Geology of the Saltese Uplands Conservation Area

Andy Buddington\textsuperscript{1}
Aaron Cleveland\textsuperscript{1}
Dillon Smith\textsuperscript{1}
Jennifer Peterson\textsuperscript{2}

\textsuperscript{1} Science Department, Spokane Community College, Spokane, Washington
\textsuperscript{2} Geology Department, Eastern Washington University

Corresponding author E-mail address: andy.buddington@scc.spokane.edu

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INTRODUCTION

The Saltese Uplands Conservation Area consists of 552-acres located within the upland hills along the northeastern side of the Saltese Flats of eastern Spokane County. The general landscape geomorphology is open hills with intersecting ravines, with an elevational range from approximately 2080 ft. to 2650 ft. above sea level. The area can be described as a shrub-steppe habitat with a grassland dominant vegetation. The Saltese Uplands CA is administered by the Spokane County Parks and Recreation Department and became a Spokane County Conservation Futures property in 2011. For more information on the park location, rules, and uses, visit the Spokane County Conservation Futures website.

The Saltese Uplands Conservation Area (SUCA) has a long-lived and complex geologic history. The park occurs in the southern part of the Spokane Dome of the Priest River metamorphic complex (PRMC); for detailed discussion on the PRMC, we refer readers to Doughty, et al., 1997. The bedrock geology at SUCA is composed primarily of the Hauser Lake Gneiss, which is a thick package of quartz and feldspar-rich gneiss with interlayered zones of biotitic schist. The Hauser Lake Gneiss exhibits strong foliation, mineral lineation, and pervasive mylonitization. The mylonitization is characteristic of the upper part of the PRMC within the Spokane Dome mylonite zone. The Hauser Lake Gneiss has been correlated to the Prichard Formation of the lower portion of the Mesoproterozoic Belt Supergroup of Idaho and Montana (Weis, 1968, Weissenborn and Weis, 1976, Doughty et al., 1997). Within the Hauser Lake Gneiss unit occur numerous amphibolite bodies, which vary in thickness and extent. Also within the park area are several small outcrop masses of granitic rock along with sporadic occurrences of ice-rafted glacial erratics.

The purpose of this study was to map and describe the bedrock units at SUCA, and to examine the mineralogy and geochemistry of the amphibolite bodies. These data were then used to test correlation of the SUCA amphibolites to diabase sills (Moyie sills) that occur within the Prichard Formation to the east in parts of northern Idaho and western Montana.

REGIONAL GEOLOGY AND CONTEXT

The Saltese Uplands study area occurs within the geological province known as the Priest River metamorphic core complex (Figure 1). Metamorphic core complexes are rather unique geologic “structures” and in western North America, occur sporadically from northern Mexico to southern British Columbia (Coney, 1980). The Priest River metamorphic complex (PRMC) is one of the larger of these Pacific Northwest core complexes and outcrops from south of the Spokane Valley, northeasterly to southernmost British Columbia. Directly east of the PRMC, into northern Idaho and western Montana, occurs a thick sequence of Proterozoic-aged (Precambrian) sedimentary rocks known as the Belt Supergroup. These rocks exhibit very weak or low-grade metamorphism and the original sedimentary features such as bedding are well preserved. The boundary between the PRMC (west) and the Belt Supergroup (east) is the north-south trending Purcell Trench and associated fault (the Purcell Trench fault). This fault boundary has been interpreted as a major low-angle detachment fault that developed during uplift, extension, and unroofing of the core complex during Eocene time (45-50 million years).
Core complexes are typically “domal” in their overall structure and are comprised of a “core” of high-grade metamorphic rocks such as schist and gneiss. These core rocks formed deep within the crust as a result of significant elevated pressure and temperature conditions causing metamorphism of preexisting rocks. Overlying the core rocks are either unmetamorphosed or weakly (low-grade) metamorphosed rocks and a definitive boundary between the core and overlying (upper plate) rocks is characterized by a zone of intense deformation where the rocks exhibit a fabric known as mylonitization. Mylonitization generally develops due to intense shearing as the upper plate rocks slide or detach from the underlying core (Figure 2).

To the east of the Purcell Trench fault, the Belt Supergroup consists of a very thick (up to 18 kilometers) sequence of sedimentary sandstones, mudstones, and dolomitic (carbonate) rocks. The Belt has been interpreted to have formed within a large inland sea into which the sedimentary materials were deposited during the Proterozoic time period of approximately 1470 million to 1400 million years ago (Digital Geology of Idaho). Within the Prichard Formation...
of the lower portion of the Belt sequence are numerous diabase to basalt igneous sills that were injected soon after the deposition of the sedimentary materials. These sills, known generally as the Moyie Sills, have been age-dated and formed contemporaneously with the Prichard sediments.

The rocks at Saltese Uplands are highly metamorphosed and mylonitized thus represent the uppermost portion of the uplifted core to the Priest River complex. Within this southern portion of the PRMC, the Spokane Dome, several researchers have proposed that the metamorphic rocks were originally (before metamorphism) part of the Belt Supergroup, specifically the lowermost portion of the Belt known as the Prichard Formation. These rocks were buried during Mesozoic time to mid-crustal levels, metamorphosed to high-grades and then later uplifted and exposed as the PRMC formed during the Eocene.

![Figure 2: Simplified cross section of a metamorphic core complex with domal internal “core” and detachment fault and associated shearing (mylonite zone). The Saltese Uplands CA is part of the Spokane Dome, which is part of the greater Priest River metamorphic core complex. The Saltese Uplands study area exhibits rocks and textures that are typical of the mylonitic shear zone directly below the detachment fault (from Link, 2006).](image)

### MAPPING

Field mapping of the park was done during five separate field visits in October and November of 2014, and in March of 2015. Approximately 25 hours were spent walking the various trails as well as off-trail, documenting the bedrock geology. The original base maps used to develop the site map were the U.S.G.S. Liberty Lake and Greenacres 7.5 minute quadrangles (1:24,000), which were enlarged to a scale of 1 inch (on the map) equals 500 feet. Individual bedrock sites were located onto a topographic map and GPS coordinates were taken at each site. Where possible, foliations and lineations were taken and recorded. A generalized geologic map is seen in Figure 3 and GPS site locations are shown if Figure 4. Data from the individual stations is in Appendix A.
Figure 3: Outcrop geology map from this study of the Saltese Uplands Conservation Area.
**BEDROCK GEOLOGY**

**Hauser Lake Gneiss**

The dominant bedrock unit at the Saltese Uplands CA is the Hauser lake Gneiss (HLG). Named after its type location at Hauser Lake (ID) by Weis (1968), this unit is composed of medium to coarse grained, quartzo-feldspathic, sillimanite gneiss with interbedded sections of biotitic schist. The outcrops are well-foliated and characteristically tan to rusty brown in color (Figure 5). Small, medium-grained red to pinkish-red garnets are rare and tend to be more abundant in the biotitic schist sections. From thin section (microscope) observation (Figure 6), the dominant mineral assemblage for the HLG consists of:

- **quartz-plagioclase-orthoclase-biotite-sillimanite (+fibrolite)-garnet**

Accessory amounts of zircon were observed along with minor amounts of muscovite after sillimanite. Folding (of the HLG) on the macro as well as microscale is common. Throughout the formation are coarse-grained, quartz-feldspar boudins, which range up to 10-15 centimeters (lengthwise). Within the unit, a defined layering can often be discerned where distinct bands (up to 1 meter thickness) composed of quartz and feldspar, and minor biotite, occur repetitively. Also occurring within the HLG are large, discontinuous pegmatite bodies composed
of coarse quartz and feldspar, with accessory amounts of garnet and rare mica. The pegmatite bodies, although very abundant in some areas, are not of mappable scale.

![Figure 5](image1.png)  
**Figure 5** (left): outcrop of typical, rusty weathering, foliated Hauser Lake Gneiss (HLG).  
**Figure 6** (right): plane polarized light photomicrograph of HLG, with garnet, biotite (brown), sillimanite, quartz-feldspar.

**Amphibolite**

Scattered throughout the study area are concordant, foliated bodies of dark-grey to black amphibolite (Figure 7, 8). Mapping has identified a minimum of four distinct bodies interbedded within the Hauser Lake Gneiss (Fig. 3). Numerous smaller, discontinuous, pod-like masses of amphibolite occur interspersed throughout the study area. In general, the amphibolite masses range from less than a meter to approximately 13 meters in width, and the dominant mineral assemblage includes hornblende and plagioclase with variable amounts of biotite, quartz, and locally, reddish garnets (5mm). From thin section (microscope) examination, pyroxene was identified along with accessory amounts of titanite, zircon, and apatite. Two of the amphibolite bodies were sampled (A-1, A-2) for thin section and geochemical analysis (Fig. 3).

![Figure 7](image2.png)  
**Figure 7** (left): prominent amphibolite outcrop forming ridgeline.  
**Figure 8** (right): close-up of amphibolite. The black is hornblende amphibole and the light is plagioclase feldspar. The pen is for scale.
Granite

At two locations are small, knobby granitic outcrops (Fig. 1). These granitics are medium-grained, moderately weathered, and non-foliated. The visible minerals in hand sample include quartz, feldspar, and biotite. Derkey et al. (2004) describes these as the Rathdrum Mountain Granite.

**BEDROCK TEXTURES, FABRICS, and STRUCTURE**

Throughout the park, the HLG exhibits a pervasive foliation with a lineated, mylonitic fabric. The foliation is defined by aligned biotite with quartz and feldspar. Locally, foliation occurs as dark biotite-rich bands. Foliation orientations are relatively consistent; the average strike of the foliation is 145°, with variable westerly dips (Figure 9). Mineral (sillimanite) lineations plunge gently (avg. 28°) with an avg. trend of 251° (Figure 10). The lineation data is consistent with that described elsewhere in the Spokane Dome mylonite zone (Doughty et al., 1998). Foliation within the amphibolite bodies is generally concordant with those of the HLG. At the outcrop scale, tight isoclinal folding of quartz-feldspar rich bands was observed (Figure 11). In thin section (microscope) analysis, tight microscopic folding of quartz-feldspar and sillimanite bands was also observed (Figure 12). Although not obvious on the geologic map, large-scale regional folding of the HLG and associated amphibolites is possible.

![Figure 9: lower hemisphere plot of the poles to foliation (diamonds=HLG, circles=amphibolite), and lineations (X) from the Saltese Uplands Conservation Area. Poles to foliation for the HLG break roughly into two groups; one with a northeasterly strike with moderate dips to the northwest and the second group striking northeasterly but with southeasterly dips. Amphibilolite foliations roughly follow this pattern. Lineations (in the HLG) are consistently plunging gently to the west-southwest.](image)
AMPHIBOLITE MINERALOGY AND GEOCHEMISTRY

The second objective of this study was to investigate the possible correlation of the SUCA amphibolites to diabase sills (Moyie sills) found within the Prichard Formation of the Belt Supergroup of Idaho and Montana.

Age dating of the Moyie sills from Montana and northern Idaho give magmatic ages of 1.46 Ga (Rogers, et al., 2014), and amphibolites from the Priest River complex yield magmatic ages of 1.47-1.43 Ga (Doughty and Chamberlain, 2008). The SUCA amphibolites are lithologically identical to the amphibolites dated by Doughty and Chamberlain (2008), and both occur within the Hauser Lake Gneiss of the Priest River complex.

Cleveland, et al. (2015), examined two samples (A-1, A-2) of amphibolite at SUCA, and based on thin section (microscope) analysis and rare earth element (REE) geochemistry, it appears that the two amphibolites are genetically related but chemically separate bodies. Sample A-1 contains both titanite and orthopyroxene, whereas sample A-2 contains neither (Figure 12).
Cleveland et al. (2015) examined the rare earth element geochemistries of samples A-1 and A-2. The REE patterns, although similar, are moderately spaced and do not overlap, and are consistent with REE patterns for continental rift basalts (Wilson, 1989). The REE plots of the SUCA samples were compared to REE geochemistries of known Moyie sills in northern Idaho and western Montana from the data of Rogers (2014). The REE plots of the SUCA amphibolites match those of several Moyie sill occurrences from northern Idaho to western Montana. Based on the age dating, lithological correlations, and the overlap of REE plots, it appears that the SUCA amphibolites represent the high-grade metamorphic equivalent to the Moyie sills of the Mesoproterozoic Belt Supergroup of western Laurentia (Precambrian North America).

GLACIAL ERRATICS

Numerous erratic boulders were identified throughout the study area (Figure 13). Glacial erratics are masses of rock that are not found as bedrock locally and were transported, and deposited by glaciers as they advance and retreat across a landscape. At SUCA, numerous boulders of rock types that do not crop out in the study area have been identified. The boulders range in size from 1 meter to 3 meters in diameter, are semi-rounded to rounded, and are composed of quartzite and non-foliated granite. The granite boulders are coarse-grained and non-foliated, and contain well-formed hornblende with minor biotite. This study did not identify any glacial till (ice deposited gravel) nor was any evidence of former glacial ice recognized. We interpret these boulders to be ice-rafted glacial erratics. Abundant ice-rafted erratics occur throughout central and eastern Washington and were deposited from melting icebergs associated with the Missoula Floods that inundated much of the region during late Pleistocene time approximately 15,000 to 20,000 years ago (Bjornstad, 2006).

The granitic boulders differ significantly from granitic outcrops at SUCA. The erratics are coarse-grained, non-foliated and hornblende-bearing. The granite that outcrops at the study area is medium-grained and is biotitic with no hornblende. The large quartzite boulders are greenish in
color, exhibit layering and are likely from the Belt Supergroup rocks in Montana. The elevational range for which erratics were identified is approximately 2260’ to 2498’.

**Figure 13a** (left): large, semi-rounded erratic boulder of coarse-grained granite. Elevation = 2335’.
**Figure 13b** (right): large, greenish erratic of argillitic quartzite. Elevation = 2498’.

**CONCLUSIONS**

Bedrock mapping of the Saltese Uplands Conservation Area has identified two dominant rock units, the Hauser Lake Gneiss and numerous associated amphibolite bodies. A third rock unit, which occurs in minor amounts, is a medium-grained, nonfoliated granitic. The HLG and amphibolite units (at SUCA) are mylonitic and exhibit upper amphibolite facies (metamorphic pressure/temperature) mineral assemblages consistent with other known occurrences within the lower plate (core) of the Priest River metamorphic complex (Doughty et al., 1998). The nonfoliated granitic rocks appear to have intruded either late in the development of the PRC or after.

Mapping at SUCA has identified at least 4 major amphibolite bodies, which are concordant to the HLG host rock and are here interpreted as having originally been intrusive diabase sills. Two of the amphibolites were sampled (A-1, A-2) and based on thin section examination and geochemical analyses, it appears that they are genetically related, but separate phases, and represent two different intrusive bodies (sills). Additionally, the REE plots for the SUCA amphibolites match and overlap the known REE geochemistry’s of several Moyie sills in northern Idaho and western Montana. Specifically, the SUCA amphibolites correlate to the diabase units of the Goat Flat group, Paradise Sill group, and the Plains sill of Rogers (2014).

Numerous ice-rafted boulders from the Missoula Floods were identified and the highest elevation of occurrence is 2498 feet.

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REFERENCES


“Digital Geology of Idaho, Mesoproterozoic Belt Supergroup” (http://geology.isu.edu/Digital_Geology_Idaho/Module2/mod2.htm)


