The Hetzel-Hunter Quarry: A Case Study in the Use of Photogrammetry to Reevaluate Previously Excavated Sites

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THE HETZEL-HUNTER QUARRY: A CASE STUDY IN THE USE OF PHOTOGRAMMETRY TO REEVALUATE PREVIOUSLY EXCAVATED SITES

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Senior Honors Research Thesis in Anthropology

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Acknowledgments

As anyone who has undertaken a large research project knows, it requires far more than just a researcher to produce a full-blown study. My first thanks has to go out to my dad, who was the first person to help me find a topic for my thesis and spent hours tramping around the woods as well as clearing and re-clearing my ‘hole in the ground’. Of course, I am also thankful for the support of my mom and brother, too, who all helped pitch in to clear the quarry and take pictures with me. I must also thank Dan, who not only listened to me practice my proposals and speeches a thousand times, but also always helped me un-do whatever mess I had inadvertently created in Agisoft and kept me from putting my foot through the computer at least once.

Family aside, there are several important scholars and professionals who have guided me through this process in immeasurable ways. First, of course, is Dr. James Jordan. Thank you for being the perfect blend of mentor, editor, and personal cheerleader and for encouraging me to take this project farther than I could have imagined. I have learned so much from you over the course of my college career, not the least of which has been how to write in a scholarly fashion thanks to your constant support of my project. It is an honor to have worked with you and to be able to count you amongst my mentors as I continue my academics.

Dr. Bates and Dr. Dalton, thank you both for constantly pushing my boundaries and helping me to think in new ways, as well as being consistent inspiration and a reminder of why I chose this field to begin with. Dr. Bates, you were the one who introduced me to prehistoric archaeology and helped me realize my passion for research. Dr. Dalton, your classes have consistently blown my mind at least once a semester, and I don’t think I will ever be able to properly articulate the effect your classes have had on my ways of thinking about the world.
Dr. Elizabeth Moore, I am so grateful to have had you to round out my defense committee. Thank you for being one of the first people to offer knowledge and connections when I was just beginning my research, and thank you most of all for agreeing to help a student you barely knew.

Last but certainly not least, I would like to thank Christopher Sperling, John Rutherford, and the rest of the Fairfax County Park Authority archaeologists. Not only did you all allow me to disturb park land in the name of science, but you provided me the tools and training to take this project the extra mile and georeference my model.

I am beyond blessed to have had so many support systems and mentors through this process, including many friends who are not listed here. Thank you all.
Introduction/Historical Background

The Hetzel-Hunter Quarry was discovered in 1893 by Mrs. Margaret Hetzel (Holmes 1897), who lived in the area and found the site while walking the woods one day. Mrs. Hetzel informed an acquaintance she knew in the Bureau of American Ethnography, a precursor to the Smithsonian Institution, and the BAE included the quarry as part of a larger study of prehistoric mining practices on the East Coast. The excavation took place for one season in 1894 and was led by W.H. Holmes with the assistance of William Dinwiddie, a BAE photographer.

An independent report on the Hetzel-Hunter Quarry was never published, but the findings from the quarry were presented in an article with other quarries that Holmes had studied. The article was published in the 15th Annual Review of the Bureau of American Ethnography in 1897. The section of the report dedicated to the Hetzel-Hunter Quarry was relatively short, but provided several pictures of the excavation and a sketch map of the site (Figure 1).

Figure 1 - Holmes and Dinwiddie’s map of the Hetzel Hunter Quarry (15th Annual Review of the Bureau of American Ethnography)
The report described the site as having two sections; the first, larger section rises from the stream bed that runs through the area, an offshoot of Bull Run Creek. It was suggested by Holmes that the prehistoric peoples—now known to be Algonquian—probably first identified the vein of steatite at or near the stream bed and then followed it up the hill, as they removed more and more of the resource. The second section of the quarry is less than half the size of the first chamber and is attached diagonally to the top corner, seating it the farthest up on the hill. Figure 1 shows the map that Dinwiddie drew of the quarry layout, which leaves much not noted. The motivation for this project to create a more accurate and georeferenced plan of the site.

The photographs included in the BAE report (Figures 2 and 3) are valuable in that they provide a scale for the depth of the quarry at the time of excavation, but they shed little light on the conditions of the quarry walls and floor. Holmes documented some of the artifacts from the quarry in the published report, but skims over the details of the site itself, not mentioning any archaeological features that might have been present. Evaluation of any features in the quarry could help shed light on prehistoric mining techniques or steatite usage in the area, another reason for re-evaluating and digitally capturing this site.
The area also has a long history apart from the native tribes and the BAE. The area in which the quarry sits is known to have the foundation of an 18th century mill and several Antebellum homesteads, and a portion of the Washington-Rochambeau Route overlaps with the region for several miles. However, the area is best known for its Civil War activity; troops from both the Confederate and Union armies are known to have camped in the area, and in one portion of the land they built a series of trenches in preparation for a conflict that never happened. Some documents indicate that there are several unmarked Confederate burials in the park, though no one has been able to locate them thus far.

The land is now owned by the Fairfax County Park Authority, and is adjunct to the Bull Run Trail Regional Park. Though it is not marked as park land on any publicly available maps, the Fairfax County Park Authority has confirmed ownership of the area. However, the parcel of
land that contains the quarry can hardly be considered a true park - it is abutted on one side by a high-end golf course, and on the other a subdivision of high-end houses (Figure 3). The closest entrance to the quarry lies at the termination of a dead end road, with a large house perched atop a hill that looms over the trailhead and thus has the air of being private property. Because of its geographical situation and lack of signage, the land is used by members of the subdivision for dog walking, jogging and other recreational pursuits.

Figure 3 - Map of the area around the Hetzel-Hunter Quarry (Marked by red pin)

The quarry is not visible from the small footpaths that wind through the woods, but it is not difficult to locate with the right information. Given the decades of disuse, the quarry has filled in with leaves and other debris from the surrounding forest, yet it is still quite deep with steep, nearly vertical, walls that reach a depth of approximately 13 feet. In fact, the Annual
Report of the Bureau of American Ethnography states that the Hetzel-Hunter quarry is notable for its remarkable depth of mining (Holmes 1897), which will be further explored in this report.
Prehistoric Steatite Mining in the Mid-Atlantic Region

Steatite, or soapstone, is more common in today’s world than some might think. It can be found in sinks and countertops in many modern homes, and was even used to form the base of the columns at Independence Hall in Philadelphia (Cole 2015). But if it is common in today’s society, it was absolutely inescapable in prehistory, particularly through the Archaic and Middle Woodland periods.

Soapstone’s popularity is due to its remarkable mineralogical makeup and properties. It is primarily talc, which gives it both the slippery texture that inspired its nickname and its soft consistency- steatite rates a 1.0 on the Moh’s scale of mineral hardness while diamonds are a 10.0. Steatite is a metamorphic rock and is most often found along mountain ridges, where adjacent tectonic plates converge and force the stone out of the earth’s crust (Grymes 2003).

The stone’s unique makeup also allows for an ability to resist acids and high amounts of heat, as well as being non-absorbent. These properties made it an ideal resource for prehistoric populations, who commonly used it to make cooking pots or stone slabs that could be placed in the fire to cook food.

Soapstone use in North America, and specifically the Mid-Atlantic region, began in the Archaic period, which stretched from approximately 10,000 bp to 3000 bp. However, on the East Coast soapstone artifacts do not appear in the archaeological record until around 3450 bp, at the end of the Archaic period. At this time, native populations had not yet developed ceramics, so soapstone was the only option for a durable container that could be used for cooking. Over time, soapstone use was expanded to include pipes and effigies, such as that found at the Prince Edward Quarry during excavations in 1988 (Jordan 1988).
Further into the Early and Middle Woodland periods, which spanned 3000 bp to 1000 bp (Pennsylvania Historical & Museum Commission, 2016) ceramic technology developed and soapstone cooking vessels, being heavy and taking longer to make, began to fall out of style. Some archaeologists refer to this as the Transitional Period (Gibson and Ames 1998), because soapstone was not altogether abandoned; it shifted to become more popular for making smaller bowls that were often decorated and used as trade goods.

Several East Coast sites have produced small steatite beads (Pennsylvania Historical & Museum Commission, 2016) and pendants which have been dated to the Transitional Period as well. Because of this, during these later periods steatite took on an air of ritual importance and shed its previous domestic affiliations. This idea is supported by several East Coast sites where small, decorated soapstone bowls were found in a fire-pit feature associated with signs of feasting (Gibson and Ames 1998).

Steatite mining techniques were the same across the region and can be divided into three steps. First, the resource had to be identified and the largest, most easily accessible vein chosen. For the most part, quarries seem to be located outside permanent living areas, but close enough for them to be no more than a day’s walk. In the case of the Hetzel-Hunter quarry, the BAE report suggests, the village complex might have been located on the floodplain near the quarry. This speculation was made based on artifacts found in the floodplain. However, this hypothesis has never been tested and there have been no more recorded incidents of artifacts being found in that area.

Given the evidence from other prehistoric quarrying sites in the region (Ericson and Purdy 1984; Grymes 2003), it is likely that what Holmes found on the floodplain were the remnants of a temporary campsite where people stayed while visiting the quarry. There are a few
reasons why this could be the case. To begin, Holmes suggested that, like many other known quarry sites in the region, the Hetzel-Hunter quarry was probably in use for a period of 500-1000 years (Holmes 1897). Even if the site was permanently occupied for even a fraction of that time, there would likely be many more artifacts- at least enough that Holmes wouldn’t have neglected to specify the types of artifacts. Additionally, there have so far been no known instances of a base camp being directly related to any specific quarry in Virginia (Hranicky 2009).

The second part of the process came in the collection and manufacture of the tools needed to extract the stone. The primary tools used were stone picks and chisels, which were made of quartzite (Hranicky 2009). Holmes recorded finding an antler pick, but there is no picture of this pick included in his report and no similar artifacts have been found in the region. Because soapstone was used through the Archaic and Early Woodland periods, the chisels were reflective of the lithic tradition of the time, which is characterized by bigger blades and tools, in particular the Savannah River tradition (Pennsylvania Historical & Museum Commission, 2016). This can be seen in many cases, such as the collection of archaic quartzite celts pictured below, which were found in Georgia (Figure 4).

![Archaic quartzite celts](www.peachstatearchaeology.org)

At the third step the actual quarrying begins. The method for forming bowls, which are one of the most common artifacts found, was to carve a circle into the rock the size the bowl
would be. Eventually, the groove becomes deep enough that the circular node of soapstone breaks off and can then be hollowed out to create a bowl. This was not a quick process. While not present in the Hetzel-Hunter quarry, it is possible in many other abandoned quarries to see the beginnings of the process that were left in the stone (Figure 5).

![Figure 5- Example of soapstone nodes (Courtesy of Newfoundland and Labrador Archaeology)](image.jpg)

When enough carved steatite was produced, the workers would abandon their temporary campsite and begin the walk back to their main camp. Given the denseness and weight of soapstone, this was likely not an easy walk, and they probably did not carry more home than necessary. At several sites on the East Coast there is evidence of both bowls and nodes of raw material being stockpiled (Gibson and Ames 1998) near the quarry, indicating that they perhaps retrieved what they needed throughout the year but did not extract unnecessary resources.
Artifacts

During the original 1894 excavation the Hetzel-Hunter Quarry yielded a number of artifacts. The report from the BAE records finds such as unfinished or flawed steatite vessels, celts and chisels, one worked antler pick, a quartzite hammerstone, and a fragment of a pipe made of steatite, which is sadly only mentioned once in the report and not photographed. Of these finds, only 3 vessels remain in the Smithsonian’s artifact collection, but are still available for study upon appointment with the Museum Support Center. The collections manager was kind enough to allow me to take pictures of the vessels, which are included in this discussion.

The vessels recovered from the quarry are housed with a collection of other steatite vessels from 4 different quarries along the East Coast. Of the 3 vessels from the Hetzel-Hunter Quarry some were fragments rather than complete, but a great deal of information could still be gleaned from the collection. This was then supplemented by the fact that I was also allowed to view celts and chisels from the other East Coast quarries. Though not specifically from the Hetzel-Hunter Quarry, it is unlikely that these artifacts would have differed to any significant degree from what would have been used by the workers of the Hetzel-Hunter site, and thus provided a good deal of background information.

Only one of the vessels from the Hetzel-Hunter Quarry was intact; a large, shallow basin (Figure 6). This type of bowl is common in soapstone, but to find it in a quarry is unusual for several reasons. The first is that the bowl is intact and seems perfectly useful. It doesn’t have handles (or any indication that it ever had handles) like many of the large basins. The other two bowls recovered from the quarry were both broken, which is expected, given the context. In resource production areas, such as the quarry, flawed or irreparably broken objects were commonly abandoned where they lay, as the workers would start over again.
The second reason the location of this bowl is unusual is because the most common use of this type of vessel was for cooking or boiling, and thus the majority of these basin-shaped artifacts are found in association with a large base camps. If one was to keep with the original theory of Holmes and Dinwiddie, the quarry was accessed as a seasonal resource, likely with only lithic specialists leaving the base camp to mine the stone from the temporary extraction camp. Holmes specifically proposed the floodplain a short distance from the quarry (Holmes 1897) as the location of this basecamp.

Similarly, this vessel is uncharacteristically shallow. The large cooking basins are generally quite deep, as demonstrated by a basin from the Rose Hill Quarry in Connecticut (Figure 7). Steatite cooking basins were generally placed in or very near the fire to cook food. This vessel is both shallow enough to potentially endanger the food it is meant to hold, and it did not have a flat or stable underside. When taken out for photographing it rocked back and forth like a seesaw before finally settling.
Figure 7- Example of a more typical cooking basin from the Rose Hill Quarry, which was too big to be safely removed from the shelf

A possible explanation for the abandonment of the bowl is that it could have been unfinished. As shown, the inside surface of the bowl is still rough and pockmarked. A rough inside surface is not uncommon in many steatite vessels along the East Coast (Holmes 1897), but there are many with smoother interiors (Figure 8) which seems to make the most sense for use as a bowl. Additionally, it may have been originally intended to be a cooking basin, but was realized to be too shallow or small. It is possible that the bowl was still being worked and was left behind as it came time to return to the base camp.
The other two bowls found in the quarry were of a smaller, deeper design and had a handle on each side (or is presumed to, in one case, as only a half a bowl was found). These smaller bowls were not likely used for cooking, and more likely used as containers or perhaps even as trade goods between tribes. Further indication that these smaller bowls are distinct from cooking items made from soapstone lies in their outer markings. The other two bowls each have linear striations on the outer surface (Figure 9) creating a decorative pattern. In general, cooking vessels made of steatite are not decorated (Ericson and Purdy 1984) which supports the idea that these bowls might have been used in a social context more than a domestic one.
Though decorated on the exterior, the interior surface of one of the smaller bowls was as rough as that of the larger vessel (Figure 10). The other fragment appears to be the side of a bowl, but the interior has been smoothed out (Figure 11). There are several possible explanations for this dissimilarity. The smoothed bowl could be from a much later time, when soapstone crafting traditions were changing. It could be a trade good made by another group, or perhaps it simply served a different purpose than the rougher bowls. We will probably never be able to provide an answer to this question.

*Figures 10 and 11- (Left) bowl fragment with smoothed interior. (Right) bowl fragment with rough interior.*

Sadly, this is the extent of the Hetzel-Hunter collection at the Smithsonian, so now we move to separate but similar East Coast quarries. The focus will shift to tools used to extract and shape the steatite. The Smithsonian has an example of a stone tool (Figure 12) that was used in the Rose Hill Quarry in Connecticut, which was also in use through the Middle Woodland period (3000-1000 years bp), making it contemporary with the Hetzel-Hunter site. This tool was a chisel, used perhaps in conjunction with a quartzite hammerstone like the one recorded in the original Hetzel-Hunter excavation.
As there is no known chronometric dating method for steatite, the Hetzel-Hunter finds can provide only relative dates through knowledge of the progression of soapstone crafting over time. The large, rough, cooking basins appear in the archaeological record of the East Coast as early as 3450 years before present (Gibson and Ames 1998) placing them firmly in the last stages of the Archaic Period (2000 years bp). Then, as the Early Woodland Period begins in 3000 bp, soapstone usage goes through what scholars call the Transitional Phase (Gibson and Ames 1998). Vessels become smaller and acquire uses beyond the realm of food production, while larger ones were still utilized as cooking basins.

Given this information, the date range for the artifacts from the Hetzel-Hunter quarry would be from 3450 years bp to 1000 years bp. They could be from several different mining episodes throughout this time range, or all from one period of use as recently as 1000 years b.p.

The artifacts are also important because of the questions they raise, such as why the completed cooking basin was abandoned, and what the functions of the decorated and smoothed bowls were within the culture. Perhaps, through future study and comparison with other East Coast sites, a pattern will emerge and shed some light on these artifacts.
During the process of clearing and photographing the quarry, a more recent artifact came to light. A horseshoe (Figure 13) was discovered near the edge of the quarry, and was identified by Fairfax County Archaeologist Christopher Sperling as belonging to the 19th century. It is possible that this horseshoe could date specifically to the Civil War era. Though Holmes and Dinwiddie were excavating well after the end of the war, it is not clear how much they actually dug in, or otherwise disturbed, the upper chamber of the quarry. There are documented instances in which troops from both sides of the conflict camped in the immediate area of the quarry (see Background), so it is not out of the question that the horseshoe could be from the war, either undisturbed by Holmes and Dinwiddie or somehow moved into the chamber after the original investigation. Of course, it is also entirely possible that the artifact is from a different background. It was left in situ, so currently there is no way to be certain.

*Figure 13- 19th Century horseshoe in situ*
The Application of Photogrammetry in Archaeological Research

A technique first developed in the 1970s, photogrammetry is the use of photography to map and survey landscapes, usually with the goal of producing a digital re-creation of the area (Lerma et al. 2010). There are a range of practices and programs that fall under the category of photogrammetrics, primarily split into two general categories - animation, where the digital reconstructions are used to create realistic backgrounds for video games, and terrestrial study.

Archaeology falls into the latter category. The use of photogrammetry is not common at archaeological sites (Kjellman 2012). In most cases, this is because the technology is still being experimented with to find the various ways that digitizing sites, units, and features can aid in our understanding of the past. The photogrammetric survey of the Hetzel-Hunter quarry was done with a terrestrial surveying method.

There are various techniques that can be used for terrestrial surveying. For larger sites it is common to collect images via aerial photography. This is usually done with a hot air balloon or droid, a system of suspended wires, or ‘photography towers’ erected at the site being recorded. However, using aerial methods can be quite difficult. In order to accurately calculate depth and position of the features, a system of equations is employed which are usually based on the exact knowledge of the camera’s location - this is referred to as ‘calibration’. In aerial situations such as the hot air balloon, it can be difficult to attain the precise measurements and calibration needed.

To deal with this issue, some researchers take matters into their own hands and take all the photographs while firmly rooted on the ground. While this allows for tight control over the specific position of the camera, the potential for human error also increases. In some projects, specifically for smaller sites, the researcher may choose to mount the camera on a tripod, or even a monopod, to ensure that the height of each photo in a series remains the same. Even with small
variations in height and angle, though, it is still possible to produce a quality model. This is partially due to the small scale of the research site, but also is a testament to the power of the photogrammetric software used to process the photos; the program has so much processing power that it is able to align and connect photos even when the camera height and position vary from frame to frame.

Whichever method a researcher chooses, it is imperative to take as many pictures as possible. This ended up being 456 in the case of the Hetzel-Hunter Quarry, so as to provide the necessary amount of data. In the digital age, we are lucky enough to be able to give these photos to one of many imaging softwares for manipulation. Most of these programs work with the same basic methods. The computer reviews the photos and automatically matches what it recognizes as overlapping points to create a 360 degree image of the site. With today’s technology, the program can often match the most minute details of a picture to that of another (Figure 14).

Then, when provided with specific details, such as the focal length or coordinates of the camera, the program is able to estimate the height and distance of every feature in the scene to create a three dimensional point cloud.
The software is powerful, but not perfect. In situations with a large data set, over 500 pictures or so, the computer can make mistakes in matching the photos or be unable to include certain pictures at all. This can happen if a photo is taken from drastically different angle or has less than 3 overlapping points, and is more common with larger data sets because, statistically, the amount of abnormal or faulty images increases with the number of overall frames, and because the more data there are the harder it becomes for the computer to process every image at the same level of detail.

For situations such as this, most programs allow the researcher the opportunity to review the photo alignments and then manually adjust overlap points. Some programs also provide a ‘masking’ tool, in which the researcher can manually select sections of the photo that are irrelevant.

Eventually, the researcher is given the option to allow the program to build the ‘skin’ or texture for the model, which is also taken from the photos. After the texture has been applied, if all went well, the researcher then has an incredibly accurate 3D map of the area they surveyed (see Figure 15).

![Figure 15- Sample 3D model with texture applied, enabling stones and grass to be seen](image)

This image shows an example of a model of a building which has been given texture. As opposed to being a uniform surface that merely shows the shape of the structure, the texture
allows researchers to see the individual bricks and distinguish the ground from the structure itself.

Many options are now open to the scientist. They could now enter coordinates for specific known points to tie their model to a map. They could create a digital elevation model or DEM, or an orthomosaic. An orthophoto is an aerial photograph onto which a computer has applied a uniform scale (Figure 16) and adjusted the image based on the known topography of the area- a process referred to as orthorectification. This allows the image to be used effectively as a map, as the scale makes it possible to use the image to determine true ground distance.

![Figure 16- An orthophoto](http://www.geocad93.com/uslugi_en.html)

An orthophoto is an aerial photograph onto which a computer has applied a uniform scale and adjusted the image based on the known topography of the area- a process referred to as orthorectification. This allows the image to be used effectively as a map, as the scale makes it possible to use the image to determine true ground distance.

An orthomosaic is a compilation of orthophotos of the same landscape that have been digitally aligned (Figure 17). Because of the uniform scale and topographical data, orthomosaics are very useful in photogrammetry. Incorporating orthomosaics into the construction of a 3D model both enhances the quality and decreases the chance of distortion in the model.
Orthorectified 3D models are often used by archaeologists, since they can be exported and placed in another software, such as TachyCAD, a popular GIS program which archaeologists use to map points and features of their site. The combination of these two technologies results in a georeferenced 3D model of a site and its features, which can be used to measure true distances.

As previously mentioned, photogrammetry is still developing, but it has the potential to assist dramatically in the way future archaeological projects are executed. A particularly important feature of most photogrammetric programs is the ability to georeference a model into real-world coordinates, associating it with a larger map. This can be accomplished by using a total station—an electronic device that measures and records the slope of the distance between itself and an object. The total station data can be integrated into Agisoft.

This process for georeferencing was used to map to Hetzel-Hunter Quarry. Using a total station, a datum point and grid were established around the edge of the quarry, and then points were shot in at intervals of two feet— a detailed account of this can be found in the section titled Methodology.
Photogrammetry has great potential for integration into archaeology. Two additional benefits of the technology are that photogrammetry is almost completely non-invasive, yet still provides a way for new information to be learned. Perhaps best of all, using photogrammetry to create 3D maps and models, such as this project did, allows for indefinite preservation, if only on a digital platform, of sites that may be endangered. Additionally, the high-quality digital preservation of sites could allow for students of archaeology from around the world to remotely view and explore the site in detail, essentially creating a virtual field trip. As technology advances, so do the ways in which photogrammetry can be applied to archaeology to collect new forms of data from any site.
Data Collection and Methodology

This project employed several phases of data collection, and the method and process for each will be outlined here. The primary method of data collection was induction, meaning the researcher used tools and technology to gather data and details about the world that were then shifted toward more abstract theories.

The first source of data came from the archives of the Smithsonian Institution, where the records from the Bureau of American Ethnography (BAE) are housed. I searched the online collections list, then requested an appointment to view the original BAE report of the excavation and a series of letters between William Dinwiddie, the BAE photographer for the excavation, and W.H. Holmes, who was the lead ethnographer on the case, and the editor-in-chief of the BAE at the time. Unfortunately, the letters did not contain anything of relevance to the quarry, so the only primary sources available were the rather vague report on the quarry and Mr. Dinwiddie’s photographs that had been published with the report.

The report on the quarry was a part of other reports on excavations from steatite quarries on the East Coast, so it was rather short. It did, however, include a brief description of some of the artifacts retrieved from the quarry, and mentioned that they had been collected and archived. I then sent in a separate request to view the artifacts from the quarry and was granted access to the depths of the Museum Support Center storage facilities.

Here, too the Hetzel-Hunter collection was lumped with steatite artifacts from various sites in Virginia, Maryland, and the District of Columbia, and I was rather disappointed to see that the Hetzel-Hunter artifacts took up only one shelf, though the original BAE report claims that ‘scores’ were removed from the quarry (Holmes 1897). It can only supposed that the
The majority of these tools and bowls have been lost in the shuffle of a century’s worth of archival storage.

The 3 remaining artifacts were several bowls of varying sizes. The Smithsonian was kind enough to let me photograph them to be reproduced here (see ‘Artifacts’ section). I was also allowed to view and photograph artifacts from other, similar steatite collections to get an idea of what the missing Hetzel-Hunter tools might have looked like.

Having viewed all the documents and artifacts the Smithsonian could provide, the data collection process turned to the quarry itself. I began with observation and exploration of the quarry and the area around it, identifying the main chamber and the higher, secondary chamber, as well as a scattered collection of smaller pits lining the bank of the nearby stream.

At this point, I secured the cooperation of the Fairfax County Park Authority. After some jurisdictional confusion due to the odd location of the site (see Background), I was put in contact with the county archaeologists and outlined my research goals to them. They were very accommodating and intrigued by my project and agreed to allow me to clear the quarry of leaves and debris, as long as there was no actual ground disturbance. Additionally, the park archeologists requested that I georeference my 3D model and make that data available to them when my project was completed. Georeferencing, the process of tying an arbitrary model to actual coordinates, is a very valuable tool in photogrammetry and as the Park offered to provide the surveying equipment at no charge and help clear the area, I agreed. The Park hopes to incorporate this georeferenced model into their digital map of the county, to help spread understanding of the obscure corner of the county in which the quarry resides.

Upon reaching the quarry, I decided that it would be possible to clear and map only what Holmes and Dinwiddie had termed the ‘secondary chamber’. This was because the ‘main
chamber’ had, over the years since Holmes and Dinwiddie had done their research, become so severely eroded and clogged with large, fallen trees that it was no longer recognizable as a cultural feature and the integrity of the remaining steatite had been compromised. The ‘secondary chamber’, however, had not suffered the years as badly as the first and was therefore chosen to be the subject of my study.

When it came time to actually clear the quarry and collect data, I was lucky enough to have my father, two volunteers, and Chris Sperling, a Fairfax County archaeologist, to help me, as it would be impossible for me to clear the quarry by myself. We used soft rakes (so as not to scratch the steatite or disturb any artifacts that might be left), and a gas-powered leaf blower to clear all of the debris.

When the walls and floor of the quarry were at last visible, Mr. Sperling and I began setting up the Total Station so that we could record the coordinates necessary for me to georeference my model. We established a datum point and a secondary point, both approximately 30 meters from the east edge of the site. Then, following basic surveying procedure, we mapped the secondary point first, and then used that information to ‘backsight’ the datum point, establishing the two points in our grid. From there we began to map the outline of the quarry and took ten points along the upper edge, which was sufficient to provide an outline of the area.

The next step was to map a dividing line between the primary and secondary quarries, so as to provide a concrete boundary to be georeferenced. To do this, we had to shoot down into the quarry from the top of the ridge. In order to ensure there was an unbroken line of sight from the total station to the quarry floor, we extrapolated another datum point, this one centered on the highest edge of the quarry. Once the new datum had been established in conjunction with the
pre-existing grid from our earlier mapping, we shot the dividing line along the floor of the quarry. We took 8 more points along the divide, enough to accurately capture the boundary.

Then, using the same data point, we shot along the inside edges of the quarry so the shape of the walls could be recorded in detail. For this step we took 15 points, both on flat sections of wall and areas where the shape of the wall changed dramatically. As the walls are one of the most important aspects of the quarry, it was essential to map them as thoroughly as possible.

Finally, having mapped the quarry boundaries, the next step was to photograph the interior of the feature to create the 3D map. Though a quicker process than surveying, the photography still had its difficulties. For a detailed model of a feature the size of the Hetzel-Hunter Quarry, the Photoscan software needs about 400 photographs of the site. This is because the software works, on a very simplified level, by looking at all of the pictures and detecting overlapping points between images which it then strings together to create a model. Therefore, the more photos and the more overlap it is given, the more clearly and detailed the final product will be.

The camera used was a Nikon D-90, with a reputation for quality and accuracy. The focal length of the camera was kept at a constant 35mm. Keeping focal length uniform helps to ensure all of the pictures have the same depth, making it easier for the Photoscan software to align images. The photos were also taken in raw format-- as opposed to .jpeg-- because the raw format produces the highest quality images,

Photos were taken by picking a starting point in the quarry then taking a picture of the area directly in front of the camera. Then, to capture the next image, the researcher would take one step to the right, using the viewfinder to ensure that there would be an overlap of approximately one foot between the new photo and the first one. This method was repeated until
every part of the quarry wall had been photographed and the last photograph in the series overlapped with the very first, creating a continuous ‘loop’ of images. This process was repeated until every aspect of the quarry had been covered, changing only slightly when the floor was photographed. In this case, the photos were taken at as close to a 90 degree angle as possible, to provide an accurate vertical view of the ground.

The result of this method of photography was approximately 450 pictures that then had to be loaded into the Agisoft program and processed. Agisoft was the program chosen for this study because it was the most cost-effective for the amount of processing power. Other programs, such as AutoDesk, are more expensive and some, such as the crowd-sourced Memento, less reliably provide high processing speeds.

The first step, after loading the photos, is to align the images. The program accomplishes this by comparing each photo to all of the others and recognizing overlapping points between them (See Figure 14).

When the photos are aligned, Agisoft produces them as a ‘sparse point cloud’, or a very basic projection of all of the overlapping points it has identified (Figure 18)
At this point, it is up to the researcher to check the point cloud for any outliers or errors, and to ensure that as many photos are aligned as possible. The larger the dataset, the more likely it is that some photographs will not align. Out of the 456 images used for this project, 30 did not align. The researcher can then try to align the photos by hand, identifying overlapping points between pictures. This process is extremely time-consuming and can often produce errors in the point cloud, because a human is almost never able to align the pictures as well as the software can, and in this project only 4 of the 30 unaligned photos were able to be properly added by hand.

When the accuracy of the sparse point cloud has been confirmed, Agisoft can run through the images again to double-check the alignments and overlap more points. This process results in a ‘dense point cloud’ (Figure 19) which becomes the basis for all further modifications and additions.

![Figure 19- Dense point cloud of quarry](image)

From the dense cloud, the program builds first a mesh, or skin of the model (Figure 20)
And then texture, which is taken from the details in the photos, such as leaves and rocks. (Figure 21)

At this point, the 3D model is complete, but there are still several features of the program that can be applied for the best possible results.
The first of these features is georeferencing, or the process of adding coordinates to the model, so it can be placed in the real world. This was accomplished by taking the points that had been mapped with the Total Station and transferring them into Agisoft. Once the coordinates were loaded, it was necessary to identify, for the computer, which point on the model related to which coordinate. When this is complete, the program updates the model again and locks the coordinates to the model.

Once the model is georeferenced, Agisoft can process it into an orthomosaic model. As previously mentioned, an orthomosaic is a 3D model which, based off of the coordinates given, is given uniform scale and takes into account the topography of the area. The orthomosaic model produced is shown below (Figure 22)

![Orthomosaic model of quarry](image)

*Figure 22-Orthomosaic model of quarry*

From here, it is possible to export the model to other programs, such as GIS software, where it can be added to a larger map. The model of the Hetzel-Hunter Quarry was exported as a
DEM and sent to the Fairfax County Park Authority, who will add it to their digital map of the county.

One of the last touches the program can put on the model is to add a scale bar. Once the model has been processed into an orthomosaic, and is therefore accurately scaled, it is possible to create a scale bar based on already known measurements. Within the quarry, I measured the diameter of one feature, a ring of stones that was presumably a fire pit, to be exactly one meter, from marked points on each side. Then, within the program, I could create digital markers to place on the known points, enter the known distance between them, and the software automatically created a scale bar (Figure 23). From here, accurate measurements of the quarry could be extrapolated.

![Figure 23- Illustration of scale bar on model](image)
Findings

The 3D model of the Hetzel-Hunter quarry that this project produced (Figure 24) aided in understanding several uninvestigated aspects of the site. Primarily, the technology enabled information regarding the size and shape of the upper pit of the quarry to be added to the archaeological record. Holmes and Dinwiddie spent most of their field season, and most of their subsequent report, studying the large, main section of the quarry, and only mention briefly the secondary chamber, which has been the subject of this report. They say that there was “Higher up a second pit about 20 feet in diameter and 8 or 10 feet deep connecting with the first but lying to the left” (Holmes 1897) and include the upper chamber on their map of the site (see Figure 1).

The map is the only image of the second chamber that Holmes and Dinwiddie provide, so the Hetzel-Hunter model is immediately a valuable addition to the record of the site, especially when it is considered that the model has been georeferenced and will be added to a digital map of
Fairfax County. The model has brought this little-known site into the digital age and put it, quite literally, on the map.

But there is more information that can be gleaned from the software. In photographing and modeling the quarry, an interesting feature was found on the ground- a ring of stones indicating a fire pit (Figure 25) Holmes and Dinwiddie never made it clear whether or not they excavated the upper section of the site, and if they did, they certainly did not photograph it or mention specific features, so it is not possible to determine if this feature was present at the time of their research, and therefore likely prehistoric.

Figure 25-Images of the fire ring seen with texture (left) and within the skin of the model (right).

A fire ring in the quarry might seem odd, but it is not illogical. As previously mentioned, soapstone can withstand very high temperatures, and therefore was often used to make cooking vessels, so the connection between steatite and fire is strong. However, there are no other known or recorded instances in the Mid-Atlantic region where a fire pit has been found in a quarry.

The other explanation, of course, is that the fire pit is a modern addition to the site, though just how modern it is cannot be said. There were, as mentioned, Civil War encampments near the quarry, so the feature could have been created by anyone from an Algonquian Indian to
a Civil War soldier to a 21st century teenager. There was no modern trash found anywhere in the chamber. Regardless of when it originated, the fire pit is still a feature of the site today and has been added, via the Hetzel-Hunter model, to the archaeological record and could be studied in the future.

Similarly, the 3D model makes it possible to see details of the ground within the chamber (Figure 26). With this view, an interesting unevenness becomes apparent on the quarry floor.

Figure 26- View of the rockpile feature

While it would be foolish to expect the floor to be completely flat, the contrast between certain areas is drastic enough to attract attention. In particular, there is an accumulation of rocks that is almost a full foot (.3 meters) higher than the rest of the floor, and from pictures and field study, it has been determined this rise is made completely of individual rocks, none of which are steatite, that appear to have been piled together.

Again, as Holmes does not reveal much about the upper chamber, it is impossible to know if the strange assemblage was present at the time of his excavation. The mound does
appear to have been *in situ* for a very long time - the individual rocks have become bound together with dirt and moss - so it seems unlikely that the feature was created in very recent times. An explanation could be that it was the specified area for collecting useless or excess rocks that were extracted through the process of quarrying, or it could be an unusual but natural occurrence. While it is so far impossible to date the feature or determine its function, like the fire pit, it has been discovered and recorded, and therefore is available for further study.

There is yet a third significant observation that has resulted from the Hetzel-Hunter model. Given the original (albeit in exact) measurements of the upper chamber in 1894 and the measurements extrapolated from the model, it is possible to determine the effects erosion and other natural factors have had on the site. As quoted above, Holmes estimated the dimensions of the chamber to be approximately 20 feet wide at its largest point and 8 to 10 feet deep. Using the scale bars created in Agisoft, truer dimensions could be extrapolated, which were calculated to be close to 5 meters (16 feet) for the width, and 3.5 meters (11.5 feet) deep. These measurements are not terribly far from what Holmes estimated, though the disparity between 16 and 20 feet could be deemed farther than reasonable error.

However, it is possible that these measurements can reveal how the site has fared throughout the past century. Left to nature, it could be that the quarry began to fill in with debris, thus narrowing the dimensions, while simultaneously the walls were slowly eroding. Now that the model has provided this new data, further research could be done into the composition of the walls and floor to determine if environmental effects have changed the dimensions of the quarry, or if it is more likely that the original measurements were just a bit off.

More importantly, the measurements of the quarry that have been extrapolated from the model now serve as a snapshot in time and can be used as a benchmark when conducting further
research into the site. Knowing the width and depth of the quarry as it was in 2015 means that measurements can be taken again in the future and compared with the data extrapolated from the model. This will help determine if there are any serious patterns of erosion affecting the quarry and can form the basis of a preservation or conservation plan for the future.

The model definitely provides a wealth of information covering many aspects of the quarry. Furthermore, it promises the potential to continue to provide information and inspire research into the future.
Future Research

There is a realm of possibilities regarding the future of the Hetzel-Hunter Quarry. As technology is improving, there are unlimited options of how to study all archaeological sites, not just previously excavated ones like the Hetzel-Hunter quarry.

First, if some enterprising archaeologist were to take on the challenge, the primary chamber of the quarry could be cleared and subjected to the same documentation and analysis that this project has applied to the secondary chamber. A model could be rendered in Agisoft and georeferenced, and even then connected to the first model to complete the digital documentation of the site. A project such as this would result in a more accurate account of the shape and size of the full quarry, as well as revealing and recording any features the chamber might hold. Such research would flesh out Holmes and Dinwiddie’s original report and help solidify the quarry’s place in the archaeological record.

A second option would be to use a 3D printing device to pull the digital model of the quarry into the physical world. The digital model is fascinating and helpful in a number of different ways, but there is still only so much to be gleaned from a model that one cannot touch for themselves. A physical 3D model of the quarry could make it easier to see specific features and patterns in the ground surface that are difficult to identify on a computer screen.

To print the 3D model, however, a program other than Agisoft Photoscan would need to be used to render the digital representation. As powerful as the program is, it was unable to fully process every aspect of the quarry, namely the trees. The few small trees that grow in the quarry unfortunately confused the software to the extent that it did not render most of them, leaving the few black patches that are visible in the model (Figure 27) for the purposes of this project, this did not matter too much, because the size and shape of the quarry could still be seen, as well as
all the significant ground features. However, for a printed 3D model to really be worth the trouble, it would have to be an absolutely identical representation, capturing even the small details of the ground.

![Figure 27: View of 'tree holes' left in the floor of the model](image)

There are also options for future study that do not require such a heavy use of technology. For example, more research could be done into the features or artifacts in the quarry—namely the fire pit, horseshoe, and rock pile feature. Some of this, such as research into the horseshoe, could be done noninvasively. The artifact could simply be documented in its location and then removed from the quarry for further study. An investigation of the rock feature would likely require ground disturbance, but could potentially have fascinating results.

Regardless of the objective or method, further research into the Hetzel-Hunter quarry would be sure to add valuable information to the archaeological record. With cooperation from the Fairfax County Park Authority and the background research supplied in this report, much more can be learned from the site and added to the archaeological record.
Conclusion

The Hetzel-Hunter site is a small piece of the heritage of Fairfax County, and an even smaller piece in the larger field of prehistoric steatite mining. Despite the efforts of the BAE, the site has remained a largely unknown spot on the archaeological radar. However, through the use of photogrammetry and 3D modeling, the Hetzel-Hunter Quarry has the potential to finally make a stand for itself in the archaeological record.

The quarry is far from unique in this respect. Given the results of this project, this is just a beginning for photogrammetric 3D modeling. The possibilities for future applications of this technique are limitless and range from recording megalithic structures, historic houses, and cave art, to name a few. The ability of this technique to record both the almost imperceptible cuts and grooves in artifacts and accurately map landscapes on a much larger scale make it applicable to any site imaginable. This is especially the case when it comes to ‘older’ sites where technology of this caliber has never before been used.

For example, imagine the studies that could be done on petroglyphs and cave art from Mesa Verde to Lascaux. The methods and tools that prehistoric peoples used to create such displays are still being examined and understood, particularly regarding the ways the artists used various carving techniques to enhance the vivid drawings. Such displays could be photogrammetrically recorded and then converted to a 3D rendering of the surface, which could then be 3D printed to provide a safe way for archaeologists to handle and experiment with the sites without posing a threat to the original artwork.

Lastly, 3D modeling is unique in its ability to create perfect visual models that can be uploaded to the internet. With this capability it is now becoming possible to create virtual museums, where online visitors can view and even move digitally rendered artifacts from
anywhere in the world. This is already employed at places such as the British Museum (Reich) who not only digitized their current collections on display, but mapped the full museum so you can now take a virtual tour of all the exhibits from the comfort of your home. This is, of course, also possible with entire archaeological sites, much like the Hetzel-Hunter quarry. A prime example of this possibility was recently published by the University of Leicester, who used not only the same technique but the same program used in the Hetzel-Hunter project to map and display an interactive 3D model of the grave of Richard III. In the not-so-distant future, virtual field trips to the world’s most important archaeological sites could be possible for students around the world.

The findings of this report have revealed new information about the quarry, and have created possibilities for future study. The technology applied through the photogrammetry and 3D rendering of the data has revealed details of the quarry shape and features that have been previously undocumented, and can be analyzed to gain more knowledge of the way soapstone was extracted and used in the region and the lives of the people who worked in the quarry.

Additionally, the way the model that resulted from this study can be tied into a functioning map has almost unlimited value. When given to the Fairfax County Park Authority and added to their digital plan of the county, the Hetzel-Hunter site and the new information that this report has uncovered will be permanently fixed in the archaeological record of Fairfax, and the Northern Virginia region as a whole. It will be difficult for the site to fade into obscurity again. This ensures that the site can receive any preservation it might need in the future.

Finally, the success of photogrammetry at the Hetzel-Hunter site confirms that photogrammetry and 3D modeling can be effective archaeological tools. This project has demonstrated that by using new technology such as photogrammetry more knowledge can be
gained from older archaeological sites, and, it can be done without disturbing the site. The model can also be used as a benchmark to measure the amount of erosion or other environmental damage, and can therefore be used to help protect the site for years to come.

There is no doubt that photogrammetry has a place in the future of archaeology. The success of this project at the Hetzel-Hunter Quarry is just the beginning of a long journey in mapping and re-evaluating sites from across the world. The use of photogrammetry at such sites will enable researchers to capture previously unknown details and broaden our understanding of prehistoric development. If the Hetzel-Hunter site is an indicator, the applications of photogrammetric technology and 3D mapping will be valuable assets in the excavation or re-investigation of archaeological sites for years to come.
Works Cited


