Ridgeley Formation Pulpit Rock Weathering Rinds: Thickness of the Rind Compared to the Altitude and Location on the Formation

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The pulpit rocks of Huntingdon are located about a mile and a half past the Smithfield State Correctional Institution on Pike Street. These rocks are part of the Ridgeley Formation, the same formation as the cliffs of Huntingdon. This formation is composed of vertical outcrop “pillars” made predominantly of sandstone. In this paper I will be exploring the thickness of weathering rinds found throughout the formation. The goal of my research is to determine if there is any pattern related to the weathering rind thickness and the surroundings (i.e. altitude, coverage, and location on formation). Weathering rinds have been tied to the ages of the rock but not yet surroundings. This information will help geologists in determining how thick weathering rinds are depending upon altitude and coverage. The relationship between weathering rinds and surroundings will either be directly proportional, which means the higher up on a formation, with less coverage, the thicker the rind, or there will be no relationship and weathering rinds will vary greatly throughout the formation.

Keywords.—Weathering Rind; Ridgeley Formation; Sandstone; Chemical Weathering; Outcrop

INTRODUCTION

The Ridgeley Formation was formed early in the Devonian Era, by an ancient sea, nearly 390 million years ago. Currently these outcrops range in heights from 50 - 250 feet tall. This formation formed within a 5 million year span called the Eifelian Era (Swartz, 1913). This puts the growth rate at 10-50 feet every million years. The Pulpit Rocks shoot up from the ground like pillars; on average, the portion of the formation that I observed was about 75 feet tall. These sandstone pillars come is many irregular shapes and sizes, varying in both width and height.

These rocks have been greatly weathered over time and therefore have many rounded edges. This outcrop is centered in the woods and has moss covering about half of the surfaces. The front side (facing the South West and the road) is rather smooth and a light gray color, while the back side (facing North East and the Juniata...
PULPIT ROCK WEATHERING RINDS

River) is rougher and a dark green color due to the moss coverage. However, after samples were taken, both sides had the same tan interior. The interior, being sandstone, is made up of compressed particles of sand mainly composed of quartz. The interior is very grainy, and the sand flakes off with just a brush of the finger. Each of the preliminary samples I had taken had a different color on the outside than the inside. It seemed like the outside was a different rock than the inside. This idea of having a different rock coating on the outside is known as a weathering rind.

A weathering rind is the outer layer of a rock that has undergone a form of chemical weathering which causes portions of the rocks outside layers to be chemically and physically altered (Mahaney, 2012). Rocks undergo many processes that can alter their chemistry. Chemical weathering is caused when water, usually from precipitation which is slightly acidic, reacts with the minerals in the rock to form new minerals. Not all rocks develop weathering rinds; however, due to sandstones high permeability we were able to see them in this formation (Heller, 2001, p. 972). These weathering rinds intrigued me, so I decided to collect more samples from different areas of the Pulpit Rocks in order to determine if there was any correlation between the rind thickness and where on the formation the sample was taken from.

METHODS

Data Collection

In order to observe the weathering rinds I collected ten samples from random portions of two neighboring outcrops. I used my rock hammer to collect the samples, an app on my phone to record altitude, and a ruler to measure the rind thickness. The whole formation was covered in melting snow which made sample collection slightly difficult. Most of the samples were moist on the inside, certain ones even excreted water.

When collecting the samples I tried to take them from not only normal spots on the outcrop but also diverse spots. I took samples from the front, back, top, and cave like indentations of the outcrop. Using the rock hammer I chipped away at the surface of the sandstone until I either broke a piece off or could see the complete weathering rinds. After breaking off chunks of the rock, I recognized and observed the widths, colors, and designs of the weathering rinds.

Formation 1 is the outcrop with the “Pulpit Rock” nametag on it. It is the one closest to the road. The bottom section, the base of the pillar, collection slightly difficult. Most of the samples were moist on the inside, certain ones even excreted water.

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<table>
<thead>
<tr>
<th>Location on Sample</th>
<th>Weathering Rind</th>
<th>Altitude ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base of formation, front side facing the road, sister under a slight overhang. Rougher and spotty when struck.</td>
<td>0.10 cm thick, dark grey crust around sandstone</td>
<td>1210 ft.</td>
</tr>
<tr>
<td>Side of formation, covered in dark green moss. Sit back far enough to receive no coverage from snow.</td>
<td>0.15 cm thick, dark grey green crust around sandstone</td>
<td>1220 ft.</td>
</tr>
<tr>
<td>Middle back of the formation, covered in a dark green moss 0.5 cm white non moss covered section. Coverage is minimal, site perpendicular from ground. Very wet, including the inside.</td>
<td>0.48 cm thick, dark green outer layer (&lt; 0.1 cm) tan white grey layer that fades into the tan sandstone</td>
<td>1250 ft.</td>
</tr>
<tr>
<td>Upper portion of the formation, back side towards the top. No coverage from above. Spotted when struck.</td>
<td>0.09 cm thick, dark deep red rind at certain sections of the broken off sample but not around the whole sample. The rind fades into a dark tan then into the light tan sandstone</td>
<td>1255 ft.</td>
</tr>
<tr>
<td>Upper portion of the formation, front side towards the top, slight overhang from above.</td>
<td>0.07 cm thick, dark green black rind that fades into the tan sandstone</td>
<td>1260 ft.</td>
</tr>
</tbody>
</table>

Table 1. Formation 1 data.

<table>
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<tr>
<th>Location on Sample</th>
<th>Weathering Rind</th>
<th>Altitude ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The front portion of the formation that is sticking out of the ground. Spotted when struck. Relatively dry, covered under formation above.</td>
<td>0.48 cm thick, dark black grey outer layer that fades to a white grey layer that fades to the tan sandstone</td>
<td>1662 ft.</td>
</tr>
<tr>
<td>Side of all of the middle section of the formation. Upper portions protruding out slightly above this section, sample site sits back inside formation, exhibits cave like feature.</td>
<td>0.41 cm thick, this dark black grey outer layer that faded to a white grey layer that faded to the tan sandstone</td>
<td>1275 ft.</td>
</tr>
<tr>
<td>Taken from the back wall of the middle section. Covered in spots of green and white moss, sample taken from section without moss. Upper portion protruding out slightly above this section.</td>
<td>0.62 cm thick, outer layer is a very thin grey crust that blends into a lighter layer that blends into an orange red layer which fades into the sandstone.</td>
<td>1078 ft.</td>
</tr>
<tr>
<td>Top section, near the back. Green mass covers the wall around rocks. Site perpendicular to formation.</td>
<td>0.58 cm thick, light orange red rind that fades into the tan sandstone interior.</td>
<td>1092 ft.</td>
</tr>
<tr>
<td>Very top of the formation, no coverage from above as it is exposed to all elements. Rounded and covered in green moss.</td>
<td>0.58 cm thick. Appears to have two different rinds. Both are dark orange fading into the tan sandstone, however the upper rind has an inner rind that forms a circle within the rind.</td>
<td>1113 ft.</td>
</tr>
</tbody>
</table>

Table 2. Formation 2 data.
is 30 feet high by 45 feet wide. The front portion facing the road is light gray in color and has no moss coverage. The front of the formation cuts back in on itself to create a slight overhang. The edges on the front section are predominantly more jagged than the rest of the formation. The base is protruding out of the ground as if a portion of the formation is buried. Both sides (East and West facing) are rounded and covered with moss. The middle section, sitting on top of the bottom section, is about 20 feet high by 30 ft wide, and is rounded and predominantly covered in moss. The top section is about 10 feet high and 15 feet wide with very round edges and a high percentage of moss coverage.

Formation 2 sits directly behind formation 1 and relative to the road is about 90 feet tall. The base portion on this formation is barely visible; the majority of it is below the surface of the ground. Out of what is visible the front portion is a dark dray, wavy section of rock that is about 6 feet high and 40 feet wide. The middle section is slightly rounded and covered in moss. The back and side have more moss coverage than the front. This section is about 30 feet high by 30 feet wide. The back side also has a small cave like feature that is about 5 feet deep. The top section is about 20 feet high and 15 feet wide. This section is very rounded and has a great deal of moss coverage.

## Results

The observations noted in tables 1 and 2 show that the weathering rinds on the pulpit rocks varied in color and width throughout the whole formation. The green rinds tended to be on sections that had green moss covering. The gray and white weathering rinds were predominantly on the samples that did not have any moss coverage on them. The top portions of the formations tended to have weathering rinds that were of orange and red shades. Figure 3 shows some of the various weathering rinds found while examining the pulpit rocks.

At first the weathering rind characteristics seemed to have no correlation. However, as seen from figures 4 and 5, I found that on average the rocks that were at higher altitudes tended to have thicker weathering rinds. My observations indicate that the type of coverage seemed to also have a role in how thick the weathering rind on a sample was. If the sample was located beneath an overhang or nestled in a cave-like area it tended to have a thinner weathering rind than

![Figure 3. A: Third sample taken from formation 2. The outer layer is a very thin gray crust that blends into a lighter layer that blends into an orange/red layer which fades into the sandstone. B: Third sample from formation 1. The white/gray layer that fades into a dark tan and then into the light tan sandstone. C: Second sample from formation 1. There is a dark green gray crust around the sandstone. D: Sample two on formation 1. There is a thin dark black/gray outer layer that faded to a white gray layer that faded to the tan sandstone.](image-url)
what was expected. The coverage aspect of the weathering rind thickness is also evident in the last samples for both of the formations. The last samples, for each formation, were taken from the top sections of the pillars. These samples had the thickest weathering rind, presumably due to high altitude and low coverage.

**CONCLUSION**

It makes sense that rocks with less coverage would have a thicker weathering rind because they are exposed to more elements than a covered rock. The uncovered rocks can be ravaged by acid rain, debris, wind, snow, and many other forms of weathering. The upper portions of the formation were faced with higher levels of harsh weathering and over millions of years the evidence of this weathering is left behind as a rind around the outside of the rock.

The data suggests that the altitude and the rind thickness are related; however, I do not believe that they are directly related. I feel that they are indirectly related over processes that have occurred over millions of years. The boulders on the top of the Pulpit rocks are the smallest of the formation and below them the boulders get larger and larger. I believe this size difference in the boulders is not a coincidence. Since a larger potion is exposed, the smaller boulders on top have received the most weathering and therefore will have thicker weathering rinds. I believe that the small boulders on top were at one time as large if not larger than the boulders that are currently at the base of the formation. They have just been weathered down over millions of years into what we see today.

The pattern of larger boulders on the bottom and smaller ones on the top is due to weathering. The top boulders acted as a canopy for the middle boulders and protected them from the elements and the middle boulders did just the same for the bottom boulders. Altitude only plays a role in this experiment because the boulders are stacked on top of each other. If the boulders all would have been formed side by side rather than on top of each other there is a good chance that they would all be the same size. Through this experiment I have determined that weathering rind thickness in the Pulpit Rocks of Huntingdon is dependent upon a combination of altitude and the type of coverage that the rock has been exposed to since its origination. The weathering rind thicknesses are directly proportional to how much chemical weathering the formation has received.

**REFERENCES**


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Heller, P. L., Beland, P. E., Humphrey, N. F., Konrad,
