Chavín de Huántar and Moche cultures: Capability for lens optics

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SUMMARY. – Suggestive evidence exists for development of lenses during the eras of the ancient Chavín de Huántar and Moche cultures in Perú. That is, virtually all necessary skills and tools needed to create lenses were mastered by available artisans and technicians working within these two societies/cultures over extended periods of time. Appropriate materials were available and employed, adequate skill at grinding, shaping and polishing (convex) hard surfaces developed, items manufactured exhibited properties of magnification and simple image formation. These properties are quite evident in rock crystal beads and pendants used for necklaces. In addition, a number of these items are quite elegant! A beautiful example of Chavín artistry (Art Institute of Chicago) is presented. A rather similar necklace dated ca a millennium or more later and associated with the Moche culture is found at the Rafael Larco Herrera Museum in Lima. In the case of the Moche, there exist at the same museum additional objects that may have been used as lenses, per se. We conclude that these peoples were clearly “lens capable”, but we cannot state definitively whether they employed lenses for generally accepted optical purposes (e.g., as magnifiers, perhaps for visual corrections, for burning glasses, etc.). When further addressing this issue, it will be particularly desirable to seek items where lenses are found in their original context, i.e., where both the lens and the object the user sought to examine occur/remain intact.

Key words: Lenses, ancient, Perú; Chavín de Huántar and Moche Cultures; ancient bead manufacture (for necklaces); presence of then-existing “capability” to manufacture optical lenses in these Cultures.

1. Introduction

The following definition of a lens is composed of statements derived from a number of reliable sources. This issue has been the subject of a number of publications (1-4).

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1.1 – Definition of a lens

A lens is an object where each optical surface serves to alter the vergence or the curvature of an incident wavefront of radiant energy in the visible spectrum by a defined amount. Note, when considering early lens forms, the argument needs to be limited to the visible spectrum. The lens material must be acceptably transparent and homogeneous, and surfaces must be reasonably regular. At least one surface must be curved, and surface irregularities must be modest. There should be a principal axis for the two surfaces, and the lens must be able to form an adequate image. The latter set of requirements implies the presence of both primary and secondary focal points. Each selected point in object space must be reproduced appropriately in image space by the lens.

In addition, it is most desirable/important that both the lens and the object viewed are both observed in their original context. Unfortunately, this is not commonly encountered, and this results in a classical conundrum – one which we will consider later in this discussion. For example, within a number of museums about the Mediterranean Sea and in the Levant, the reader will probably encounter a display case containing lens-like items. How does one decide whether these objects were used as magnifiers, or burning glasses, or for visual corrections, or for other established optical purposes? Or were these objects well crafted lens-like items, such as architectural embellishments, objects of veneration or purity, attractive items attached to belts, or to weapons or armor, or perhaps they were used in jewelry, or other? We are faced with indeterminate issues when we seek to consider these objects as true lenses. It is the special pairing of a lens and the object viewed jointly which enable us to make the argument and to prove the point vis-à-vis lens use.

In some instances, judgments concerning lens use may be made by association, or as a logical extension of a discovery. For example, the famed British Archaeologist Flinders-Petrie found a number of convex/plano lenses in the home of an artist in Tanis, in the Nile Delta in Egypt. He deduced that this ancient artist used them in his work.

Those studying the Dead-Sea Scrolls at The Princeton Theological Seminary, New Jersey, USA, deduced that workers, who labored in a building complex below and near to the Qumran caves, had to have used magnifying lenses. They took this position because, in their work-rooms, these artisans had produced micro-sized, hand-drawn Hebrew letters comprising portions of the scriptures to be used as tefillin or phylacteries. JME viewed examples shown to him and found he needed considerable magnification in order to see these very small, delicate and beautifully hand-drawn letters. It was stated to him that these tiny printed letters could not be drawn or be seen naturally without magnification even by quite highly trained myopic young individuals. Similar arguments have been used (a) relative to miniscule coded messages scratched by early Christians upon Roman coins, (b) in regard to almost non-resolvable details executed in very low contrast upon ancient cameos produced before
the time of Christ (see such items in the Archaeological Museum in Florence, Italy), or (c) micro-printed messages in cuneiform text impressed upon wet clay and other objects in Mesopotamian civilizations, (d) assuming one excludes early seals from the argument, in later-generation seals there occurs quite a clear trend in design to execute ever more complex micro-carved and detailed patterns. No doubt one purpose of the latter effort was to minimize counterfeiting of these elegant designs, etc.

It is often suggested that high myopic young people could be used to fabricate and read such fine items. No doubt they were used for some such activities. JME has seen such usage around mid-day when the sun was near its zenith at the Acoma Pueblo Indian Reservation located to the West of the City of Albuquerque, New Mexico. These teen-aged individuals carefully painted rather fine lineal grid-patterns onto pottery. So saying, these line patterns were relatively quite coarse when compared to the extraordinarily fine grid-patterns executed well before the time of Christ (e.g., see examples in the collection of Ancient Turkish seals at the University of California at Berkeley).

A second or interposed-party scheme (such as the use of high myopic youths) such as those recruited to draw, or to read messages or seals, had to be quite ponderous at each step of the process. That is, they might have been called upon to both create finely printed messages or patterns, and, separately, to read, to describe, or to interpret written micro-patterns. Such an arrangement placed considerable reliance upon the good intent of the “interpreter”, i.e., the interposed individual(s)/scribe(s).

1.2 – This Paper

Here, we will demonstrate that individuals from both the Chavín and the Moche Cultures had the knowledge of techniques and technology needed to create or construct lenses, but at this time we cannot satisfactorily close the gap and say they actually employed lenses for a defined optical purpose. So saying, evidence for adequacy of technology and skills, takes one a long way towards realization of such an achievement. Thus, we talk only of “lens capability” here.

It has been pointed out to JME that there is a common belief that development of lens technology may have emerged from skills encountered in the production of fine ground and polished beads created for jewelry. This was first suggested to JME in conversation with Richard Stone, a senior member of the Department of Objects Conservation, at the Metropolitan Museum of Art, New York City. Based on materials presented here, there is support for such an argument.

An example of such technology in use in ancient Egypt is presented in Fig. 1 taken from the work of Carole Andrews (4,5). Here, one sees a workshop producing non-optical beaded necklaces most probably for distinguished citizens associated with, or serving the Court of the Pharaohs. Note the “mass
production” techniques employed incorporating triple or quadruple bow drills used by obviously skilled technicians.

![Drilling Egyptian beads and jewelry](image)

**FIG. 1**

This is, “A wall-painting from the tomb of Sobhotep, depicting the activities of jewelry makers and precious metal workers. Beads are being bored with quadruple and triple bow-drills. Elsewhere they are being polished and strung...” While these are not optical elements, this painting does provide some idea how teams of artisans worked and polished hard-rock objects. The painting is from West Thebes, Tomb #63, Dynasty XVIII, New Kingdom, Egypt, dated during the reign of Thutmose IV, ca. 1395 B.C.” This Pharaoh reigned between ca. 1397 and 1387 B.C. This figure is reproduced from Ref. 5, p. 76 (see also Ref. 4, p. 647). It is reproduced with the kind permission of the author and publisher.

When one speaks of materials, technology, and skills in this context, one considers the abilities of artisans or technicians (a) to alter a suitably transparent and homogeneous rock crystal or similar stone to a desired size and general shape, (b) to grind upon the surface of the bead a chosen (here) convex
curvature (the issue of possible birefringence in early lens-like rock crystal objects was apparently not considered), (c) to polish satisfactorily that surface, etc. Please also note (d) the drilling of central holes in beads for stringing. Quite a number of the beads presented below exhibit conical ground drilled holes, others have cylindrically ground stringing holes. The stringing holes serve as effective in situ objects viewed through the lens and appear as magnified by the convex ground bead surfaces encountered. It could be a relatively simple step to make convex/plane (or plano) or biconvex lenses out of such items! Was this done in some cases?

Would astigmatism (and other aberrations) have been encountered? Of course! But surely the magnified image, even if rather distorted, would have both been appreciated and valued in many situations. In many primitive societies, imagery encountered was considered as a form of magic, etc., but surely some relationship between curvature/bead-shape, thickness, and stringing channel appearance had to be appreciated (see the elegant pieces illustrated below).

In this paper, we concentrate largely (but not wholly) upon necklaces found in Chavín and Moche collections in Perú and in the USA. Early lens-like objects used in necklaces mainly originated through use of naturally occurring materials such as rock crystal (alpha silica or fused silica, or quartz) or other crystalline materials. It is important to note that rock crystal has a Mohs Scale hardness value of about 7. Hence, relatively hard rock grinding and polishing were early requirements for processing of these crystalline substances. Ancient corundum (or Carborundum\textsuperscript{8}) mines have been found in Naxos in the Greek Cycladic Islands, in ancient Anatolia in modern Turkey, and in the Indus Valley. Other materials, such as emery (similar to corundum) or quartz sands, have been employed for these purposes as well. As an example, these latter materials are found in ancient Egypt. River silt was also apparently used as a polishing medium. It is not clear what materials were used in the settings considered in ancient Perú. In other contexts, the writers have encountered statements that rock crystal is not well ground or polished by rock crystal used as a self-abrasive or grinding compound.

2. Necklaces Demonstrating Lens Capability Encountered During the Chavín de Huántar Horizon (circa 800-300 B.C.)

Four Chavín necklaces are presented. The most interesting and elegant one is located at the Art Institute of Chicago. Two different photographs of this item are presented. One was recorded by JME in the Museum display using a US $12 disposable camera (Fig. 2), and a second truly fine photograph was kindly provided by the Museum for presentation in Lima and publication in this paper (Fig. 3). The latter item has been provided through the good offices of Dr. Richard Townsend, Director, The Amerindian Collection at the Art Institute of Chicago, and it is presented here, courtesy of the Museum.
Fig 2 is presented because a number of the pieces of rock crystal employed in this fine necklace were composed of a natural combination of milky (white) and transparent rock crystal or quartz. The milky segments of these beads are observed to be located to the rear of the stringing holes in the larger (otherwise transparent) beads. It would be interesting to determine how this orientation was maintained when the necklace was worn. The effect of this white background backing seen in the larger beads created a rather dramatic background highlight-like effect. This was not a chance occurrence.
The Art Institute of Chicago necklace is identified by Catalogue Number # G 25437 Chavín de Huántar, Alsdorf Foundation Fund, 2002.7, and the photo in Fig. 3 was taken by Robert Hashimoto. This necklace is dated at ca. 800 BC by the Museum. Chavín culture spans the time period from ca. 1300-400 BC, according to one source (Ref. 6, p. 200), and achieved a peak period from ca. 800-300 BC during “The Early Chavín Horizon” according to a second source in the same volume (Ref. 6, pp. 29-30). Checking other sources in the list of references, e.g., Refs. 7,8, and others found on the web, one finds variance in these estimates by about 100 or 200 years (occasionally more). Thus, such figures need to be considered as approximations or best estimates. For practical purposes, we will accept the estimates presented in Ref. 6 (although it is not the most scholarly of these citations, rather it is the most recently dated publication cited here). The Art Institute of Chicago necklace has been dated at the outset of the peak years of “The Early Chavín Horizon” (6).

This is a superb photograph(!) of the Chavín necklace recorded by the Art Institute of Chicago, and shown here with the kind permission of the Museum and made possible through the good offices of Director of Amerindian Art, Dr. Richard Townsend, and his associates. This is the same necklace as shown in Fig. 2. Please compare this figure with Fig. 11 as well.
The second source of Chavín de Huántar-like rock crystal necklace records was found in Ref. 9. Necklaces presented in this book appear on pp. 155, 167 and 169, and they are reproduced here as Figures 4-6. The necklace on p. 155 is listed as “Chavín”, and those on 167 and 169 are listed as “Chavín, Tardío” (= late).

The necklace on p. 155 of Ref. 9 (Fig. 4) appears to us as most similar in style and form to that presented in Figs. 2 & 3. There are a modest number of rock crystal beads on p. 155 in Ref. 9 (Fig. 4) which may be compared to the well “matched set” of beads seen in Figs. 2,3 of this paper. And if one looks at the beads strung on the rising part of the necklace (Figs. 4, and 2,3), e.g., to the left in each case, there are stylistic similarities between the alternating long and shorter beads between 9:30-11:00 on an equivalent clock-face.

Figures 4-6 are reproduced through the kind permission of the publishers of Reference 9. Please compare details of necklaces displayed in Figs. 4,5,6 with Figs 2,3. This Chavín necklace is copied from Page 155 of the book by de Lavalle & Lang, please see text.
Note, the necklace on page 155 in Ref. 9 (Fig. 4) includes beads made of rock crystal, amethyst, and grey quartz. There are less similarities between Figs. 2, 3 and the “later” designs of necklaces shown on pp. 167 and 169 of Ref. 9 (Figs. 5, 6). Note that the large and somewhat imperfect-appearing rock crystal pendant (p. 169 in Ref. 9) (Fig. 6) represents a fish.

![Fig. 5](image)

This fine Chavín-Tardio (=late) necklace appeared on Page 167 of Ref. 9.

Clearly, in each example, the drilled stringing hole exhibited magnification; quite a number of the stringing holes were made using a conical drill; and sometimes the conical drill was introduced into both ends of the same bead.
In other cases a cylindrical drilled hole was apparently employed (e.g., see some beads in Fig. 3). The magnification effect had to have been noticed at least by the person fabricating and stringing the necklace.

![Fig. 6](image)

This fine Chavín-Tardio (=late) necklace appeared on Page 169 of Ref. 9.

Taken together these are remarkable products for their time and one wonders if additional evidence of lens capability existed, and if, in fact, true lenses were manufactured and subsequently used by the Chavín. We would expect additional necklaces such as are pictured in Figures 2-6 items to have been created. This technology appears to have been sustained over a very lengthy period of time(!). Similarly, it would be reasonable to expect skills
developed by the Chavín artisans (and perhaps by others as well) to be transferred to the Moche peoples (and other peoples) either before, or as the Chavín Culture waned in about 300 BC.

3. Necklaces and added items which demonstrate lens capability encountered during the early intermediate period, ca. 300 BC - 600 AD, in the Moche Culture

We are sure those reading this paper appreciate the rich and multifaceted nature of the arts and sciences exhibited by the early peoples of Perú. The Moche, like the Chavín de Huántar, clearly had highly talented, artistic, and inventive societies with their individual and collective skills exhibited in many different ways.

JME’s first encounter with Moche Culture took place at a display on loan from The Rafael Larco Herrera Museum in Lima held at the De Young Art Museum in San Francisco in the 1996(?). The entire exhibit was quite breathtaking! Included was the necklace on loan from the Museum which features a very large polished eggplant/aubergine-shaped rock crystal pendant attached to a collar of polished rock-crystal beads (Fig. 7). It was displayed lying on a velvet fabric substrate (JME earlier had mistakenly called the fabric “felt”). Looking through this large pendant, each tiny fiber of the magnified velvet fabric stood out like a piece of wire. Magnification could not be missed! True, aberrations were evident, but this item could readily have been used as a magnifier or burning glass. Also, the stringing fiber(s) within this elegant necklace were greatly magnified by the polished beads contained in the necklace. JME remembers writing Dr. Larco, Director of the Museum in Lima, and expressing his excitement at observing this remarkable necklace with such obvious optical implications. Dr. Larco, expressed interest and there was discussion of a visit to Lima. Unfortunately, health issues arose and a visit was not possible at that time. Dr. Larco kindly sent to JME the illustrations seen in Figures 8,9,10. Fig. 8 is an elegant view of the necklace and pendant seen in Fig. 7. Figures 9 &10 are of lens-like rock-crystal objects contained within shell(?) bezels or collars. Dr. Larco properly asked whether these items might have been used as lenses? JME’s response to his query relates to issues considered in the Introduction. Sadly, without information concerning the context of their use, one cannot say for sure if, or how, these intriguing items might have been used as optical elements. Having since had opportunity to view these two lens-like objects, they had not very uniform curvatures. And their curvatures were not great. So saying, the familiar conundrum described above was encountered. We hope added examples are found or become available, and the question can be resolved satisfactorily. It may also be possible further to deduce the utilization of these objects based upon descriptions of the environment within which they were discovered.
In addition to the fine/outstanding necklace with the aubergine-shaped pendant, one finds in the “Vault” of the Larco Museum a group of Moche necklaces made of hard rock substances. Included in this group there is a rock-crystal one (Fig. 11, this group of necklaces is located in the center cabinet on the left wall in the Vault; the rock-crystal one is to the left of center in this figure) which in many ways is similar to the earlier Chavín necklace (Figs. 2,3) presented above. It was dated at approximately 500 AD or 1300 years later than the Chavín necklace in Chicago. Given uncertainties of approximations involved in such estimates, a millennium may be a better time estimate. The general designs of these two items are similar, with a “keystone” centered among the beads. The keystone as defined here is the largest stone, but only modestly so. Not surprisingly, the backgrounds of white quartz or rock crystal found in several stones of the Chavín example are not present in the Moche

**Fig. 7**

This Figure has been reproduced from Reference 4, p. 655, Fig. 27.8, and from a slide generously provided by the De Young Museum of Art, Golden Gate Park, San Francisco. This absolutely elegant rock-crystal necklace with a large(!) ground and polished rock-crystal pendant (it must have weighed heavily!) was apparently worn by a high-ranking priest. At that time, this item was on loan to The De Young Museum from The Rafael Larco Herrara Museum located in Lima, Perú. The background fabric was of velvet. The individual threads of this very fine fabric were readily seen in high magnification. Also, magnification of the stringing fibers was readily appreciated through the rock-crystal beads of this necklace.

In addition to the fine/outstanding necklace with the aubergine-shaped pendant, one finds in the “Vault” of the Larco Museum a group of Moche necklaces made of hard rock substances. Included in this group there is a rock-crystal one (Fig. 11, this group of necklaces is located in the center cabinet on the left wall in the Vault; the rock-crystal one is to the left of center in this figure) which in many ways is similar to the earlier Chavín necklace (Figs. 2,3) presented above. It was dated at approximately 500 AD or 1300 years later than the Chavín necklace in Chicago. Given uncertainties of approximations involved in such estimates, a millennium may be a better time estimate. The general designs of these two items are similar, with a “keystone” centered among the beads. The keystone as defined here is the largest stone, but only modestly so. Not surprisingly, the backgrounds of white quartz or rock crystal found in several stones of the Chavín example are not present in the Moche
necklace. In both designs, the stones gradually diminish in size as one proceeds towards the joining of the two sides or the “clasp-equivalent”. Also, the alternating thin stone/longer stone design noted towards the “clasp” area in the earlier Chavín design (Figs. 2, 3) is not seen in the later Moche necklace (Fig. 11). In a number of necklaces observed in Fig. 11 (in examples where these items were assigned a date, they apparently originated in about 500 AD), one encounters materials used, and designs/styles of beads employed similar to those seen in the Chavín necklaces presented in Figs 2-6. We deduce that skills needed to create these fine necklaces most probably were sustained by individuals or groups of artisans during the intervening time period.

Figure 8-10 were kindly supplied some years ago to JME by the late Dr. Larco, who was then the Director, the Rafael Larco Herrara Museum, Lima. This figure is a photograph of the necklace and endant shown in Fig. 7. Here it is shown hanging. One can readily appreciate something of the quality of this masterful design, and the optical effects already mentioned.
These are the lens-like objects referred to some years ago by Dr. Larco in his communication(s) with Prof. Enoch. There is a lens-like center-element made of rock crystal, and a shell (light yellow-green?) bezel-like component surrounding the centered lens-like components. These items are located at the Rafael Larco Herrara Museum, Lima.

This is a drawing of the lens-like components at the Larco Museum (Fig. 9) with details as to dimensions of these artifacts. This drawing was provided in correspondence to JME by the late Dr. Larco.
Chavín de Huántar and Moche cultures: …

4. Conclusions

As just noted, both Chavín and Moche necklaces displayed here were separated in time by a meaningful span of time – perhaps 1000 years. There was unquestionable planned convex grinding to size and shape and polishing of transparent rock crystal beads (and additional transparent materials which were employed in these necklaces). Obvious magnification was observable in both the pendants and beads of these fine/beautiful necklaces. At the very least, the artisans had to have clearly observed magnification effects. The Moche aubergine-like pendant had considerable optical power and could function as a good magnifier(!). So saying, when this pendant was used as a magnifier, images seen were rather aberrated and distorted. Clearly (Fig. 7) in this necklace, stringing fibers and the holes which they occupy in the beads also appear magnified.

Question: Did these fine artisans make use of these same technologies/their discoveries in order to develop optical lenses? Or simply, were lenses developed and used for optical purposes? We urge further investigation of
these issues! It is emphasized that we speak of a time period of perhaps 1000 years. These Cultures produced truly outstanding products and demonstrated advanced and necessary applicable optical technical skills! At the very least, we can state that both the Chavín de Huántar and the Moche Peoples of Perú were lens capable!

Here, we present evidence that “lens capability” was already present during the time of the Chavín de Huántar Horizon (circa 800-300 B.C.). And it is most interesting that rock crystal necklaces, featured both at the Art Institute of Chicago and at the Rafael Larco Herrara Museum in Lima, had rather similar designs and features.

Acknowledgements:

The authors would like to express appreciation to the late Dr. Larco, Director of the Museo Rafael Larco Herrara, Lima, Perú, for pictorial materials sent to JME (some years ago) which addressed the issue of ancient lens-like Moche objects. We also wish to extend our appreciation to the current Director, Dr. Larco, for his very kind cooperation during a recent visit to Lima. Both the current Director and Prof. Guillermo Baldwin, Faculty of Physics, Pontificia Universidad Catolica del Peru, Lima, and their associates are currently studying aspects of questions considered here. There is similar interest in these topics by those working at the Museum of Archaeology and Anthropology in Lima.

We want to thank Dr. Richard F. Townsend, Chairman, Department of African and Amerindian Art, of the Art Institute of Chicago, Chicago, Illinois, USA, for discussions regarding the Chavín de Huántar rock-crystal necklace located in their fine collection, and for drawing attention of JME to the book assembled by A.J. de Lavalle and W. Lang. Dr. Townsend also kindly arranged for permission from the Art Institute of Chicago to include Fig. 3 in this paper, and also directed JME for further discussion of this work to Prof. C. Donnan of the Department of Anthropology, UCLA.

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