The purpose of this article is to explore the identification of the black coloring or staining I observed on many of the cracks on the Ridgeley Sandstone Cliffs beside the Juniata River. It occurred on all sides of the cliff faces. My original hypothesis upon observation was that the black color was staining due to some process of weathering. My second hypothesis was that the black color was some sort of lichen that could inhabit the sandstone. I had some difficulty collecting the samples from the Cliffs because they were covered in snow and ice. Another issue lay in getting the black substance off the sandstone. I collected the samples from various cracks using a rock hammer and chisel and transported them in plastic bags. When looking under a microscope and finding what appeared to be the small grains of a black rock mixed in with the quartz, I ran an X-ray diffraction. The diffraction pattern revealed a small amount of hematite in my sample. My conclusion is that the black colored particles on the Ridgeley Cliffs are hematite.

Keywords.—Quartz sandstone; Hematite; Ridgeley Cliffs; Quartz; Sandstone cliffs

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INTRODUCTION

The purpose of this article is to identify the black staining observed on the majority of the cracks on the Ridgeley Sandstone Cliffs beside the Juniata River. The identity of the black staining could provide insight into the processes that formed the Ridgeley Cliffs, or what processes are continuing to shape and change the Cliffs. If the staining is indicative of certain environments, it may reveal what environment the sediment that formed the Ridgeley Cliffs came from. Most likely, however, it will show what sort of particles were present most recently as the staining did not go very deep into the sandstone itself. This is important because it will give clues as to what has been happening to the Cliffs recently in geologic history.

My original hypothesis was that the black staining was due to weathering. This changed as further research and analysis was conducted. There are several possible answers that range from weathering, to inorganic particles, to organic material and microorganisms. It is not unheard of to find lichen in sandstone. Lichen
can act as both a chemical and physical weathering agent in sandstone (Beyer, Blume, & Chen, 2000). There are many different minerals that are often found or associated with quartz, and since the Ridgeley Cliffs are comprised of almost entirely quartz sandstone it would not be unexpected to find any of these minerals in or around the Cliffs.

Processes that form sandstone are similar to those that form other sedimentary rocks. Sand sized grains are collected on beaches as weathered particles make their way to the ocean. Over millions of years, these particles either become compressed into rock, cemented together, or a combination of the two. Because the Cliffs are sandstone, it can be inferred that this process formed the area where the Juniata River flowed over. The Ridgeley Cliffs themselves are crosscut, and therefore were formed, by the Juniata River via erosion. The Cliffs were most likely formed in the Devonian era (Carter K. M, et al., 1939) from 416 to 359.2 million years ago. This erosion process occurs at a rate of about 27 meters every one million years (Sevon, 1989). This rate is not surprising, as sandstone tends to have very high resistance to weathering.

**METHODS**

I spent much of my preliminary analysis involved observing the Ridgeley Cliffs and the cracks. It was slightly difficult to make quality observations due to the fact that there was snow on the Cliffs. I brushed the snow off various places to observe the tops of the Cliffs to see if there was black coloring. Most of the observations of the coloring were on the cracks on the Cliff’s faces. The staining was on all sides of the Cliffs, however some areas had more than others. I took several pictures of the cracks and the Ridgeley Cliffs themselves to get a clear idea of where the staining was (See Figure 1).

Collecting samples was difficult, as there was eight inches of snow and ice covering the Cliffs. The difficulty lay in that in order to get the samples I had to go to the edges of the Cliffs in the snow. I made sure to bring appropriate sampling materials with me, however I forgot to bring a partner in the event that I should slip and fall off. I chose two sections on the Cliffs that appeared to be the least dangerous and, using a chiseled rock hammer, collected samples from the cracks and stored them in plastic Ziploc bags. The quartz sandstone samples were difficult to retrieve with the hammer I brought, and I had trouble getting pieces of rock with enough of the black coloring on it. The samples with the black staining were predominately quartz with the black on the outermost layer.

I took my samples back to the Geology lab to look at them under the microscope. I could not draw any conclusive results from my observations or the streak test I performed thereafter. I attempted to run an X-ray diffraction and ran into two main problems; the X-ray diffractometer (XRD) would not receive a signal from the computer and my samples had such a high concentration of quartz that the XRD would most likely not pick up the comparatively small concentration of black particles, therefore being unable to identify the particles. The XRD issue was the result of the
computer not being plugged into the XRD and was an easy fix. For my concentration problem I needed to go back to the Ridgeley Cliffs and try to collect samples that had a higher concentration of black particles than quartz.

My second trip to the Ridgeley Cliffs was no better than the first. They were still covered in eight inches of snow and ice. I did, however, remember to bring a partner along in case I needed help. I used my rock hammer to dig through the snow and chip through the ice on some of the cracks, and with the help of a chisel, I managed to collect slightly better samples than my first samples. The chisel made it easier to break off the desired pieces of sandstone. However, I could not get to the second section of the cliffs to take samples as I decided after I almost slid down the Cliffs that the trail was too dangerous and I could not see what I was putting my feet on.

After my second trip to the Ridgeley Cliffs, I went back to the lab and tried to scrape off as much of the black substance as I could with various materials, such as my knife, a dentist probe, a scraper, and tweezers. This yielded mixed success. I ground up the scrapings into silt-sized particles and put them under a microscope. Using tweezers, I carefully extracted some of the black particles from the quartz and put them in a vial. Though I still had more quartz particles than black particles, I managed to extract a high enough concentration of black particles to run an X-ray diffraction pattern. The XRD managed to pick up enough of the black substance to identify it.

**RESULTS**

My preliminary observations on the Ridgeley Cliffs were that the Cliffs were quartz sandstone and that majority of the cracks on the faces and tops had black coloring that did not seem to extend far from the cracks. I also thought that some of the sandstone could have metamorphosed into quartzite. The staining occurred almost anywhere there were cracks, therefore, all sides of the Ridgeley Cliffs had some black staining on them. However, some sections of the cliffs had a higher concentration of black colored cracks. As I took the samples, I noticed that the black was very shallow. It only appeared in a thin layer on the outmost (exposed) side. Other interesting observations were a burning smell as I struck the rock with the hammer as well as sparks. However, on my second visit to the sampling sites, I did not smell smoke or see any sparks like I did the first time.

When I looked at the samples under the microscope, I observed small, black and grey, almost shiny grains that looked more inorganic than organic. This prompted me to revise my original hypothesis of the staining being due to weathering or a type of lichen. I performed a streak test to see if I could get a streak on the working hypothesis that the black particles were a mineral that may often occur with quartz. However, I could not get a streak from the sample. The X-ray diffraction pattern (Figure 2) I ran showed mostly quartz, but it also detected enough hematite mixed in with the quartz to suggest that the black grains were hematite.

**DISCUSSION**
The main reason I had originally suspected the staining on the Ridgeley Cliffs was due to weathering was because it appeared predominantly on the cracks, and only appeared on the outside. As I learned that lichen and other microbial life could be found in and on minerals and act as agents of chemical and physical weathering (Beyer, et al., 2000), I suspected the staining could be due to lichen. However, the particles I observed under the microscope looked more like mineral grains than lichen. The streak test was not helpful in determining whether or not the particles were in fact mineral grains or lichen. This could have been due to the high concentration of quartz or slight metamorphosis. I was not expecting the black particles to be hematite, however, as hematite has a very indicative red-brown streak. However, the inclusion of hematite in the sandstone is interesting, as hematite is a product of the weathering of minerals that contain iron in many rocks (Nesse, p 400). Therefore, the presence of hematite not only suggests that there has been weathering, which would make my hypothesis of the staining existing due to weathering valid, but that at one point there may have been some other mineral containing iron in the quartz sandstone. I am not sure what kind of mineral the hematite may have weathered from, or if it was just always hematite.

A potential problem with my data could be that not all the black staining is hematite. I could only collect samples from an admittedly small amount of the Cliffs, the area made even smaller by the fact that the Ridgeley Cliffs were covered in snow and I could not safely access many sections of the Cliffs. I also only took samples from the cracks that I could reach from the tops, while the cracks on the bottom may have given me slightly different results. Another concern is that the XRD only picks up minerals, and not other substances that could be in the quartz sandstone that may affect the presence of hematite. Also when I was sampling the Cliffs, I could not avoid bagging some snow as well as the rock samples. However, I do not believe that it affected my results, as snow was part of the environment the cracks were in.

REFERENCES


