

HINDSIGHT

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2006 OHS Board Members:

The Optometric Historical Society Executive Board Members and the years of expiration of their terms on the Board are as follows: Jerry Abrams (2009), Walter Chase (2006), Jay Enoch (2006), Chuck Haine (2008), Bridget Kowalczyk (2008), Doug Penisten (2007), and Melvin Wolfberg (2009).

The OHS President is Chuck Haine and the Secretary-Treasurer is Bridget Kowalczyk.

Call for Nominations to Board:

The terms of OHS Board Members Walter Chase and Jay Enoch will expire at the end of this calendar year (December 31, 2006). Please submit your nominations for these two Board positions by June 15, 2006, to:

David A. Goss, Hindsight Editor
School of Optometry
Indiana University
Bloomington, IN 47405 USA

OHS members who receive at least three nominations and agree to serve on the Board will have their names placed on an election ballot to be mailed later this year with a copy of Hindsight. Self nominations are welcome and encouraged! A nominations form is enclosed with this issue.

Dues notice enclosed with this issue:

A notice for 2006 OHS dues is enclosed with this issue. This is the only notice you will receive! OHS dues remain a bargain at \$10. Consider giving a colleague a gift membership in OHS.

Jay Enoch's Column:

Early Indian Mirrors: An Interesting Historical Question is Asked

Jay M. Enoch, O.D., Ph.D., Dr.s Sci.(h.c.)

**Collaborating Librarians: Mrs. Pamela Sieving, Bethesda, MD;
Ms. Nirmala Krishnan, Elite School of Optometry; Chennai, India; Mr.
Nazeer Badhu Kasim, Sankara Nethralaya, Chennai,
India.**

Introduction

This past summer, I was invited by the very kind people at the Elite School of Optometry, Chennai (formerly Madras), Tamil Nadu State, India, to participate in their 20th Anniversary Celebration. I had been one of those who participated early in development of this modern-style optometry school, which, in many ways, was a first for India. I was honored to deliver the dedication lecture for the School in 1985, as well as the first lecture in this optometry program. As part of the recent celebration, they asked me to present two invited lectures, one of which, "Archaeological Optics, The Very First Known Mirrors and Lenses",¹ served as Plenary Lecture for the associated meeting (over 700 participants – just amazing!).

I have been interested in the history of the earliest mirrors and lenses for well over a decade. To my surprise, I had not read about early contributions made on this set of topics by people(s) living in the Indian sub-continent. So saying, early civilization(s) in the Indus Valley were of special moment (some were quite ancient), e.g., Harappa and Mohenjo-daro.² I felt I should investigate this topic. Unfortunately, my research into the matter was not nearly complete when my lecture was presented in Chennai. The librarians listed above were very helpful in pointing me to critical sources. And, I must give Librarian Ms. Nirmala Krishnan a special vote of thanks!

Some years ago, Prof. P. Hunt of Stanford U. stated to me that one of the early known corundum (product name, carborundum) mines had been located in the Indus Valley. This suggested that cutting, grinding, and polishing of hard materials (e.g., flint, etc.) might have been conducted in the region. There are reports of a variety of astronomical devices being built elsewhere in India. The Harappans are known for fine and distinctive glazes (frits, faiences), colorful and well made beads, glass seals, metal tools, etc. But, I encountered naught about Indian or Pakistani participation in early mirror and lens development. One issue I addressed in my talk in Chennai was the fact that mirrors had been developed most probably a millennium or more prior to the appearance of lenses (World-wide). I concentrate here on items gleaned about early mirror development in India. In turn, this raises additional interesting questions.

I previously noted³ that the Worlds' oldest known mirrors were developed in the Stone Age by Anatolians in Çatal Höyük which is located in the Konya Plane in South-Central modern-day Turkey (ca. 8000 years ago). Next mirrors were reported in Mesopotamia (modern Iraq) and in Egypt 6000-5000 years ago.^{4,5} Chinese mirrors appeared somewhat later, i.e., about 4000 years ago (i.e., ca 2000 B.C.).⁶ The somewhat different style mirror support structures found in China can be traced to earlier West Asian and/or Siberian sources. And therefore, two different style mirror *support structures* evolved in time. They were a "Western style" which evolved from early Mesopotamian and Egyptian mirrors which had a tang which was held or inserted into a handle (alternatively a handle was included in place of a tang), and an "Eastern style", developed in Siberia and China which featured rear-central-mirror supports or hand-holds. This rather distinctive stylistic difference will be considered in this discussion.

Major Indian, or better, early Indus River Valley settlements included Harappa, which was located between the Chenab-Jhelum, Chenab, and Ravi Rivers – major upstream tributaries of the Indus River. Mohenjo-daro was located on the Indus River South-West of the location where those tributaries join with the Indus River. (Op. cit. 2, p. 9) Both Harappa and Mohenjo-daro were included in the larger Indian sub-continent, but, after the 20th Century partition these former settlements were allocated to (Western) Pakistan. The Harappan civilization existed ca 2500-1500 B.C., with their most mature period occurring during ca 2000-1900 B.C. Harappa is located ca 500 km northwest of Mohenjo-daro; the latter community apparently came under the influence of the Harappan culture. Just a short distance southeast of Mohenjo-daro is the somewhat older community of Koto-Diji (2700-2100 B.C.). In the latter community, they had mud-bricks, not baked-bricks as were found in later settlements. In early Koto-Diji, copper and bronze items were not evident (i.e., in ca 2605 B.C.). In addition to a lack of metallurgy, in Koto-Diji town planning and writing were found to be missing. (Op. cit. 2, p. 170)

The Question Addressed Here

Were early Indian mirrors, which were located, in the Indus Valley designed in the "Western style" or in the concurrently developing "Eastern style". That is, were early Indian mirrors dominated by maturing Mesopotamian or Egyptian styles (Western),³⁻⁵ or evolving Siberian/Chinese styles (Eastern),⁶ or did they follow a third totally separate style or canon? The argument is centered upon the century, 2000-1900 B.C.

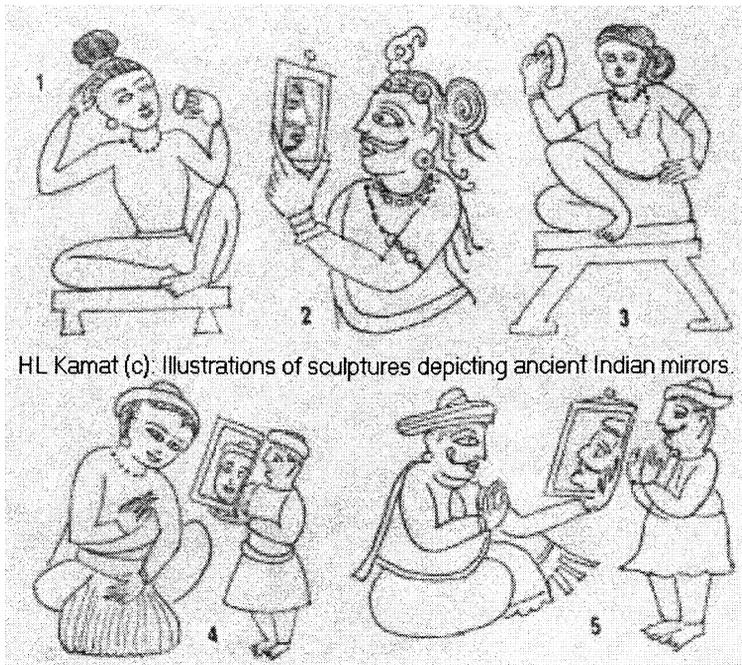
The illustration (Fig. 1) included here was taken from a web site provided by Ms. Krishnan of the Elite School. It provides a collage of images based upon earlier drawings reproduced by H.L. Kamat of Indians using mirrors (time period or originals?).⁷ In Fig. 1, items 1 & 3 are in the Eastern tradition with a central rear-mirror-surface hand-hold. The remaining drawings are closer in style to Western traditions, none exhibit a handle nor tang.⁷

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Figure 1



HL Kamat (c). Illustrations of sculptures depicting ancient Indian mirrors.

Access to Indus Valley Civilizations and interactions and trade of this area with other peoples needs to be considered. Somewhat later, perhaps about 959 B.C., the “Silk Road” developed between points in China and terminations of the Silk Road which were located in modern-day Antioch in Syria, as well as in Turkey, etc., in the Middle East and along the Mediterranean Coast.

King Mu or Mu Wang, a West Chou king, was perhaps the first traveler of note on the Silk Road (from China). A written account of King Mu’s travels appeared in the 5th-4th century B.C. One should not forget that trade existed in both directions along the Silk Road, and the path(s) traveled were more than one.⁸

Interestingly, there are reports that silk cloth remnants were used rather early on along this route to wrap (assume this was done in order to protect the surfaces of) manufactured mirrors. There also developed a land route or spur from the Silk Road Southward from the community of Bactra which was located on the southern Silk Road route. This spur led to Indus Valley centers as well as to the port city of Lothal (and no doubt to other Harappan-influenced ports). This route passed Southward via the community of Taxila, which was located to the North of the Indus Valley.^{9,10}

As an aside, apparently, somewhat north of Bactra there were available sources of rock crystal associated with the City of Samarkand (located on the more Northern Branch of the Silk Road). Also, lapis lazuli was to be found near the latter location. Thus, although the Silk Road developed later than the time period considered here, there is evidence for the presence of communications between the Indus Valley and more northern locations in Asia and Siberia.^{2,8-10}

One must also consider the long existing coastal sea-trade to and from a number of ports serving the Indus River Valley at its southern terminus as well as locations located near its river delta on the Arabian Sea. Lothal was a substantial port settled by Harappan peoples. It had substantial ancient dock facilities which are intact today. It was located on the Gulf of Cambay on the Arabian Sea to the Southeast of the mouth of the Indus River.² Sea trade occurred West of Lothal with the Middle East, including Mesopotamia, Egypt and other centers in the Levant and also in East Africa. Egypt had access via the Red Sea. To the South-East of Lothal, there was also trade along the West Coast of India to the South, as well as around the tip of India to the East. In other words, the Indus Valley civilization was neither isolated landwise nor seawise from external influences. Thus, the Indus Valley and its settlements were subject over time to (reciprocal) influences from Mesopotamia and Egypt Civilizations to the West and to inputs with other Indian and Asia civilizations to the South and East.

Returning to the question posed, one asks which influence was applied to mirrors utilized by Harappa in about 2000/1900 B.C., that is, during the period of the height of that special civilization? At that same time mirror use was spreading with some rapidity within the known World.¹⁻⁶

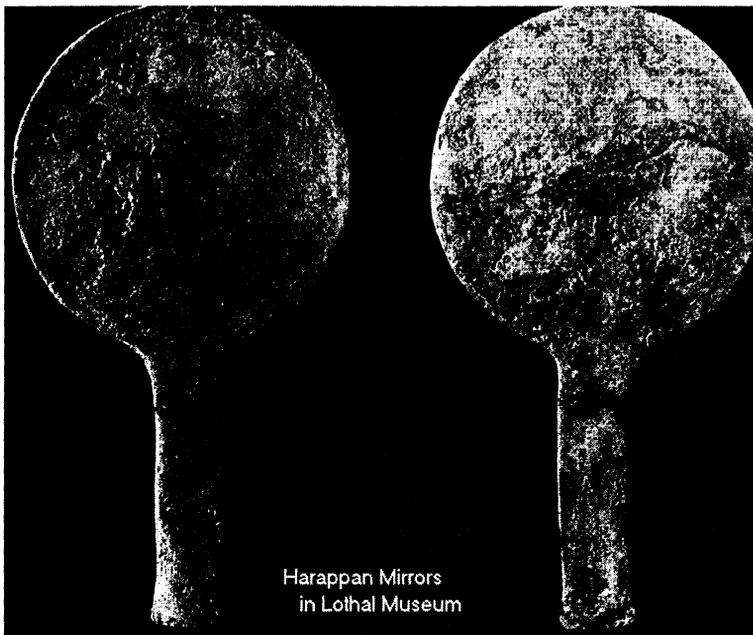
Intuitively, one might expect Western-style mirrors to influence the result in Harappa as well as its derivative community at the port of Lothal. This is because mirror use was then greater in areas influenced by Mesopotamia and Egypt, while the Chinese and East Asian communities were first developing their own mirrors. That is, although a mirror had been located in a tomb in China dated during that century, one assumes such items were not yet broadly distributed in that great land. Further, while land routes into the Indus Valley from the North already existed, it is doubtful they were as well developed as they would be at a later time period, e.g., by the end of the First Millennium A.D. and thereafter, with maturation of the Silk Road. And, most probably, reciprocal sea trade to the West of Lothal was probably greater than to the South and East. (Op. Cit. 2, p. 117)

And this is exactly what one finds. In Lothal's modern-day Museum, there are four mirrors identified as Harappan on display. Two of these four are shown in Fig. 2. This is a reproduction of Plate XVIII C from the cited book on Lothal.² These mirrors are round, made of copper, and have handles similar in general form to Western-Style mirrors. Curvature of surfaces? Decorative themes are not visible. These mirrors seem rather simple in design; one assumes they were molded and then ground to shape and polished. There are also additional mirrors shown in Fig. 20 on p. 83 in that book, one was from Mohenjo-daro (MD), and one had origin in Lothal (L). (Op. cit. 2: Fig. 20, #28 (MD), p. 83; Fig. 20, #18 (L), p. 83; also see text pp. 82-84) The latter mirrors were made of copper or an alloy of copper.

A note on bronzes and copper alloys: After discovery of metallurgy using copper, in time, there followed use of harder and more durable bronze products. "Bronze" results from a mixture of copper and tin. Early-on, there was no single entity which

today we call bronze. Apparently, the greater the proportion of tin added, the more brittle the resultant product. Thus, in current cited references, one often finds discussion of “copper alloys” and rarer use of the terms “bronze” and “brass”. In the cited book on Lothal, a limited number of copper-based items were sampled for tin content.(Op. cit. 2, p. 81,82) The following measurements were recorded: Spear 2.27% tin; Mirror, 5.47% tin; Chisel 9.62% tin; Bangle 11.82% tin; and Pin 13.80% tin. It is not indicated whether these data apply to the copper mirrors shown in Fig. 2, this paper.

Figure 2. Plate XVIII C, Copper Mirrors. Reproduced from S.R. Rao, Lothal and the Indus Civilization. New York, Asia Publishing House, 1973.²



The following quotations were included in an excellent essay by D. P. Agrawal,¹² titled “The Indus Civilization = Aryans Equation: Is it really a Problem?” [Note, this title refers to the competing peoples who settled Harappan areas and communities. This topic was also discussed in the book on Lothal.] (also see, Op. cit. 2, pp.168-175) Quoting from Agrawal,¹² “The Indus civilization was remarkable for its uniformity and standardization in weights, measures, ceramics, architecture, town planning and in arts and crafts, though there were variations in ceramics, town plans, and perhaps religious beliefs. This uniformity appears all the more imposing when one considers that the culture extended over more than a million sq km, an area more than that of Pakistan today. Recent studies, however, are bringing out a good deal of regional variation too.” [The author adjusted original verb forms to the past tense in the quotation.]

“In a Third Millennium B.C. context, when communication and transport must have been difficult, the credit for unifying the north and west of the sub-continent goes

to the Harappans. They were the first to achieve this unification of a society with so much diversity. The location of their main metropolitan towns in a peculiar network of intersecting circles may have provided impetus for travel to these far-flung areas of the Harappan state. In later times, it was achieved by locating main pilgrimage centers at the farthest points of the country: from Amarnath and Badrinath in the north, Dwarka in the west, Puri in the east, to Rameshwaram in the south.”¹²

Of pertinence here is the following paragraph from the same document. Note; the Harappan civilization reached a peak and then was in an early stage of dissolution in the early 2nd Millenium B.C. (2000-1900 B.C.) This dissolution occurred unevenly, with some of the larger changes occurring in the region of Sindh (also written as Sind),¹² which is located in an area in the lower Indus Valley now in Pakistan. There also were round bronze mirrors with tangs found there.

“There is now archaeological evidence of *new Central Asian elements appearing in the Harappan zone*. The bronze cosmetic flagon known at Hissar, at Altyn-depe, and in Bactria, also occurs at Chanhudaro as a beautifully fluted piece, in a probable Jhukar Culture context. *Round bronze mirrors with tangs for fitting into wooden handles, as at Hissar, Altyn-depe, Gonur I, Sapalli, Dashly, Shahdad and Khinaman, and Mehi - some of them with a handle shaped as a human body - also occur at Harappa and Mohenjodaro. Twelve such mirrors occurred in graves at Harappa and one in a Kalibangan (Rajasthan) grave.*”¹² [Author’s italics.]

As indicated, tangs/handles signify the use of Western-style mirrors. From the previous statement, one assumes these influences came from the North and/or West from Central Asia into the Harappan culture.

Separately, we know that Eastern-style mirrors were in use at that about that same time in Scythia (at Kelermes which is located north of the Caucasus Mountains near the Black Sea) which is quite a bit to the West and North of Harappa in Central Asia! Eastern-style mirrors were also in use North and East of Harappa in Southern Siberia, e.g., in Andronovo by 2000 B.C., and also at Karasuk. (Op. cit. 3, see papers by Juliano, A. Possible origins of the Chinese mirror. Pp. 36-45, and K.S. Rubinson, K.S., Mirrors on the fringe. Pp. 47-50) Mirrors from Scythia and Southern Siberia apparently influenced co-development of mirrors in China at that time.⁶ Thus, it is apparent that styles of mirrors in use may have varied in local areas across the Central part of the Asian Continent. There is some uncertainty here.

Thus, Harappan civilization apparently imported Western-style mirror formats during the time period considered here (2000-1900 B.C.). After that time period, the Harappan civilization waned, while Chinese, or East-Asian, mirrors exerted growing influence on mirror technology in future years to the East. This is an interesting study of ebb and flow of development of technology, with clearly meaningful influences active and in flux.

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11. The Ancient Indus Valley: Includes trade routes to the Indus Valley through Baluchistan (Pakistan), Helmand (Afghanistan):
<<http://www.harappa.com/har/har0.html>> Read 2005;
12. a. Sindh (also written as Sind) is an area in the lower Indus Valley now in Pakistan, there was evidence of round bronze mirrors with tangs, etc.
12. b. Separately, Essay (quoted in part) by D.P. Agrawal titled, The Indus Civilization = Aryans Equation: Is it really A Problem? See web site:
<http://www.infinityfoundation.com/mandala/h_es/h_eagraw_indus/htm> Read 2005.
12. c. See also an important review of a paper by Sen, S.N., and Chaudhary, Mamta. *Ancient Glass and India*. New Delhi: Indian National Science Academy 1985, Pp. 201, here, a commentary was written on the Sens and Chaudhary manuscript by Agrawal, D.P. and Shah, Manikant. This tract deals with glass and India and to some extent refers to early mirrors in the Indus Valley and elsewhere in the subcontinent. It is concluded, that although present, the importance of glass was underestimated (Subbarayappa, B.V. (Ed.), 1999, was cited).

J.M.E.

One hundred years ago:

Glancing through the first few issues of *The Optical Journal* from 1906, I happened to note several advertisements for books. Among them was an ad for *Ocular Refraction and the Shadow Test*, by F.A. Bates, O.R., of New York, on page 146 of the January 4, 1906, issue (volume 17, number 2). That book of 200 pages, with 145 illustrations, sold for \$2.00.

On page 148 of that same issue was an advertisement for *A System of Ocular Skiametry*," by A. Jay Cross. It was billed as the "greatest shadow-test book of the day," "attractively gotten up," and "immensely popular." The advertisement also states that it was "...the first book ever written by Mr. Cross, who is one of the foremost opticians of America. This book is an exhaustive study of the shadow test, and cover[s] not only the methods of other writers and a description of all instruments used in the work, but also gives the results of years of study and research on the part of Mr. Cross..." The book, which contained 181 pages and 93 illustrations, could be purchased for \$2.00.

On page 152 also in the January 4, 1906, issue was an advertisement for "The Lockwood Series of Optical Text Books," which were four books authored by R.M. Lockwood, Scientific Editor of *The Optical Journal*. The cost of each of them was 50 cents. The titles were: *Principles of Optometry*, *The Trial Case and How to Use It*, *Frames and Lenses*, and *Subjective Tests for Difficult Cases*. There were chapters in the first book on lenses in general, plus lenses, the wave theory, minus lenses, compound lenses, some measurements, cylinders, sphero-cylinders, prisms, and dispersion. The chapters in the book on subjective tests were reasons for special tests, special methods of testing, special methods for the detection of astigmatism, tests for

small children, illiterates, and others, muscle tests, tests for malingerers, and spasm of the accommodation.

Below the ad for the Lockwood series was an ad for the fourth edition of *Manual of Diseases of the Eye For Students and General Practitioners*, by Charles H. May, M.D. The book was described as beginning "...with the external examination of the eye, the full routine being explained and with descriptive cuts. Next comes the subjective or functional examination of the eye, also well illustrated with descriptive cuts from life. The balance of the work is given up to a discussion and explanation of the diagnostic appearance of the various ocular diseases, all the leading conditions accompanied by plates in color. At the close of the work 50 pages of more are given up to the practice of refraction." The 390 page book sold for \$2.00.

The January 25, 1906 issue (volume 17, number 5) announced a new book in press by R.M. Lockwood, *Skiascopy Without the Use of Drugs*. The book was to be sold for 50 cents and would be about 100 pages in length. The ad notes that the book "...is written in the author's well-known clear, interesting, and explicit style, and is to a considerable extent the result of personal investigations and experiments, not a mere compilation of what has already been written by others...."

D.A.G.

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