perpetration, he argues that we should see far greater peril for the modern world than in the Goldhagen version of perpetration. The last sentence of this quote by Browning is his warning. If the men of this group can, as he believes, follow so many different roads to the same murderous actions, this model becomes a warning for the process following and even future genocides may take place. Goldhagen, in contrast, asserts that the singular anti-Semitic ideology of one time and one place- Nazi Germany in the 1930s and 1940s- explains perpetration in Eastern Europe from 1941-2.

Their debate held at the United States Holocaust Memorial Museum in Washington, D.C., on April 8, 1996 and the transcript of the debate is even more eye opening than their respective written works. The museum debate was spirited and useful for gaining and understanding of these two authors in an easily digestible format. Both men reiterated their original theses and strengthened their points before the museum audience. In his presentation at the debate, Goldhagen stated that: “Not coercion, not obedience to authority, not bureaucratic myopia, not peer pressure, not personal profit or career advantage – none of these, but instead, the perpetrators’ antisemitism explains the various features of the Holocaust that must be accounted for.” For his part, Browning begins his attempt to refute Goldhagen’s thesis with a quote from German historian David Bankier. Bankier states: “Ordinary Germans knew how to distinguish between acceptable discrimination… and the unacceptable horror of genocide… The more the news of mass murder filtered through, the less the public wanted to be involved in the Final Solution of the Jewish Question.” To Bankier’s thoughts, Browning adds:

“If such a group of “indifferent” Germans not only provided the autonomy for the regime to implement genocidal policies but also many of the killers, then the focus of explanation would shift from Goldhagen’s single cognitive model producing a uniform group of willing killers, to the combination of ideological and situational factors that allowed a popular, ideologically driven, dictatorial regime and its hardcore followers to mobilize and harness the rest of society to its purposes. In such an approach, antisemitism would certainly not be absent but it would also not be sufficient.”

Again, in this instance from the museum debate as with the earlier Browning quote, his last sentence is the most important. This research takes the view that multiple possibilities exist in the realm of perpetrator motivations.

Christopher Browning utilizes a quote from Primo Levi, the Jewish-Italian Holocaust survivor and author, in both his book and his statements at the debate. Levi speaks of the nature of historical debate and understanding when he says people:
“Tend to simplify history; but the pattern within which events are ordered is not always identifiable in a single unequivocal fashion, and therefore different historians may understand and construe history in ways that are incompatible with one another. Nevertheless, perhaps for reasons that go back to our origins as social animals, the need to divide the field into “we” and “they” is so strong that this pattern, this bipartition—friend/enemy—prevails over all others. Popular history…is influenced by this Manichean tendency, which shuns half-tints and complexities; it is prone to reduce the river of human occurrences to conflicts, and conflicts to duals—we and they… The desire for simplification is justified, but the same does not always apply to simplification itself, which is a working hypothesis, useful as long as it is recognized as such and not mistaken for reality. The greater part of historical and natural phenomena are not simple, nor simple in the way we would like.”15

What Levi and Browning are pointing out here is the inherent debatability of history and how difficult and dangerous it is to place historical events or human motives into ‘black and white’ categories. Browning utilizes this quote by Primo Levi in order to highlight what he sees as the fatal flaw of Goldhagen’s work. Goldhagen has placed the events of the Holocaust and the motivations of its perpetrators into a far too limited box. Levi’s quote also leads perfectly into the next section of the historiography of this research. Levi views both history and human motivations as gray areas perfectly in keeping with the title essay “The Gray Zone” from which his above quote is taken.

Section 3: Historiography beyond the Debate:

Along with the debate regarding the level to which ideology contributed to or controlled the actions of rank and file German soldiers and police in the Holocaust are several other factors for consideration. Ideology is not the only possible rationale for ordinary Germans to have participated in the Holocaust. Some may state the exigencies of combat or the pressures of war to explain their actions. Still others may state as their reasons for participation military discipline or fear.

Psychologists have long struggled with how the perpetrators of mass murder were able to participate in acts that run so glaringly contrary to sane behavior. Hilary Earl, in the only major study of the Einsatzgruppen case that exists, mentions the issues that Nazi captors, interrogators and later scholars have had understanding Nazi war criminals.16 Despite the inability of some to come to terms with the fact that participants in genocide can be sane and even highly educated, scholarship has moved beyond these misgivings in order to explain the behavior of participants in the Holocaust. Earl points out in her book on the Einsatzgruppen that the historiography to date has not cleaned up the matter of perpetrator motivations, it rather “does not allow for easy characterizations. Instead it yields a myriad of personality types and variable factors that more accurately recreate the complex human reality of events on the eastern front.”17
In support of her argument that perpetrator motivations come from many sources Earl divides the twenty-four Einsatzgruppen defendants into three categories. These categories are labeled ideological soldiers (though she takes pains not to agree with the full Goldhagen interpretation of ideological motivation), deniers and conflicted murderers. The four defendants that she places in the category of conflicted murderers illustrate her argument most vividly. First mentioned of these four men is Paul Blobel, commander of Einsatzkommando 4a in Southern Ukraine. Blobel was, by all accounts, a motivated murderer capable of acts so revolting that while on trial his own co defendants attempted to distance themselves from him. For all his seeming enjoyment in the task of mass murder, however, he was among the defendants who admitted to becoming alcohol dependent because of participation. To the example Blobel and his alcohol addiction Earl adds the case of defendant Eduard Strauch. Strauch was an equally sadistic killer as Blobel, yet also became alcohol dependent as a means to cope with his actions. Earl notes that Strauch “was the only defendant at Nuremberg who exhibited genuine signs of mental collapse” during the trial. For this defendant, mental imbalance was a factor noted in his own SS personnel record as early as March 1941. In both cases, the defendants show all the signs of having moral conflicts with their actions, yet not to a level that caused them to stop what they were doing. Strauch seems to have exacerbated a pre-existing mental condition while Blobel’s actions seem to have caused him to develop alcohol dependency. Earl has highlighted a possible flaw in the Goldhagen thesis with the example of these two men. If they were perfect adherents to Nazi ideology, proffering that Jews are the enemy of the German people and are not human, then why do they still show these flickering signs of remorse? The illness or addiction of these two men is not now, nor was it then, a defense. It is merely brought forth to show that they possessed reservations about their actions yet were driven on by a force that overcame their own personal morality.

Omer Bartov’s *Hitler’s Army* offers four further explanations of perpetrator motivations. Bartov’s work does not relate as perfectly to this research as that of Earl. His book focuses on the German Wehrmacht and the process that drove this force to commit the crimes it did both inside and outside the context of the Holocaust. *Hitler’s Army* is useful, however, in how it explains a different route to the commission of atrocities. Bartov constructs a four-part thesis that explains the process through which the Wehrmacht, through battle on the Eastern Front, became Hitler’s army. According to Bartov’s work the four necessary components of change from a modern fighting force which believed in the basic rules of war to an unbridled killing machine are “The demodernization of the front,” “destruction of the primary group,” “the perversion of discipline” and finally “the distortion of reality.” These factors, in the words of Bartov, “Confronted [the Wehrmacht] with a battlefield reality which no longer corresponded to their previous image of war, and with an enemy who could not be overcome by employing familiar military methods,
German soldiers now accepted the Nazi vision of war as the only one applicable to their situation. It was at this point that the Wehrmacht finally became Hitler’s Army.27

What Bartov means by the demodernization of the front is the material loss of technology and equipment suffered by the fighting force in the east.28 An army that had been used to lightning advances and victory through the superior employment of armor and air power became mired in a costly war of attrition that all but destroyed the modern materials of war at their disposal. The destruction of the primary group is the effect of massive casualties on the force as a whole. Gone in short order were the long serving veterans that bound together the social structure of the force as a whole.29 The perversion of discipline is Bartov’s term for the radicalization of German military law.30 Punishments became so harsh and immediate for even the most minor offenses that the system of military discipline “became responsible not only for the troops’ steadfastness on the battlefield, but also for their profound brutalization.”31 Finally, the Wehrmacht, along with the rest of German society, were subjected to a Nazi engineered distortion of reality that only increased as the war dragged on. Bartov states that indoctrination of the Wehrmacht “served the double purpose of strongly motivating the troops and greatly brutalizing them, for it legitimized both one’s own sacrifices and the atrocities committed against the enemy.”32

What if we extend these factors brought forth by Bartov to the whole of German society? Germans were uniformly subject to Nazi ideological reasoning and attempts to control thought. Draconian discipline was a feature of not only the armed forces, but also of the entirety of the dictatorial state. Allied bombing, blockade and pressure on the German home front demodernized life throughout Germany as the conditions of battle did in the east. Loss of primary groups can parallel the deployment (away from home and standard social structures) experienced by all German forces, to include the Einsatzgruppen. What Bartov contributes is a possible route to rationalizations of actions that can exist alongside Nazi Party ideological teachings, but is not the same as a pure definition of true belief ideology. Through individual experiences and beliefs, these two possibly competing ideological systems- the true Nazi ideology and the conviction that Nazi ideology was right based on circumstances and conditions- could even feed off or support the other. Varying daily realities may even make one ideology more important one day and the other the next in a highly fluid experientially based explanation of perpetrator motivations.

The final author to be included in this historiography is Waitman Beorn. In the interests of full disclosure, Beorn studied under Christopher Browning at the University of North Carolina – Chapel Hill and therefore his views on perpetrator motivations are perhaps quite unsurprisingly in line with those of Browning. Beorn’s article “Negotiating Murder: A Panzer Signal Company and the Destruction of the Jews of Peregruznoe, 1942” provides an analysis of a rear echelon German company’s participation in the Holocaust.33 His article covers many of the same themes of divided justifications of participation and varying rationales already covered in this research.
The article is especially useful in its inclusion of a continuum of perpetrator types that can help frame the analysis of differing personalities. In the following table taken from his article, Beorn lays out his classification system for the motivations and ideological persuasions of Holocaust perpetrators from his case study of 4th Company. Beorn classifies the perpetrators he studies along an ascending scale from “True Believers” to “Active Group Resisters.” Individuals classified at the lowest level as “True Believers” encountered the least risk to self and embodied the greatest willingness to kill. Those at the highest level of “Active Group Resisters” encountered the greatest personal risk and actively refused to commit atrocities while even attempting to get others to refuse to shoot as well.

Beorn’s model of the army unit studied does not fit perfectly into a study of members of the Einsatzgruppen. No Einsatzgruppen members featured in this research ever came close to being an Active Group Resister. None ever even rose to Beorn’s Non-Complier category. All, it is sad to say, range from Initiative Takers to Compliers. These categories represent individuals who took part in all the atrocities that they are ordered to persecute and may have even self-initiated others. It is their reasons or motivations for perpetration that will be the focus of the research to follow. The intent of this research is to enter the Browning – Goldhagen debate on perpetrator motivations in the case of Einsatzgruppen members. Earl, Bartov and Beorn offer a guide against which the words of the perpetrators may be tested. Bartov provides a parallel understanding of ideology in addition to the Goldhagen thesis. In the following research the idea of whether wartime conditions, in line with Bartov, scattered motivations, as posited by Browning and Beorn, or
true ideological adherence in the Goldhagen mold contributed most to perpetrator actions will be explored. Beorn and Earl have also provided a useful scale for the interpretation of what is found in this research.

Section 4: Original Research:

“One of counsel has characterized this trial as the biggest murder trial in history. Certainly never before have twenty-three men been brought into court to answer to the charge of destroying over one million of their fellow human beings. There have been other trials imputing to administrators and officials responsibility for mass murder, but in this case the defendants are not simply accused of planning or directing wholesale killings through channels. They are not charged with sitting in an office hundreds and thousands of miles away from the slaughter. It is asserted with particularity that these men were in the field actively superintending, controlling, directing, and taking an active part in the bloody harvest.”

The above are the words of one of the prosecutors in the Einsatzgruppen case. In the course of this trial the prosecution went to great lengths to draw a line between this case and the other cases of the International Military Tribunals at Nuremberg. The singular difference between this trial and all others is that fact that the accused members of the Einsatzgruppen had firsthand experience of the crimes for which they stood accused. These were not “desk murderers” and no claim to a “banality of evil” could be made about these men in the eyes of their accusers. The men on trial all stood accused of the following three counts: crimes against humanity, “war crimes such as murder and ill treatment of prisoners of war” and finally “membership in organizations declared criminal by the International Military Tribunal (such as the SS and the Gestapo).” Of the original twenty-four defendants, one committed suicide, one was separated from the trial due to ill health, eight received sentences other than death and the remaining fourteen were sentenced to death by hanging.

In this, the final section of this research paper, the focus will be examples of the defenses and statements of the accused. As the highest ranking, and possibly most interesting of the defendants, Otto Ohlendorf’s testimony will be used extensively. Other defendants will be brought in to strengthen or supplement the statements of Ohlendorf. The section will begin with testimony relating to the process of joining the SS and becoming a member of the Einsatzgruppen. From the matter of membership, this research will move passages of perpetrator testimony that deal directly with matters of motivation and ideology.

Ohlendorf, as with other defendants, recounts the process by which he came to be a member of the Einsatzgruppen as a non-voluntary process. In his early testimony Ohlendorf states
that he “was not a voluntary member of the SD, or of the SS,” he says that he was “conscripted for the campaign.” In this assertion, he is not alone. Throughout the trial transcript, the members of the Einsatzgruppen point to a recruitment procedure that was short of voluntary. Defendant Walter Haensch backs up Ohlendorf’s characterization of the non-voluntary nature of his coming to be a member of the Einsatzgruppen in his testimony as well. In several pages of testimony Haensch was pressed on the matter of his membership in the organization and repeatedly states that he was forced to become a member and that his interests did not lie in fieldwork, but rather in administration. If the defendants can be trusted on the matter of recruitment for the Einsatzgruppen, this could open a hole in the argument that they were all perfect followers of ideology. The process of selection that they lay out does not suggest that they were chosen for their thoughts or views. The men chosen for assignment to the organization instead seem to have been surplus bureaucrats in many cases. Ohlendorf himself had come from the economics office and Haensch spent the majority of the war as an administrator in Occupied Denmark. What seems to have been more important to the selection of men for this task was their expendability in their current tasks rather than selection on a basis of outlook.

After the defendants were called to address how they had become members of the Einsatzgruppen, the trial could move on to more interesting matters of adherence to orders and comfort/lack of comfort with the task they were assigned. Here again, the comments of Ohlendorf offer the best insight as to the mindset of those accused. The court president questioned Ohlendorf about whether his men had ever expressed distress or resistance to the order to kill. In response to the question Ohlendorf admitted that there was no resistance that he “would have had to break by force,” but that many of his men “suffered terribly under the task, and, therefore, had to be sent home for many, various, reasons; either that their nerves went to pieces, or they could not stand this morally.” Ohlendorf was also called to testify about these matters before an earlier Nuremberg trial. In this trial prior to the Einsatzgruppen case Ohlendorf spoke on several matters relating to perpetrator issues with their assignment. In this testimony, Ohlendorf stated that the order to kill unarmed civilians was “psychologically, an immense burden to bear” for the men under his command. He also speaks of the methods that he ordered executions carried out under in order to spare the perpetrators of these shootings from additional mental stress.

In the spring of 1942 Einsatzgruppe D, Ohlendorf’s command, received gas vans for the purposes of carrying out the execution of women and children. Ohlendorf testified that this was due to the strain placed on the men of the group by shooting women and children. His testimony in this area is of great importance to the idea of ideological motivation among the men of his unit.

Colonel Amen [American prosecutor]: Were all victims, including the men, women, and children, executed in the same manner?
Ohlendorf: Until the spring of 1942, yes. Then an order came from Himmler that in future women and children were to be killed only in gas vans.

Colonel Amen: How had the women and children been killed previously?

Ohlendorf: In the same way as the men—by shooting.

Colonel Pokrovsky [Russian prosecutor]: You said that mostly women and children were executed in these vans, for what reason?

Ohlendorf: That was a special order from Himmler to the effect that women and children were not to be exposed to the mental strain of the executions; and thus the men of the Kommandos, mostly married men, should not be compelled to aim at women and children.

This testimony is interesting because it highlights the fact that despite ideological teachings of the Nazi regime that would not consider Jewish women and children to be human, the men of the group still saw their humanity and were, in the words of Ohlendorf, able to see their own wives and children in the faces of those they killed. While this passage does not rule out a combat ideology among them men, as offered by Bartov, it does raise issues with the idea that the men had the perfect eliminationist ideology offered by Goldhagen. In further testimony on this issue Ohlendorf states that the men were resistant to the use of the gas vans due to the spectacle of their aftermath. Apparently cleaning the dead women and children out of these vans was considered worse than participating in execution by rifle. Even though the executions carried out by the Einsatzgruppen are stated to have caused strain among the killers, it is worth repeating that most still found the ability to carry on. Those Ohlendorf mentions as having been sent home “for their own protection” are the only examples of Einsatzgruppen members mentioned in this testimony who may rise to the level of Non Compliers on the scale provided by Beorn.

Willy Seibert served on the staff of Einsatzgruppe D under the command of Otto Ohlendorf. In his testimony, Seibert raises another issue with the mindset of men in the unit, and perhaps more distressingly, German forces as a whole. During a line of questioning relating to the defendant’s knowledge of the Geneva and Hague conventions Seibert makes a statement impossible to overlook. The prosecutor asks:

Q: Wasn’t it known to you from your studies that the killing of civilians in occupied areas without trial is considered by international law and the law or recognized warfare to be murder?”

A: I cannot reply to that, Mr. Prosecutor, because I simply don’t know where murder starts and murder ends. It was no war of man against man. There were only exceptions. Tens of thousands of defenseless people were killed in all countries, and by all means. I, therefore, cannot say whether this is murder of that is not murder.
While it is certainly possible that Seibert is simply being elusive in order to save himself, it is more shocking to realize that he may actually believe this statement. In perfect alignment with the idea of combat ideology proffered by Bartov, it is equally possible that Seibert’s experience of total war (he specifically mentions bombing campaigns carried out against civilians by all sides) has warped his sense of right and wrong. Seibert has undoubtedly seen all of the brutalization process explained by Bartov both in his service with the Einsatzgruppen and in the later retreat into Germany. Therefore, while it is impossible to know when Seibert came to these conclusions, it is possible to accept that he and others like him may truthfully no longer see the difference between murder and actual combat operations.

Ohlendorf, for his part, attempts to justify his actions both through the bombing example Seibert uses and more importantly on a basis of anti-communist total war. Ohlendorf speaks of his orders to kill civilian populations in the East being based on “our security and those persons who were assumed to be endangering the security were to be designated as such [designated as those to be killed].” Ohlendorf refuses to admit that murdering Jews as part of racial war was the focus of his actions. He instead insists that Eastern Jews could be singled out for execution due to their adherence to communism. Ohlendorf stated that:

> It was obvious that the number of Jews in the general population in Russia, in relation to their number in the higher administration, was very, very small. The prosecution has submitted a report from my Einsatzgruppe to the army. In this report in enclosure No.2 it explained the situation of Jewry in the Crimea. Unfortunately, this enclosure was not available. It would have shown that in the Crimea, for example, up to 90 percent of the administrative and leading authoritative positions were occupied by Jews. The information service in the same field, conversations with innumerable Ukrainians and Russians and Tartars, and the documents which the prosecution submitted show that this was not only the case in the Crimea. For us it was obvious that Jewry in Bolshevik Russia actually played a disproportionately important role.

> Three times I was present during executions. Every time I found the same facts which I considered with great respect, that the Jews who were executed went to their death singing the “International” and hailing Stalin. That the Communist functionaries and the active leaders of the Communists in the occupied area of Russia posed an actual continuous danger for the German occupation the documents of the prosecution have shown.

> Again, it is possible that defendant Ohlendorf’s testimony is merely intended as an excuse for his actions that he hopes will save his life. It is, however, equally possible that in the
scope of what he sees as acceptable in a total war against communist Russia, Ohlendorf truly
does see his actions as justified. The nature of fighting on the Eastern Front in World War II was
savage in the extreme. Nazi Germany and the USSR engaged in atrocities against each other
outside of the scope of the Holocaust that may contribute to Bartov’s explanation of Holocaust
perpetration.

Bartov, as covered earlier, explains a route to the creation of Holocaust perpetrators that
requires the brutalization of German forces and a simultaneous perversion of discipline. In the
case of the Holocaust in the east, the perversion of discipline is straightforward. The Einsatzgruppen
were ordered to kill. Their pre-existing understanding of military discipline and the order
to kill that follows changes their reality. What may have previously been unacceptable was now
policy. This factor in combination with the experiences of total war on the Eastern Front makes
carrying out these orders more palatable. It was not necessary for a member of the Einsatzgruppen
to identify entirely with Nazi racial ideology in order to commit the crimes they did. All that
was necessary for an Einsatzgruppen member to do was square the war and the perceived threat
of communist Russia with their orders as Otto Ohlendorf did.

In this short survey of the vast transcripts and body of evidence presented by the Einsatzzgruppen trial, issues can be seen with the idea of a single route to perpetration. In the example of Seibert and Ohlendorf two perpetrators exist who are more concerned with the exigencies of total war than they are with the concept of racial war. None of the men at this trial were innocent. All fell short of being Non Compliers as laid out in Beorn’s article. The point of this research was never to provide comfort or excuse for the murderers of over 1.5 million people. The intent here is to see what lessons can be learned from the study of those responsible for this phase of the Holocaust. The trial transcripts show that the Goldhagen thesis of a single eliminationist anti-Semitism explanation of perpetration is too narrow. The Goldhagen thesis is seductive perhaps because it offers readers a way to distance themselves from the events of the Holocaust. If the reader can say that they do not come from an anti-Semitic society then they can rest assured that if placed in the same situations they may have refused to take part. The less comfortable reality is that the recurring issue of genocide is enabled by many factors. Ohlendorf and Seibert found a war to justify what they did in light of the war. Others found still more ways to make themselves comfortable with what they were doing. It is in these disparate and varying roads to perpetration that the evidence agrees with Browning and Beorn. It is also in these many roads to perpetration that the lessons of the Holocaust are found.

References
1. Patrick Desbois, The Holocaust by Bullets: A Priest’s Journey to Uncover the Truth Behind the Murder of 1.5 Million Jews (New York: Palgrave Macmillan, 2009.)


9. Ibid.


14. Ibid.


22. Ibid.
26. Bartov, Hitler’s Army, 12, 29, 59, 106.
27. Bartov, Hitler’s Army, 28.
28. Bartov, Hitler’s Army, 12.
30. Bartov, Hitler’s Army, 59-60.
32. Bartov, Hitler’s Army, 118.
35. Ibid.
36. Ibid.
Bibliography

Primary Sources


Secondary Sources


Abstract

This study examines the effects of the booms and busts of the coal mining industry on the citizens of Hanna, Wyoming. The objective of this research was to determine how extractive energy industries, such as coal mining, affect rural populations in Wyoming when production halts and leaves rural towns and populations in ruins. My methods included a number of ethnographic methods used by anthropologists today. Using unstructured and open-ended interviews with current citizens living in Hanna who have been affected by the many booms and busts of the mining industry, I engaged community members in a number of topics, ranging from memories and stories about the coal mining industry in Hanna, to discussions on residents’ connections to the scarred landscape they are surrounded by. I also drew on the use of photography as an important ethnographic method throughout this research in hopes of engaging a larger audience with this research. What my research has uncovered will add to the existing academic literature on the “ruins of modernity.” Specifically, my research can be used to work toward a further understanding of the cultural implications of industrial development and its decline in rural America.

Post-Industrial Ruins in Rural Wyoming

The history of the rural town of Hanna, Wyoming is dominated by the rise and fall of its coal mining industry. Today, residents live in a landscape indelibly marked by what the industry left behind. Rusting railroad tracks wind through the heart of town, decaying buildings once used by Union Pacific dot the landscape, and the echo of houses abandoned after the mining bust are a constant reminder of the town’s industrial past. In this research, I use ethnographic methods common to the field of anthropology in order to consider the consequences of living in this landscape. Particularly, my research focuses on how the ruins of the coal mining industry affect the day to day lives of the citizens of Hanna.
Introduction

The history of Hanna, WY is tightly linked to its former coal mining industry. In the early 1900s the town served as one of the principal areas for coal extraction in Wyoming. However, after a series of mine explosions (1903 and again in 1908), mining companies retreated from Hanna, and in 1954, when the Union Pacific Railroad turned to diesel power, the mining companies abandoned the town. In 1979 a strip mine opened and employed 600 people until coal in the Powder River Basin lured the mining companies away. In 2001, the last underground mining operation in Hanna and the United States closed down, leaving the town without a major industry once more. The history of coal is not easily forgotten, however, by those families that chose to stay in Hanna long after mining declined. Daily reminders of the failed mines surround the town, embedded in its landscape as well as the memories of those residing in it. My research explores what it means to live among the ruins of modernity in rural Hanna, and what it means to confront the remnants of the fallout of post-industrialism every day through the use of ethnographic methods.
Literature Review

Anthropologists who have focused on the ruins of modernity, defined as the damaged spaces that industry leaves behind, (Hell and Schönlie 2009; Woodward 2003; Edensor 2005; Buck-Morss 1991) have largely focused on urban America, specifically the post-industrial decline of cities such as Detroit and Dayton, as well as the Rust Belt of the Eastern United States. In Europe, emphasis has been on the post-war remnants of major cities such as London and Athens. While this literature is significant, an understanding of the effects of post-industrial decline, specifically extractive energy industries, in rural America is important.

My interest in this decline is inspired by Stewart (1996) who provides an account of rural Appalachia and of a landscape and society scarred by the arrival and departure of the mining industry (see also Hell and Schönlie 2009; Woodward 2003; Edensor 2005; Yablon 2010; Buck-Morss 1991; Hussyen 2003). Stewart’s work is innovative in that it pays great attention to the stories and memories of her interlocutors while focusing on the effects of post-industrial decline in a rural context. My work too focuses on stories and memories, drawing together a conflicted history of Hanna, WY through the accounts of those who live there (Note Connerton (1989) for

One of the many black and white photos of the original mining town of Hanna found in the Hanna Basin Museum’s archives.
an account of how anthropologists engage with issues of history and memory). A crucial aspect of my research is the richness, complexity, and even contradiction of these accounts from a number of residents presently living in Hanna. Hanna’s derelict landscape blurs the boundaries between rural and urban, past and present; tying these spaces to memory and a sense of place within the greater context of modernity. My research builds upon this existing ethnographic analysis, offering new and valuable information to the rising literature on the ruins of industry in rural America.

A focus on material culture and on landscape is also central to my research. Drawing on the work of Daniel Miller (2010; 2008; 1997), I interviewed community members about their memories and engaged with them through discussions of the objects they own or had strong connections to (photographs, memorabilia, ornaments, buildings). I also asked my interlocutors to describe their personal connections to the landscape, drawing on Christopher Tilley’s work on the power of landscapes (2004), Gaston Gordillo’s (2011) work on stories surrounding the abandoned machinery of colonial development in the Belgian Congo, and on the work of Yael Navaro-Yashin (2009) who discusses the connections between landscape and affective objects in the contested spaces of Northern Cyprus.

More broadly, my research design was inspired by Ann Laura Stoler’s notion of “the ruins of colonial modernity” (2010) (see also Hell and Schönlie 2009 The Ruins of Modernity) and by the work of Walter Benjamin (2002), particularly in his essays in the arcades project and their suggestion that development is inseparably tied to destruction.

One of the many businesses in Hanna that have been forced to close their doors since the end of the last mining boom, this auto garage was Hanna’s only automotive repair shop. Now citizens take their vehicles to nearby Medicine Bow for simple repairs.
My research aims to contribute to anthropological theory and the discipline of anthropology as a whole by proposing new ways of thinking about: [1] post-industrial decline in rural America, especially in relation to extractive energy projects, and [2] the effects of ruined rural landscapes on their inhabitants. Since the decline of the mining industry in Hanna in the late 1980s, many other rural areas of the United States have been defeated by industry. Recognizing the importance of such industrial ruins is vital to a greater understanding of the implications of industry in rural areas. These implications are important, particularly within the context of modernization and the effects of modernization on rural peoples. Research conducted in rural industrial and post-industrial areas can provide important data on the planning stages of modernization efforts across America and the world.

Also crucial to understanding the repercussions of industry in rural America is the affect that post-industrialized landscapes have on the people inhabiting the areas. To ethically make decisions regarding the development and urbanization of rural areas, it is vital to understand the affects these decisions will have on the residents of the area long after the industry has perished. My research thus has the potential to illuminate the complex ways in which industry and modernization can impact rural America in both the short and long term, enabling anthropology to have a clearer understanding of the effects of post-industrialization in rural America.

**Methods**

For my research, I drew on a number of common ethnographic practices, including unstructured interviews, participant-observation, recordings and transcriptions of conducted interviews, archival research, and photography. My research was conducted during a number of trips to Hanna in the months of June, July, and August 2012. An important aspect of my research was gaining access into the community, and conducting interviews with as many residents as were willing. Over the course of my fieldwork, I conducted six interviews, ranging in duration from one to two hours. Utilizing the Hanna Basin Museum for my research, I conducted all interviews in the museum. Participants in my research were all current residents of Hanna, WY, or had lived in Hanna during one or more booms and busts. All participants were 18 years or older as required by the University of Wyoming Institutional Review Board (IRB). All participants had the option of signing an additional waiver which would allow me to photograph them and any personal objects as they saw fit.

As previously stated, a crucial aspect of this research was my ability to gain access into the community of Hanna. This was accomplished with the help of a close friend, Nancy Anderson. A resident of Hanna since 1966, she knows close to everything there is to know about the town of Hanna, its history, and its past and current residents. She was one of the most valuable resources for me throughout the duration of this research, and she became my “key informant,”
guiding me through Hanna’s history and introducing me to a number of residents who were more than willing to aid me in my research. Through these new connections I conducted all of my interviews. This method of finding key informants and asking them to take the lead on introductions is referred to as “snowballing,” and is widely used in anthropological research. Snowballing is useful for gaining access into a community in which the researcher is a stranger. I was only able to conduct interviews and engage the residents of Hanna in my research because of the first connections I made.

The concept of the key informant is also important to my research. Rather than interviewing a random sample of residents from Hanna, I looked for members of the community who were well known and willing to talk with me at length. They were also knowledgeable about the town, its residents, and most importantly its history, many having lived in Hanna during at least one of the mining booms. My key informant, Nancy, was the one who introduced me to her friends and other residents of Hanna, and often helped to clear up any confusion or questions regarding my research.

It is important for me to note that key informants participating in any anthropological research may share a different mindset than the majority of a population, especially that of historical or archived information. This can be seen in many anthropological studies, but is duly noted in the research of Michael Harkin (2009). Harkin notes that “…great value lies in the oral record, as it is likely to record (and silence) different events from written record, and to produce a view of the past that challenges hegemonic nationalist and colonialist histories.” While it is these differences in opinions and memories that make research such as mine rich with feeling
and emotion, it is important to remember that these perspectives may be biased which can greatly influence the outcome of the research. In my research specifically, my key informant set the tone for the final analysis and discussion of my data.

The interview process I used in my research consisted of mostly unstructured and open-ended interviews, meaning they were loosely guided by my questions and largely influenced by the direction the interviewees wished to take our conversations. Specific topics, however, included: discussions of memories and stories related to the coal mining industry, discussions of individual ties to the landscape of Hanna such as family histories, and discussions about objects and/or memorabilia associated with the coal mining industry (for a full list of the standard questions I asked my participants, see page 18). My main focus in this research was on the feelings and memories Hanna residents associated with the decline of the coal mining industry in Hanna, and their overall views and opinions of big industry in rural settings, specifically extractive energy projects.

The Hanna Food Mart served the Hanna community until 2006. Residents of Hanna now travel to Laramie or Rawlins to purchase their groceries and other essentials.
As an example of the way in which I conducted my interviews, I have included two excerpts from my longest interviews. Jerry Leturgey has been a resident of Hanna since 1979. Jerry’s story is similar to that of many members of the Hanna community. As a young boy, he moved from Pennsylvania to Wyoming due to the economic opportunities available in the mining town. His father worked in the mines until the late 1980s, and chose to stay in Hanna even after the boom had come to a close. During Hanna’s prosperous years, Jerry managed the town’s grocery store up until it was forced to close its doors in 2006. In my first interview with Jerry, he shared one of his memories about the boom days of Hanna with me, and his thoughts on big industry in the rural spaces of Wyoming.

*Lacy: Jerry, when you think about abandoned buildings in Hanna, which ones come to mind? Can you describe them for me?*

*Jerry: I think the building that always comes to my mind is the grocery store. I drive past it almost every day and can’t help but think about it and all of the other things we had here [Hanna] when the mines were still booming.*

*L: What specifically do you remember about the grocery store?*

*J: How many employees we had, how many people would be in there at any one time during the day, and how many rows of groceries we had. I know it doesn’t sound like a lot, but at one point there were probably 20 employees, making two deliveries a week around town. And then about six or seven years ago things started to slow down. We had to let employees go, and the store changed owners four or five times. Finally, the store closed in 2006, and now I manage the rec center and two employees. People go to Laramie or Rawlins to get their groceries, and it makes me kind of sad to think about how much this town had when things were good.*

*L: Knowing what has happened in Hanna since the end of the boom, how do you personally feel about big industry in rural areas such as Hanna, Elk Mountain, Wamsutter, and other parts of Wyoming?*

*J: Even though Hanna is in a slump right now, I think that in general, industry is good for Wyoming. Any jobs are good for Wyoming. Also, I think that Hanna is a product of circumstances. It isn’t that we’re out of coal; it’s just currently too expensive to mine here. I have a feeling that the industry will come back to Hanna and when it does it will*
be good for all of us. And if it doesn’t come back to Hanna, there’s Uranium in Medicine Bow, and oil in places like Wamsutter and Pinedale. That’s just how Wyoming’s economy works.

The second excerpt comes from one of my initial interactions with Nancy Anderson, whom became my key informant for the duration of my research. Nancy has been a resident of Hanna since 1966 and has played a special role in the community of Hanna during here time there. In 1983 Nancy became one of the original founders of the Hanna Basin Historical Society, in turn creating what is now the Hanna Basin Museum. Nancy’s love for the town of Hanna and its history is obvious from the moment you meet her. Her enthusiasm for the topic of Hanna’s coal mining industry and its less than prosperous side effects guided the duration of our discussions.

Lacy: Nancy, what type of impact has the end of the mining boom had on your life?

Nancy: For myself, and I think a number of others within the community, there is a feeling of impermanence that has been created. Things like shopping centers and churches were built during the late 70s early 80s, waiting for a population that never came. Those buildings are still here though and they stand as symbols of the end of mining in Hanna.

L: Are there other buildings or objects that you think about when you remember the boom days?

N: Yes! This building [Hanna Basin Museum] was originally a saloon outside of #1 Town, and then it was brought into town and converted into a community hall. Then in 1983, the volunteer fire department was recycling old houses and buildings from the mining days, practicing on them. They were going to burn this building down just for one of their practices! That’s what pushed the decision to form the Hanna Basin Historical Society and save this building and others around town. Preserving the history of this community has always been important to me and other community members. There are a lot of good things that came from the mining booms, and there are a lot of people that are hopeful for the return of a boom.

L: So there are people that really do think that the mining industry is going to boom again?

N: Oh yes, I think quite a few people do. That’s why so many have chosen to stay here as long as they have. There are still people who maintain two households, one in Hanna,
and another somewhere else where they actually work. There have also been a number of residents that have moved into the community from elsewhere. They come because the property is cheap, but they stay because this is an optimistic group of people who have always been more than welcoming. It’s a great place to raise a family, and if you don’t mind driving an hour or two for groceries or work, it really is a great place to live.

Most of my interviews revealed similar memories of the mining booms. Interviews were the best way for me to learn about the town’s history and its current state from the perspective of its residents, which is crucial to the analysis of this research.

In addition to interviews, I conducted research through recorded observations. When I was not talking with my interlocutors, I explored the town and its landscape, taking notes and photographs. Utilizing various local hangouts such as a cafe, the recreation center, and the town museum, I kept a detailed account of the interactions between Hanna residents and their surroundings. I focused particularly on the interactions with and reactions to the ruined landscape and any objects associated with the decline of the coal mining industry, such as buildings, memorials, or old mining equipment.

To further enhance my understanding of the effects of post-industrial decline in Hanna, I drew on the methods of Ann Laura-Stoler (2009) in analyzing archival data. The archival data at the Hanna Basin Museum provided valuable insights into the history of Hanna’s coal industry. These archival sources revealed much information about the industry’s birth, the many booms and busts, and finally the departure of the industry from Hanna. While analyzing these

While these two photographs depict two very different things (a café and a drag line), they are both reminders of the failed coal mining industry in Hanna. This café recently went out of business, and just like the old mining drag line that sits overlooking the landscape of Hanna, it has been abandoned.
documents, I took special care to note the authors and their relation to the coal mining industry. Documents from government sources such as accident reports and safety inspections gave little insight into the day to day lives of Hanna residents during the booms in the early part of the 1900s. Some documents, however, were authored by miners themselves, widows, or other residents like shop owners, and proved to be very useful in tracing the reactions and feelings of Hanna residents toward the mining booms and busts. A few memoirs from those residents lucky enough to survive through a number of booms and busts were especially useful to my research, because they allowed me to gage any changes in attitudes or opinions about big industry in a rural space like Hanna over a number of years.

Finally, through my use of visual anthropology, specifically photography, I hope to better illuminate the effects of industry and its decline in Hanna. Photography can often capture what thousands of words cannot, and it has recently become a means by which anthropologists share their work. Photographs are more easily related to than technical anthropological analysis, making them a powerful tool for sharing my research with a broader public. This method has been important to my research in a number of respects, but most importantly it is through photography that I wish to convey the stories of those living in Hanna, still affected by the fallout of the coal mining industry, without explaining their situation away with a deeply theoretical analysis, which could leave today’s community without a space in their own history.

As with any research, there were a number of moral, ethical, and legal considerations I had to make while conducting my research. The first of these was to complete the Institutional Review Board’s (IRB) proposal and approval process before beginning any sort of research. In doing so, I created a detailed proposal outlining the reasons for wanting to conduct the research and the process I would follow for the research, answering a number of questions regarding ethicality and the treatment of the research participants. There was a very slight chance that my research would cause any sort of emotional turmoil and no chance of physical harm for participants, deeming my proposal appropriate for approval. Originally, I thought the process of

This mining memorial, located near Hanna’s recreation center, is a reminder of the legacy of coal mining in the Hanna Basin.
obtaining IRB permission to conduct research would be the most difficult part of my research in regards to ethics and moral obligations. I quickly realized I had underrated the undergraduate research process.

As I started my fieldwork, I thought it best to review some of the literature regarding the ethics of anthropological fieldwork. In doing so, I came across an article by Laura A. Lewis entitled “Modesty and Modernity: Photography, Race, and Representation on Mexico’s Costa Chica (Guerrero)” (2004:471-499). In her article, Lewis raises a number of concerns regarding photography, race, and the representation of individuals through anthropological and non-anthropological photography and research. In her discussion of the photography of the people of San Nicolás, Lewis argues that a set of photographs of the San Nicoladenses which were published in the book Tierra Negra (Maya Goded 1994) were taken unethically, and represent a key issue in the use of photography in both research and social contexts (Lewis 2004:472).

Lewis’s argument that photos without captions lead their viewers to a “what you see is what you get” perspective, placing the subjects of the photographs under the viewer’s understanding, however limited it may be, is important for my own research. Lewis states, “…captionless photos [of this genre] essentially invite viewers to understand their subjects through the sedimented racial meanings with which First World peoples read Third World ones” (478). This became important for me and throughout my research I tried to accurately represent those residents of Hanna who allowed me to take their photographs. For this ethnographic methods project specifically, I chose to exclude the photos of my interlocutors. It is my hope that this will put an emphasis on their stories and memories about the landscape and objects associated with the mining booms without “exoticizing” the town of Hanna and its people. Also, leaving these photos without captions could send the message of Hanna as a derelict and abandoned town, directly contradicting the friendly and inviting atmosphere that Hanna maintains today.

Lewis also discusses the use of black and white photography in relation to representation (479). While my research does not directly deal with race or colonial/post-colonial settings, Lewis’s article did lead to an important consideration I made concerning the use of colored photographs in my own work. Keeping Lewis’s article in mind, I chose not to manipulate my photos of Hanna or its residents in any way. Specifically, I chose to leave my own photos in color, which contrast with archival photos that are primarily black and white. These black and white photos represent the history of Hanna and to have my own photos in black and white could present Hanna as a town that is stuck in the past, unable to move forward into modernity, which is clearly not the case.

Once I had completed the interview process, I began the arduous task of transcribing my interviews with my interlocutors. Because a number of the interviews I conducted were conversations with an older generation of community members, I took on the duty of recording
and transcribing each interview and compiling my photographs into a shareable document. As an anthropologist, it is my obligation to the community of Hanna to share my research. Giving copies of photos, interviews, and other transcripts to the Hanna Basin Museum and the American Heritage Center (Laramie) allows this research to be accessible to not only Hanna residents, but other interested researchers and non-researchers.

Conclusions and Discussion

Due to the allotted time for this research, my preliminary conclusions are just that, preliminary. This research is by no means conclusive and in analyzing the data I have collected thus far it is important to note that this is not my final analysis of this research or topic. There is a lifetime’s worth of research material in Hanna alone, and the scope of undergraduate research is not wide enough to touch on more than one aspect of this material. For my initial analysis, however, I have chosen the narrow focus of social memory to discuss the impact of the coal mining industry on Hanna, WY.

Social memory theory suggests the basic function of any community will be to retell stories and share memories of certain events or versions of history that actually reinforce the way the past is remembered within that community, for better or for worse. My research in Hanna has
shown patterns in memories, stories, and events which all contain very positive themes despite the busts of the coal mining industry. Nobody is playing the blame game; rather they are all hopeful for the return of the industry. While this positive pattern in interview responses could be due to the snowballing method I chose (previously mentioned on page 8), there is also the possibility of a community wide attitude that has become part of Hanna’s ideology. The creation of these positive memories and hopeful outlooks likely started early in Hanna’s history, and this same outlook is being actively maintained today by members of the community through town events, the Hanna Basin Museum, and the stories/memories each individual chooses to share with community members and outsiders alike.

While the use of social memory theory suggests that industrialization has actually had a positive impact on Hanna, it also recognizes that the community has created its own understanding of the impact of industrialization, choosing to focus their opinions of a seemingly dismal situation on positive outcomes and hopeful futures. This is a valid part of my research that cannot be discounted no matter how naïve it may seem to outside perspectives. Regardless of the way in which one chooses to analyze this research, these perspectives are important to take into consideration during the planning stages of large scale industrial projects. The stories, memories, and opinions that the residents of Hanna chose to share with me provide a greater understanding of the implications of industrialization in rural spaces.

**Standard Question List for Interviews**

1. How long have you lived in Hanna?
2. What do you do for a living?
3. Do you remember the coal mines from the 1980s?
4. Were you involved in any aspect of the mining boom?
5. What did you do for a living during the mining boom?
6. Did you have to switch jobs/professions after the mines were closed?
7. What type of impact did the closing of the coal mines have on your life?
8. What is your most vivid memory from/of the boom?
9. How do the abandoned mines and buildings associated with the boom make you feel?
10. When you think about the different buildings that have been abandoned since the end of the boom, which ones come to mind? Can you describe them and any of your memories to me?
11. What types of feelings do you associate with the mining booms/busts? Positive, negative?
12. How would you feel if the mining industry were to come back to Hanna once more?
13. Do you think that the oil industry will have the same types of affects that the mining industry has had in Hanna?
14. In general, what is your opinion of big industry in the U.S.? In rural vs. urban areas?
Works Cited

Benjamin, Walter  

Buck-Morss, Susan  

Connerton, Paul  

Edensor, Tim  

Gordillio, Gaston  

Harkin, Michael  

Hell, Julia, and Schönlie, Andreas  

Hussyen, Andreas  

Lewis, Laura A.  
Miller, Daniel

Miller, Daniel

Miller, Daniel, ed.

Navaro-Yashin, Yael

Stewart, Kathleen

Stoler, Ann Laura

Tilley, Christopher

Woodward, Christopher

Yablon, Nick
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**Research Topic:** Amino Acid and Isotope Composition of the Auditory Bulla in Baleen Whales

*Introduction:*

The auditory bulla of baleen whales is a rapidly formed bone with an altered composition compared to normal bone. Adaptsions needed for aquatic hearing have changed the density and collagen structure greatly. It has been proposed that the bulla is fully mineralized very early in life, between the ages of 1 and 2 years (Buffrenil, 2003). Whereas normal bone has a density of 1.6-2.0 g/cm³, bulla has a much greater density of 2.6-2.7 g/cm³ (Buffrenil, 2003). This helps to isolate the bulla from vibrations of the skull which cuts down on background noise allowing the whales to hear more effectively. The collagen fibrils associated with the bulla are greatly reduced in diameter (10-30 nm) and arranged in a significantly reduced network (Buffrenil, 2003). Christensen et al. showed what they hypothesized to be yearly accretions in the outermost periosteal layer of the bulla. Estimates of age resulting from these layers proved to be inaccurate, but are still being considered as a way to interpret age of the organism. The bulla also has the unique characteristic of having no inner remodeling (Buffrenil, 2003). This could mean that the inner portions of the bulla have the same composition throughout life, allowing us to analyze information about formation time and conditions. The increased density, reduced collagen network, and lack of remodeling separate the bulla from other bone making it a unique medium for analysis possibly leading to conclusions not normally available from standard bone analysis. Our study will look for further differences between standard bone and bulla using stable isotope analysis and amino acid abundance analysis. We will also attempt to tease out formation times and conditions in order to understand the circumstances around the bulla’s formation.

*Methods and Materials:*

For the first round of amino acid samples, 50 mg of powdered bulla was obtained via microsampler from chosen areas around the bulla. Samples were then decalcified in 10ml of 0.5M HCl for 24 hours at ~5°C. Samples were then rinsed five times with deionized water. They
were then placed into the freeze drier for 24 hours until samples were completely dry. The result-
ing protein plugs were placed into 5ml glass vials. 1ml of 6M HCl was added to the vials which were then flushed with nitrogen. Vials were then sealed and caps were wrapped with teflon tape in case of leakage. Samples were placed in a dry bath at 110°C for 20 hours. Samples were analyzed at the University of Wyoming Macromolecular Facility.

For the second round of amino acid samples, 10 mg of powdered bulla was obtained via dremmel from previously drilled areas. Samples were decalcified with EDTA over four days at room temperature until protein flecks floated to the bottom extremely slowly or didn’t sink at all. Samples were then rinsed five times with deionized water. The samples were placed in the freeze dryer for 24 hours until completely dry. The resulting protein plugs were hydrolyzed using the same method as the previous samples.

For carbonate isotope samples, 5 mg of powdered bulla was obtained via microsampler from areas selected for hypothesized isotope differences. Samples were then treated with 200µl of H2O2 and vortexed before sitting for 24 hours at ~5°C to remove organic matter. Samples were then rinsed five times with deionized water. They were treated with 1M acetic acid with calcium buffer for 4 hours in order to remove secondary mineral contaminants. Samples were washed five times in deionized water. The samples were then freeze dried overnight and wrapped into tin capsules. Samples were submitted to the University of Wyoming Stable Isotope Facility.

For collagen isotope samples, ~25 mg of bulla was taken as a whole piece via dremmel. Samples were decalcified with 0.5M HCl until pieces were completely soft and no calcium was present. Lipids were removed with 1 rinse of a 2:1 solution of chloroform and methanol and sonicated for 30 minutes. Bulla showed no signs of lipids to extract. Samples were then rinsed with deionized water 5 times. The samples were then freeze dried for 24 hours until completely dried. Samples were encapsulated in tin and submitted to the University of Wyoming Stable Isotope Facility.

Phosphate samples were started using 2mg of powdered bulla from selected areas. Bulla was treated with a 2.5% solution of NaOCl for 17 hours one time. Samples were then rinsed five times with deionized water and dried overnight at 50°C. Then, 100µl of 0.5M HNO3 was added and allowed to rest overnight at room temperature. The samples were then treated with 75µl of 0.5M KOH and 200µl of KF. The vials were then centrifuged for 7 minutes at 13000 RPMs and the supernatant was placed into a new vial. 250µl of silver amine was used to precipitate the phosphate out into silver phosphate. Samples were left in a dry bath at 50°C overnight. The resulting AgPO3 crystals were rinsed five times with deionized water, encapsulated in silver, and submitted to the University of Wyoming Stable Isotope Facility.
**Results:**

Original results of amino acid analysis showed high levels cysteine. These results proved to be a misinterpretation of the protein curves and were removed. The protein results were normalized to the highest amount to produce level curves for analysis. The bulla showed curves matching that of standard bone collagen (Estoe, 1955).
Carbonate and collage isotope results showed differences in relation to species but no obvious correlation to sampling area.

Collagen isotope results are still being compiled. There is a close relation in isotope values of the organic and inorganic carbon.
**Discussion:**

The amino acid composition of the auditory bulla matches that of standard bone collagen with some small but noticeable differences (Eastoe, 1955). Valine and leucine levels are over that of standard values but this may be due to improper analysis of the original data. Many of the samples had glycine levels that were too high to measure, needing correction by macromolecular staff. Improperly measured glycine values can alter the entire curve because the amino acids are normalized to the glycine values. Further analysis is pending and will move towards understanding if there is an altered composition in the amount of individual amino acids in the collagen fibrils.

The carbonate and collagen data show a very close relation unlike that of herbivores and far closer than that of carnivores (Clementz, 2009). This suggests that much of bulla formation happens while the calf is still drinking its mother’s milk. If this were the case, we would expect to see a close relation of collagen-carbonate values due to bioapatite C13 tracking that of bulk diet and C13 of protein tracking that of dietary protein. The mother’s milk would contain high levels of C13 depleted proteins and lipids leading to low ‰ values in the calf’s tissues.

The phosphate process ultimately failed and no useable phosphate data was obtained from the bulla. Methods analyses were conducted in order to determine the number of rinses needed in order to properly remove all traces of organic matter. Samples of manatee bone were run through 1, 2, or 3 rinses in 2.5% NaOCl and H2O2. These samples were then treated with the same procedure listed above and run to see how many rinses were required for an accurate phosphate measurement. Second and third rinses showed no change in isotope values, therefore two rinses were decided to be sufficient. The process was run again using the two rinse procedure giving similar results to those of the one rinse procedure. This suggests that organic matter present in the samples was not the cause of the failed procedure and something else must be causing it.

Analysis is ongoing and will hopefully yield results relating formation times, diet, and conditions surround the bulla. Nitrogen and oxygen values from the carbonate and collagen runs are currently being analyzed and carbon to nitrogen ratios are being use to asses validity of protocols.

**Citations:**


1. Abstract

This study investigates the transportation of low density polyethylene (LDPE) (a surrogate material for ammonia borane, NH3BH3, a hydrogen storage material) using a co-rotating twin-screw extruder. Studying the implications of using the twin-screw extruder for hydrogen fuel transportation on-board a vehicle equipped with a hydrogen fuel cell. The objective evaluates experimentally and theoretically the use of the extruder in transporting the hydrogen storage material of ammonia borane to and from the hydrogen extraction component and the fuel tank. Methods in experimentation included three operating conditions of assisted, unassisted, and filling conditions at varied horsepower supplied to the extruder. The twin-screw extruder was tested first with a pair of rounded thread screws made of aluminum and ABS plastic, respectively. During each operating condition torque requirements, power supplied, and volumetric flow rates were determined. Results of the experimental testing showed that the ABS plastic screws volumetric flow rate was 46% greater than the aluminum screws at the same power supplied. The assisted flow conditions resulted in an average increase of 3.5% volumetric flow rate over the unassisted flow conditions. With uncertainty analysis it was determined that the increase was contained within the uncertainty of the increase in volumetric flow rate. The uncertainty increase range was -6.1% to 5.2% increase of assisted flow over the unassisted flow conditions. The aluminum screws also produced greater torque requirements over the ABS plastic screws for all values of power supplied. The differences between the aluminum and ABS plastic screws was determined as the result of the production methods, the aluminum screws were 4 mm larger in diameter than the ABS plastic screws. The development of the transportation mechanism for ammonia borane for a hydrogen fueled vehicle may improve the hydrogen fuel cell’s adaptation in to commercial use.
2. Introduction

Energy security, environmental quality, and economic vitality are major factors that influence the way the United States interacts with energy. As a result support of research and development of hydrogen transportation systems has amplified. The US Department of Energy (DOE) has set for the advancement of hydrogen powered vehicles. The objectives set for compact, lightweight, and low-costs systems for improving competition with current technologies. This also includes the ability to achieve or surpass the 483 km (300-mile) driving range per fueling. Hydrogen transportation systems currently use pressurized or liquefied hydrogen carriers. The current systems reveal setbacks in the weight of the fuel required and the storage conditions. This results in two overall performance goals of the DOE, first a higher gravimetric capacity (2017 target of 5.5 wt. % hydrogen) and second moving towards ambient storage environments of the on-board systems [1]. Current hydrogen carriers being researched include metal hydrides, chemical hydrides, and hydrogen absorbents. Chemical hydrides have large gravimetric capacities (up to 20 wt. %) and favorable properties at ambient conditions. Chemical hydrogen storage material of ammonia borane (~17 wt. %) is the focus of a large portion of research and development. The high hydrogen storage capacities and rapid hydrogen release is largely responsible for this focus [2]. With the use of catalysts, low reaction temperatures can be reached and utilized for on-board energy conversion. A one-pot regeneration scheme for spent ammonia borane has been reported of a consistent regeneration of 92% [3]. Through current advancements with ammonia borane as a hydrogen carrier, the development of on-board delivery systems is now possible.

![Diagram](image_url)

**Fig. 1.** Example flowchart of on-board chemical fuel system.
For vehicle level ammonia borane delivery systems the system must support a solid or slurry material. Various System simulation models have been suggested for on-board hydrogen storage structures [4-7]. A simulation framework specifically for comparing performance of various hydrogen storage systems for light-duty fuel cell vehicles has been developed [4]. Specifically for chemical hydrides the operating requirements have been established. The simulation of ammonia borane meeting the demands through a recirculating reactor system incorporates an auger to move the material [5]. In addition other on-board and off-board performance simulations for light-duty vehicles with ammonia borane show great potential due to the development of better regeneration schemes [6]. With the advancements since that research, the regeneration schemes have been boosted to a profound level [3]. Resulting in the simulations using of ammonia borane as a hydrogen carrier that can meets the DOE targets for hydrogen energy. With these simulations resulting in success the research for a solid material transportation could begin. Through the attempts of Holladay and co-workers, the design of an auger system was fabricated and tested. However, the cohesive properties of the solid material resulted in a clogging of the auger system [7]. A schematic representation of a chemical hydrogen fuel system for ammonium borane is shown in Fig. 1. The material is transported from the fresh ammonia borane fuel tank by the twin-screw extruder to the reactor and separation component. At the separation component the hydrogen bonds are broke and then hydrogen is transported to the fuel cell for electrical generation. At the end of the separation component spend ammonia borane would be transported back to the spent fuel tank by an additional twin-screw extruder. The next step is designs accounting for these properties in order to justify development of the ammonia borane powered vehicle.

The use of a co-rotating twin-screw extruder for transporting spent ammonia borane was developed at the University of Wyoming’s Department of Mechanical Engineering. From the studies of a senior design group the design was based on the DOE minimum hydrogen mass rate requirement for compact vehicles to a 1/10th scale. Two thread types of rounded and triangular intermeshing screws were made from ABS plastic. Using the surrogate material of low-density polyethylene the volumetric flow rate, power and torque were measured. In compliance testing the rounded thread screw geometry delivered a maximum flow rate of 158% above the target for the design. The triangular thread geometry was unable to meet the target flow rate. The testing was able to provide the background that with the twin-screw extruder system adequate volumetric flow rates of the spent ammonia borane. Using ABS plastic for the screws material the durability of the system is in question for extended use. Resulting in the proposal of the rounded thread screws be machined out of aluminum [25]. In testing the development of the clogging with in inlet of the system was found. In addition to the inlet, the outlet of the system is unbounded and undirected.
Transporting ammonia borane using a self-wiping co-rotating twin-screw extruder for an on-board vehicle system is the application of this paper. With the developments in hydrogen energy, the applications of this science would help streamline the progression of ammonia borane for commercial use in the transportation sector. Using theoretical and experimental simulations the optimized proposal specifically for the transportation of ammonia borane can be developed.

3. Co-Rotating Twin-Screw Extruder

3.1 Background

Within processing industries, solid delivery systems are seen by extrusion of plastics, pharmaceuticals, and food products. Extruders can utilize a single screw or multiple screws to produce desired conditions of the flow. The use of a self-wiping co-rotating twin-screw extruder produces interest in their ability to scrape solid materials from one screw to the other for increased flow rates of cohesive materials. Early development patents of the twin-screw extruders were quickly adapted into industry. Leading publications of the mathematical modeling of the extruders begin appearing in the 1980s. Establishments in the research of the flow modeling with respects to the axial pressure were used to estimate the throughput rates of the systems [8]. The mathematical modeling continued with the finite element approach to the intermeshing flow regions of the screws [9]. Then in 1990, the in depth study of the heat transfer of the systems were modeled [10].

As development of the research continued for the flow rates, new approaches for the velocity, temperature, shear, and pressure contours were demonstrated [11]. In studying the kneading sections of the twin-screw extruder, the relationship of the pressure gradients of the transporting elements were established as independent of the rotation speeds of the screws [12]. Further producing accurate theoretical modeling approaches for the system. Proof of the finite element approach or numerical method accounted for visoplastic and wall slip behaviors [13]. The intermeshing regions elongation viscosity on the flow was recognized [14]. With the development of the starve fed conditions, additional studies of the degree of filling of the screws as well as the residence time distributions functions were shown for the flow [15]. For industry the heat transfer control is essential for extruder cooking and polymer processing. The calculations of the heat transfer coefficients resulted in the velocity of the material as a major contributor to the equations [16] and further expanded for low pressure conditions that the screw speed did not influence the velocity [17]. In the transportation of material through the self-wiping twin-screw extruder the residence-time distribution is essential in the accuracy of the flow rates of the device. One of the beginning studies of Residence time distributions is commented to give realistic approximations of the flow by quantifying the capacity of displacement and axial mixing [18]. The study was then further refined for the best fit equations for a variety of situations using predicted input variables of the material and system dimensions [19].
In progression of the study of the self-wiping twin-screw extruder the considerations for the extruded material was researched to design systems specific for desired materials. These studies were focused around the food processing industry in the extrusion of corn starch. The theoretical flow, heat transfer, and melting kinetics of the corn starch were studied along with the transport phenomena of the starch in order to optimize the science behind the extruders [20]. Later examination of the macromolecular effects that took place on the corn starch from the extruder was found [21]. Moving from the food industry, the use of the properties in the study of the twin-screw extruder for reactive extrusion was seen [22]. In implementing all of the mathematical simulations of the twin-screw extruder, advanced mathematical modeling of current processing equipment was developed [23] resulting in specialized food extruder designs, fabrications and testing. In these food extruder explorations the functionality of implementing the designs into worldwide use resulted in the conclusions that the twin-screw extruder can be implemented into less developed countries [24].

3.2 Design Approach

Fig. 2. Twin-screw extruder (a) screw geometry, (b) gear box, and (c) general view graphics provided by the Senior Design Team [25].
The extruder used in this study was designed by the senior design team [25]. The screw design consists of two screws with rounded threads in two threads per 2.45 cm (1 in) configuration shown in Fig. 2a. Two pairs of screws were made of ABS plastic and aluminum, respectively. Powered by a 1/8 hp DC motor, with a voltage controller with range 0 to 0.125 hp. The angular velocities of the screws were determined by the gear box configuration of 4 to 1 ratio shown in Fig. 2b. The general view of the twin-screw extruder device is shown in Fig. 2c. The general view shows the drive shaft and gear box for the screw due to the removal of the casing of the gear box. In the general view the materials used are aluminum for the gear box casing and outlet casing, acrylic screw channels, and steel for the gears and drive shaft. The use of acrylic for the screw channels enabled the flow to be monitored while in the system. This system is designed based on the DOE minimum hydrogen mass rate requirement for compact vehicles to a 1/10th scale. DOE hydrogen mass flow rate requirement of 70 g H_2/L and 7.5% H_2 by weight to the properties of ammonia borane for a volumetric flow rate of 17.70 mL/s (64.8 in³/min). With the 1/10th scale the extruder is designed to reach 1.775 mL/s (6.5 in³/min) ammonia borane volumetric flow rate.

4. Experimental Procedures

4.1 Experimental Apparatus

In testing the twin-screw extruder’s ability to transfer the ammonia borane, a surrogate material of low-density polyethylene was used. The low-density polyethylene (LDPE) has properties between the hydrated and dehydrated states of ammonia borane. With current high costs of ammonia borane, LDPE was a sensible model for flows through the extruder [25]. This application of the surrogate material reduced the expected costs of the experimentation.

The experimental apparatus for the testing is shown in Fig. 3. The material enters the system though the feeder were the material depending on the flow conditions is gravitationally feed or forced feed though the inlet of the twin-screw extruder. The material is then dropped in the transition region of the screws. The transition region is the regions were the material is being scraped from one screw to the other. The material is conveyed by the screws to the outlet of the extruder. At the outlet the material drops from the machine, collected, and weighted. To measure torque the twin-screw system was placed in a suspension cradle. The DC rotary motor was attached to the drive shaft. The ammonia borane feeding system is placed over the inlet to the extruder and filled with LDPE. The torque forces were recorded from a force transducer (SM-250). A Whetstone bridge connected the force transducer to the computer program LabView. The program was built to record the average force exerted over one second interval based on the voltage readings over the interval. Calibration of the force transducer was based on voltage at a known force. Calibration was verified before beginning each test. The force transducer was
mounted on the stand that gave the top of the transducer equal height to the top of the twin-screw extruder. Connecting the moment arm to the extruder resulted in the moment arm also resting on the top of the transducer. For calibration in LabView the object of known mass of 658 grams (1.45 lbm) was placed on the moment arm resting on the force transducer as shown in Fig. 4. The voltage setting in LabView were adjusted so the average force record over the interval would equal the force of the known weight. With calibration the moment arm would rest on top of the transducer without producing a force.

4.2 Experiments

Testing was divided between different operating conditions of assisted flow, unassisted flow, and filling flow. The tests were performed first using the twin-screw system assembled with the pair of screws made of aluminum, and then replaced with the pair of ABS plastic screw for the second round.

The assisted flow was done to test the maximum flow rate of the screws. Working with the stirring rod the material within the feeder is continuously stirred during the experiments. The screws were filled to simulate flow conditions during steady state. LabView recording was started simultaneously with the start of the twin-screw device. Beginning at the power setting of
Fig. 4. Force transducer calibration method.

Fig. 5. Closing of the inlet to stop the flow of material.
0.025 hp and increased by a factor of 0.0125 hp. The power was supplied continuously for 30 seconds then cut simultaneously with the LabView recordings. Utilizing the scooping tool the material was collected on the material collector. The total mass collected is recorded and repeated four additional times at each power supplied.

The unassisted flow tests are done to test the flow rate of the weight-in feeder. This weight-in feeder uses the weight of the material to feed the screws. Unassisted flow has the same procedure for the assisted flow without continuously stirring of the material in the feeder. Starting at 0.025 hp supplied for 30 seconds for a total of five times and increasing by 0.0125 hp supplied increments. The total mass collected at the outlet in the 30 second intervals for each test was recorded.

Filling flow conditions provide tests with the screw channels not being filled at the beginning of each test. By placing the blocker between the feeder outlet and the device inlet, shown in Fig. 5, the flow was stopped to the machine. Running the machine without material being supplied the screws were emptied. The screws were empty before each test. Starting at 0.025 hp than increasing by increments of 0.0125 hp. Each test were performed a total of three times at each power supplied. With the machine running LabView recordings were started and the blocker was removed from the feeder simultaneously. The material filled the screws as LabView recorded the torque forces. The time elapsed for the material to first begin exiting the device was recorded. LabView and the machine were stopped after 30 seconds.

Reassembled with the ABS plastic screws, the second set of tests were performed. The reassembled twin-screw extruder was placed in the suspension cradle and attached the rotary motor. The moment arm was attached to the device and the force transducer was calibrated. The testing was then repeated for each operating condition. The measurements of the torque forces, mass transported, and the time elapsed were recorded.

Results from the aluminum and ABS plastic screws for assisted, unassisted, and filling operating conditions were compiled. Calculations of the torque ranges and volumetric flow rates were computed. The standard deviations were calculated from the measured variables for the torque and volumetric flow rates.

5. Results and Discussion

The Results of the assisted and unassisted volumetric flow rate experiments in terms of power supplied are shown in Fig. 6. Volumetric flow rate linearly increased with the amount of power supplied to the system. When assembled with the screws made of ABS plastic, volumetric flow rates of 46% higher than the aluminum screws for both conditions of flow. With inspection a difference between the diameters of the screws was found as a 4 mm larger diameter for the aluminum screw pair. This discrepancy between the screw pairs is a possible consequence of the machining methods. As a result the volume of the channel is greater for the ABS plastic system,
thus increasing the channel flow capacity. With examination the differences between the assisted and unassisted operating conditions provide to be minimal. The assisted flow conditions resulted in an average increase of 3.5% volumetric flow rate over the unassisted flow conditions. With uncertainty analysis it was determined that the increase was contained within the uncertainty of the increase in volumetric flow rate. The uncertainty increase range was -6.1% to 5.2% increase of assisted flow over the unassisted flow conditions.

The torque produced during operating conditions of the system is shown in Fig. 7. For the ABS plastic screw pair lower requirements of torque were recorded for all cases of volumetric flow rate. This is explained as a result of the additional channel clearance of the ABS plastic screws the intermeshing clearance of those screws. Causing less friction between the screws thus less torque generated. The ABS plastic screws had a steady decrease in torque required. The aluminum screws provided to be decreasing in torque till approximately 0.956 mL/s (3.5 in³/min). Then after 0.956 mL/s (3.5 in³/min) volumetric flow rate, an increase in torque requirements was found. By observation at lower speeds the material penetrated between the screws causing additional friction and

![Fig. 6. Assisted and unassisted volumetric flow rate for power supplied.](image-url)
forces that needed to be overcome. As the speeds were increased the material was transferred from screw to screw without the penetration in the nip region. This penetration could be the cause of the increased torque at low volumetric flow rates. As screw speed increased this lessened friction forces between the screws and the material with generally lower torque requirements.

The results from the uncertainty analysis of the assisted verse unassisted operating conditions, the filling conditions tests were performed using unassisted flow. Results of the torque requirements for the filling screw conditions are shown in Fig. 8. The torque required in filling the screw channels show a decreasing pattern for the ABS plastic screws. The torque of assisted, unassisted and filling operating conditions for the aluminum screws show an increase in torque required. With the torque for filling remaining in between the assisted and unassisted conditions it is predicted that this increase is due the material penetrating between the screws during the filling process. This penetration is then believed to be due to the position of the inlet over the transition region of the screws. This position would increase the friction between the screws at that point, resulting in higher torque values.
6. Conclusions

The twin-screw extruder system has potential in transporting the ammonium borane throughout an on-board fuel system for a hydrogen powered car. The volumetric flow rates that can be achieved by the system exceed the DOE requirements to a 1/10th scale. For the assisted flow conditions the increase in volumetric flow rate was contained within the uncertainty of the unassisted flow conditions. The assisted flow conditions resulted in an average increase of 3.5% volumetric flow rate over the unassisted flow conditions. The uncertainty in the volumetric flow rate range was -6.1% to 5.2% increase of assisted flow over the unassisted flow conditions. With the additional power required for the assisted flow condition, assisted flow operation was seen as unbenefticial to the system. With this uncertainty a weight-in feeder that is operating under unassisted conditions is sufficient. The decision for minimizing the power required and maximizing the volumetric flow rate supports the weight in feeder option as well. The torque requirements of the system are greater for the aluminum screw pair. This is due to friction between the screws.
from minimal clearance in the screw channel. With further investigation an optimum diameter of the screws could be reached. The filling conditions of the system vary in the length of the system needed.

7. Future Work

Using the co-rotating twin-screw extruder for the transportation of ammonia borane has unique opportunities for an on-board system. Limits in space and weight make the optimization of the systems design essential for commercial use. For the future work of this project various flow properties could be the key to the success of this system. These flow properties include investigating channel clearance, pressure distributions, heat transfer to the material, mixing potential and continued look at the volumetric flow rates. With the extensive possibilities for this system for on-board transportation the basic design flaws of the extruder need to be resolved. This will involve alterations to the current twin-screw extruder systems gearing system, inlet, and outlet of the device.

![Fig. 9. Proposed gearbox working principle of common twin-screw extruders [27].](image)

The gear box of the current model is difficult to take apart and repair, this would pose problems within the operation of the system if a failure would occur. This current gear configuration has meshing conflicted between the driving gear and the screw gears, resulting in periodic slipping between the two screws. The periodic slipping between the screws increases the friction and the torque requirements of the system. The gear box will need to be modified to account for the spatial constraints and increased reliability of the system. The proposed gear configuration is shown in Fig.9 with the concept of double torque division most commonly used in small to medium twin-screw extruder gear boxes [27].
In order to decrease the chance of the clogging, the position of the inlet will be moved to the side of the downward rotating screw shown in Fig. 10. This will increase the amount of material fed to the channels with each rotation. The new position of the inlet is shown in Fig. 10b with this position the chances of clogging decease significantly as a result of eliminating the upstream velocity from the transition region. The torque required will also decrease, due to the position change reducing the penetration of the material between the screws.

The outlet of the device will be restructured for transporting the material to replicate the fuel lines of the car. This change in outlet will adjust the system to push the material away from the screws, instead of falling out once the screw channel stops. This outlet will make collection of the material easier thus making the feeding to a new component more efficient. The proposed outlet configuration is based from a tapering extrusion die shown in Fig.11.

Incorporating all the proposed design changes will resolve the design flaw discovered during this experimentation. With the new system the co-rotating twin-screw extruder could be then further modified for specific vehicular use, taking in to consideration the various flow

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Fig. 10. (a)The current designs inlet position, (b) proposed position of the inlet and (b) the side representation of the material flow in the cross section [26].
properties that could be incorporated into the system. The flow properties as mentioned before will be investigating are channel clearance, pressure distributions, heat transfer to the material, mixing potential and continued look at the volumetric flow rates. The channel clearance will influence the torque requirements. With a decrease in clearance an increase in torque will occur. The channel clearance will also influence the pressure distributions along the length of the screws. In investigating pressure distributions the stress on the material could be assessed. If excessive amounts of pressure were to be shown then the ammonia borane has the potential to release the hydrogen bonds prematurely outside of the separation component of the system. The heat transfer of the twin-screw extruder systems are used frequently in industry, the application of incorporating this idea to the ammonia borane transportation is an option. With this option the hydrogen separation component could be compacted into a single twin-screw system. With the

Fig. 11. (a) top view of the current design of the outlet, (b) tope view of proposed design of the outlet, (c) side view of the current design of the outlet, and (d) the side view of the current design of the outlet.
heat transfer rates controlled the ammonia borane could be heated sufficiently to release it hydrogen bonds that can then be transported to the fuel cell. Additional options of mixing ammonia borane with catalysis within the twin-screw extruder system could enhance the hydrogen release to a low reaction temperature for the separation.

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References


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Research Topic: Attributional Styles and Negative Life Events: Depression in American Indian, Alaskan Native, and Alaskan White Adolescents

Abstract

Negative life events are thought to be a major contributor to the development of depression in some individuals. However, not all people who experience negative life events become depressed. The attributional style of the individual is what tends to predict depression in the face of negative life events. Those with a depressogenic attributional style tend to attribute negative life events to internal, stable, and global factors. People with a depressogenic attributional style are more likely to develop depression in the aftermath of a negative life event. This study examined archival data of 164 adolescents (72 boys and 89 girls) in fifth through eighth grade. The adolescents that were studied were from ethnicities of; American Indian, Alaskan Native, and Alaskan White. The goal of this research was to examine how negative life events and attributional styles affect adolescents of certain minorities.

Depression is one of the most common and burdensome psychological disorders (Gilmer et al., 2005; Gotlib & Hammen, 2002). Depression is highly comorbid with anxiety, sleep, and sexual disorders and is associated with a number of negative outcomes, including significantly impaired social and occupational functioning; poor subjective wellbeing; great amounts of service use; and high rates of suicidality (Arnow & Constantino, 2003). Generally, depression is most often experienced in adulthood. However, as the transition from childhood to adulthood occurs, rates of depression increase quite dramatically. According to Lakdawalla, Hankan & Mermelstien (2007), approximately 2% of 13 year olds are depressed. As children go through adolescence, the rates of depression increase fairly drastically, with 17% of 18 year olds experiencing depression (Hankan, Abramson, Moffitt, McGee, Silva & Angell, 1998).

There are many different theories as to why individuals develop depression. Negative life events are thought to be major contributors in the development of depression for some individuals (Abramson, Metalsky & Alloy, 1989). Although this tends to be a larger problem with adults, children and adolescents are susceptible to this risk factor as well. For example,
Straus and Kantor (1994) found that corporal punishment from parents was associated with an increase for developing depressive symptoms for certain individuals. Furthermore, Monroe, Rohde, Seeley and Lewinsohn (1999) found that a recent break-up with a romantic partner brought an increased likelihood to develop a first depressive episode among some adolescents. However, not all individuals who experience negative life events go on to develop depression.

**Hopelessness Theory of Depression**

Abramson et al., (1989) described a subtype of depressive disorders which they called hopelessness depression. According to their hopelessness theory, individuals with hopelessness depression have expectations that highly desired outcomes will not occur or that highly undesired outcomes will occur, which are accompanied with a sense of helplessness that there is anything they can do to influence these outcomes (Abramson et al., 1989). In hopelessness theory, the impact of negative life events on depression is influenced by an individual’s attributional style.

Attributional style refers to how a person interprets a negative life event and its causes. Some people have depressogenic attributional styles. Whereas some individuals may attribute negative life events to external and situational factors, individuals with a depressogenic attributional style tend to attribute negative life events to internal, stable, and global factors (Abramson et al., 1989). For instance, a person prone to depression might interpret receiving a bad grade as due to being stupid, which represents an internal (stupidity is a characteristic in me) vs. external (e.g., test was unfair) characteristic, a stable (I will always be stupid) vs. unstable quality (e.g., I was just tired the day I took the test), and a global (stupidity will affect many outcomes) vs. a specific (I am just not very good at math) quality. Abramson et al. (1989) discussed how negative life events and a depressogenic attributional style can lead to general feelings of hopelessness. Hopelessness develops when a person feels that they cannot control the outcomes of negative life events, and when they begin to expect negative outcomes of events in general. This development of hopelessness is shown to be a proximal cause to developing symptoms of depression.

In hopelessness theory of depression, attributional style is viewed as a moderator between experiencing negative life events and developing hopelessness depression (Abramson et al., 1989). In a diathesis-stress model for the development of depression, many individuals may experience temporary feelings of hopelessness immediately following a negative life event (Abramson et al., 1989); however, an individual with a depressogenic attributional style (the diathesis) are likely to experience more severe hopelessness and develop depression, sometimes even in the absence of negative life events (the stress; Abramson et al., 1989).

There are individual differences in people’s inferences about particular events. In the diathesis-stress model of depression, depressogenic attributional style serves as a cognitive
vulnerability for developing depression (Abramson et al., 1989). In fact, individuals with such an attributional style may have a lower threshold for stressful situations, where even daily hassles and minor events may trigger negative attributions. Symptoms of depression and lowered self-esteem are associated with attributions about a negative life event which are internal, stable, and global (Abramson et al., 1989). If a person attributes the event to particular characteristics about the self, as opposed to external factors, they are more likely to feel hopeless about the likelihood of the circumstances changing. Similarly, if the negative life events are inferred to be long-lasting (i.e., stable) and affecting many different areas of one’s life (i.e., global), individuals with such attributions are more likely to experience hopelessness about remediating the situation or future events (Abramson et al., 1989).

Empirically, there have been a number of studies demonstrating that a depressogenic attributional style increases the risk of developing depression in adults. However, the literature examining the role of attributional style in youth depression is less extensive. I now will examine the empirical literature examining the role of attributional style in youth depression.

**Review of Empirical Studies Examining Role of Attributional Style in Youth Depression**

Gibb and Alloy (2006) studied fourth- and fifth-grade children from twenty-four different schools in the Philadelphia area. Each child was administered three different measures. The first was the Childhood Trauma Questionnaire-Emotional Abuse (CTQ-EA) scale to assess what levels of verbal victimization each child had experienced. The second measure was the Revised Children’s Attributional Style Questionnaire (CASQ-R) to measure each child’s attributional styles. The last measure used was the Children’s Depression Inventory (CDI), which was used to assess each child’s levels of depressive symptoms. These three measures were given to each of the children participating two separate times; once in the fall, and once in the spring.

In short, the researchers found that attributional styles mediated the relationship between negative life events and depression among fourth-graders, whereas attributional styles both mediated and moderated that relationship among fifth-graders. In other words, in younger children, attributional style operates more as a process than an individual difference variable. That is, younger children who make more negative attributions for negative life events are more depressed. However, for older youth, the authors inferred that as a result of making repeated negative attributions, they in fact had developed an attributional style in which they chronically made such negative attributions. The authors inferred that negative attributional styles develop over childhood and possibly exist as a personality structure by early adolescence, increasing the risk for developing depression in adolescence (Gibb & Alloy, 2006).

Prinstein and Aikins (2004) examined 158 adolescents from a suburban high school. The students were all in tenth-grade and ranged from ages fifteen to seventeen. Four different
measures were administered to each of the participants. The first measure was a peer-nomination sociometric procedure, which was used to indicate the adolescents’ peer acceptance/rejection. The second measure was the CASQ to determine each of the participant’s attributional styles. Another measure was administered to indicate how important it was for the adolescents to be accepted by their peers. The final measure that was given was the CDI to assess each of the participant’s levels of depressive symptoms. These measures were given to some of the participants again seventeen months later.

The results that were obtained from this study indicated that peer rejection was a significant predictor of depressive symptoms. However, it was when peer rejection was coupled with a depressogenic attributional style that was the largest predictor of youth depression. This was found to be more common in the female adolescents. From the results of this study, it can be determined that peer acceptance and attributional styles can have a big impact on an adolescent’s mental health (Prinstein and Aikins, 2004).

Garber et al. (2002) examined 240 youth in a longitudinal study, first assessing them in sixth-grade and last assessing them in eleventh-grade. Measures used in this study were the CASQ to determine each of the participant’s attributional styles and the CDI to assess each of the participant’s levels of depressive symptoms.

The study found that participants whose attributional styles were increasingly negative across time experienced the most depressive symptoms. This further demonstrates that a person with a depressogenic attributional style is more likely to develop depression. This study also found that female youth were more likely to have a depressogenic attributional style. Moreover, female youth who had mothers with a depressogenic attributional style were more likely to develop that style themselves (Garber et al., 2002).

A review of twenty-one studies was compiled by Jacobs, Reinecke, Gollan, and Kane (2008). The studies that were reviewed included the three studies that were described earlier in this section. Jacobs et al. (2008) found these studies to support the potential effects of attributional styles on depressed mood in children and adolescents.

Limitations of Empirical Literature Examining Role of Attributional Style in Youth Depression

While there is some empirical literature investigating attributional styles and depression in adolescents, there are some limitations. First, not as much research has been done on children and adolescents as there has been done with adults. So while there is some evidence supporting a depressogenic attributional style as a diathesis for depression, it is difficult to make a strong claim that attributional styles affect depression in youth as it does with adults. Another limitation is that minority youth are often overlooked. Many of the studies do not focus on minority youth, and none have been found to focus on American Indian, Alaskan White, and Alaskan Native
youth, as will be the focus of this study. This is important, because minority youth tend to experience more negative life events, and may produce different results with depression than youth from the majority culture.

**Present Study**

Depression is a major problem for many people today. It appears that depression increasingly becomes an important issue in adolescence. This study will examine how negative life events and attributional styles affect depression symptoms among adolescents of minority populations, such as American Indian, Alaskan White, and Alaskan Native adolescents. I hypothesize that adolescents who experience more recent negative life events will have higher depressive symptoms. Moreover, adolescents with more negative life events and higher scores on the attributional style questionnaire will report higher depressive symptoms than adolescents with lower scores on the attributional style questionnaire.

**Method**

**Participants**

Participants were 164 adolescents (72 boys and 89 girls) in fifth through eighth grade. Ninety-five of these participants were American Indian adolescents who attended a high school on an Indian Reservation in the Northern Plains of the United States. Sixty-nine participants were from Alaska; of these, 48 reported their ethnicity as American Indian and 21 as European American.

**Measures**

**Recent negative life events inventory (NLE).** A recent negative life event measure was developed specifically for American Indian adolescents (Novins, Beals, Roberts, & Manson, 1999). The measure assesses whether specific negative life events have occurred in the past six months. Items range from relatively minor stressors (e.g., “breaking up with a girlfriend or boyfriend”), to chronic strains (e.g., “living with someone who has an alcohol problem”), to severe events (e.g., “suicide or death of a family member or close friend”).

**Childhood depression inventory (CDI).** The CDI was administered to assess depressive symptoms. The CDI is a 27-item questionnaire that measures the cognitive, affective and behavioral symptoms of depression. Each of the items on the CDI is presented in a multiple-choice format. These choices range from 0 to 2 in terms of intensity (0 = I am sad once I a while, 1 = I am sad many times, 2 = I am sad all the time). The CDI is a widely used self-report measure of childhood depression and it possesses adequate psychometric properties (Craighead, Smucker, Craighead, & Illardi, 1998; Saylor, Finch, Spirito, & Bennett, 1984; Smucker, Craighead, Craighead, & Green, 1986). Furthermore, the CDI has been shown to possess good
psychometric properties with similar samples of American Indian youth from a Northern Plains tribe (Hamill, Scott, Dearing, & Pepper, 2009; Scott & Dearing, 2012).

**Children’s attributional style questionnaire - revised (CASQ-R).** To assess attributional styles that adolescents use to explain negative events, we used the CASQ (Thompson, Kaslow, Weiss, & Nolen-Hoeksema, 1998). The instrument contains 24 items with 12 positive (e.g., “You get an ‘A’ on a test”) and 12 negative events (e.g., “A team that you are on loses a game”). For each item, there are two response options (e.g., “I am smart” vs. “I am good in the subject that the test was in”, or “The team members don’t help each other when they play together” vs. “That day the team members didn’t help each other”) which map onto three dimensions of causality, namely the internal-external, stable-unstable, and global-specific dimensions. The scale has shown to have good internal consistency (r = .61) and good test-retest reliability (r = .53, p < .001; Thompson et al., 1998).

**Procedure**

Paper versions of the measures were collected from students in the Northern Plains region and Alaska in 2003. Measures were administered by graduate students working on the study. The general size of the groups in which the students completed the measures ranged from ten to thirty students. For the present study, archival data from the samples of the two regions were combined and examined in SPSS. For a detailed description of the procedure see Scott, Dearing, Reynolds, Lindsay, Baird, and Hamill (2008).

**Statistical Analyses**

In order to examine whether negative life events predict higher depressive symptoms, we used a correlational analysis to examine the relationship between NLE and the CDI. To determine whether negative life events and attributional style lead to an increase in depression symptoms, hierarchical multiple regressions were computed. In the first step, we entered NLE scores and CASQ-R scores as predictors of depressive symptoms. In order to determine whether there were moderation effects, we entered the interaction between NLE and CASQ-R in the second step of the hierarchical regression.

**Results**

We hypothesized that adolescents who experience more recent negative life events will have higher depressive symptoms. Negative life events experienced in the past six months were strongly correlated with elevated scores on the CDI (r = .34, p < .01). Examining this relationship further revealed that recent negative life events were significantly correlated with the CDI only for adolescents from an Indian Reservation in the Northern Plains (r = .38, p < .01); this rela-
tionship was non-significant for American Indian adolescents from Alaska ($r = .26, p = .10$) nor European American adolescents from Alaska ($r = .08, p = .74$).

Moreover, we hypothesized that adolescents who have experienced more negative life events and score higher on the internal-stable-global attributional style questionnaire would report higher depressive symptoms than adolescents with lower scores on the depressive attributional style questionnaire. In order to test whether recent negative life events, depressive attributional style, and the interaction between recent negative life events and depressive attributional style predicted symptoms on the CDI, we conducted a hierarchical multiple regression. Table 1 shows the results of the hierarchical regression for participants from the Northern Plains; Table 2 shows the results of the hierarchical regression for participants from Alaska. In the first step, we included main effects for recent negative life events and depressive attributional style. In the second, we entered the interaction term between recent negative life events and depressive attributional style. In short, in the first step, recent negative life events predicted CDI scores, whereas a depressive attributional style did not predict CDI scores among adolescents from the Northern Plains. However, the interaction between recent negative life events and depressive attributional style was significant, and accounted for an additional 7% of the variance in CDI scores. Therefore, the relationship between recent negative life events and the CDI depended on depressive attributional style scores. To examine the nature of this interaction, we mean-centered the NLE variable and values that were 1 SD above (SD = 2.50) and 1 SD below (SD = -2.50) the mean set of values on the NLE were inserted as the predictor variables. Similarly, we

<p>| Table 1 |
|-----------------|---|---|---|
| <strong>Hierarchical Regression Analysis for Recent Negative Life Events and Internal-Stable-Global Attributional Style on the CDI among Adolescents from the Northern Plains</strong> |</p>
<table>
<thead>
<tr>
<th>Predictors</th>
<th>$\beta$</th>
<th>t</th>
<th>Step $R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NLE</td>
<td>.40</td>
<td>3.77***</td>
<td>.20***</td>
</tr>
<tr>
<td>CASQ</td>
<td>.11</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>2. NLE x CASQ</td>
<td>-.53</td>
<td>-2.61*</td>
<td>.07*</td>
</tr>
</tbody>
</table>

Note: NLE = Recent Negative Life Events; CASQ = Children’s Attributional Style Questionnaire; $\beta$ = standardized regression coefficient. *$p < .05$, ***$p < .001$. 
Table 2

Hierarchical Regression Analysis for Recent Negative Life Events and Internal-Stable-Global Attributional Style on the CDI among Adolescents from Alaska

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>t</th>
<th>Step R² change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NLE</td>
<td>.32</td>
<td>2.87*</td>
<td>.16**</td>
</tr>
<tr>
<td>CASQ</td>
<td>.20</td>
<td>1.84</td>
<td></td>
</tr>
<tr>
<td>2. NLE x CASQ</td>
<td>.03</td>
<td>.24</td>
<td>.001</td>
</tr>
</tbody>
</table>

Note: NLE = Recent Negative Life Events; CASQ = Children’s Attributional Style Questionnaire; β = standardized regression coefficient. *p < .05, **p < .01.

Figure 1. Interaction effects of recent negative life events (NLE) and depressive attributional style on self-reports of depressive symptoms (CDI) among adolescents from the Northern Plains.
mean-centered the CASQ variable and values that were 1 SD above (SD = -2.19; the lower the score, the more depressogenic the attributional style) and 1 SD below (SD = 2.19) the mean set of values on the CASQ were inserted as the moderator variables. The graph derived is presented in Figure 1. For the group with a highly depressive attributional style, an increase in negative life events was associated with an increase depressive symptoms reported on the CDI. However, for the group with a less depressive attributional style, an increase in recent negative life events was not associated with a significant increase in depressive symptoms reported on the CDI.

**Discussion**

It was hypothesized that depressive symptoms would be found more often in youth who had experienced more recent negative life events than those who did not. This appeared to be the case when looking at the relationship between negative life events and depressive symptoms for American Indian adolescents. More depressive symptoms were reported by American Indian youth who experienced more negative life events. This relates to previous studies which found that negative life events, such as corporal punishment (Straus & Kantor, 1994) and a break-up with a romantic partner (Monroe et al., 1999), were related to depressive symptoms. However, the same relationship was not found for either of the Alaskan groups.

When the relationship between negative attributional styles and depressive symptoms was examined, there were no significant results found for either the American Indian or Alaskan groups. These results are consistent with the by the diathesis-stress theory (Abramson et al., 1989). Youth may begin to form certain cognitive patterns or have particular schemas under development; however, without the presence environmental stressors, these cognitive processes may not be directly linked with symptoms of depression. In other words, an increase in depressive symptoms may only present with the combination of both negative life events and negative attributions about those events (Abramson et al., 1989).

The main focus of this study was to determine whether negative life events and attributional styles interacted to predict symptoms of depression. We predicted and found that the relationship between negative life events and depression depended on whether the youth possess a certain cognitive diathesis. Specifically, American Indian youth with a highly depressogenic attributional style tended to experience more depressive symptoms after experiencing negative life events. Conversely, American Indian youth with low depressogenic attributions experienced similar levels of depressive symptoms regardless of the number negative life events reported.

Some limitations of the present study should be noted. Negative life events and depressive symptoms were not significantly correlated among the Alaskan Native or Alaskan White adolescents. This relationship may not have been present due to a few possible factors.
There may have been problems with the methods that were used, such as poor reliability with the CASQ and NLE. There is also the possibility that the environment has an effect on whether negative life events lead to depression. The Alaskan youth were in a different location and environment than the American Indian adolescents, so it is likely that they experienced different stressors than the American Indian youth, stressors which may not have been captured by the NLE questionnaire. Another possibility is that the Alaskan youth may have different social support than the youth from the Northern Plains, which may serve as a protective factor against depressive symptoms. The Alaskan youth may also be required to engage in different activities or traditions that are specific to their location. Being raised in a different environment, the Alaskan adolescents may have been less susceptible to depression due to negative life events alone. Future studies may benefit from gathering information regarding protective factors such as social support, communal engagement, and participation in traditional practices.

Our findings supported the hypothesis that adolescents with more negative life events and higher scores on the attributional style questionnaire will report higher depressive symptoms than adolescents with lower scores on the attributional style questionnaire. These results expand on the findings by Abramson et al. (1989), but also extend to explaining increases in depressive symptoms among American Indian youth. These findings have implications for clinical intervention. For example, cognitive behavioral therapy has been found to be effective in helping youth to develop a more positive attributional style, and to provide them with useful skills for coping with negative life events. If youth can change their attributions regarding negative life events, our findings suggest this may help them become more resilient to developing depression.

References
Relationship Between Motivations for and Consequences of Non-Suicidal Self-Injury and its Impact on Frequency of Non-Suicidal Self-Injury

Non-Suicidal Self-Injury (NSSI) is a phenomenon that has received relatively little research focus and therefore remains a partially understood behavior (Nock & Prinstein, 2005). NSSI is beginning to receive an increase in research and attention due to its puzzling nature and escalating prevalence (Nock & Prinstein, 2005; Chapman, Gratz, & Brown, 2006). For those researchers and scholars who are aware about NSSI and its multiple dimensions, there are still numerous questions that go unanswered in dealing with the motivations for, consequences of, and best treatment methods for individuals who have chosen NSSI as a means of coping with life’s obstacles.

Definitions and Nature of NSSI

There are multiple terms used interchangeably to talk about NSSI that researchers and scholars have used in previous research. Many of the terms have slightly varied meanings depending on the author implementing these terms for a given purpose. Consequently, an overarching consensus within the literature for a universal term to describe this area of behavior has yet to be established (Hicks & Hinck, 2007). Other terms that previous studies have used to refer to this behavior include self-mutilative behavior (Nock & Prinstein, 2004), deliberate self-harm or DSH (Chapman, Gratz, & Brown, 2006), parasuicidal behavior (Linehan, Comtois, Brown, Heard, & Wagner, 2006) and self-wounding (Klonsky, 2009), just to name a few. Although there isn’t common agreement for which terms to use, most of the surrogate terms are used interchangeably and refer to the same types of harmful behaviors such as scratching/cutting oneself, burning oneself, hitting or biting oneself, and/or banging body parts. For the purpose of this paper, the term NSSI will be defined as it is the most widely used, “deliberate damage to one’s own body tissue without suicidal intent” (Nock & Prinstein, 2005).
Research conducted by Favazza and Rosenthal (1993) has proposed a classification system of three groups of self-injurers. Superficial and moderate self-injurers are grouped together and include individuals who perform behaviors including cutting, burning, interfering with wound-healing and hair pulling. This cohort is usually associated with a wide range of mental disorders. These two categories are sometimes studied separately (e.g. Duffy, 2009), but most research combines them together. The individuals who fall into the major self-injurers category often have a psychotic or intoxicated background (Duffy, 2009), and are described as conducting severe tissue injuring including gouging at their eyes, amputating their limbs or castrating themselves. Lastly, stereotypical self-injurers are explained as individuals that perform repetitive rhythmic behaviors that occur in a pattern. Often these individuals have learning, developmental, or intellectual disabilities and can engage in behaviors such as head banging or self-biting. It is important that distinctions be made in the populations engaging in NSSI because motivations, reinforcements, and treatment will all differ depending on the factors involved in each individual case (Duffy, 2009). This study will focus on the superficial category of NSSI.

As the definitions and terms used for NSSI have changed over the course of research, so has the perception of prevalence and typical self-injurers. Klonsky (2007) explained that early on in the study of NSSI, many experts believed that NSSI was a symptom of only one psychopathology condition called borderline personality disorder. Over time, researchers concluded that patients with other diagnoses spanning a wide variety of disorders can also engage in NSSI. The presence of NSSI is most often assessed using self-reporting techniques through either interviews or rating scales (Nock, 2010) Around 4% of adults have reported engaging in NSSI behavior at some point in their lives (Briere & Gil, 1998; Klonsky et. al 2003). Research also commonly suggests that NSSI rates are higher among adolescents and that this lifetime period is the most frequent age-of-onset for NSSI behavior (Nock, 2010). Nock (2010) reported that studies focused on community samples have found 13-45% of adolescents have engaged in NSSI behavior at some point. Likewise, Klonsky (2009) found that other studies suggest a more narrow percentage between 15-17% of adolescents and young adults reported a history of self-injurious behavior. Favazza and Conterio’s research (1988) suggested the peak years for self-mutilative behavior are between ages 15-35. Research has found that NSSI is more common among clinical settings for both adults and adolescents, with a higher percentage consistently being found within adolescent and young adult populations. (Klonsky, 2009, Nock, 2010, Nock & Prinstein, 2005).

Frequency in itself has also been a scope for many researchers. Research thus far has determined great differences in the lifetime frequency for NSSI behaviors. Laye-Gindhu and Sconert-Reichl (2005) did work with community samples and reported that lifetime frequency of NSSI behavior could potentially vary from as little as one episode to hundreds of episodes. Furthermore, Whitlock, Muehlenkamp, and Eckenrode (2008) discuss that lifetime frequency
can also vary in terms of gender and race. An overwhelming majority of studies propose that more females and more Caucasians engage in NSSI than their counterparts (Laye-Gindhu & Schonert-Reichl, 2005; Duffy 2009). Since lifetime frequency of NSSI can vary so widely, it is an important thing to continue to research in order to find relationships between what maintains and what halts NSSI behavior among individuals of diverse backgrounds in hopes of informing understanding and influencing treatment.

**Functions of NSSI**

To date, most of the research has centered upon examining the reasons individuals choose to self-injure with the hopes of informing treatment for those engaging in NSSI. In a meta-analysis conducted by Klonsky (2007), he categorized the proposed functions of NSSI into seven of the most commonly studied functions. The seven possible functions he outlined in his analysis were: affect regulation (e.g. to alleviate acute negative affect or aversive affective arousal), anti-dissociation/feeling generation (e.g. to end the experience of depersonalization or dissociation), anti-suicide (e.g. to replace, compromise with, or avoid the impulse to commit suicide), interpersonal boundaries (e.g. to assert one’s autonomy or a distinction between self and other), interpersonal influence (e.g. to seek help from or manipulate others), self punishment (e.g. to derogate or express anger toward oneself), and finally, sensation seeking (e.g. to generate exhilaration or excitement). There was evidence for the affect-regulation function of NSSI, which can be defined in a simplistic way as: to feel better. Support was also found for the self-punishment function. Less support was found for the functions of anti-dissociation, interpersonal influence, sensation-seeking, anti-suicide and interpersonal boundaries. Based on this research and similar findings of multiple other studies (e.g. Hicks & Hinck, 2007; Chapman, Gratz, & Brown, 2006; Chapman & Dixon-Gordon, 2007) it can be concluded that NSSI is mostly an attempt to receive some type of relief (Klonsky, 2007).

A review of the current literature has made clear that each study designs and categorizes their own functions to best meet the purpose and scope of their study. For the purposes of this paper, we will be using the four function model of NSSI as described by Nock & Prinstein (2004). Nock & Prinstein categorized four separate functions along two dichotomous dimensions. All categories deal with either positive or negative reinforcement. Positive reinforcement refers to adding something in order to increase a desired response and negative reinforcement refers to taking something away in order to increase a response. The categories are described as follows: automatic-negative reinforcement, which involves individuals reducing negative affect states; social-negative reinforcement explains individuals who are able to flee from interpersonal demands; automatic-positive reinforcement, which allows individuals desired psychological states to increase; and social-positive reinforcement, which allows individuals to
gain either attention or access to others. Results from this study suggested that the primary purpose of self-injury was most often related to dimensions on the automatic reinforcement spectrum.

**Consequences of NSSI**

Most researchers have focused on determining the functions of self-injury in hopes that those answers will lead to more effective treatment options for self-injurers. Although research is increasing in this area, there is little research focused on the relationship between the reported reasons for NSSI and the consequences that follow an NSSI episode. In fact, there is a much smaller literature of studies that focus on the consequences or after-effects of NSSI overall. One method to study this relationship is a functional analysis described by Nock and Prinstein (2005) as an understanding of both the antecedents and consequences that develop and maintain a behavior that leads to classification and treatment of behaviors. Many people may engage in NSSI for a specific reason, but may actually be getting reinforced for a different reason. For example, if an individual wishes to engage in NSSI to feel better, it may also be allowing them to avoid social places such as school or work settings, even though they weren’t consciously engaging in the behavior for these effects. These unintentional consequences then may be an advantage and add to the probability that this individual will repeat their behavior. From research conducted on the consequences of NSSI, Chapman and Dixon-Gordon (2007) studied the emotional antecedents and consequences of NSSI and found that the majority of individuals reported they experienced relief immediately after an NSSI episode. Relief, calmness, and sadness were the most frequent emotions whereas boredom, anger, and tension were the least common emotions experienced immediately following an NSSI episode. Similarly, Klonsky (2009) found that the most common emotions after a NSSI episode were relief, anger, and calmness. Klonsky’s research also found some evidence that actual physical pain and visible marks tended to be desired consequences of NSSI episodes (2009). Klonsky (2007), in his review, also found that the majority of participants stated that NSSI episodes were preceded by negative emotions such as tension, depression, irritability, and anxiety and that 94% of self-injurers reported a decrease in these feelings following NSSI behaviors. Similarly, another study found that 90% of participants felt less angry and anxious and more peaceful following engagement in an NSSI incident (Klonsky, 2007). The majority of research therefore finds that negative emotions precede NSSI episodes and for most individuals, positive feelings of relief and escape from negative emotions result following an NSSI episode.

Although much of the research has developed categories or assessed self-reported feelings either before or after an NSSI episode, little research has focused on the relationship between motivations to self-injure and whether or not the motivation is actually congruent with
the consequence felt after the NSSI episode. Chapman and Dixon-Gordon’s work (2007) is an exception to this. Their research concluded that most often NSSI episodes resulted in a transfer from negative to neutral or positive emotions. Research done by Klonsky (2009) found negative affect states preceding NSSI episodes in fact were converted to positive affect states after an NSSI occurrence. In essence, this describes a negatively reinforced behavior instead of a positively reinforced behavior due to the consequence most often being a release of negative emotions. This study in particular took research one step further and looked at the congruence between motivations for NSSI and consequences of NSSI and found that the frequency of NSSI behavior increased for individuals who encountered the largest affective advantages. In other words, the frequency of self-injury may be tied to the desired consequences of an NSSI episode actually being met following the act.

**Current Study**

NSSI cannot necessarily be studied experimentally in a laboratory setting due to obvious reasons including ethical constraints. Therefore, measures used to study this cohort of behaviors are typically interviews conducted by mental-health professionals or researchers and/or self-reports completed by participants (e.g. Linehan et al., 2006). The present study was conceived in order to address the relationship between motivations for and consequences of NSSI. It will explore whether or not the motivations for NSSI are congruent with the actual consequences of NSSI for a particular episode. Further, this study also seeks to study whether this relationship affects the maintenance or frequency of NSSI behaviors over time. These findings are necessary to obtain a better understanding of the phenomenon of NSSI and could provide a better understanding of the return of urges to self-injure. Further, this could lend information on the relationship between motivations, consequences, and frequency of self-injury in an attempt to develop more effective treatment options for each of the sub-groups of individuals who engage in these behaviors. This particular study will draw upon data from both structured interviews and self-reported questionnaires to explore/study the congruence between motivations and consequences of NSSI and the relationship between congruence and frequency of NSSI over time.

From the studies described, we hypothesized that self-reported reasons for NSSI will be correlated with the corresponding consequences of the NSSI behavior. Further, we hypothesized that a positive correlation between each reason and consequence will be associated with increased frequency of NSSI behavior over time.
Method

Sample

The sample consisted of a total of 52 college students at the University of Wyoming with 44 females and 8 males. Participants were chosen from the psychology department participant pool after each participant endorsed at least one episode of NSSI behavior on the screening form. The participants age ranged from 18 to 26 (M=19.81, SD=1.92). The sample was found to be predominately White/Caucasian (90.4%). Other ethnicities included were 3.8% Latino/Hispanic, 3.8% Biracial and 1.9% Asian/Pacific Islander. Data for the current study were collected as part of an earlier study by Saraff (2011). Participants were given research credits for their participation.

Measures

The screening measure used for this study was the first section of the Inventory of Statements about Self-Injury (ISAS; Klonsky & Olino, 2008), which asks about an individual’s lifetime history of NSSI behavior. Participants who affirmed at least one NSSI episode were invited to participate in the study.

Inventory of Statements about Self-Injury (ISAS) (Klonsky & Olino, 2008) has two sections assessing the lifetime frequency and functions associated with NSSI behavior. The first section was created to measure the number of times individuals have performed twelve possible NSSI behaviors. If participants endorsed at least one episode on NSSI behavior that was carried out on purpose without suicidal intent, they then proceeded to complete section two, which assesses the possible functions of NSSI behavior. The eight functions measured by this instrument are affect regulation, self-punishment, anti-dissociation, anti-suicide, interpersonal influence, peer bonding, sensation seeking, and interpersonal boundaries. Each function is assessed by three items and participants then rate each item on a 3 point scale selecting either “very relevant”, “somewhat relevant” or “not relevant”. The ISAS has been found to have two separate factors, one measuring automatic reinforcing functions and the other measuring socially reinforcing functions (Glenn & Klonsky, 2007). The ISAS in its entirety has high test-retest reliability (.85). The section on lifetime frequency of 12 NSSI behaviors also showed good test-retest reliability (median=.74). The ISAS correlated moderately (r=.45) with the self-harm/suicide item of the McLean Screening Instrument for Borderline Personality (MSI-BPD; Zanarini et al., 2003).

Suicide Attempt Self-Injury Interview (SASII) (Linehan, Comtois, Brown, Heard, & Wagner, 2006) is a structured interview created to provide detailed information about NSSI behavior. The assessment consists of 6 screening items, 9 open-ended questions, and 22 items measuring frequency, timing, methods, intent, impulsivity, physical condition, and medical treatment. Inter-rater reliabilities for the SASII were reported separately for lethality of method
(r=.85) and physical condition following episode (r=.93). Validity was calculated by examining rates of agreement between therapist notes and SASII for the number of episodes (76%), and presence/absence of NSSI across assessment intervals at 4, 8, and 12 months during treatment (83%). From the SASII (2006), data were collected from question #11 which asked, “Would you say that you injured yourself/attempted suicide for any of the reasons on this list and, if so, which ones?” and had a list of 29 different possible motivations for NSSI behavior. Question #42 was also used which asked, “Did any of the events or experiences on this list happen immediately following your self-harming/suicidal incident? If so please give a rating for each question on the 1-5 scale: 1= ‘Not true at all/did not happen at all,’ to 5= ‘very true/happened a lot’” and had a list of 30 different consequences following an NSSI behavior.

Procedure

The procedure described below was performed during the time period of January to December of 2010. Saraff (2011) reported that to gather participants, undergraduate students in psychology classes were administered a screening form as part of mass testing which asked them to indicate how often they performed different types of NSSI behaviors (ISAS Section I). Eligible participants were then sent an invitation for further participation and those who consented to the study were screened once more using the same measure as before. Each participant filled out multiple measures of which the current study will utilize the following – demographic data form, ISAS and SASII. As each participant arrived for the study, they signed the consent form and completed the demographics form and the ISAS. Next participants were interviewed using the SASII. Each participant was then debriefed and thanked for their time and participation. All procedures were approved by the University of Wyoming Human Subjects Review Board.

Results

The first hypothesis predicted that each self-reported reason for engaging in NSSI behavior would positively correlate with each reason’s corresponding consequence. To test this hypothesis, each reason and each consequence were matched and then categorized into the three reinforcement categories – automatic negative, automatic positive and social. The automatic positive category had six items, the automatic negative category had 11 items and the social category had nine items to be analyzed. A bivariate correlation test was run for each category to determine the correlation using Pearson’s Correlation Coefficient (r) to find the statistical significance (see table 1). The reasons and consequences in the automatic positive category (r = .506, p = .000), the automatic negative category, (r = .516, p = .000), and the social category, (r = .346, p = .012) were all statically significant. Thus, the results indicate that our hypothesis was supported for all three function categories - automatic negative, automatic positive and social reinforcement.
The second hypothesis predicted that a positive correlation between each reason and its corresponding consequence would increase the frequency of NSSI behavior over time. To test this hypothesis, only the most frequently endorsed reasons were considered. Reasons that had been endorsed by at least 15 of 52 participants were included, resulting in a list of eight reasons. Next, each reason-consequence match was found by first determining all possible consequences that could result from each of the eight most endorsed reasons. A match was found if a subject endorsed both the reason and at least one of its corresponding consequences. For instance, if a participant endorsed the reason “to stop bad feelings”, she would score a match if any of the following consequences were endorsed: “bad feelings stopped”, “you got away or
escaped”, “you stopped feeling numb or dead”, “feelings of anger, frustration or rage stopped”, and “feelings of anxiety or terror stopped”. Two raters independently listed each reason and all possible consequences for them. Before discussion between raters, inter-rater reliability was moderate (r=.56). They then compared the lists and came to an agreement about the consequences for each of the eight frequently endorsed reasons. Thus, a separate match variable was created where the participant scored a 0 if they endorsed the reason, but did not endorse any of the consequences. The participant scored a 1 only if they endorsed both the reason and at least one of the corresponding consequences.

To determine the relationship between match and lifetime frequency, an independent-sample T-test was conducted between the lifetime frequency of NSSI for groups scoring 0 and 1 on each match variable. There were no significant differences in lifetime frequency of NSSI between groups with and without a match between the reasons endorsed and their corresponding consequences (see table 2).

For all 8 reasons, the groups with and without a match did not differ significantly in lifetime frequency of NSSI. Thus, our results did not support our hypothesis suggesting that the correspondence between each reason and its possible consequences does not adequately predict the frequency of the behavior over time.

**Discussion**

Analyzes were conducted to test two hypotheses about the relationship between self-reported reasons and consequences of NSSI and the match between reason and consequence and how that impacts frequency of the behavior over time. According to the principles of operant conditioning, the repetition/occurrence of a behavior depends on the consequences that follow it. Based on this logic, it follows that individuals who continue to engage in NSSI receive reinforcement for that behavior, whether from internal or external sources. The study aimed at examining the reinforcements for NSSI behavior. To this end, we first hypothesized that the self-reported reasons for an episode of NSSI would correlate with the consequences experienced after engaging in the behavior. The results from the first hypothesis suggest that reasons in all three categories of function - the automatic positive category, the automatic negative category and social - have a significant positive correlation with their corresponding consequences. That is, when an individual engages in NSSI to increase a desired psychological state, decrease an unwanted psychological state, flee from interpersonal demands and/or gain access or attention to others, they are in fact receiving the corresponding desired consequences. Overall, research has shown that changes in affective states seem to be the most common self-reported reason for NSSI behavior (Nock and Prinstein, 2004). Relating our study back to the four original reinforcement categories proposed by Nock and Prinstein (2004), our research supports this finding and
goes beyond to show that for two subgroups of these reasons (automatic positive: increasing an individual’s desired psychological states and automatic negative: reducing an individual’s negative affect states), the individuals also experience the corresponding consequences. Furthermore, our results found correspondence for social reinforcement functions (including social positive: allows individuals to gain attention or access to others and social negative: the individual’s ability to flee from interpersonal demands as well.

The second hypothesis, that a match between self-reported reasons and their consequences would lead to a higher frequency over time, was not supported. Relating this idea to operant conditioning once again, if a match between reason and consequence is present, then the self-injurious behavior is reinforced in the way the individual was expecting, they are likely to continue engaging in the behavior again to continue to be reinforced. In other words, the behavior has served its purpose. In terms of our study, even when the relationship between a reason and consequence is very strong, this does not predict the frequency of the behavior over time. This indicates that the match between the reasons for engaging in NSSI and consequences that are received after an NSSI episode do not predict the frequency of the behavior. The only possible exception is for the reason described as, “to feel something, even if it was pain” (t(50)=-1.83, p=.07). This relationship showed a statistical trend. Had a larger sample been used, these results may have been shown to have statistical significance which is a motivation for future research using a larger sample size.

The fact that the reason/consequence match did not predict frequency is unexpected because operant conditioning principles would predict that experiencing congruence between reasons for and consequences of NSSI behaviors would encourage individuals to continue engaging in it, predicting the lifetime frequency. However, it must be noted that the sample size for this study was small and participants mainly endorsed reasons in the automatic positive category, leading to more data to work with and therefore more reliable results for that category. Also, this study only took the most frequently endorsed reasons and the total number of matches when analyzing these items was still low. Moreover, it may be that the reason/consequence relationship has no direct impact on the frequency of the behavior over time. Another consideration is that we only analyzed data from the most severe episode that individuals reported on. Therefore, the participants may have experienced different rates of matching overall. Furthermore, the participants may not have been aware about what occurred following an episode and how that relates to what they expected from the behavior. It is also possible that this cross-sectional measure of number of episodes to date will not correspond with the total number of lifetime self-injury episodes. Those with matches between reasons and consequences may go on to self-injure more in the future. Longitudinal studies are needed to assess this possibility.
Future research on NSSI should further clarify the relationship between reasons and consequences, especially concerning under-represented demographics. As previously mentioned, females and Caucasians are highly over-represented, so emphasis on minority groups not often studied may give further insight into the relationship between reasons and consequences for these under-represented groups. Perhaps instead of relying on the exact reason to consequence correspondence, the relationship between a reason and whatever consequence occurs can be studied to find some type of relationship that will impact the frequency of the behavior over time. Furthermore, we need more indirect measures of studying antecedents and consequences of behavior, such as direct observation and functional analyses of behavior. That is, if individuals are unaware of the relationship between reasons and consequences, self-report data may not always identify this, so functional analytic methods of data collection may be more revealing. One of the major limitations of this study is the low response rates for reasons and consequences other than automatic positive. This limitation is not unique to our study, the majority of individuals participating in NSSI studies report more automatic than social observations. Because we chose the most frequently endorsed reasons, where 15 of the 52 participants had to endorse that reason, that means that only 28% of the sample had to endorse it in order to be analyzed, which is low. There were also low matches in terms of reason to consequence in general. On average, of the 52 total participants, when analyzing for matches there were typically less than 10 matches per item to be analyzed. Having a larger sample size and therefore greater range of data for each reinforcement category may help better clarify the relationship between reinforcement and the impact on frequency.

For practitioners, it may be beneficial to pay attention to the relationship between the reasons why individuals are engaging in the behavior and what reinforcements they are receiving following the behavior in order to find patterns and relationships between the motivations for wanting to perform these behaviors and what type of relief it is bringing each participant. Continuing to study the frequency of this behavior is important because it will help us continue to look for predictors and influence treatment for individuals at risk of or engaging in the behavior. Mental health professionals will hopefully be able to develop and implement treatments to increase the desired psychological state received from the behavior and find more effective coping mechanisms to achieve that in non-self-harming ways.

Overall, this study looked at the congruence between each self-reported reason for and consequence of NSSI and whether that relationship helps maintain the behavior, i.e. predict the frequency of NSSI over time. The results indicate that although individuals may experience a match between self-reported reasons and consequences for a particular episode, this match does not predict the frequency of NSSI behavior over time. This study adds information on the relationship between motivations and reinforcements of NSSI and shows there is further need for
research that explores how motivations and consequences of NSSI contribute to impacting the frequency of the behavior because questions involving what maintains and predicts NSSI still remain. Both of these concepts are not frequently studied. In fact, only a small number of studies have delved into the relationship between motivation and consequence. Further exploration of these relationships and their ties to frequency may warrant advanced understandings and implications for NSSI and clinical psychology.

References:


Abstract

Classic roll-front type uranium deposits in Tertiary basins of Wyoming occur at the contact between a zone of reduced rock containing one or more ‘reductant’ phases and an oxidized zone in which the ‘reductant’ phase has been depleted. Common reductant phases include buried organic matter and pyrite; other potential reductants include methane gas, liquid hydrocarbons, and sulfate-reducing bacteria. The deposit grows and advances down the hydrologic gradient as the reductant phase is depleted in the oxidized zone. Roll-front deposits lacking obvious reductant phases and typical spatial relations between mineralized zones and the occurrence of potential reductant phases also occur. Framboidal pyrite is ubiquitous in both the oxidized and mineralized portions of the deposit in this study but only rare, cubic, non-framboidal pyrite occurs in the reduced zone down-gradient from the deposit. Framboidal pyrite is biogenic in origin suggesting bacterial activity as the reductant. The existence of this pyrite in both the oxidized and mineralized zones, and its absence in the reduced zones suggests that processes responsible for its deposition post-dated the initial formation of the ore deposit, and pyrite is not a likely controlling reductant phase in this deposit. Calcite is also rare to absent in all zones suggesting a lack of both digenetic and epigenetic carbonate. Organic matter is rare in this deposit, and no systematic variation in abundance of organic matter between the oxidized and reduced zones has been recognized. X-ray analysis of clay minerals associated with this deposit reveal that clays in the oxidized zone include abundant corrensite, while corrensite is absent in the reduced zone, but biotite is common. Chlorite in the reduced zone, and coexisting with the ore deposit, has higher Mg/(Fe+Mg) than the biotite, and poorly crystallized ferrihydroxide materials are abundant. We infer that in-situ alteration of biotite to chlorite and corrensite generated the ferrous iron in solution. This ferrous iron acted as the reductant responsible for the formation of this ore body. Formation of this deposit required (a) rapid erosion and deposition of biotite-rich sandstones, (b) diagenesis without formation of significant carbonate, and (c) diachronous
formation of corrensite from biotite and reduction of U(VI) to U(IV) to produce coffinite and rare uraninite. Understanding the formation and composition of uranium roll-front deposits is important to the safe and viable extraction of uranium. Using the wrong type of lixiviant in a formation containing swelling clay such as smectite can cause the smectite to swell destroying the porosity and permeability of the formation.

**Introduction**

Clay minerals, crystallites the size of colloidal particles, viruses, or the particles in smoke from a cigarette, are the most abundant minerals at the surface of the earth (Moore and Reynolds, 1997). Due to the small size of clay minerals (4µm), one must use X-ray diffraction (XRD) to identify them. Much work has been done analyzing clay mineralization. Clay minerals associated with unconformity-type uranium deposits have been used to determine the spatial distribution of hydrothermal alteration and the conditions of uranium deposition (Beaufort et al., 2005). Previous studies involving roll-front uranium deposits have focused on the nose of the roll-front deposit, leaving the reduced and oxidized zones poorly understood. Little to no research has been done on clays found in the oxidized and reduced zones. Understanding and determining the structural features of clay minerals in and around the roll-front deposit is important for identifying different clay types, mixed layer clays, and altered clays. Identification of altered clays is important to have a better understanding of the types of mineralization happening in the roll-front.

The preparation, analysis, and interpretation techniques found in X-Ray Diffraction and the Identification and Analysis of Clay Minerals (Moore and Reynolds, 1997) are a foundational part of this study. Using these techniques allows a systematic analysis of the structure, layering, alteration, and chemical makeup of the clay minerals found in this deposit. Clay mineral diffraction patterns contain a good deal of variation. This character is manifested by the diffraction peak’s position, intensity, shape, and breadth (Moore and Reynolds, 1997). The application of the methods in Moore and Reynolds will provide a better understanding of clay alterations and the reduction of U6+ in a roll-front deposit.

One of the harder aspects of clay identification using diffraction patterns is identification of mixed-layer clays. XRD identification of mixed-layer clays containing swelling clays such as smectite is based on the expansion of these clays with ethylene glycol (Śrondoń 1980). Mixed-layer clays involving smectite are the most common clay components of sedimentary rocks (Śrondoń 1980). Contrasting the change in 2θ between air-dried and glycolated samples can identify these swelling clays if they follow a regular sequence of 001 reflections (Śrondoń 1980). Successful identification of mixed-layer clays requires that we consider the entire diffraction pattern, because the breadth and symmetry of each diffraction peak may be diagnostic, together with the peak position and intensity (Moore and Reynolds, 1997). Peak width is also
an important factor when analyzing with mixed-layer clays. Peak broadening is indicative of the spacing between peaks of the individual clays present in the mixed-layer clay. If the sequence is irregular, then it is probable that mixed-layer clays are present.

Methods

Samples

We drilled two cores in the Great Divide Basin roll-front deposit indicated by the two solid black lines in figure 1. These cores are from the reduced zone and oxidized zone (Fig. 2). The cores are composed of immature arkosic sandstone. Of these cores, 14 samples were selected to analyze using XRD, six from the reduced and eight from the oxidized zone. The sample area contains a large volcanic component. Smectite is the dominate clay found in our study area along with subordinate kaolinite and small amounts of illite. In the reduced and oxidized zones (Fig 5) the distinctive smectite peak shifts left with exposure to ethylene glycol.

Sample Preparation

Minimal processing of samples is important to reduce the possibility of error or artifacts in the XRD analysis. The sand of the roll-front is friable, poorly indurated sandstone that required no grinding or crushing. Oriented clay mounts were made using the filter-peel technique. Samples were initially disaggregated by hand. Five to ten grams (depending on clay concentrations) of each sample were placed in glass jars with deionized (di) water and 10 ml of Calgon wetting agent. Each sample was sonically disaggregated for 2.5 minutes. Settling occurred over four hours. Forty milliliters of the clay suspension was then added to a Millipore filtration device. A 0.45 μm Metricel membrane filter was used to capture the clay particles. Samples were then rinsed with di water then with MgCl2. Samples were mounted onto a glass slide and allowed to air dry. Samples were then exposed to ethylene glycol vapor in a glycolator for 12 hours. A separate set of air-dried samples was prepared using the filter method above and then heated to 375° C for one hour.

X-ray Diffraction Analysis

All diffraction data were obtained with a CuKα radiation source in a Scintag XDS 2000 diffractometer at the University of Wyoming. Step size is automated using 20 increments of 0.03° and a scan speed of 0.50 degrees 2-theta per minute. Mounts were scanned from 2-30° 2-theta. The diagnostic spacing between parallel layers in the clay crystal structure (the d spacing) will be determined using Bragg’s law, \( n\lambda = 2d\sin\theta \), where \( n \) is an integer greater than or equal to one, \( \lambda \) is the wavelength of the X-ray source 1.5418 Å (a constant), and \( \theta \) is the observed angle of diffraction. Peak intensity and position were compared with known positions of different types of clays.
Results
Reductants

With no obvious reductant found in the Great Divide Basin, we investigated ferrous iron from detrital biotite as a possible reductant. The role of Fe2+ as a reducing agent for uranium (VI), which is typically known to be very stable under subsurface conditions, has been established (Lucchini et al., 2008). We also analyzed the organically produced framboidal pyrite in the deposit (Fig. 3), but we do not believe the pyrite is the source of the reductant. Pyrite cannot be the source of the reductant for two reasons: first we believe the pyrite post-dates the formation of the deposit due to its position in the oxidized zone; second, there is not enough pyrite present to provide sufficient amounts of reductant to have a significant impact on the deposit. During organic decay processes calcite may be formed diagenetically but calcite is rare in our deposit, further reinforcing the lack of an organic reductant (Goldhaber et al., 1979). No other possible reductants appear present in the deposit.

Ferrous iron is the likely reductant and detrital biotite is the source of the iron. To liberate ferrous iron from biotite as in so it is free to interact with uranium (VI), the biotite needs to be altered to chlorite (Yeo et al., 2010). The chloritization of biotite can be seen in the Eq. 2 (Yeo et al., 2010). Chlorite has more Mg than biotite so we are left with excess iron as seen in the microprobe data (Fig 4). The reduction of uranium (VI) to uranium (IV) is seen in Equation 2

\[
\text{Equation 1} \quad \text{K(Mg,Fe)₃AlSi₃O₁₀(OH,F)₂ (biotite)} + \text{H}^+ + \text{H}_2\text{O} + \text{Mg}^{2+} \rightarrow \text{Mg}_₂(\text{Al,Fe})₃\text{Si}_₃\text{AlO}_{₁₀}(\text{OH})₈ (chlorite) + \text{K}^+ + \text{SiO}_₂ + \text{Fe}^{2+}
\]

\[
\text{Equation 2} \quad \text{U}^{6+} + 5\text{H}_2\text{O} + 2\text{Fe}^{2+} = \text{UO}_₂{s(l)} \text{ (uraninite)} + \text{Fe}_₂\text{O}_₃{s(s)} + 10\text{H}^+
\]

Figure 5 shows a distinct difference in the defraction patterns between the oxidized and reduced zones around 3-4° degrees 2-theta. There is a peak in the oxidized zones that is not present in the reduced zones. With exposure to ethylene glycol, the peak in the oxidized zones shifts to the left, indicating an increase in d-spacing. The position of the peak before and after glycol solvation is distinctive of corrensite. Corrensite is a mixed-layer clay composed of chlorite and smectite layers. The smectite in the corrensite is responsible for the peak shift.

Conclusion

To summarize we will compare the reduced to the oxidized zones. The reduced zone does not contain corrensite, but it does contain rare chlorite and cubic, non-framboidal pyrite. The reduced zone has pure biotite and is Fe rich. Transitioning from the reduced to the oxidized
zone biotite turns into chlorite layer-by-layer. In the oxidized zone we see abundant corrensite, chlorite, low Fe/(Fe+Mg), and organically produced framboidal pyrite. As the roll-front migrates through the sand, biotite is altered to chlorite, liberating Fe2+. Ferrous iron reduces U(VI) to U(IV), forming the ore body and leaving corrensite in the oxidized zone. Identification of a reductant in a basin is important to uranium exploration because the ore body will not form without a reductant. The viability of a basin’s uranium is dependant on the presence of a reductant. In basins that do not have an obvious reductant, the presence of biotite may indicate that iron is present and working as a reductant for uranium. Alteration of biotite to chlorite could also be used as a possible spatial constraint for the location of the uranium ore body.

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**References**


Lucchini, Jean F., Jnin Khaing, Michael K. Richmann, Marain Borkowski, and Donald T. Reed. “Plutonium (IV) and Uranium (VI) Reduction by Iron (II) at High pH under subsurface Conditions.” Los Alamos National Laboratory.


Cartoon of a Roll-Front

**Figure 1** Cartoon representing a roll-front deposit. Black lines represent cores drilled through reduced and oxidized zones.

Oxidized and Reduced Cores

**Figure 2** Photos of oxidized (top) and reduced (bottom) cores taken as they are removed from the coring tool. Picture scale is three feet across cores are 2 1/2 inch diameter.
SEM Image of Framboidal Pyrite

Figure 3 Organically produced framoidal pyrite showing an ordered morphology.

Fe-Mg Chlorite vs. Biotite in the Reduced and Oxidized Zones

Figure 4 Microprobe data showing $[\text{Fe}/(\text{Fe}+\text{Mg})]_{\text{chl}} < [\text{Fe}/(\text{Fe}+\text{Mg})]_{\text{bio}}$ so $\text{Fe}^{2+}$ is left over in reaction.
Figure 5 X-ray diffraction patterns comparing the reduced and oxidized zones.