Structural Features and Fracture Orientation similarities between outcrops of the Ridgeley Sandstone

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Two outcrops of the Ridgeley (Oriskany) sandstone were observed for similarities between structural features and fracture orientation to show how both outcrops were influenced by the same geologic events. Measurements of fracture orientation and appearance of structural features were recorded at each site. Joint orientation measurements at both sites indicate that tectonic events influenced both outcrops and observation of structural features indicates that similar erosional events also influenced both sites. By comparing this data and observations with previous research, evidence supports that Paleozoic tectonic events created fracturing at both of the outcrops. Observation of the outcrop’s structure and the nature of the underlying rock formations also provided key information on how the Juniata River exposed both outcrops through erosional processes.

Keywords.—Ridgeley formation; Joint data; Tectonics; Structural features; Erosional processes

INTRODUCTION

The Ridgeley Sandstone formation (also known as the Oriskany formation) is a part of the larger Old Port formation that covers a wide area of the ridge and valley province in Pennsylvania (Diecchio et al., 1984). Two outcrops of the Ridgeley sandstone parallel to the Juniata River along Warrior’s Ridge in Huntingdon County, Pennsylvania exhibit similar features and composition. The question arises as to what kind of events influenced these outcrops and if so were they the same geologic events. Paleozoic tectonics and the erosional processes of the Juniata River are the proposed events that created the features present at both sites. Fracture orientation data as well as observation of the present structures and underlying rock formations support this interpretation. By observing the formation’s tectonic and erosional history and evidence from two separate sites, further insight can be provided on the history of the Ridgeley formation and how it was influenced by major geologic events.

The Ridgeley formed during the early Devonian
period that lasted from about 419 to 393 million years ago and the existence of the Onondaga limestone and Marcellus shale on top of this formation shows that the Ridgeley was later lithified under sediments that were deposited in increasingly deep-water environments (Dennison, 1985). It consists mostly of calcite cementation with some occasional quartz cementation (Diecchio et al., 1984). It has also been regarded as a formation that is strongly resistant to weathering and due to this aspect it is usually exposed at the tops of ridges. Because of these traits, it is a defining feature in the central Pennsylvania area known as the Ridge and Valley Province (Chamberlin, 1910). Fossils of brachiopods, crinoids, and trilobites have been discovered throughout the Oriskany as well as the aragonite fossils that contribute to its calcite cementation. Gastropods have been reported but are a rarer occurrence (Seilacher, 1968). Several outcrops of the Ridgeley have been recognized as valuable silica deposits and have been mined for the glass-making industry (Seilacher, 1968). While several Huntingdon area outcrops of the Ridgeley have contributed to the silica industry, other outcrops were kept intact because of higher concentrations of calcium carbonate and iron ores which devalued them to the silica industry (D'Invilliers et al., 1885).

The sediments that make up the Ridgeley formation have been interpreted as forming in a shallow marine (beach) environment that supported carbonate-depositing life forms (Seilacher, 1968). The early Devonian environment in which the Ridgeley was deposited occurred prior to the Acadian Orogeny of the middle and late Devonian period and after the Taconic Orogeny, both mountain building events that eroded to produce much of Central Pennsylvania’s rock record (Faill, 1985). The formation’s association with the Onondaga limestone formation and the Marcellus black shale formation show that the Ridgeley was deposited at an interval between major orogenic events (Patskowski, Peterson, and Slingerland, 2009).

The Ridgeley formation’s resistance to weathering has contributed to the exposure of cliff faces along the Juniata River in Huntingdon County. Through studying the way tectonic events have fractured the cliff formations, a better understanding can be reached concerning the influence that ancient events have on local rock formations. Erosional events have contributed to the cliffs current appearance and through observing the interaction of river systems with Paleozoic formations a better understanding of geologic events in central Pennsylvania and their wide-ranging effects can be reached. Additionally, this research can increase tourist’s understanding of the geologic events that contributed to form the features present at both sites.

METHODS

Two different sites were observed for joint orientation data and physical characteristics. Both sites are in Huntingdon County along Warrior’s Ridge overlooking the Juniata River: site one is near the town of Huntingdon and site two lies within the state game lands near Petersburg. Joint measurements were taken with

Figure 1. Image of site one in Huntingdon County, PA. Note the columnar formation.
an Azimuth compass on well-defined fracture surfaces. Fifteen measurements were taken randomly at each site. Physical characteristics of the sites such as lithology and presence of vegetation were also observed and noted for later comparison. Pictures of the sites were taken for use in comparing similarities between structural features. Pictures of rock fractures were also taken for comparison.

### RESULTS

**Results**

The joint orientation data gathered at both sites displayed several trends. At site one, two general directions of fractures were observed (see Table 1 and Figure 2). Most joints ran at about 250° (slightly southwest) with several other fractures running in a slightly northwesterly direction around 280° (see Table 1). Similar fracturing was recorded at site two (Figure 4). Most joint measurements were between 270° and 281° or slightly towards the northwest. Other measurements were around 250° and 260° in a slightly southwesterly direction (see Table 1). On average the joints could be said to be striking west.

Both sites contain similar structural characteristics. Sites one and two both contain the same well fractured columnar cliff faces (see Figures 1 and 3). While both sites exhibit the same near vertical columns, site two has greater elevation and larger cliff faces. Site one has greater proximity to the Juniata River and contains more vegetation. The lithologies of both sites similarly consist of white-grey calcite cemented sandstone. At site two, dark black and red blotches of iron ore can be seen on some of the rock faces.

**Interpretation**

The similar joint orientations of both sites indicate that a single geologic event occurred to create fractures in both outcrops. The fractures all occur in a roughly westerly direction and so show a related history between the two sites. The fractures also run in a direction that is roughly perpendicular to the strike of the surrounding ridges. This indicates that both sites contain features linking them to major tectonic events central to the formation of the Appalachian Mountains. The pervasiveness of fractures at both sites is further evidence of a tectonic event that deformed the Ridgeley Sandstone in Huntingdon County, Pennsylvania.

### Table 1. Joint measurements taken at two separate outcrops of the Ridgeley Sandstone in Huntingdon County, Pennsylvania.

<table>
<thead>
<tr>
<th>Site 1</th>
<th>Joint Measurements</th>
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<tbody>
<tr>
<td></td>
<td>272°</td>
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<tr>
<td></td>
<td>250°</td>
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<tr>
<td></td>
<td>254°</td>
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<tr>
<td>Site 2</td>
<td>Joint Measurements</td>
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<td></td>
<td>254°</td>
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<td>252°</td>
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<td>285°</td>
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Figure 2. Jointing at site one where fracture orientation measurements were taken.
formation over a certain period in the geologic past.

The similar appearance of both sites as tall columnar faces is evidence that similar erosional events have caused the cliff’s current structure. Both formations are noticeable outcrops overlooking a river valley indicating their erosion resistant nature and are examples of the long erosional process inherent to river systems. That both sites exist as ridge-top outcrops in proximity to the Juniata River indicates that river erosion is the key geologic process responsible for exposing and, in part, shaping both locations. Additionally, observation of the surrounding geology indicates that two formations underneath the Ridgeley—the Onondaga limestone and Marcellus shale—may have succumbed to erosional forces from the Juniata River earlier than the more resistive sandstone, leaving behind the exposed outcrops and creating a river valley.

**DISCUSSION**

Prior research on Appalachian tectonics and fracture orientation provides evidence that both sites share similar geologic histories. A major tectonic event that contributed to the formation of the Alleghanian Orogeny of the Appalachian Mountains occurred during the Paleozoic era and was the result of a tectonic plate traveling northwest and colliding with North America (Faill, 1973). Research has shown this direction to be around 35° northwest in some areas of the Appalachians (Wise, 2004). This tectonic collision is responsible for creating the series of ridges and valleys in Pennsylvania and shows how Paleozoic tectonic events contributed to the current alignment of Pennsylvania’s mountains in a south-west to north-east direction (Fail, 1973). The tectonic collision was also responsible for deforming and fracturing formations that were previously lithified, such as the Ridgeley. The joint data collected in Table 1 displays fracture data directed to the northwest. Both sites exhibit this fracture direction indicating that the Paleozoic collision that contributed to current central Pennsylvania geology also fractured the Ridgeley formation and this is visible in both of the outcrops.

River erosion is a key factor in Appalachian geology and its influence on Huntingdon’s outcrops of Ridgeley sandstone is visible in their structural features. The Ridgeley formation’s origins are shallow marine tropical sediments that hosted carbonate life forms and its chemical makeup can be seen in the deposits of carbonate that make up its cementation and deposits of red
and black iron ore can be seen on many cliff faces at site two (White et al., 1885). At both sites, the Ridgeley rests on top of the Onondaga limestone formation showing its affiliation with other carbonate containing sediments (White et al., 1885).

The exposure of the outcrops along the valley can be traced to the nature of the underlying formations. In Huntingdon, the Ridgeley rests on top of the Onondaga limestone and Marcellus shale formations (White et al., 1885). The less weathering-resistant limestone and shale formations are much more susceptible to river erosion and the consequent valley cut by the Juniata River easily eroded less resistant rocks and exposed the tall sandstone cliff faces. The process of erosion in the Appalachian Mountains in which more weathering resistant siliciclastic ridges remained as carbonate valleys were eroded by rivers is a process that has created much of the topography of Appalachia (Stanley, 2009). Across the valley from both sites is the outcrop entitled Pulpit Rocks which is composed of tall columns of Ridgeley sandstone resting directly on top of limestone (White, et al., 1885). This shows a continuity of the Ridgeley formation with in a local region and its ability to resist complete weathering. The structure of the cliffs as tall columnar outcrops protruding from the valley sides reflect the erosional process of the Juniata River that caused less-resistant formations to be weathered away in turn exposing the more resistant Ridgeley formation.

**Research Improvement**

Several expansions could have been made to the field methods to increase data quality. First, a greater number of joint measurements might have been taken and then averaged to statistically show that fractures at both sites point in the same general direction. Secondly, pictures could have been taken of outcrops of the underlying formations (the Marcellus and Onondaga). Evidence for river erosion exists as outside sources in this document and the addition of photographic evidence of the other formations and description of their lithologies may have increased the validity of the study.

**CONCLUSION**

The large cliffs composed of calcite-cemented Ridgeley sandstone in Huntingdon County contain key features that expose their geologic history. Assessment of joint orientation data from two separate outcrops provided evidence for similar Paleozoic tectonic influences at both sites. Observation of the cliffs and their underlying geology also revealed evidence on the processes that exposed the cliffs and the erosional influence of the Juniata River on less weathering resistant rock types.

**REFERENCES**


