Microscopes Reveal Prehistoric High Technology

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Since the beginning of human civilization, people have apparently been fascinated with the reflection of light from surfaces. The creation of shiny surfaces extends from 4,000 B.C., when Neolithic farmers in ancient China polished jade objects, to the present day where modern polishing techniques are key to creating flat surfaces in the fabrication of electronic microcomponents. The question we are posing here is how does one determine when high technology was introduced in the process of polishing? Recently, Peter Lu, Nan Yao, Jenny So, George Harlow, Jianfang Lu, Genfu Wang, and Paul Chaikin offered an answer to this question.[2] Interestingly, microscopes were used to provide the answer.

As pointed out by Lu *et al.*, the physics of polishing are still poorly understood, but it stands to reason that a substance of a certain hardness can only be effectively polished by a harder substance. Corundum (ruby, sapphire) and diamond are the hardest naturally-occurring minerals (9 and 10 on the Moh's scale, respectively). Lu *et al.* analyzed a series of stone axes that were recovered from Chinese tombs that could be dated as far back as 4,000 B.C. By combining energy-dispersive spectroscopy and scanning electron microscopy mapping electron backscattered diffraction patterns, it was unambiguously determined that the specimens contained 40% corundum. Also, the location and orientation of the grains could be visualized and correlated with what was seen in the atomic force microscope (AFM). One specimen was a fragment of an axe that allowed Lu *et al.* to examine its surface with an (AFM) and to perform limited destructive experiments.

Using the AFM, Lu *et al.* found that the microscopic corundum grains, which gave the surface of the axe fragment its high reflectivity, have a root-mean-square roughness of only a few nanometers. In other words, it was almost perfectly smooth. They did not find any residual abrasive on the specimen, so Lu *et al.* experimented to duplicate the polished surface. They cut slices from the fragment and polished them with the best commercially available forms of several different abrasives (quartz, corundum, and diamond) suspended in oil as might have been done in ancient times. Interestingly, Lu *et al.* point out that diamond abrasives could have been extracted from alluvial deposits a few hundred kilometers from the site of the tombs using ancient techniques; when wet diamond-bearing gravel is run over a greased surface such as a fatty animal hide, the diamonds stick to the grease while the remainder washes away. Qualitatively, of the three polished samples, the diamond-polished surface most closely matched the surface polished in antiquity when examined with the AFM. Quantitative analysis of height histograms showed that the diamond-polished surface most closely matched the ancient surface. Other characteristics of the surface also support the conclusion that these ancient stone axes were given their final polish with a diamond abrasive.

The microscopic evidence along with the availability of abrasives to the ancient Chinese craftsmen and securely dated specimens strongly suggest that corundum was used as an abrasive as early as 4,000 B.C. and diamond around 2,500 B.C. Since corundum and diamond remain among the most advanced abrasives used to this day, it can be said that this high technology was probably used 6,000 years ago. Previously, the earliest use of this technology was thought to be used by a Minoan culture around 1,700 B.C. Lu *et al.* present convincing evidence that Neolithic craftsmen of ancient China were using advanced polishing technology about two millennia before anyone else was known to have done so! ■

References:

1. The author gratefully acknowledges Dr. Peter Lu for reviewing this article.
2. Lu, P.J., N. Yao, J.F. So, G.E. Harlow, J.F. Lu, G.F. Wang, and P.M. Chaikin, The earliest use of corundum and diamond in prehistoric China, Archaeometry 47:1-12, 2005.

INDEX OF ARTICLES

ABOUT THE COVER

The image is a polarized light micrograph of the illicit drug Ecstasy (3,4-methylenedioxy-methamphetamine HCl) recrystallized from methanol. Ecstasy is popular among middle-class adolescents and young adults. It is sold primarily at legitimate nightclubs and bars, at underground nightclubs sometimes called "acid houses," or at all-night parties known as "raves." Production cost is as little as 25 to 50 cents per tablet, with a street value typically between $20 and $30. Ecstasy is known to cause hyperthermia, muscle breakdown, seizures, stroke, kidney and cardiovascular system failure, possible permanent damage to sections of the brain critical to thought and memory, and death. Image courtesy of John Reffner and Pauline Leary. See their forensics article beginning on page 6.

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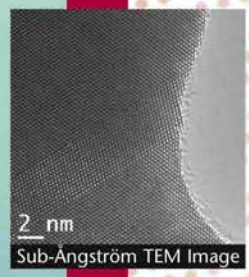

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