# Estimating the Age of a Man-Made Stone Hole from Eastern South Dakota

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## Abstract

This paper reports on an attempt to estimate the age of a man-made, triangular stone hole found in a granite stone in eastern South Dakota. This type of stone hole is found elsewhere in the region, which includes a large concentration of stone holes found at the Kensington Rune Stone discovery site. It has been suggested that these stone holes could provide corroborating evidence that the region around the Kensington Rune Stone was visited by Nordic explorers in the 14th century. Raman Spectroscopy testing was the method used to estimate the age of this stone hole. Unfortunately the test results showed that an age estimate could not be achieved in this case due to contamination of the stone hole surface and the inherent non-uniformity of the granite stone.

## Background - Stone Holes

It is a common occurrence in the U.S. as well as other countries to find large stones which contain single man-made holes. These holes come in many shapes and sizes depending on their purpose. In many cases these holes are round and clearly made by machine tools. In other cases these stone holes are triangular and apparently made using a hand held chisel (see figure 1).

There is a larger than expected concentration of these triangular stone holes in the border region near the Minnesota, North and South Dakota borders. Many uses have been proposed for these triangular stone holes, such as dynamite blasting and holding pins for mooring boats, however none of these explanations have been widely accepted for many of the stone holes in this region. Their purpose essentially remains a mystery.

It is of interest that the greatest concentration of these stone holes in this region is found at the discovery site of the Kensington Rune Stone (hereafter KRS). If it is a genuine artifact, the Kensington Rune Stone dates itself to 1362. Given the locational association between stone holes and the KRS there is some reason to believe that estimating the age of the stone holes may give some insight into the age of the KRS.

If a stone hole in the region produced an age estimate that closely bracketed the year 1362 it would provide strong support for the 1362 creation date of the KRS. If the estimated age does not bracket 1362 then it is difficult to know what this means in terms of the authenticity of the KRS, although most observers would surly argue that it detracts from the authenticity of the KRS and its meaning for history.

On the other hand, if the KRS age could be confirmed it might be argued that it gives us a potential starting point for estimating the age of the stone holes in its vicinity.

In any event, most observers would want to see a result from more than one stone hole. So, if the test of the first stone hole was a technical success it would serve as encouragement to test other relevant stone holes or related objects, perhaps including the KRS itself, using the same technology.

A Stone Hole from Eastern South Dakota

This paper reports on an attempt to estimate the age of triangular stone hole found in a granite stone in eastern South Dakota. The stone hole is about one inch in diameter at its now somewhat rounded top and about 4” deep. It appears that it was man-made using a metal chisel and that it is representative of many other stone holes that have been discovered in the region. (see figure 2a for a top view and figure 2b for a cross section view of the stone hole)

This particular stone hole is of interest because it actually has surfaces with four different ages:

1. an ancient, original surface
2. a surface that was known to have been cleaved in 1899
3. a stone hole that was known to have been chiseled no later than 1899
4. a fresh surface created in 2004

We shall see shortly that this is a very fortuitous situation.

Background – Raman Spectroscopy

The science underlying Raman Spectroscopy (hereafter “RS”) was discovered decades ago, but only recently has instrumentation become available that uses this method to estimate the age of non-original stone surfaces. The basic idea behind RS is that as a non-original surface from a stone ages it undergoes changes at the atomic level that are not taking place away from the surface of the stone. There are many potential causes for these changes, but a critical one is bombardment of the surface by Radon.

RS works by applying radiation (often just simple infrared light) from a laser to the surface of interest and then measuring the intensity of the luminescence spectrum curve emitted from the surface (see figure 3 for an example of a RS Intensity curve). Generally, the greater the intensity of the luminescence spectrum the older the surface being tested.

RS does not provide a direct estimate of the age of a surface. Rather it works by comparing the intensity curve from the surface (or very shallow sub-surface) being tested with a surface of the same material that has a known age. So, if the test surface demonstrates about the same intensity as the standard surface we would estimate that they are about the same age. If the intensity is higher we would estimate that it is proportionately older and if it is less we would estimate that it is proportionately younger.

Typically, RS testing takes place in one of two situations.

Most commonly, there is a stone object that has at least one non-original surface (usually man-made) but the age of that surface is unknown. The first task in the testing process is to determine the type of stone to be tested. This can be done using standard techniques, but RS can sometimes be used in this process as well, however that application of RS will not be described here. The tester then looks up the intensity curve for this kind of stone in a library of RS intensity curves, if one is available. Finally the tester compares this standard curve with the curve generated from the surface of interest using the RS test measurement device.

Two major problems occur in this situation. It may not be possible to find a match for the stone being testing in a library of standard intensity curves or it may not be possible to demonstrate that the proposed standard actually matches the stone being tested.

Another less common but also less challenging situation arises when the object of interest has more than one non-original surface and the age of one of these surfaces is known while the age of another surface is unknown. In this case the surface with the known age can act as the standard of comparison. This eliminates the serious potential objection that the composition of the standard chosen from the library is not close enough to the composition of the tested object. Unfortunately as we shall see momentarily this simple sounding situation still presented us with serious problems.

## Results

The RS test described here is based on testing samples from the four surfaces of the stone found in eastern South Dakota. This stone is an example of the second situation described above. In this case we have a stone with a stone hole of unknown age and a surface that was known to have been cleaved in 1899. Since we want to know if the stone hole could have been several hundred years old it would have been better if the age of the cleaved surface would have been older. Still we are starting off in the very desirable testing situation of having a surface with a known age whose intensity curve result should be bracketed by an original and a fresh surface. Furthermore the intensity curve of the unknown surface should be greater than or equal to the intensity curve from the 1899 cleaved surface.

Unfortunately, there are two serious problems in this case.

First, it is known that molds were made of this stone hole and there is a concern that the surface of the stone hole could be contaminated with molding material. RS testing (see figure 4) revealed that the RS intensity curves were being heavily influenced by the presence of contaminating material, thereby making the interpretation of results very difficult.

Second, this was a granite stone. Granite is composed of several constituent substances. In this stone, these substances distributed themselves in a highly non-uniform way throughout the stone and were of widely differing size granules. The net effect is that it was never clear on what type of substance the laser was focused, thereby making comparison of the intensity curves even more difficult. (see Figures 3 & 5)

The bottom-line is that it was not possible to overcome these two problems. As a result an age estimate for this stone hole was not made.

While the failure to achieve an age estimate for the stone hole was a serious disappointment, some value resulted from this effort. The authors have learned several important lessons about what it takes to make a successful age estimate. These are lessons that can be applied to the testing of other related objects, should the opportunity arise. Also, the authors are heartened by the fact that they have established a relationship with a testing service capable of performing age estimates when presented with appropriate objects.

<u>The Lesson of Contaminated Surfaces</u>

As Figure 4 shows there was contamination in the stone hole making the interpretation of results very difficult. The surface being tested does not have to start out perfectly clean, so long as the surface contaminant can be cleaned away with a simple water bath or with an alcohol solution. That cleaning method was not sufficient in this situation.

Unfortunately many mold and cast making materials penetrate the surface of stones and can not be cleaned in this way. It may be possible that other cleaning methods can be developed if there is a future need to test a surface that has been contaminated with a difficult to clean material. One idea is to immerse the test area in an ammonia solution and then induce vibration of the solution via sonification.

One important lesson is that there is no longer a need to contaminate stone surfaces with mold or cast materials. Given the wide availability of 3D photogrammetry or 3D scanners along with 3d printers, nearly any three dimensional surfaces can be represented and reproduced without risking contamination of the surface.

Contamination could be a major issue if there is an attempt to perform RS testing on the KRS. It is well known that the surface of the KRS has been exposed to many potential contaminants, including molds/casts and oil.

<u>The Lesson of Non-Uniform Stones</u>

Some stones have uniform compositions that lend themselves to RS testing. That is why arrowheads made of chert/flint have been shown to be good candidates for RS testing. However, granite is an example of a stone that can often exhibit a great degree of non-uniformity. In this case the non-uniformity was so great that it was essentially impossible to know what kind of material was been hit by the laser (see figure 5).

So, one lesson is that testing of granite objects should be done with a great deal of caution, if at all. This is unfortunate as many objects of interest are found to be granite.

The KRS is a greywacke stone. This stone type is also non-uniform but its fundamental structure may be more amenable to RS testing. The authors do not know if RS testing has been successfully performed on this type of stone.

There is some hope that the problem of non-uniformity can be overcome through the application of appropriate statistical methods. In short, such a method would require taking many more measurements than would normally be taken in the typical RS testing situation. This is an unproven solution that awaits further development.

Next Steps

At this point there are no firmly committed next steps, although several possible follow-up actions are under consideration, including:

1. Retest the current stone-hole core sample using a revised cleaning procedure. Also take many more measurements and use a statistical procedure to overcoming the non-uniformity problem.

2. Seek other potential stone-hole samples that have a datable surface that are at least free of the contamination problem. There may be 1-2 such samples available.

3. Test a piece of the core sample taken from the back of the KRS to see if suffers from too much contamination. Also examine the general testability of greywacke stone. This would require the cooperation of the Kensington Rune Stone museum that has possession of this piece of stone. They have not yet been approached about this idea.

Conclusion

It was not possible to estimate the age of the stone hole available for this study. This was due primarily to the fact that the surface of the stone hole was contaminated and the non-uniform nature of the granite stone.

Still, RS testing holds promise for dating stone artifacts if these two problem areas can be controlled. Therefore it is the authors' hope that 1) improved cleaning methods for contaminated objects can be developed and tested, and 2) that a statistical approach to overcoming non-uniformity of stone can be developed and tested.

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Figure 1:  Stone Hole Example

Figure 2a Top View of Stone Hole from Eastern South Dakota (aka “1899 stone”)

Figure 2a Cross Section View of Stone from Eastern South Dakota


Figure 3 Raman Intensity Curve showing variation in results

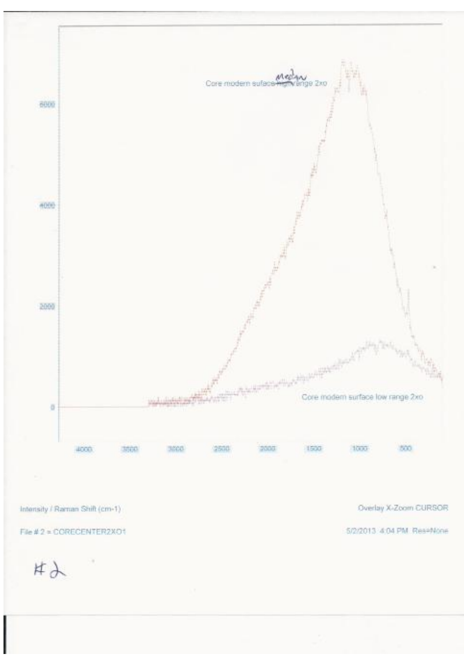

Figure 4 Raman Spectroscopy Curve Showing a Contaminated Surface

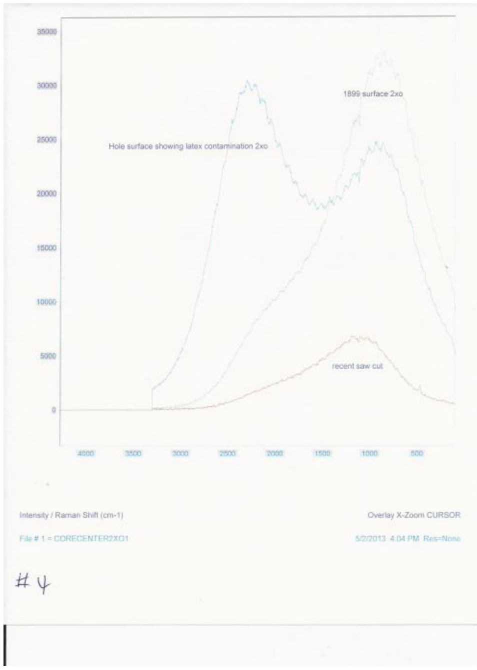


Figure 5  Microscopic View Showing Non-uniformity of the Granite Stone