Ancient Aluminum? Flexible Glass?

Looking for the Real Heart of a Legend

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The story has hardly been well-enough authenticated to warrant the publicity which it has long received.

Pliny, *Natural History,*
Book 36, para. 195

This incredible story is still being repeated and amplified even after almost 2,000 years. Is there any basis for it? What accounts for its longevity?

Do you like strange stories? What about one with ingredients like an inventor of genius, flexible glass, a tyrannical emperor, and a surprising end? The story, so critically commented upon above by the Roman encyclopedist Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79), "who was besides not unduly skeptical" (Trowbridge 1930), has it all. And more: According to the editors of Time-Life Books (1990) in their *Feats and Wisdom of the Ancients,* the story could be about aluminum. If true, then certainly "the ancient metalsmith was centuries ahead of his time."

Are you curious about it now? Here is the detailed version given by the contemporary Roman author Petro-

nius in his *Satyricon* (chap. 50, para. 7, to chap. 51, para. 6), where inserted in a conversation on metal tableware the swank Trimalchio boasts:

> Personally I prefer glass; glass at least does not smell. If it were not so breakable I should prefer it to gold; as it is, it is so cheap. But there was once a workman who made a glass cup that was unbreakable. So he was given an audience of the Emperor with his invention; he made Caesar give it back to him and then threw it on the floor. Caesar was as frightened as could be. But the man picked up his cup from the ground: it was dinted like a bronze bowl; then he took a little hammer out of his pocket and made the cup quite sound again without any trouble. After doing this he thought he had himself seated on the throne of Jupiter, especially when Caesar said to him: "Does anyone else know how to blow glass like this?" Just see what happened. He said not, and then Caesar had him beheaded. Why? Because if his invention were generally known we should treat gold like dirt.

Pliny (*Nat. Hist.*, bk. 36, para. 195) relates the story in a matter-of-fact manner:

> The tale is told that, during the reign of Tiberius, a glass was devised, so compounded as to be flexible, and that the workshop of the inventor was utterly destroyed, lest there should be a decline in the value of copper, silver, and gold.

The story must be seen in its historical context in the first century A.D. The rather new invention of glass-blowing spread at that time, and glass vessels became readily available, competing economically with luxury metal tableware (Pliny, *Nat. Hist.*, bk. 36, para. 198; Forbes 1957: 170-171). Should the new decolorized glass of crystal-like appearance have had the desired metallic properties (fracture strength, forming by cold work), then the market for metal tableware would have totally broken down.

In the Middle Ages, this fascinating story was often repeated (Trowbridge 1930: 112). Alchemists searched for the secret of malleable and flexible glass in pursuit of perfect matter (Kunckel 1689; Ilg 1873: 133-134).

Ancient Aluminum

Where does the idea that the story is about aluminum come from? Every encyclopedia dates the discovery of aluminum to the nineteenth century, so the existence of Roman aluminum is certainly an extraordinary claim.* So, what about the necessary extraordinary proof? Although Time-Life correctly gives Pliny and Petronius as sources and cites them speaking of glass, its version of the story clearly contains fakes, as is easily revealed by direct comparison. Time-Life calls the craftsman a "metalworker" and says the material of the cup "looked like silver but was much lighter" and "was extracted from clay—just as aluminum is." All these claims are fabrications that have nothing to do with the original story. Based on these and not, as it falsely claims, on Petronius's and Pliny's descriptions, the Time-Life book says, ". . . however, modern experts have speculated that it [the cup] might have been fashioned from aluminum." Invent citations and you certainly have a lot to speculate about!

Of course the Time-Life editors did not do it themselves; they got their version thirdhand. By a search in libraries, I traced this account back to Henri Sainte-Claire Deville (1818-1881), the founder of the industrial production of aluminum. His "silver from clay" was shown at the World Exhibition in Paris in 1855. In 1864, during an evening lecture at the Sorbonne, he told his audience that he had had a Roman predecessor. He cited a General de Béville verbatim, who had "discovered it in many latin texts" (Menault 1864). From this quotation, de Béville's intentions are obvious. He did not only try to flatter the modern aluminum producer for reviving an ancient Roman tradition. He also contrasted the tyrannical ancient Roman emperor Tiberius, who suppressed the invention, with the modern French emperor Napoleon III, who acted as a patron of the technical innovation.

De Béville's idea to relate the story to the production of aluminum might come from a misinterpretation of Petronius's expression *aurum pro luto habere* (literally: to have gold as dirt). The Latin word *lutum*, which means either dirt or clay, is here (and in other passages of the *Satyricon*) used in a comparison as an example of something totally valueless. De Béville possibly interpreted the word as indicating that the vessel itself was made from clay. In his mind, what else could the material of the vessel be? It behaves like a metal and competes with gold and silver, as "silver from clay," i.e., aluminum? A nice anecdote, indeed, perhaps intended to cause a smile and not be taken seriously. Later readers apparently did not understand that—and so the story of Roman aluminum was born. And there is one lesson of experience with such stories: Once promulgated, they never go away.

One simple. question was forgotten by all advocates of ancient aluminum: How did the Roman craftsman produce it? Although there are claims in connection with Chinese finds (Needham 1974), no repeatable method has been demonstrated using known ancient technical skills for the production of aluminum or its alloys in the gram-size lumps necessary to form artifacts from them. Despite Time-Life's listing of a large number of editorial researchers, special contributors, correspondents, and consultants, no one has attempted just looking at

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*There are also claims of ancient Chinese aluminum (see Editors of Time-Life 1990:26, and Needham 1974), not under investigation here. As opposed to the purported Roman aluminum, they refer to real objects and can therefore be taken more seriously. However, the analyses, the dating of them as ancient, and the speculations on production methods are not beyond every reasonable doubt.

what Pliny or Petronius really wrote or what the background of their not "surprisingly true," but unsurprisingly untrue version is.

Perhaps, Time-Life editors are less to blame for what they included than for what they missed—the real wonders of science and archaeology. As has been shown recently (Craddock 1990), there is, indeed, a strange metal known to some ancients whose secret of production was lost during the ages, at least in Europe: zinc. A true feat of the ancients!

Thermally Toughened Glass

Clearly, Pliny and Petronius were speaking of glass, and the later repeaters of the story understood it just the same. Even the first glass technologists, living in the seventeenth century, did not believe in the malleability and flexibility of glass vessels, because of their own experience with that brittle material and despite the alchemists' claims (Kunckel 1689). Their modern colleagues will certainly agree. But what about the fracture strength? Although one cannot render glass unbreakable, its strength can be improved, e.g., by thermal toughening. When the first method to quench red-hot glass (in oil of 200-300°C) was patented in 1874, the new "verre trempé" reminded H. E. Benrath (1875) of the old story of Pliny and Petronius. Von Lippmann (1897) even drew a parallel with the hardening of steel, a process done similarly and well known to the ancients. A crucial step was taken recently by Rottländer (1990), when he connected the old story and the modern technique with a definite group of Roman glasses found in Cologne. They appeared to have broken during burial into tiny pieces that lay close together. Archaeologists remembered at first sight the fracture pattern of thermally toughened glass, but a closer look can reveal the characteristic differences of the craquelé pattern. Long-necked Roman bottles, which unlike open forms (sheets, plates, and cups) could not be toughened thermally even today, have the same craquelé patterns, most likely due to corrosion during burial.

All other evidence in favor of the hypothesis could be refuted in a detailed study (Eggert 1991b) as well. Therefore, it has been concluded that "hitherto no one has presented unquestionable scientific evidence for Roman toughening of glass" (Eggert 1991a).

What Else?

If not aluminum or thermally toughened glass, what else could it have been?

Other scientists, other speculations! Even Pliny himself, by referring the unusual properties to a special composition, implicitly makes an assumption on the technical background. However, up to now there has been no glass composition with properties similar to those of the one purportedly shown to Tiberius.

Broken like thermally toughened glass? Craquelé on a Roman glass fragment from Flertzheim, Rhineland. Scale in cm. (Photo: RLMB/H. Lilienthal)

According to Muspratt (1858), the vessel was therefore not made from glass but possibly from molten silver chloride, which is a little transparent and plastic. Unfortunately, although silver chloride is a frequent corrosion product on silver objects excavated from salty soils, no Roman object deliberately made from molten silver chloride has been found up to now.

Ilg (1873) critically discusses the idea that the Latin word *vitrum* here means enamel instead of glass, but concedes that this, too, would not explain the malleability.

Mellor (1964) says that the story *"recalls the Delhi flexible sandstone."* But this can only be taken as an analogy ("recalls"), not as an explanation, because the interior microstructures of glass and sandstone are totally different.

Kisa (1908) connects the alleged flexibility of the glass vessel in the story with fun glasses known from early modern times having a spiral cut into the thin walls. When filled they hold liquids, but, because of the slight flexibility of thin glass, they leak when the rim and the bottom are drawn apart. Even if Roman glass-workers knew this nice trick, one should have found relics of such objects. And, of course, this glass would not be malleable, as Kisa himself admits. By the way, he has an interesting suggestion as to the origin of the idea of malleable glass: a layperson, not knowing the new technique of glass-blowing, might imagine that *form-blown glass with reliefs* would be produced similar to their hammered metallic counterparts.

Forbes (1957) is aware that the story cannot be literally true. In his eyes, "it is more probable that *flexile* refers originally to nothing more than the production of 'bent' hollow ware, with 'bent' handles, in 'stony' glass, for the ancients often classified glass with stone." The story then became inconclusive, because such glass was— obvious to the audience in the first century

A.D.—frequently produced, so no such invention was lost.

Bailey's speculation (see Pliny) is perhaps the most entertaining one. He commented upon the similar version of the story given by Dio Cassius in his *Roman History* (bk. 57, chap. 21, para. 7), where the inventor repaired the glass with his hand: "Tiberius had him put to death, and we may conjecture that he had found him out to be a conjuring impostor." A true story about a false trickster?

Altogether, these speculations form an impressively long list of possibilities. But by weighing up the evidence, one can only agree with McDermott (1962): "The anecdote, its later versions, and the problem of flexible glass have been much discussed with little result."

Just a Good Story

Despite Pliny's critical comment it seems that all authors looking for explanations implicitly made conclusions like this: the "story had been repeated so often, that one at last has to believe in some true heart" (Neuburger 1919). This kind of false reasoning is very well known to skeptics. Be it extraterrestrial UFOs, Noah's Ark, or the Yeti: the number of "sightings" is taken as evidence by believers that there must be at least "something," despite the bad factual quality of the individual observations throughout.

If not because of its "truth," why then was the story retold again and again for almost 2,000 years? The trivial explanation missed so far by all the scholars and scientists: Consider the main characters, look at the plot—it is just a good story! An inventor is surprisingly, but convincingly, punished for economic reasons instead of being rewarded as expected, and the invention is discarded.

Certainly, like modern urban legends, an interesting story might appear in very different versions. Twenty years ago I heard the following: an inventor filed a patent on a razor blade that would never become blunt. He sold his invention to a big company for a share in the sales of that type of blade. But the company didn't start production, so as not to lose the market for its normal blades. The man therefore died poor. Despite the modernizing changes (another invention, a big company taking over the role of the tyrant, not getting rich instead of capital punishment), this is essentially the old story.

Tales that the breakthrough of an invention is prevented by conspiracies are quite frequent today, see, e.g., the rumors on green-powder inventor J. Andrews's death (*SI*, Fall 1993, p. 20).

Stories might be true or false; perhaps the most fascinating and remarkable ones are those where you do not know exactly which, as in the case of still not knowing today of the possibility of manufacturing razor blades that remain sharp for a long time. (There may be better methods than to put them inside a pyramid!) The ancients might have thought similarly of glass with unusual metallic properties. What a challenge it is to our human endeavor to search for the truth in such stories.

Conclusions

There is a lesson to be learned from this case study. As we have seen, scientists like to speculate. That is part of their normal work of finding hypotheses that are open to experimental falsification or support by further evidence. When publishing uncertain explanations, scientists must always make clear their limited probability, otherwise it becomes bad science and may be exploited by pseudoscientists. What a grand opportunity our story is for those who need ancient aluminum or thermally toughened glass for their religion of ancient spacecrafts! (So far, I am unaware of such exploitations. Are there any?) Don't forget: when finding a possible explanation for something, your job is not done. See if you can find (or others have found) alternative ones. Then apply Occam's razor! I am convinced that the "just a good story" hypothesis performs best with this test, at least in our case. So, when looking for the true material heart of a legend in reality, don't forget the zero-hypothesis: *there might be none!*

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