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A Fifth Dynasty Reference to Annealing

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Annealing is a metallurgical operation in which a hammered piece of metal is heated in order to reduce its hardness and brittleness. This heat treatment causes a rearrangement in the crystalline structure of the metal, releasing the strains induced in the metal by hammering, and thus restoring its ductility. Metallographic analysis has revealed that the ancient coppersmiths learned the technique of annealing relatively early in the development of a metallurgical technology.[1] Textual evidence from Egypt for annealing has so far been very sparse because of both the laconic nature of the metallurgical reliefs and their accompanying inscriptions and the absence of any description of the technological aspects of metal-working in the papyri and on stelae. Nevertheless, two references to annealing are known to me from ancient Egypt, both dating to the Fifth Dynasty (*ca.* 2494–2345 B.C.). One occurs in a metal-working scene in the tomb of Ti; this reference has already been noted by Montet.[2] The second is in a similar scene in the tomb of Wepemnofret; this one, however, seems to have escaped scholarly notice, and will therefore form the subject of the present note.

The relief in question is in the mastaba of Wepemnofret, located in the large mastaba cemetery east of the pyramid of Khafre at Giza.[3] The date of the tomb can be fixed to the middle-late part of the Fifth Dynasty by the presence of the cartouche of Neferefre in a personal name on one of the tomb reliefs.[4] Inside the mastaba are two chapels, one for the owner, Wepemnofret, the other for his eldest son, Iby. Four registers of various daily life scenes are carved in low relief along the southern half of the eastern wall of the chapel of Iby. The top register of these four is primarily devoted to metal-working.

The metal-working tableau consists of three scenes which are to be followed in a sequence

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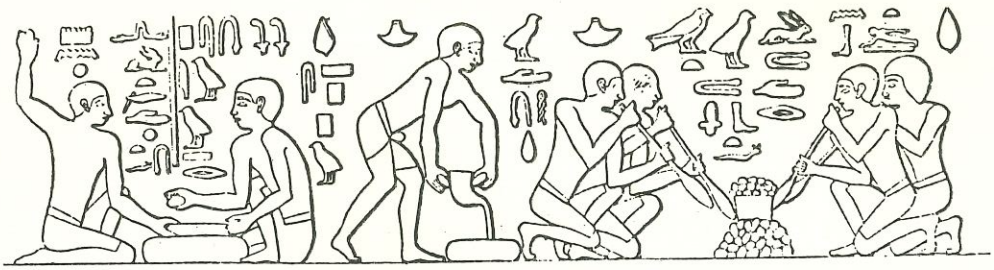
[1] The earliest Egyptian copper object analyzed so far, a Gerzean axe-head, shows evidence of cold hammering and annealing, or hot hammering: Carpenter, *Nature* 130 (1932), 625–26. A fifth millenium B.C. copper pin from Tepe Sialk in Iran is the earliest Near Eastern copper object for which there is metallographic evidence of annealing; see Wertime, *Science* 146 (1964), 1260.

[2] Montet, *Les scènes de la vie privée dans les tombeaux égyptiens de l'ancien empire*, 284–85. In the Ti scene, which has been published several times (Steindorff, *Das Grab des Ti*, pl. 134; Wreszinski, *Atlas zur altaegyptischen Kulturgeschichte* III, pl. 35; Capart and Werbrouck, *Memphis à l'ombre des pyramides*, fig. 345; Wild, *Le tombeau de Ti*, pl. CLXXIII), two men are shown hammering a metal bar or sheet. One of them says to the other, *dỉ spr pw r ḥs ỉw·ḟ twꜣ*, "Place this sheet (?) for heating; it is supported (?)." There can be little doubt that the metal-worker is telling his comrade to heat the object, i.e., anneal it. For the word *spr*, see Montet, *op. cit.*, 285. I am not at all certain of the correctness of my translation of the word *twꜣ*, a verb which frequently means "to prop, support, or elevate" (see *Wb.* V, 248–50; cf. Badawy, *ASAE* 54 [1956–1957], 70, 74). Perhaps the craftsman is saying that he has a good grasp on the object. On the other hand, Montet may be right in translating *twꜣ* here as "hammered" (*écrouie*) because of its context.

[3] This mastaba was excavated by Selim Hassan during his 1930–1931 season at Giza and was published in his *Excavations at Gîza* 1930–1931, 179–201.

[4] *Ibid.*, fig. 219, second register from bottom, cf. p. 200.



Metal-working Scene from Tomb of Wepemnofret (from S. Hassan, *Excavations at Giza 1930–1931*, fig. 219).

from right to left (see above).[5] The first scene shows two men with blowpipes kneeling on either side of a small melting crucible which sits on a heap of charcoal fuel.[6] The men are forcing the fire with their blowpipes. Inasmuch as it would be undesirable to have the charcoal and copper come in contact during the refining operation, the material shown above the melting cup must be interpreted as an artistic rendering of the copper pieces in the vessel, and not charcoal heaped up over it. The melting vessel itself is not the rhyton-shaped crucible so frequently shown in Old Kingdom metal-working scenes. Instead, it is a simple, open melting cup. Nearly identical vessels have been used in this century by the Jur tribe in the Sudan in the production of iron.[7] This cup is probably the model for the small earthenware cup used as a determinative with various words showing the consonants *bỉꜣ*.[8]

Ḥmty,[9] "metal-worker," is inscribed above the man on the extreme left, while the superscription to the far right reads *nbt ḥmty*,[10] "melting copper." In the center of the scene is written *wn-ṯw wrt wdỉ r ṯbt·f*. The phrase *wdỉ r ṯbt·f* occurs in metal-working scenes in the Old Kingdom tombs of Isy,[11] Iymery,[12] Senedjemib,[13] and Wepemnofret, while a variant, *wdỉ m ṯbt·f*, occurs in the tomb of Ankhmahor.[14] The verb *wdỉ* has two basic meanings, "to put or place," and "to thrust, push, or throw."[15] If the latter meaning is applied, then the *Wörterbuch*'s interpretation of the phrase, "von Einstoßen des Tonpfropfens am Schmelzofen (das Suffix geht auf das Erz)?"[16] may be correct, and the remark should be interpreted as referring to the removal of the clay plug or end of the crucible in order to let the molten metal run out.[17] However, if the former meaning is used, then the sentence may be interpreted somewhat differently. Thus the phrase *wn-ṯw wrt wdỉ r ṯbt·f* may be translated, "Hurry, quickly, put (it) at its base (literally, 'sole')," and would be an order by one of the metal-workers to another to direct the end of his blowpipe towards the base of the oven or crucible in order to keep the fire sufficiently hot.

[5] *Ibid.*, fig. 219, pls. LXXIV–LXXVI, cf. pp. 192–93.

[6] For some possible examples of the melting cup, see Curto, *MDAIK* 18 (1962), 64, 69, fig. 3e, pl. V.

[7] Crawhall, *Man* 33 (1933), 43, figs. 2, 4; Forbes, in Singer, Holmyard, and Hall, eds., *A History of Technology*, fig. 382.

[8] Cf. Weill, *Rev. d'Ég.* 3 (1938), 73–74; Gardiner, *Egyptian Grammar*[3], Sign-list W 10.

[9] The reading of the hieroglyph for "metal-worker" as *ḥmty* follows Simpson, *The Reisner Papyri* II, 42.

[10] The reading of the ideogram for "copper" as *ḥmty* follows Harris, *Lexicographical Studies in Ancient Egyptian Minerals*, 62.

[11] Davies, *The Rock Tombs of Deir el Gebrawi* II, pl. XIX.

[12] *LD* II, pl. 49b.

[13] *Ibid.*, pl. 74a.

[14] Capart, *Une rue de tombeaux à Saqqarah*, pl. XXXIII; Wreszinski, *op. cit.* III, pl. 34. Curto, *MDAIK* 18(1962), 62 and n. 1, has tried to reinterpret *wdỉ r* as the verb *dr* ("to remove"), with the *w* before it being a prefix. The occurrence of the preposition *m* in the Ankhmahor scene, however, shows that the *r* in the other scenes should be understood as a preposition rather than as part of the verb.

[15] *Wb.* I, 384–87.

[16] *Wb.* V, 363, 2.

[17] See, e.g., Erman, *Reden, Rufe und Lieder auf Gräberbildern des alten Reiches*, 40; Forbes, *Studies in Ancient Technology* IX, 53, Table V; Curto, *MDAIK* 18 (1962), 62.

Inasmuch as the phrase in question always occurs in the scene in which the metal-workers are shown blowing air through their blowpipes towards the crucible or oven, it is my opinion that this second explanation is the correct one.[18]

In the second scene a man (identified once again as a "metal-worker") is shown pouring liquid metal out of a rhyton-shaped crucible into a mold. The scene is labelled *wdḥ ḥmty*, "pouring copper." The amount and rate of flow of the discharge could be controlled by a stick pushed into the hole by an assistant; this procedure would also prevent any slag from getting out. This action is not shown in the Wepemnofret scene, but does appear in the metal-working relief in the tomb of Mereruka.[19] Since the crucible would be too hot to allow the man to hold it in his bare hands, he holds the crucible with the aid of two oval stones. Such stones are also used by a metal-worker in the Mereruka scene.[20]

The final scene, which is the crucial one for the subject of this paper, shows two men hammering a copper sheet or bar[21] which rests on a stone block. The man on the right says, *ps nn iw wšr*: "Heat this; it is dried up." Behind him is the remark *ḥmty sšp pw*: "It is shining copper."[22] The significance of the first remark is clearly that the object should be heated, i.e., annealed, because it is getting too hard or brittle. The metal-worker on the left replies, *n wnt šd ps·t(w)·f mnḫ*: "There is no cracking(?)[23] if it is heated excellently." Thus, he explains to his co-worker, if the object is annealed, it will not have any imperfections or irregularities caused by over-hammering; in other words, the remedy for brittleness is annealing.

The Egyptians never had a very extensive metallurgical terminology. The verb *psi*, from earlier *fsi*,[24] literally means "to cook." *Fsi* occurs in a metal-working scene in the Unis causeway at Saqqara. There, *fst ḥḏ*, "heating silver," is written above a depiction of two metal-workers with blowpipes melting silver in a crucible.[25] However, the Unis relief does not pertain to annealing, but to the original melting of the silver metal as a prelude to casting. Thus it is only in the tombs of Ti and Wepemnofret that we have references to annealing from ancient Egypt.

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[18] This is apparently the interpretation given to the sentence by Hassan (*op. cit.*, 192), who translates the text as follows: "Make great haste! Place it to its sole (bottom of the oven)!"

[19] Duell, *The Mastaba of Mereruka*, pl. 30.

[20] *Ibid.* In those scenes where the metal-worker seems to be holding the crucible in his bare hands (e.g., Blackman, *The Rock Tombs of Meir* V, pl. XVII; Wild, *op. cit.*, pl. CLXXIII; possibly also *LD* II, pls. 13 and 49b), one must assume that, since the crucible would obviously be too hot to handle without some protection, either the ancient draftsman or the modern copyist has neglected to show the stones in the metal-worker's hands.

[21] Old Kingdom metal-working scenes rarely show the metal-workers hammering on anything other than a metal object of simple, rectangular shape; for an exception, see Davies, *op. cit.* II, pl. XIX. In several cases the craftsmen seem to be hammering the stone anvil itself (see, e.g., *LD* II, pl. 49b; Duell, *op. cit.*, pl. 30). In the latter situation we are probably to suppose that the object is being hammered right in the stone mold, or possibly that the artisan has simply forgotten to draw in the object. The rectangular object in the other scenes may simply be a sheet or bar of metal, but I think that it is also possible that at least in some cases the rectangular objects are schematic representations by the artist of a tool.

[22] Junker, *MDAIK* 14 (1956), 93, associates the *ḥmty*-sign (read by him as *bjꜣ* (?)) with the *ps nn* rather than with the *sšp pw*. There is a clear gap, though, between the second and the , and the latter sign lines up vertically so well with the *iw wšr* that it seems certain that it should go with this remark rather than with the *ps nn*.

[23] The precise meaning of the word *šd* is not clear to me. The verb *šdi* means "to take away, seize, remove" (*Wb.* IV, 560–62), and is closely related to the verb *šꜣd*, "to dig, hollow out, excavate" (*Wb.* IV, 414, 11—415, 4). Hassan, *op. cit.*, 193, translates *šd* in this text as "hollow." The general significance of the word in its present context is perhaps that there will be no depressions or cracks in the surface of the object if it is annealed.

[24] Gardiner, *op. cit.*, §281; Edel, *Altägyptische Grammatik*, § 114.

[25] Hassan, *ASAE* 38 (1938), pl. XCVI; Badawi, *ASAE* 40 (1940), fig. 64.