CONTRIBUTIONS MADE BY UNDERGRADUATE RESEARCH IN THE ABSAROKA VOLCANIC PROVINCE

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ABSTRACT

Undergraduate research projects focused on the geology exposed in the Absaroka Mountains have added knowledge through petrologic descriptions of textures and minerals, X-ray diffraction for mineralogy, and geochemical signatures of major and trace elements. Initial characterization of the volcanic province in these projects started with a literature review and comparison of igneous rocks in the Absaroka Mountains with those from the Yellowstone Caldera. Although adjacent, these two volcanic provinces are vastly different from one another. Volcanic units of the Absaroka Mountains are distinctly intermediate to mafic in composition and are dominated by volcaniclastic rocks whereas the Yellowstone units are typically more felsic and fine-grained. Volcaniclastic units in the Absarokas include brecciated and conglomeratic textures with a wide variety of igneous lithologies exhibited in the clasts. Clasts in the breccias are commonly porphyritic basaltic lava and are variable in size and shape. Comparatively, clasts in the volcaniclastic conglomerates are rounded, often cobble-sized and have lithologies ranging from porphyritic dacite to basaltic lava flows. The volcaniclastic units are separated by and sometimes contain lava flows of intermediate to mafic composition. Previous studies have utilized these lava flows and dike intrusions in the area to determine the timing of igneous activity during the Tertiary. Dike intrusions into these volcanic units have also been used to delineate several volcanic centers across the province. Geochemical signatures of the igneous rocks in the province have SiO2 compositions of 50.8-65.6% indicating the overall intermediate composition of the province. Some of the samples have unusually high K2O compositions given the silica content while others indicate some minor enrichment of Cu. The geochemical signatures and petrographic observations are verified with data from X-ray diffraction indicating feldspathoid minerals and alteration products where K2O compositions were high and feldspar varieties that are congruent with Na and Ca compositions. Together, these undergraduate research projects of rock units in the Absaroka Mountains have provided pieces of information that can be used to build on the existing knowledge base in the area.

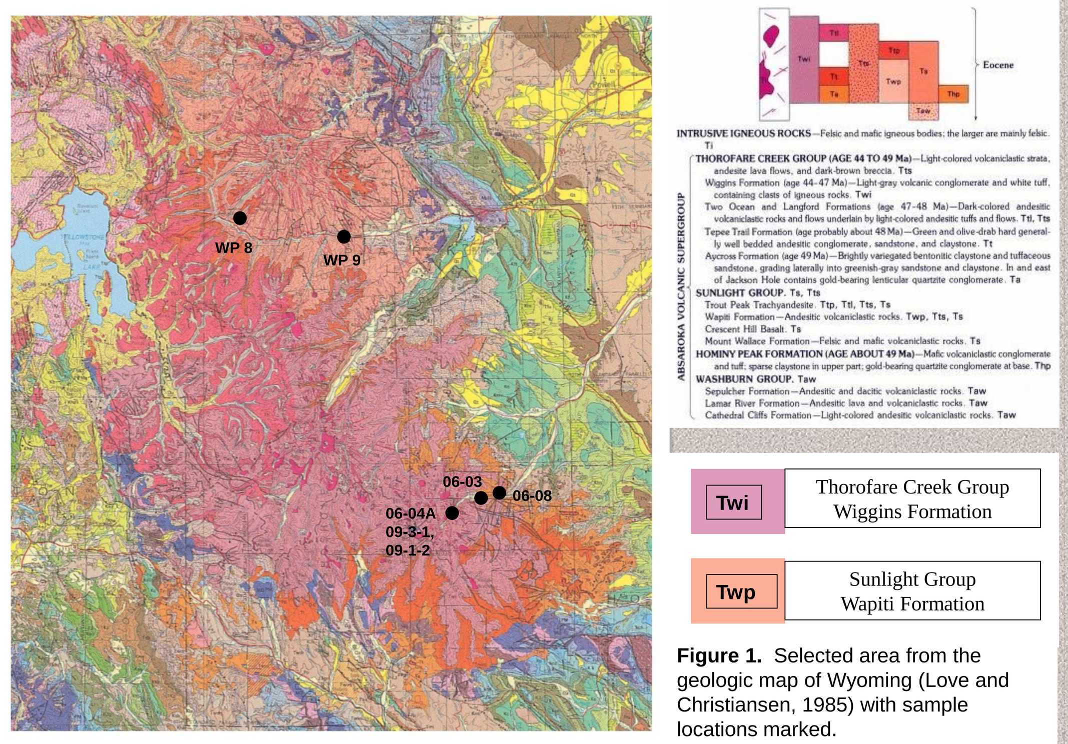
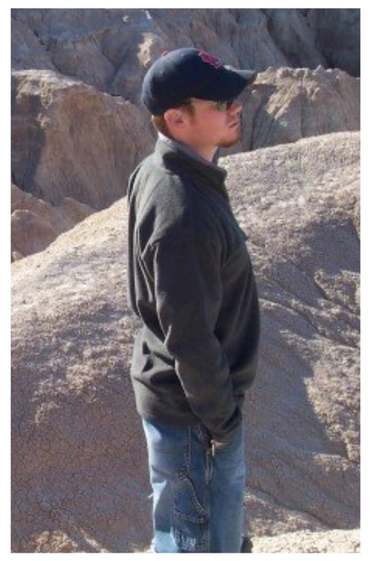


Figure 1. Selected area from the geologic map of Wyoming (Love and Christiansen, 1985) with sample locations marked.

BACKGROUND

The Absaroka Volcanic Province (AVP) of northwestern Wyoming is composed of intermediate and mafic rocks. Most of the volcanism occurred between 53 and 38 million years ago (Sundell, 1993). It is the largest Eocene volcanic field in the Northern Rocky Mountains covering nearly 9,000 square miles. These Eocene volcanic rocks have been named the Absaroka Volcanic Supergroup. The three groups that comprise the supergroup are the Washburn, Sunlight, and Thorofare Creek Groups (Smedes and Prostka, 1972). The Washburn Group makes up much of the northern AVP and is the oldest part of this series. This group was named for the type area, the Washburn Range, and produced from volcanic centers located around northeastern Yellowstone National Park (Smedes and Prostka, 1972). The group contains basaltic lavas and volcaniclastic rocks composed of hornblende and pyroxene andesite, biotite andesite and dacite, and rhyodacite ash-flow tuffs (Smedes and Prostka, 1972). The Washburn Group includes the Sepulcher, Lamar River, and Cathedral Cliffs Formations. The Sunlight Group includes much of the central part of the Absaroka Range just east of Yellowstone. It overlies the Washburn Group to the north, but rests directly on prevolcanic rocks to the south (Smedes and Prostka, 1972). Associated rocks include dark-colored pyroxene andesite lava flows, volcaniclastic rocks, and potassium-rich basalts (Smedes and Prostka, 1972). The Sunlight Group is comprised of the Mount Wallace Formation, Crescent Hill Basalt, Wapiti Formation, and Trout Peak Trachyandesite. The youngest of the three groups is the Thorofare Creek Group comprising much of the southern half of the Absaroka Range. This 6,000 foot layer of rock generally overlies the Sunlight Group, but also interfingers with it in some areas (Smedes and Prostka, 1972). Light-colored volcaniclastic rocks and andesitic lavas are found in the Langford Formation. Dark-colored, coarse volcaniclastics comprise the Two Ocean Formation, while the Tepee Trail Formation consists of fine-grained green and brown rocks. The Wiggins Formation consists of well-bedded, light-gray volcaniclastic rocks which were closely examined during this study. Igneous activity has produced many structural features. Magmatic intrusions of dikes, sills, stocks, and other hypabyssal rocks have caused folding and faulting in the surrounding volcaniclastic rocks (Sundell, 1993). Most of the dikes are five to fifteen feet in thickness and occur in clusters or ring-like complexes of several dikes (Nelson et al., 1980).

PETROLOGY AND GEOCHEMISTRY OF THE ABSAROKA VOLCANIC PROVINCE



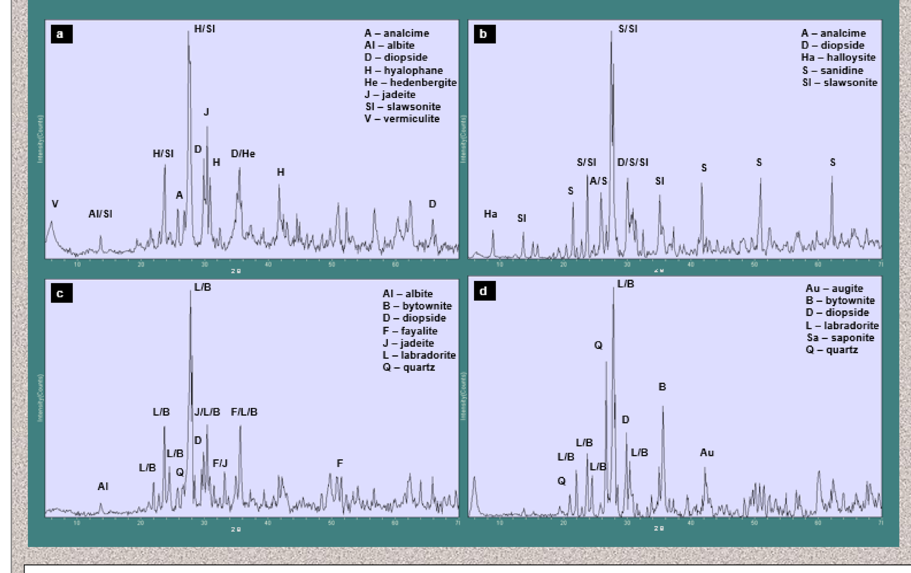
RESEARCHER: Allen K. Anderson, Senior-level geology student

TIMEFRAME: Fall 2007-Spring 2008

PROBLEM STATEMENT: What processes took place to produce the volcanic and intrusive rocks in the Absaroka Volcanic Province?

PURPOSE: Use mineralogical, petrological and geochemical methods to collect information about igneous rocks within the Absaroka Volcanic Province and compare that with existing data to both, contribute to the knowledge base and gain some understanding of the processes leading to the formation of the area.

CONTRIBUTION 1
The work done on Allen's project was our starting point for research in the Absaroka Volcanic Province. He had visited the area and was interested in doing an undergraduate research project focused on Mineralogy and Petrology. A brief literature review provided the basis for developing a problem statement that could be investigated at a beginning level to see if we could reproduce some of the results. His first and most significant contribution to the research in this area was the collection of a sample set representative of the AVP, corresponding thin sections, and preparation of powdered samples for X-ray diffraction.



CONTRIBUTION 2
The petrology and chemistry of the samples matched previous studies in the area, providing continuity and confidence in his results. Volcanic breccias in the area were intermediate in chemical composition and showed plagioclase and clinopyroxene as the primary mineralogy with brecciated textures. The intrusive dikes showed low silica and high alkali chemical composition with corresponding minerals evident in the samples.

Figure 2. X-ray Diffraction patterns analyzed using JADE 8 software. (a) WP8-D1 dike. (b) WP9-D3 dike. (c) 06-08 clast. (d) WP8 breccia.

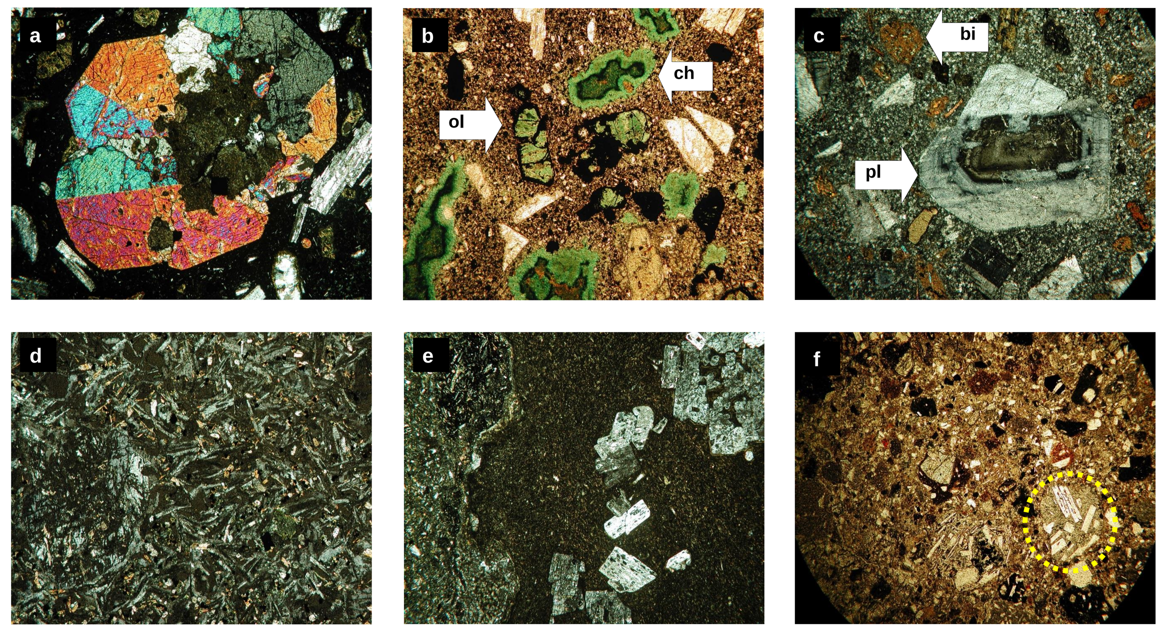


Figure 3. (a) Twinned pyroxene in mafic clast (06-04A); XPL – 40x. (b) Olivine and chlorite in mafic clast (06-08); PPL – 40x. (c) Compositional of plagioclase phenocryst in intermediate clast (06-03); XPL – 40x. (d) Fine-grained crystalline texture of absarokite dike (WP8-D2); XPL – 40x. (e) Chill margin of absarokite/shoshonite dike (WP9-D3); XPL – 40x. (f) Plagioclase-rich clasts in breccia matrix (WP1); PPL – 40x.

CONTRIBUTION 3
This project paved the way for future students to work on rocks in the AVP. The samples and data from this project were used to develop a petrology lab on intermediate volcanic rocks. Students in Petrology found this to be relevant to their own understanding and brought interest for continued undergraduate research.

PETROLOGY OF VOLCANICLASTIC ROCKS IN THE WIGGINS FORMATION, SOUTHERN ABSAROKA RANGE, WYOMING

RESEARCHER: Sara Courter, Junior-level geology student

TIMEFRAME: Summer 2009-Spring 2010

PROBLEM STATEMENT: How are the clast size and rounding related to the observed mineralogy and petrology of volcaniclastic rock units in the Wiggins Formation.

PURPOSE:
The purpose of this research project is to observe the petrology of the Wiggins formation and characterize the mineralogy and textures of clasts to gain a better understanding of volcanic eruptions that were occurring 44-46 million years ago. Retrieving this information will be done by examining the sample thin sections and use GIS to find the average area of the volcaniclasts using field images.

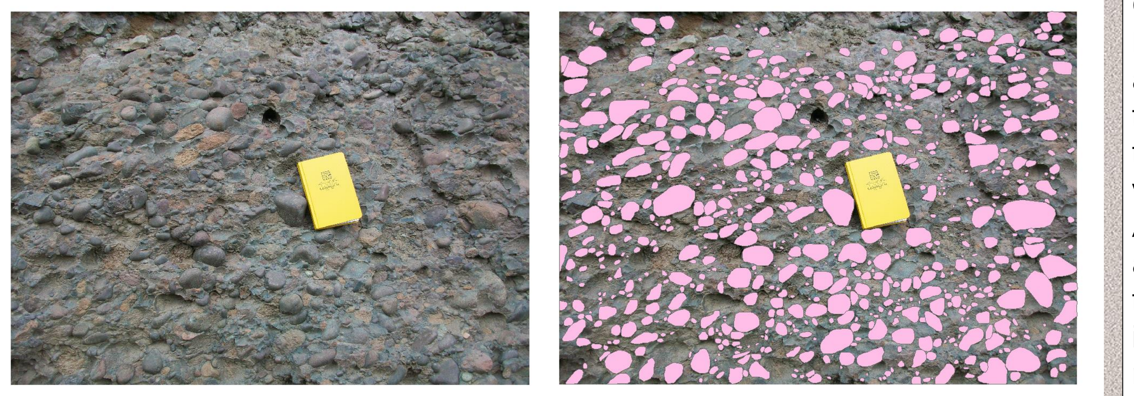


Figure 4. Outcrop location for Wiggins formation in the Thorofare Creek Group with field book for scale. Field book scale was used to determine the clast size on individual clasts identified from the imgage using Geographic Information Software to determine size and rounding.

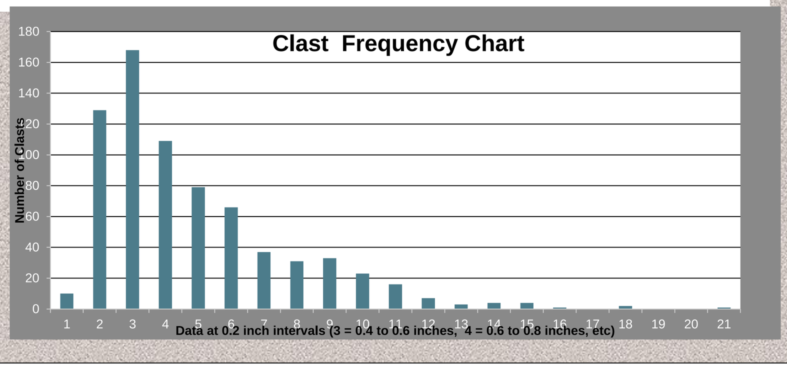


Figure 5. Size frequency chart for clasts in the image based on GIS.

CONTRIBUTION 1
Based on previous work in this area, we expected to find clasts in the volcaniclastic conglomerates that were representative of earlier volcanic events within the Absaroka Volcanic Province. We also expected the composition of those clasts to be variable and to include some intermediate to mafic rock types. Given the results of this study we are able to conclude that most of the clasts are dominated by plagioclase and clinopyroxene with a porphyritic texture, typical of a porphyritic basalt. Also, the plagioclase was usually zoned (oscillatory) with Ca-rich cores may be indicative of magma mixing.

CONTRIBUTION 2
The mineralogy of the clasts also revealed another piece of information. Most of the clasts showed some secondary mineralization by the presence of chrysocolla and goethite. Though unexpected, with additional research of the area, the chrysocolla can be linked to an abandoned Cu-mine further up into the Absaroka Range. Goëthite is commonly associated with chrysocolla and may represent the outer, oxidized zone of a porphyry-copper deposit.

CONTRIBUTION 3
In characterizing the conglomerate as a whole, including the matrix, this project found that the volcaniclastic conglomerate is clast-supported and that the matrix is sand to silt-sized. One distinct observation is that the chrysocolla found in the clasts is essentially missing from the matrix suggesting that the copper mineralization took place prior to the formation of the conglomerates. Also, one sample indicated a lava flow and siltstone instead of just a siltstone, as expected. Therefore the timing of the conglomerates may be determined in the future using isotopic methods.

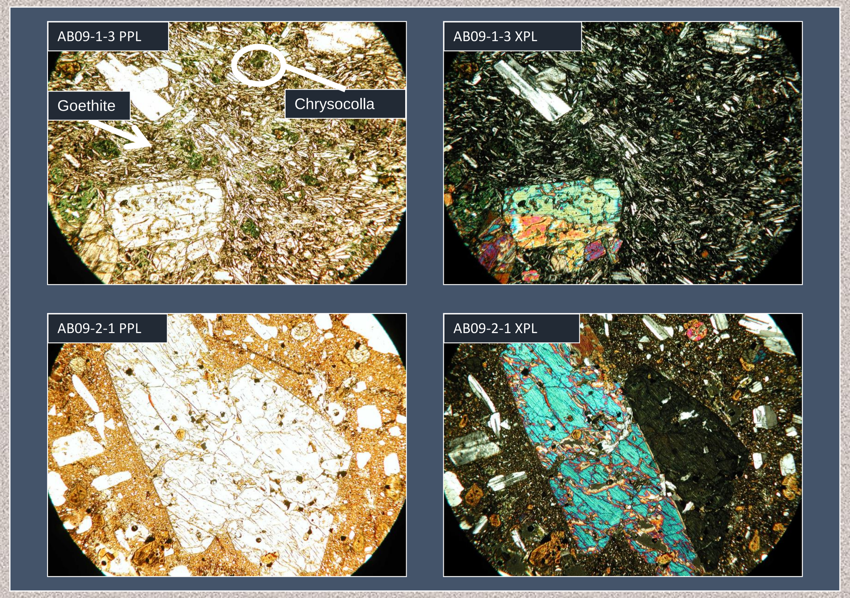


Figure 6. Top left image shows mineralogy and petrology of a clast collected from the volcanoclastic conglomerate in plane-polarized light (PPL). The same image is shown in cross-polarized light (XPL) in the upper right. The lower left is at 100x power in PPL while the lower right is in XPL showing a twinned pyroxene crystal common in phenocrysts found in the AVP .

PETROLOGICAL COMPARISON BETWEEN THE SUNLIGHT AND THOROFARE CREEK GROUPS IN THE ABSAROKA MOUNTAINS, WYOMING

RESEARCHER: Rachel M. Schulta, Senior-level geology student

TIMEFRAME: Summer 2013-Fall 2014

PROBLEM STATEMENT: What are the similarities and differences between the mineralogy, petrology and geochemistry of the Sunlight Group and the Thorofare Creek Group.

PURPOSE:
The purpose of this undergraduate research project is to compare and contrast the petrological, geochemical and mineralogical data between the Sunlight and Thorofare Creek Groups in the Absaroka Mountains. .

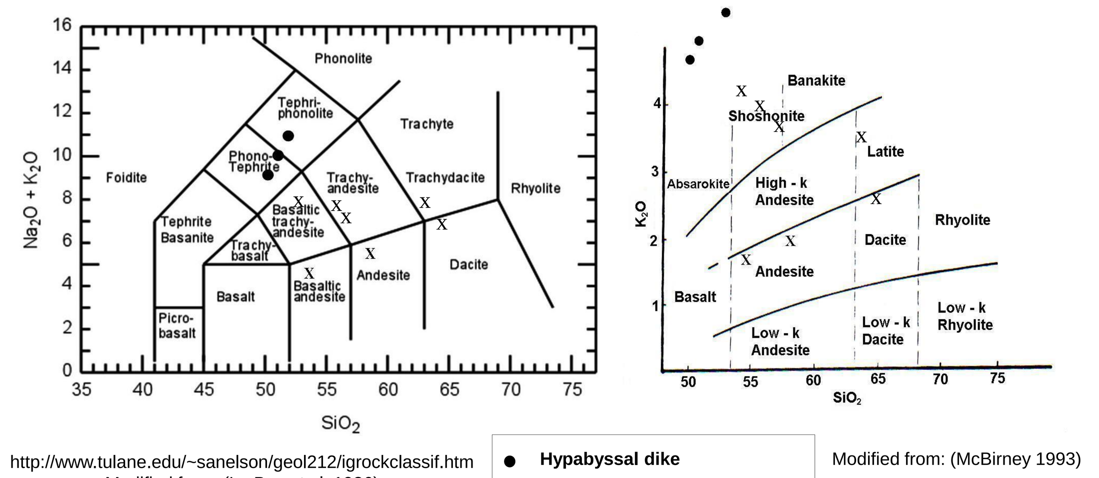


Figure 7. Chemical data for samples from the AVP (a) Geochemcial ……. (b) Calc-alkaline…….

CONTRIBUTION 1
This undergraduate research project used the chemistry and petrology to evaluate the relationship between the breccias and dikes of the Wapiti formation within the Sunlight Group in comparison to the volcaniclastic conglomerates and flows of the Wiggins formation of the Thorofare Creek Group. Based on the chemical signatures of the rocks evaluated, there appear to be two distinct magma groups. The first is a normal calc-alkaline series ranging from basaltic andesite to dacite. The second group is an alkali-rich, silica poor magma with phono-tephrite and tephra-phonolite composition. There are several samples ranging between these two magma groups suggesting the possibility of magma mixing to produce shoshonites and a latite.

CONTRIBUTION 2
The petrology and chemistry of the samples matched previous studies in the area, providing continued continuity. Volcaniclastic conglomerates showed consistency between the X-ray diffraction patterns and the petrology with dominating minerals being andesine and labradorite plagioclase and along with quartz. The vesicular lava flows were andesitic to dacitic in composition separating the volcaniclastic rocks.

Figure 8. X-ray diffraction for samples 09-3-1 showing the primary mineral to be the labradorite variety of plagioclase. Sample 06-03 with the presence of quartz and andesine plagioclase, matching its dacite classification. Sample 06-08 containing clinopyroxene but dominated by labradorite. Finally, sample 06-05 showing quartz and plagioclase.

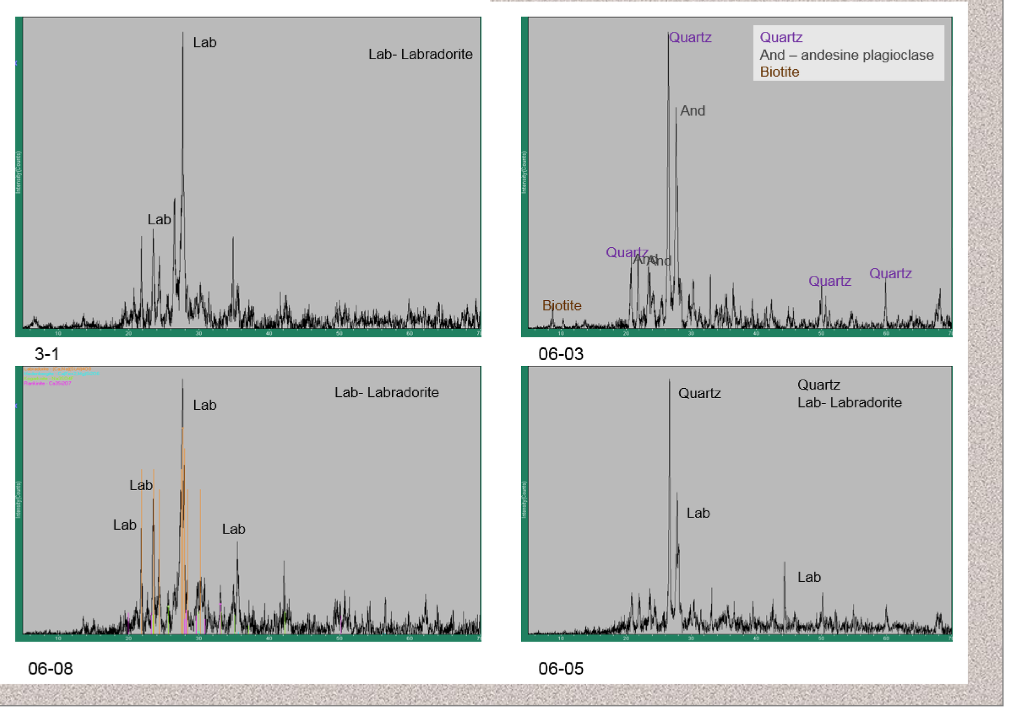


Figure 9. Outcrop location for Wiggins formation in the Thorofare Creek Group showing intermediate clast 06-03.

CONCLUSIONS FROM AVP SAMPLE SET

Sunlight Group- Wapiti Formation
- This formation is dominated by pyroclastic rock units.
- The textures commonly occurring within the pyroclastic units is brecciation.
- Overall compositions of the volcanic breccias are intermediate to mafic.
- Breccia compositions are supported by clast identification and mineralogy.
- Dikes intrude into the pyroclastic rock units and exhibit porphyritic textures.
- The dike intrusions are very high in alkalis and have a silica content comparable to mafic compositions.

Thorofare Creek Group- Wiggins Formation
- This formation is primarily volcaniclastic but not necessary pyroclastic.
- The majority of the textures are conglomeratic with variable matrix material.
- Between conglomerate layers there is evidence lava flows.
- Many of the clasts range in composition including felsic to intermediate to mafic.
- In general this formation contains minerals that are higher in Fe and Cu content

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