Evidence of Vitrified Stonework in the Inca Vestiges of Peru

By Jan Peter de Jong & Christopher Jordan

INTRODUCTION

Vitrified stones are simply stones that have been melted to a point where they form a glass or glaze. There is much debate in archaeological circles over the ancient examples under study for two reasons. Firstly, few cases are known to have been tested and even if they have, there are many questions over how they were made.

Glassy rocks form naturally under conditions of high temperature and pressures found in and around volcanoes. Glass or glazes are traditionally created using a furnace. Furnace or kiln examples are found on everyday objects such as glassware and ceramics. The ceramics glazes are created by pasting certain finely crushed stones, sometimes with tinctures, onto fired pots and plates. The whole is then fired to temperatures usually in excess of 1000 degrees centigrade.

The difficulty with many of the curious ancient vitrified examples is that they are found on objects so large that they cannot be placed in a furnace. The vitrification process itself is quite a mystery. A team of chemists on Arthur C. Clarke's Mysterious World subjected rock samples from 11 forts to rigorous chemical analysis. They concluded that the temperatures needed to produce the vitrification were up to 1,100°C. Simply burning the walls with wood interlaced with stone could not achieve such temperatures. Recent experiments along these lines have had virtually no success at all.

There are several confirmed cases of unusual vitrified remnants from across the globe. In Europe, there are several forts and buildings with vitrified ramparts. The crude stone enclosure walls seem to have been subjected to the action of heat. No mortar has been found in any of these structures. Despite this, the rocks seem to be fused together.

This fusion is uneven throughout the various forts and even in a single wall. Some stones are only partially melted and calcined. Whilst in others their adjoining edges are fused firmly together. In many instances, pieces of rock are enveloped in a glassy enamel-like coating, which binds them into a whole. At times, the entire length of the wall presents one solid mass of vitreous substance.

It is not clear why or how the walls were vitrified. Some have argued that it was done to strengthen the wall, but the heating weakens the structure. Battle damage, as some have proposed, is unlikely to be the cause. The walls would need carefully maintained fires to ensure vitrification.

There are about fifty examples that have been discovered in Scotland. It was thought that these forts were peculiar to Scotland. However, they are also found in County Londonderry and County Cavan, in Ireland. On mainland Europe, they have been identified in Upper Lusatia, Bohemia, Silesia, Saxony and Thuringia. A further example can be found in the Ucker Lake, in Brandenburg, where the walls are formed of burnt and smelted bricks. There are also displays in several places in France, such as Châteauvieux, Péran, La Courbe, Sainte Suzanne, Puy de Gaudy and Thauron

There are some forts that have been placed on practically infusible rock. The quartz conglomerates of the Old Red Sandstone at Craig Phadraic and on the limestone of Dun Mac Uisneachain are good cases. Here pieces of fusible rocks were selected and carried to the top from a considerable distance. This demonstrates that the act of vitrification was deliberate.

There are many more examples from Malta, Egypt, Iraq, Sudan, South East Asia and others that are speculated to fall into the grouping. However, these have not all been subjected to scientific testing like the European cases. They simply appear to be glazed finishes on equally large objects or on walls that are impossible to fire conventionally. In many cases, it looks as if there has been the deliberate action of a great heat.

There has been much discussion about the Inca vestiges in the Peruvian Andes. It mostly revolves around whether the stones are vitrified or not. In these cases, vitrification appears to be present on different kind of stones, and seems to have been caused by deliberate action. This article will now concentrate on these Peruvian cases where there are indications of heat treatment.

THE PERUVIAN CASE STUDY

The vitrified examples under study for this paper come from famous Peruvian sites, considered to belong to the Incas, in South America. To the author's knowledge, there have been no scientific tests made on these stones. This has left the debate open to claims of unusual polishing techniques, natural degradation, lava flows and many other odd explanations. The analysis below eliminates some of these ideas.

The vitrified stones of Peru were first brought to popular attention by Erich von Daniken in the 1970s. He saw the vitrification at Sacsayhuaman and noted it in his book Chariots of the Gods. Peruvian Alfredo Gamarra had identified this vitrification earlier. The identification and cataloging of these intriguing stones has been carried on by Alfredo's son Jesus Gamara, and Jan Peter de Jong.

In Sacsayhuaman, there are many indications of the use of heat. Strange marks on the stones like the one on the right can be found; shiny, completely smooth and with another color to the rest of the rock.

Vitrification appears on different kinds of stones and structures. It is found on the perfectly fitted walls with irregular blocks. It is also observed on walls made with regular oblong blocks. It has been spotted on mountainsides, caves and rocks in situ. The location arrangements vary as well. Some sites are surrounded or overbuilt by walls whilst others have single exposed isolated stones. There seems to have been some very adaptable ancient technology at work. A list of vestiges where stonework seems to have been treated with this technology include; Inside the city of Cusco: the walls of Koricancha and Loreto Street, Sacsayhuaman, Kenko, Tetecaca, Templo de la Luna (or Amaru Machay), Zona X, Tambo Machay, Puca Pucara, Pisac, Ollantaytambo, Chinchero, Machu Picchu, Raqchi and in Bolivia in Tiahuanaco.

Archaeologists assume that the perfect fitting stones are the most developed style of the Incas. Regardless, there is no explanation of the shiny surfaces that can be observed. These often appear on the borders where the stones join perfectly. There has been nothing other than simple geological analysis of these stones to determine what the phenomenon is. No chemical analysis is known to have been executed. It is normally assumed that these parts were simply polished by the Incas.

During many visits to the vestiges mentioned, Jesus Gamarra and Jan Peter de Jong have examined these stones with highly reflective surfaces. They have captured many of them on video. Through personal observations and analysis of the video material, they have concluded that something other than polishing must have occurred.

The material convinces in several ways. Many cases display some or all of the following qualities mentioned below. The vitrified spots show discoloration and smoothness around the particular areas. They clearly look like the stone has been melted just in those spots.
A simple flashlight test was developed, which helps to identify the layers of glaze or glass. Filming was carried out at night with a flashlight beam passing through the glaze. This shows the reflection and diffraction of the light as it passes through the surface. Sacsayhuaman, Kenko and Loreto Street were all filmed at night using a flashlight or the nocturnal illumination to capture the effect.

Identifying Vitrified Stones.

The following traits help to identify vitrified stones:

* The melted effect is obvious
* Reflection is high
* The layer refracts, diffracts and diffuses light
* A separate vitrified layer is present on the surface
* Damaged layers show a ´film´ on the stone
* The glazed layer is independent of rock type
* The surface is smooth to the touch even if the surface is irregular
* There is often associated heat discoloration surrounding the glaze

The diffraction effect can be seen in the video of 'the Inca Throne' at Sacsayhuaman. The rainbow effect is clearly captured by the camera. This is directly linked to the light passing through the glass layer and splitting into its constituent parts. After noticing this effect, it was also detected on videos of other vitrified stones. This can be viewed on this short video: http://www.youtube.com/watch?v=ae_8ri2fiwI, and on the DVD that will be available shortly.

The DVD "The Cosmogony of the 3 Worlds" shows an overview of this phenomenon in the chapter on Vitrified Stones.
This is available on youtube: http://www.youtube.com/watch?v=x81-5SWVtUQ

VITRIFIED STONE SAMPLE ANALYSIS

In order to get a clear idea of what the make up of these intriguing layers of stone are, a sample has been tested. A small sample from the Peruvian site called Tetecaca has been collected for further analysis. This smooth layer has been analyzed by the University of Utrecht, Holland.

The sample is from a rock outcrop above Cuzco. Inside a cave there is an altar formed from rectangular shapes made of the rock. Several lines in the rock have a shiny surface, as if they were branded into the rock. They are on right lines on the wall of the cave. The walls are cut out with curved and rectangular forms in them. These are man made structures, which rules out natural phenomena.

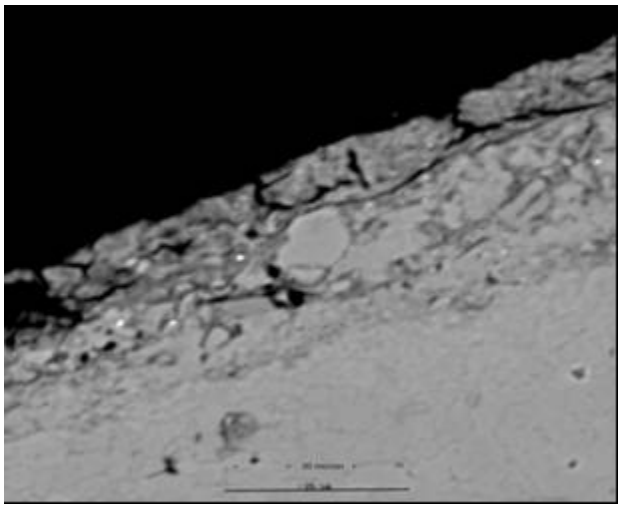
Pictures from inside of the cave, walls with long, straight reflecting lines and an altar structure:

Below is a picture of the spot where the sample was found.

The white line indicates where the thin section was made. The smooth layer on the picture is about 2 cm wide and 1.3 cm deep. The sample was carefully cut into two parts and a thin section was taken for analysis in the Microprobe, jxa 8600 Pioneer. Several points were measured on the inside of the sample and on the smooth surface.

RESULTS

Microscope Photos



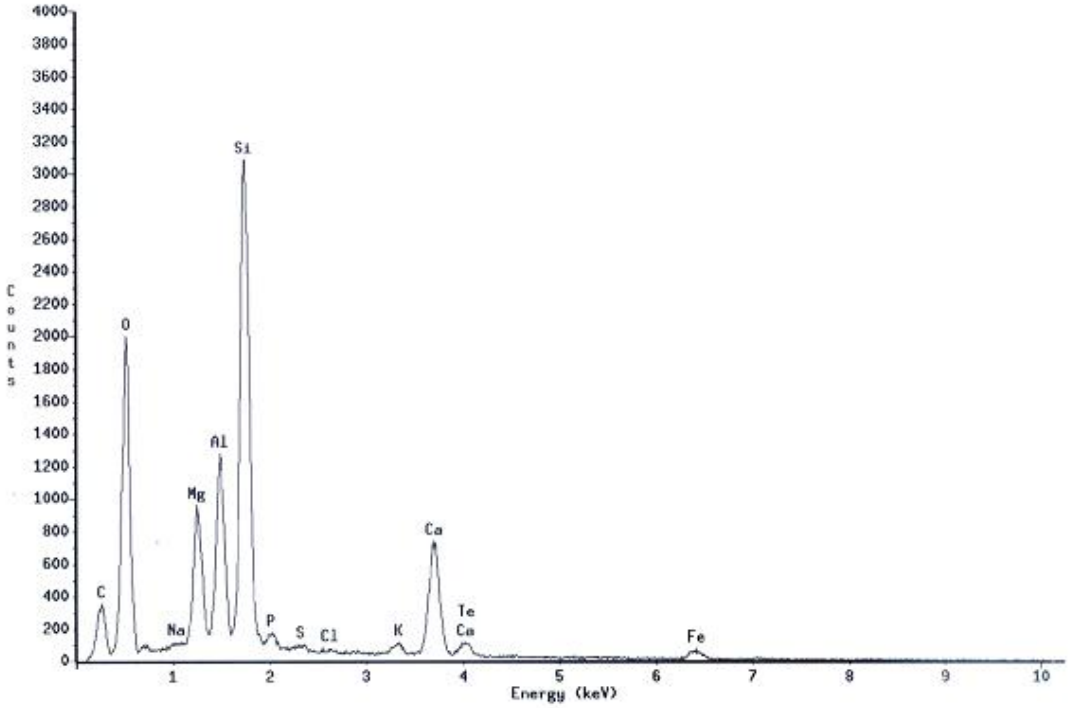
The sample as photographed by the microscope. It shows two distinct regions, the surface layer and the body stone. There is a less distinct intermediate area between the two that seems to transition from stone body to surface layer. Samples from all three regions were subjected to detailed analysis.

Photo 1: The Vitrified Surface of the Stone

(The line at bottom is 21 micrometer)

Spectral analysis

Composition of the Surface Layer



Note: The full set of photos, spectra and tables can be found in the full article

The main body of the stone shows the spectral composition for limestone. High levels of calcium, carbon, oxygen and minor trace elements are the constituents of limestone. This is not unusual since the University of Cusco recognize the Sacsayahuaman archaeological park as being a karst landscape. Many cave systems are made in limestone bedrock and the sample was from this sort of cave. However, this cave was worked on by people in the past as is clear by the photos above.

The Vitrified Surface of the stone shows a very different spectrum of elements to the limestone body. The glaring difference is that Silicon is the predominant component with much higher concentrations. The trace elements of Aluminum and Magnesium are also significantly higher than the body of the stone. Oxygen is also present in double the quantities found in the body. The quantities of Calcium and Carbon are much lower than the body sample.
The Silicon, Aluminium and Magnesium seem to indicate that a material was added to the surface of the stone. The oxygen may have been part of this matter or it may have been introduced as part of oxidation during an aerobic heating process. This could have been during the formation of silicate, SiO_2.

The analysis of the intermediate region between the surface and body of the stone shows a gradation of compositions. This is a surprising result, it implies either the surface layer was somehow ground and mixed with the body of the stone. The body limestone somehow merged/melted with the surface layer. Lastly and most unlikely, the limestone constituents could have been a part of the added surface layer. If this last one were true the second and third spectra would have been more similar.

CONCLUSIONS

The body stone is limestone, but the surface is more complicated. Its spectrum shows some similarity to Wollastonite, which forms when impure limestone is subjected to high temperatures and pressures. However, the impurities that are seen in the surface are not present in similar amounts in the stone body. This indicates that the compounds in the surface layer were most likely added. Other stone types may be comparable, but they cannot have formed naturally in the layer on the man made surface. It appears they were applied and treated with heat. This option does have some merits, but it is moving towards the arcane world of the ceramist.

If an antique ceramic sample is compared to the spectra of the glaze above there is little to separate the two. In the Paper X-Ray Techniques Applied to Surface Paintings of Ceramic Pottery Pieces From Aguada Culture (Catamarca, Argentina) there are several comparable results. The samples are from pottery pieces from Argentina so an exact match is unlikely. These researchers tested a variety of different colored samples from Argentine pottery shards, which had residual gold leaf on the surface. The spectra are surprisingly similar if the gold leaf is ignored along with the Manganese (Mn) and Iron (Fe). The latter two elements have oxides that are common colorants in ceramic pastes. This is the source of the various colors in their research paper. The key constituents Silicon, Aluminum, Magnesium, Carbon and Oxygen are present in the same ratios.

Whilst the spectra do not show explicitly that the surface is vitrified, the composition is that of a glaze. It has a different makeup to the limestone body. This means it is very likely that the glaze was made from a ceramic paste applied to the limestone surface. This is clear from the comparison with the ancient glazed ceramic pottery shards.

The microscope photos above of the surface do not show the amorphous state of the layer. This can be shown explicitly by electron microscopic analysis. Further analysis needs to be carried out to confirm the state of the layer. The different chemical composition makes it very unlikely that these surfaces were created by polishing. The layer has the composition, sheen, hardness and glassy texture of a glaze.

The results strongly indicate that heat was used to produce the surface, which raises several questions. Even if a layer of a ceramic paste was applied, how was the whole heated to the requisite temperatures without cracking the limestone? It tends to shatter at these sorts of heats.

How was the heat produced to treat these structures? Whilst this sample is from a cave, there are similar structures that are outside with the same kind of glaze. The same conclusion cannot necessarily be applied to these other cases.

Chemical analysis is needed, but the similarities with the investigated sample and other photographed cases, are clear. It is likely that these other cases are also vitrified. The amount of heat needed to fire the huge stones on which these glazes are found is enormous. In furnaces, the whole body has to be raised to the temperature of the surface glaze. This is done slowly over the course of many hours. How the heat would have been produced is unknown.

DISCUSSION

The stones pictured above provoke much debate. Explanations on how they were produced vary from the use of advanced machines, simple metal or stone tools, molded stonework, concentrated sunlight and fire methods. Whilst the analysis above says little about the way the shapes were made, it does eliminate some ideas on the means of producing these exquisite finishes.

The finish on the stone sample was not the thickest, shiniest or the glassiest of the examples. However, its composition and morphology are the same as a ceramic glaze. This means that heat was somehow applied to the stone. How the heat was applied is not clear. What is clear is that an unknown technology has been used. To create ceramics on this scale, the heat production must have been greater than the normal ceramic methods.

The most referenced work on the stonework of Peru was produced by Protzen. His work deals primarily with the carving of the stones with primitive tools. However, Protzen has looked at these effects and has suggested it could be achieved with polishing. To date, only Andesite has been attempted with very limited success. After the analysis of the surface layer above, it is clear that polishing alone will not produce the requisite heat needed to produce a ceramic glaze. This eliminates polishing as a means of creation.
The scale and form of the phenomena also precludes carving and polishing. It would take truly incredible amounts of time to produce a single vestige, let alone the thousands that dot the landscape.

Peruvian Alfredo Gamarra has identified vitrification on many stones and has argued that the ancients had a technology to treat stone with heat and that the stone was soft at the moment of construction. The comparison at the spectrum level with clay and ceramic pastes is interesting. Ceramic pastes and clay are soft prior to being treated with heat.
Conventional geological understanding is not compatible with this idea. However, the impression from the vitrified stonework is that the stone was once soft. In many of the stones, there are places where it looks as if objects or molds were pressed into the stone. The perfect fitting stones in the walls of Cusco and the other Inca vestiges could have been obtained more easily this way.

If the stones were fired in a kiln like bricks, the glaze could be a result of the extremely high temperatures. It is not uncommon for the bricks in ancient kilns to get so hot they melt. This usually occurs near the top of the chamber where the heat rises. The knowledge of ceramics in ancient Peru suggests this is a distinct possibility. This prospect however, only arises with the stones that can be placed in a kiln or stonework that is part of a kiln.

The examples laid onto the sides of huge natural rocks cannot have been produced by standard fire techniques. The European studies of vitrified forts and experimental work show that it is not possible to create the consistent heat required for the smooth finishes. Compared to the European examples there must have been a much more controlled process, since the layers in Peru are even

over large parts of the stone surfaces. The scale of giant perfect fitting walls and some vitrified mountain walls makes the technology question even more complicated than in Europe.

Another option is the use of sun dishes and concentrated sunlight by the ancients. This is briefly discussed by Prof. Watkins in his 1990 paper on fine Inca stonework. He did consider these stones to be vitrified, "The rock surfaces on Inca stones are similar to those that have been thermally disaggregated. Indeed, some of the slick surfaces on the Inca building stones are glazed, so it becomes apparent that the Incas must have used thermal disaggregation."

In this seminal paper, his chief concern was the methods of cutting the stone. Since he was proposing intense heat to cut the stones, it was not a large step to consider the stones melted. His conclusions have been much maligned since there had been no analyses performed.

The analysis above does point in this direction, but the location of the test sample raises issues. Clearly the stone was not moved before or after the glaze was created. The ceramic paste had to be heated whilst on the stone vestige. This means light would have to be reflected deep into the cave. Whilst it is possible that the ancients were capable of producing flat mirrors for the task, it does seem overly complicated. This method could work for stones on the surface, but is clearly limited in its use deep within a cave.

One last possibility is that the cave itself was a kiln. Pots or vases may have been fired in the cave and the ceramic pastes may have been applied to protect the stone mass of the structure. There is a lot of stone discoloration within the cave and innumerable glazed areas. There are several things that could confirm this view. There would be a route for the smoke to exit. There would be evidence of soot deposits, though they may have been washed away over the years. The comparison to Inca vestiges with vitrification found out in the open air or in places without a smoke escape, leaves many open questions.

On balance, it has to be admitted that a method is difficult to define. Further analysis of samples from the various locations needs to be undertaken to confirm the use of heat in all of the sites. However, the sample tested shows explicitly that the similarity to ceramic pastes is near certain. It is obvious to conclude that heat was used. The treatment method may have been similar to the technology used for ceramic pastes, only on a much larger scale. It is suggested that further investigations are carried out at the geochemical level to shed more light on what happened to these stones and what technology was used.

ACKNOWLEDGEMENTS

-Jesús Gamarra Farfan especially, for showing, explaining and filming these stones.

The following persons we want to thank for their cooperation and feedback:
-Prof. Schuiling, Tilly Bouten and Anita van Leeuwen, Geology department University of Utrecht.
-prof. Kars, Institute for Geo and Bioarchaeology, IGBA, Faculty of Earth and Life Sciences, Vrije Universiteit, Amsterdam
-David Campbell, http://www.anarchaeology.com
-Paul D. Burley, http://www.pauldburley.com

REFERENCES

-Jordan, C., The Ancient Solar Premise, Smashword edition, 2011, http://secretsofthesunsects.wordpress.com
-Gamarra Farfán, J.B., Parawayso. April 2008.
-de Jong, Jan Peter, www.ancient-mysteries-explained.com
-Morris, M., The great pyramid secret, Scribal arts 2010.
-Protzen, J.-P. l986. Inca stonemasonry. Scientific Amer. 254: 94-105.
-Prof. Watkins, I. 1990. How Did the Incas Create Such Beautiful Stonemasonry?" in "Rocks and Minerals" Vol. 65 Nov/Dec 1990.
-Thurlings, B, Wie hielp de mens? Uitgeverij Aspekt. 2008.
-X - Ray spectra of minerals and materials: http://www.cannonmicroprobe.com/XRay_%20Spectra.htm.
-Silvano R. Bertolino, Victor Galván Josa, Alejo C. Carreras, Andrés Laguens, Guillermo de la Fuente and José A. Riveros in Wiley Interscience Online, Dec. 2008. X-Ray Techniques Applied to Surface Paintings of Ceramic Pottery Pieces From Aguada Culture (Catamarca, Argentina).

Jan Peter de Jong
website Ancient Mysteries Explained
Video The Cosmogony of the Three World

Christopher Jordan
Website Secrets of the Sun Sects
Books The Ancient Solar Premise , The Secrets of the Sun Sects

