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Were the Golden Plates Made of Tumbaga?

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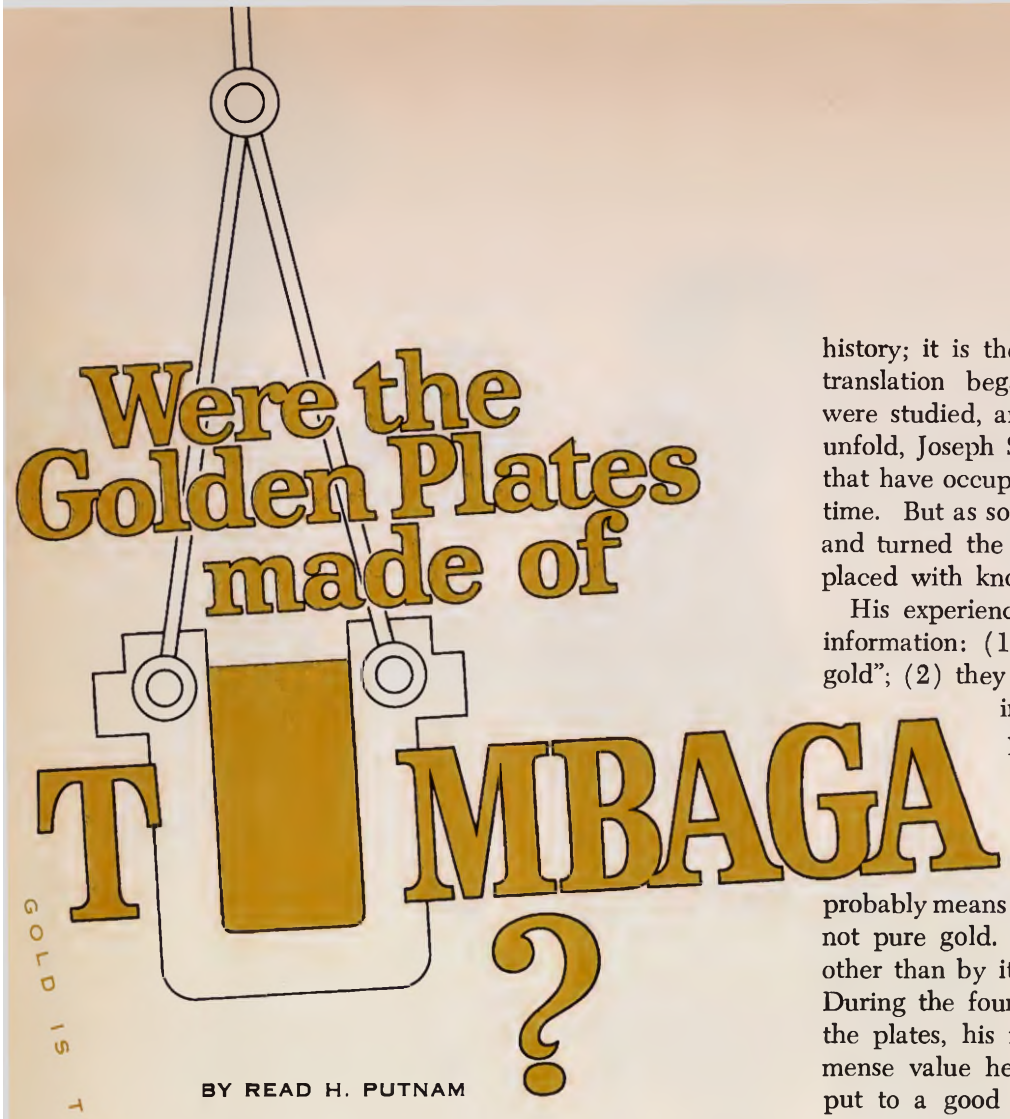
Abstract: This article considers the physical properties of the golden plates of Nephi, the engraving of metal plates, and the stone box that stored the plates. The author suggests that the plates may have been made of tumbaga, an alloy of gold and copper.

Were the Golden Plates made of TUMBAGA?



BY READ H. PUTNAM

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GOLD IS THE MOST DUCTILE OF ALL METALS. IT CAN BE HAMMERED INTO A

The archaeology of the Book of Mormon begins with a stone box and a set of metal plates. These articles produced the first knowledge of the Nephite people in modern times, although there were other items in the box. The other items were not the products of the Nephites, however, so are not to be considered here. The plates, in part at least, were manufactured by one of the first men of the Nephite nation, while the stone box was probably made by one who saw the collapse of that nation.

The first consideration in the study of Book of Mormon archaeology is not translation, text, or family history; it is the plates themselves. Long before the translation began, before the engraved characters were studied, and before the Nephite story began to unfold, Joseph Smith's mind was busy with questions that have occupied the minds of generations since his time. But as soon as he had hefted, handled, smelled, and turned the pages, his questions began to be replaced with knowledge.

His experience has passed on to us the following information: (1) The plates had the "appearance of gold"; (2) they were about 6" x 8" x 6", or 288 cubic inches in size; (3) the surfaces of the plates were engraved with figures of "curious workmanship"; and (4) they could be easily lifted and carried by one man.

The term "appearance of gold" probably means that the plates were yellow in color but not pure gold. The easiest way of identifying gold, other than by its color, is by its weight and softness. During the four years the Prophet waited to receive the plates, his mind perhaps speculated on the immense value he thought they represented. He was put to a good deal of schooling by the messenger to insure that he would not attempt to convert them to wealth. Reflection on the subject later caused him to say "appearance of gold" rather than gold or pure gold. He must have realized they were not 24-carat gold. Perhaps he noticed some red fracture around the binding holes or realized they were lighter in weight than he had expected they would be. Evidently there were reasons that he thus decided to qualify his description of them.

The engravings on the plates, he reported, were "small" and "of curious workmanship." The plates were "filled with engravings" and were "not so thick as common tin." The exact size of the engravings, or glyphs, and the distance between them and between the lines are not known. However, the author has a specimen of hand-engraved work in English that is very legible and in which the lower-case letters are less than 1/16 of an inch in height.

The "curious workmanship" displayed by the plates seems to indicate that the Prophet was unfamiliar

with the script. The surface of the plates probably would have been polished. The plates probably would not have exceeded .02 of an inch in thickness, and might have been a good deal thinner than that. In any event, the manufacture of the plates would be a prime factor in the success or failure of the engraver. The metal would need to be soft enough at the surface to accept the engraver's tool yet firm enough in the center to keep the plate from distortion under the pressure; it would also have to be smooth enough for the lines and figures to retain their proportions. The plates were described by Joseph Smith as "beautifully engraved," so we may suppose the metal met all these requirements.

The plates were not so heavy that a man could not carry them. Joseph Smith was a man of youth and vigor, yet Mormon was 74 years of age when he turned them over to his son. (See Morm. 6:6.) We are not led to believe that the weight of the plates was a great hindrance. The witnesses testified that they had "hefted" them, indicating that the weight seemed tolerable.

Gold is the most ductile of all metals. It can be hammered into a leaf .0003 of an inch in thickness, and a single ounce can be drawn into a thread 35 miles long. Silver and copper, the next two most ductile metals, range very close to gold, both having properties almost beyond imagination.

A SINGLE OUNCE CAN BE DRAWN INTO A THREAD 35 MILES LONG

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Tumbaga is an alloy of gold and copper, the only two colored metals known to man. Gold melts at 1060°C. and copper at 1083°C. Yet an alloy of the two metals that has 15 to 40 percent copper melts at 200 degrees C. less than gold.

The early American smiths used the alloy of tumbaga extensively. It ranged in content from 97 percent gold to the same proportion of copper, with several trace metals as impurities and silver as an impurity or deliberate alloy up to 18 percent.

Studies have been made of metals of pre-Hispanic Panama and the peoples who possessed them. Of the 15 cultures studied, all worked with gold, 9 employed silver, 11 or perhaps 13 knew copper, and 8 worked tumbaga. All 15 knew the hammering process, while six employed the art of engraving. These cultures employed a wide range of gold and copper alloy in both hammering and casting, but they seem to have employed the higher gold alloys more in objects manufactured by hammering.

Artifacts now accredited to these fifteen cultures may or may not have been made from alloys employed for the first time. The wide range of analysis and the apparent diversified methods and objects manufactured with like alloys indicate that the metal was used many times before it appeared in the articles discovered as artifacts of the cultures. The workmanship of the artifacts was the prime means of identification for classification rather than the alloy. It is very unlikely, then, that metals employed by the Nephites or objects they manufactured that later fell into the hands of successive nations would be preserved in workmanship, analysis, or location for us to identify and declare as being peculiar to them. In the case of the plates from which the Book of Mormon was translated, then, we have the artifact and the positive identification.

The versatility of tumbaga indicates that the American smiths were not required to be exacting as to particular gravimetric alloy. And it is apparent that whatever the alloy or object, once the gilding was applied, the result to the eye alone would be gold.

There is one property of tumbaga that should be remembered. When the copper content is particularly high and the gilding not perfect, the whole inside of the alloy beneath the gilding skin will destroy itself with electrolysis.

Tumbaga, the magic metal, can be cast, drawn, hammered, gilded, soldered, welded, plated, hardened, annealed, polished, engraved, embossed, and inlaid. Yet with all this versatility, tumbaga will destroy itself if it is improperly alloyed, improperly stored, or improperly finished. (*Continued on page* 828)

Tumbaga

(*Continued from page* 789)

A word now about some of these processes: It is not suggested that all early American metal workers used all the processes listed above; indeed, each smith would probably use only those few that suited his talent and that were in demand by the people for whom he worked. The processes of hammering, gilding, annealing, and to some degree of smelting would have been useful in the manufacture and binding of the Book of Mormon plates. The engraving would have required a separate skill from that of the smith and need not necessarily have been done by the person who manufactured the plates. This was the case in at least one instance in the Book of Mormon. (See Omni in the Book of Mormon.)

The gilding could have been done by yet another workman, using one of two possible methods. The first is called *mise en couleur* by the French and consists of allowing the surface copper to be eaten away by citric acids and then spreading and burnishing the remaining gold into a thin surface gilding. The second consists of mixing some powdered gold (dust) with mercury, spreading the mixture over the surface to be gilded, and then heating a little to spread the gold mixture and disperse the mercury. This is essentially the amalgam process and differs from the first method in that the gold is added from another source, whereas in the first process the gold used is contained in the article itself.

Annealing, it is stated, is the process of heating the metal and allowing it to cool slowly, which makes it softer and less brittle. However, this statement, so far as copper and the alloys of gold are concerned, is incorrect, since copper becomes very soft and malleable when it is strongly heated and immediately immersed in cold water, its behavior under these circumstances being diametrically opposite to that of steel. Further, many of these alloys (speaking of gold alloys, among which are those of copper and silver) are age-hardening; consequently, they can be softened by heating to temperatures around 700°C., followed by quenching, and then hardened by reheating to the appropriate range needed to produce the physical properties desired. Thus copper alloys could be hardened by applying heat and omitting the quenching process. The heat produced by cold-hammering or gilding would be equally effective. Since gold is unaffected by this series of heating and quenching necessary to cold-hammer the alloy, the gilded surface, when finally applied, would remain soft; the application of heat to spread effectively the gold of the gilding would harden the alloy beneath.

Let us now consider the box in which the plates were stored. The Prophet Joseph Smith said, "In the bottom of the box were laid two stones crossways of the box, and on these stones lay the plates and the other things with them." Did the artisan who made the box intend merely to hide the plates, or did he intend to preserve them also? He must have intended to preserve them, since he (Moroni) sealed them up.

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THE PROPHET SPEAKS

BY JACK S. BAILEY

The Prophet speaks.
His words I hear,
His message seeks
Our thoughts so clear.
I wonder at his source
Which penetrates my mind,
The simple gospel course
Which lends a different kind
Of feeling. It burns deep—
His pure words to impart
A contrite, willing weep
That gently fills my heart
With something more
Than ever filled my heart before.

This could not have referred to the portion that was sealed together so that each plate was inaccessible, but rather to the disposition of the entire stack, since what was sealed included the portion to be translated. The sealing, then, must refer to the box in which the plates were deposited. Moroni was careful that no dirt or water should get to the plates, knowing that under certain conditions they could be damaged or destroyed. The title page of the Book of Mormon indicates that the plates were "sealed up, and hid up unto the Lord, that they might not be destroyed."

Dr. Sidney B. Sperry has said that the word "ziff" in the Book of Mormon probably referred to zinc, meaning "bright." (See Mosiah 11:8.) Another explanation may be that the Prophet Joseph Smith, upon coming to this term, could find no English equivalent and therefore transliterated the Nephite sounds into English letters. The Nephite term could have meant "tumbaga," a name borrowed from the Spanish. (The same alloy is called *quanin* by the Arawak.) Tumbaga, when properly finished by gilding, is also "bright."

Native workman have said that tumbaga had a peculiar odor. Do you have a copper penny in your pocket? Rub it briskly, then smell it. Gold and silver have no odor, but copper, even when heated at very low temperatures, has an odor.

It is impossible to calculate the exact weight of the plates. The Small Plates of Nephi may have been of a different alloy than those made by Mormon, who leaves some doubt as to whether he himself manufactured the plates he used or wrote on plates previously made by another.

Joseph Smith said the plates were 6″ x 8″ x 6″, in which case they were 288 cubic inches in volume. Others have given different dimensions that would amount to volumes ranging from 244 to 336 cubic inches. The Prophet's figures are preferable, since they represent an average and since he was more familiar with the plates than anyone else. A solid block of gold totaling 288 cubic inches would weigh a little over 200 pounds. (Gold weighs .697 pounds per cubic inch; silver, .379 pounds; and copper, .321 pounds.)

But plates would weigh much less than a solid block of the same metal. The unevenness left by the hammering and air spaces between the separate plates would reduce the weight to probably less than 50 percent of the solid block.

As already noted, though, the plates were not made of pure, or 24-carat, gold. On one hand it seems probable that they were not made of an extremely low-gold alloy because of the danger of electrolysis and brittleness. On the other hand, they were probably not of an extremely high-gold alloy either, since the weight would thereby be increased. There would also be a danger of distortion while the plates were being inscribed, because of the ductility of these higher alloys.

Some writers have suggested an 8-carat-gold alloy for the plates of Mormon. If this is assumed, then, using the gravimetric system of William C. Rott, a block having the dimensions of the plates would consist of 25.79 pounds of gold, occupying 37 cubic inches of the block; 77.84 pounds of copper, occupying 242.5 cubic inches; and 3.25 pounds of silver (3 percent added as an impurity), occupying 8.5 cubic inches. Thus a block of tumbaga of the dimensions indicated for the plates of the Book of Mormon and with 8-carat alloy and 3-percent native impurity would weigh 106.88 pounds. Using such a block as a beginning point, 50 percent of the weight should be subtracted for air space; thus the weight of the stack of plates would be about 53 pounds. If these figures seem unrealistic, remember that gold has twice the density of copper and therefore occupies about one-sixth of the total volume.

If each plate were .02 of an inch thick, it would occupy up to .05 of an inch in the stack, and there would be 20 plates to the inch. The unsealed portion would then consist of 40 plates or 80 sides. Present-day food cans are manufactured of metal that is about .01" to .015" thick. How this compares with the "common tin" referred to by Joseph Smith remains to be investigated.

If the plates have been made from a 12-carat-gold alloy, they would have weighed 86.83 pounds, following the same system used for the 8-carat postulate. As the proportion of gold in the alloy is

increased, so are the alloy's weight and ductility and the tendency of the plates, if hammered very thin, to distort and wrinkle.

We must conclude that ancient American smiths had sufficient knowledge and skill to make a set of plates using the alloy that the Spaniards called tumbaga. The plates of the Book of Mormon, we allege, were of this alloy and were probably of between 8- and 12-carat gold. They thus appear to have weighed between 53 and 86 pounds. We further allege that the plates were manufactured by hammering the metal to a thickness of .02 of an inch with a 23-carat gilded surface of .0006 of an inch, resulting in a hardness of 30 Brinells to the engravers tool, while the center of the plate maintained a Brinell of 80 or above.

The plates themselves would have presented a solid gold surface to the eye, yet they would have weighed as little as half as much as pure gold.

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