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THE CHEMICAL COMPOSITION OF A FAIENCE BEAD FROM CHINA

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During the past few years, there has been a vigorous renewal of interest in the study of ancient Chinese glass. This has been prompted largely by recent archeological finds and by the availability of new scientific laboratory techniques for studying glass objects. Research in the past decade by Chinese archeologists and chemists has probably doubled our previous knowledge and understanding of the subject.[1] Much of the current research is centered on investigations of technological aspects of early glassmaking.

Among the areas receiving special attention are the early Chinese glasses containing lead and barium, glass imported overland across the Silk Road into China, glasses that might have been imported along maritime trade routes terminating at ports in southern China, and intriguing groups of early beads uncovered in Shaanxi Province. It is one of these beads that is the subject of this paper.

Excavations in Baoji and Fufeng County have uncovered hundreds of small beads. The contexts in which they were found have been dated firmly by archeologists to the 11th–10th centuries B.C., during the early Western Zhou dynasty. The finds raise several important questions, including the characterization of the material of which the beads are made. Initial reports suggested that they were made of glass. Had this been the case, the beads would have been the earliest glass found in China—earlier by some five or six centuries than previously known examples. However, the few beads that have so far been subjected to laboratory examination have turned out to be made of faience rather than glass. At first, this might have disappointed specialists working with glass, but a few moments' reflection shows that it really does nothing to diminish the beads' importance, either archeologically or historically.

Except for these beads, faience is rare in China; few examples, if any, are known even from later periods. This suggests that the beads could well have been imported, most likely from somewhere to the west. If this is ultimately demonstrated to be the case, then these faience beads represent some of the very earliest archeological evidence of contacts with civilizations to the west of China. This is not to say that such early contacts are unexpected, but only that there is little other existing archeological evidence of them. Several Chinese archeologists have told us it is generally believed that the only other excavated evidence of contacts this early is in the form of certain bronze tools and weapons

1. See, for example, Gan Fuxi, ed., *Research in Ancient Chinese Glasses: Proceedings of the International Symposium on Glass, Beijing, 1984*, Beijing: Chinese Building Industry Publications, 1986 (in Chinese). An English edition is being prepared for publication. For information, contact the authors of this paper.

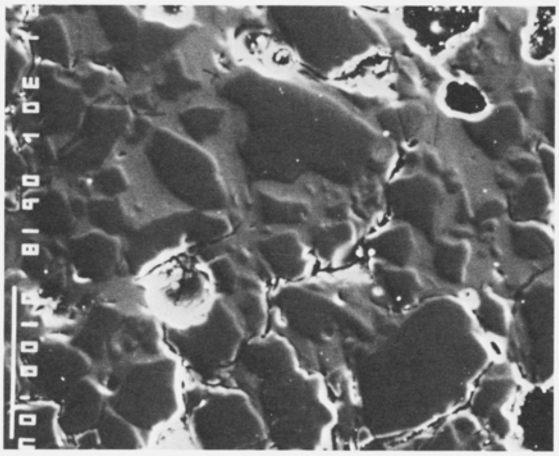

FIG. 1. *Photomicrograph of polished cross section of faience bead, sample no. 5895. Crushed grains of crystalline quartz are held together by a continuous glassy phase having a blue color. Length of bar = 100 microns. (All photomicrographs by S. S. C. Tong.)*

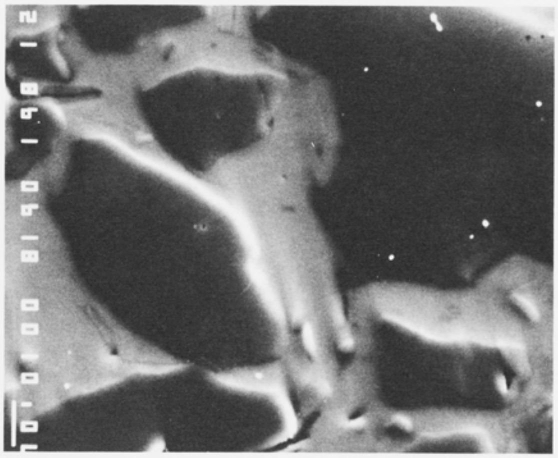

FIG. 2. *Detail from Figure 1. Length of bar = 10 microns.*

known to have been imported from Central Asia into the very westernmost reaches of China.

A great deal still remains to be learned about these faience beads, and appropriate studies are under way. Some of these studies involve stylistic comparisons between the beads found in China and faience beads found in Iran, Mesopotamia, and Egypt. The beads found in China include not only tubular shapes, which seem to be ubiquitous wherever faience is found, but other shapes as well. Certain roughly spherical beads were found that appear to the authors to be distinctly different in cross section from Near Eastern examples.

Our present investigations included microscopic examinations, X-ray diffraction, and an electron microprobe analysis of a tiny fragment of a single specimen. Previously, a bulk chemical analysis had been reported by one of the authors (Z.F.).[2]

A polished cross section of the fragment is shown in Figures 1 and 2. It is immediately obvious that the material is not a homogeneous glass throughout, but instead is faience. The large angular inclusions (with rounded edges and corners) account for some 90% of the weight and volume of the material. The microprobe analysis showed that these inclusions are nearly pure silica. X-ray diffraction confirmed that the phase is alpha-quartz.[3] There is nothing unusual in this finding. However, a microprobe analysis of the continuous glassy phase did indeed produce an unexpected result. (See Table 1.) The alkali in this glassy phase is predominantly potassium instead of sodium; it contains 15.0% K_2O and only 2.29% Na_2O. There is not much lime present, but there is 8.16% cupric oxide (CuO), which accounts for the blue color of the bead throughout its interior.

Figures 3–7 show concentration maps of SiO_2, Al_2O_3, K_2O, Na_2O, and CuO. It can be seen that SiO_2 is present throughout the entire region analyzed, but that the inclusions are richer in SiO_2 than the interstitial glassy phase. This finding is consistent with the chemical analyses and with the X-ray diffraction results. On the other hand, the K_2O, Na_2O, CuO, and Al_2O_3 are confined to the interstitial glassy phase, and they are generally uniformly distributed. (Only the Al_2O_3 shows additional concentration patches corresponding to a fine-grained phase. Some of these patches are also visible in the photomicrographs in Figures 1 and 2.)

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2. Zhang Fukang, Cheng Zhuhai, and Zhang Zhigang, "An Investigation of Ancient Chinese Liuli," *Journal of the Chinese Silicate Society*, v. 11, 1983, pp. 67–76 (in Chinese).

3. The X-ray diffraction pattern was run by Bryan Wheaton of Corning Glass Works.

TABLE 1

Analyses of Faience Bead

	*Qualitative, emission spect. Body plus glaze G6**	*Quantitative, electron microprobe. Glassy phase only 5895***
SiO_2	94	70.6
Na_2O	0.3	2.29
CaO	0.4	nf
K_2O	0.3	15.0
MgO	0.2	0.30
Al_2O_3	0.7	2.85
Fe_2O_3	0.4	0.56
CuO	0.8	8.16
L.o.i.	1.7	
Sum	98.8%	99.76%

* Analysis by Zhang Fukang. G6 is thought to be from same bead as 5895.

** Analysis by Stephen S. C. Tong. Interstitial glass phase only.

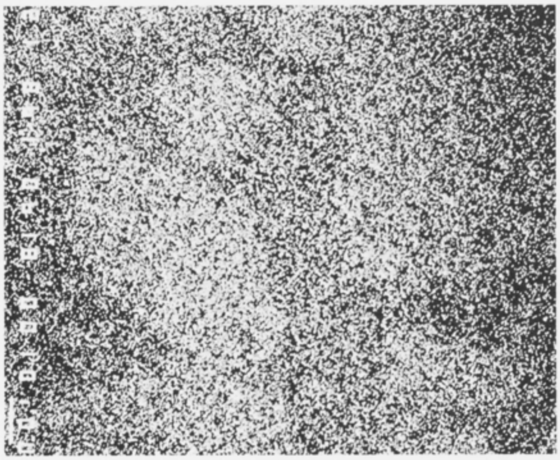

FIG. 3. *Concentration map of SiO_2. (All maps are same field and magnification as Figure 2.)*

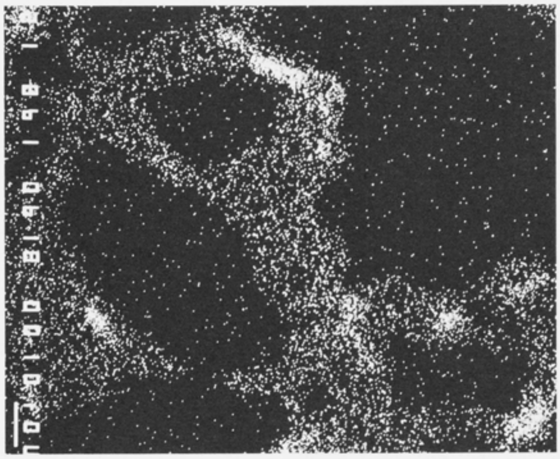

FIG. 4. *Concentration map of Al_2O_3.*

Not many analyses have been done of faience beads from locations to the west, although it seems generally believed that soda was the alkali used in Egyptian and all Near Eastern faience. The few analyses reported support this belief,[4] which is precisely what one would expect from the compositions of glasses from these same places. The alkali used in glasses from those regions was essentially soda in the form either of natron or of ashes obtained by burning specially selected plants. Since small amounts of alkali are also used in making faience, it is reasonable to assume that within any given region, the alkali used for preparing faience would customarily have been of the same kind as that used for making glass. Consequently, the fact that the bead under investigation here was made with potassium raises the strong possibility that it was produced somewhere other than Egypt, the Mediterranean world, or the Near East. This, in turn, leads one to wonder whether the bead could have been made in Central Asia or even in China itself. The authors do not know much about faience from Central Asia, or whether it is even found there. This is a question we shall look into in the future.

There is another noteworthy feature of this analysis. Among medieval glasses from the West, those containing substantial amounts of potassium almost always have high impurity levels of mag-

4. See, for example, Alexander Kaczmarczyk and Robert E. M. Hedges, *Ancient Egyptian Faience*, Warminster, England: Aris and Phillips, 1983, pp. 195–197, and unpublished analyses of The Corning Museum of Glass.

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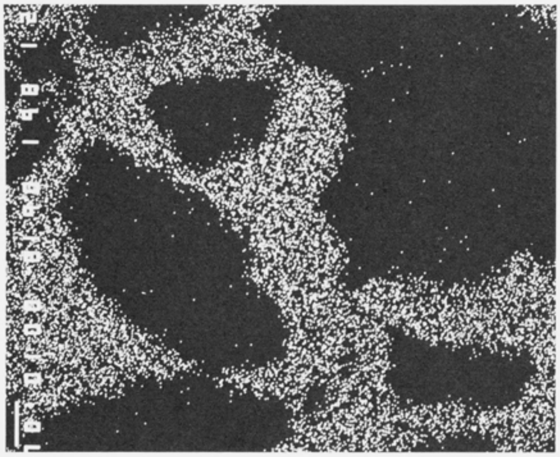

FIG. 5. *Concentration map of K_2O.*

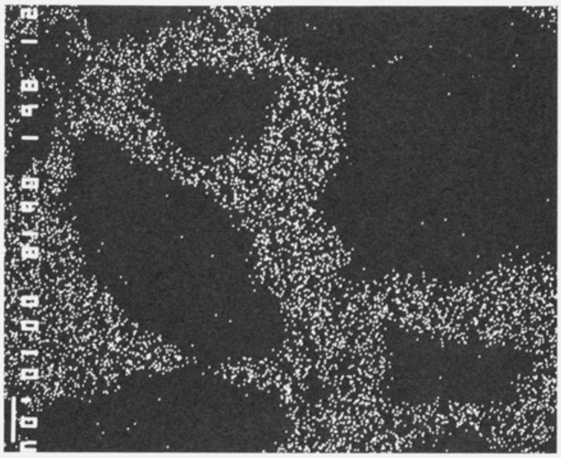

FIG. 6. *Concentration map of Na_2O.*

nesia. The percentage of MgO usually ranges between ¼ and ½ that of the K_2O. This is because the source of the potassium was potash, that is, the ashes of trees, shrubs, ferns, or other inland plants. We have numerous unpublished analyses of unpurified ashes of such plants, confirming that they are rich in magnesia. Interestingly, however, those Chinese glasses in which the main alkali is potassium are usually much lower in MgO than are their Western counterparts.[5] This would be accounted for if the Chinese batch ingredient had been potash purified by leaching and recrystallization. In such a process, the magnesia, alumina, lime, and certain other impurities are removed from the potash because they are insoluble in water. But for Chinese glasses, another explanation may be even more plausible, namely, that the potassium was not supplied in the form of plant ash but rather in the form of saltpeter (potassium nitrate). Saltpeter occurs naturally in great abundance in several parts of China, including Shaanxi Province, and it has a long history of having been put to various technological uses. Saltpeter collected as an efflorescence from soils has already, in effect, been purified by leaching and recrystallization; therefore, if it is collected carefully, it is probably low in magnesium salts. What all this adds up to is that the low magnesia content of the glassy phase in the faience bead can be taken as being consistent with the hypothesis that the bead in question was made in China. However, in itself, this evidence is not sufficient to prove the hypothesis. As to whether or not the bead could have been made in Central Asia, we must reserve judgment on that for now.

In summary, two points are clear. Even though the beads from Baoji and Fufeng County are faience and not glass, that does not in any way diminish their archeological importance. While it is true that they do not move the date of glassmaking in China back five or six centuries, they nevertheless may be evidence of very early contact between China and other civilizations to the west. Archeological evidence of contacts as early as the 11th–10th centuries B.C. is very scarce indeed. The second point is that the beads require much further study so that their significance may be properly interpreted. One must look for parallels for the ways in which the rounded beads were formed and for the unusual potassium-based composition of the interstitial glassy phase. Clearly, too, larger numbers of the beads should be examined and analyzed so as to determine to just what extent the observations

5. Shi Meiguang, He Ouli, and Zhou Fuzheng, "Investigation of Some Chinese Potash Glasses Excavated from Tombs of the Han Dynasty," *Archaeometry of Glass: Archaeometry Session of the 14th International Congress on Glass, New Delhi, 1986*, Calcutta: Indian Ceramic Society, 1987, Section II, pp. 15–20.

noted here for a single specimen are representative of the entire group of beads. In the meantime, however, we want to draw to the attention of Chinese archeologists and historians of technology the fact that one of the beads has this unusual potassium-based composition, and that this raises some truly intriguing possibilities.

Sample Description

5895. Small fragments of a faience bead found in Shaanxi Province, People's Republic of China, 11th–10th c. B.C. Friable, porous body with light blue glaze, somewhat weathered. Blue color extends throughout body. Apparently from a rounded form of bead of the nutshell type, rather than from one having a straight bore. Wall thickness 0.5–0.8 mm. Some buff-colored residue adheres to the inside. Sample G6 in table 3 of footnote 2; similar to G1 in same reference.

FIG. 7. *Concentration map of CuO.*