Iron-smelting furnaces and the metallurgical traditions of the South African Iron Age*

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Discussion of the above paper

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The steely nature of the Iron Age objects mentioned in Dr Friede's paper point to two hypotheses.

(1) The African iron workers were conversant with the art of direct steel manufacture.

(2) They were less knowledgeable of the art of the production of carbonless iron. In this context I cannot but quote T. A. Wertime[1].

> In order to avoid absorption of carbon the following controls were applied: the judicious placing of tuyères and directing the draft; careful charging of charcoal and ore to avoid too intimate contact between them (in some cases the charcoal forming a central column between columns of iron); the use of such quantities of charcoal as would help develop an excess of carbon dioxide and smother the fire; slagging of the smelted iron with a poker; the occasional use of siliceous fluxes to encourage oxidation of carbon towards the end of the heat, and a relatively short time of contact between iron and fuel.

The above and the consistent occurrence of carbon as pearlite would seem to favour hypothesis (1).

I am entirely in agreement with Dr Friede that the temperatures involved were below 1300°C. A higher temperature, coupled with a slag high in ferrous oxide, would soon lead to slagging of the ceramic tuyères and an early cessation of the smelting process.

That high temperature is not necessary for the carburization of iron seems to be indicated by the Stelling[2] process, a 'direct' process for the reduction of iron ores with carbon monoxide. This process operates with a fluidized bed, and a significant feature of the process is the production of cementite at temperatures as low as 1100°F (583°C):

$$3FeO+5C0=Fe_3C+CO_2$$

$$3Fe+2C0=Fe_3C+CO_2.$$

One can possibly translate the Stelling process to a primitive iron-reducing furnace operating with bellows, very rapid movements of the bellows producing a situation obtaining in a fluidized bed; the large volumes of carbon monoxide produced would favour the above reactions and tend to the production of a steely iron.

In conclusion, it can be pointed out that, while it is possible to achieve a certain measure of superficial carburization (case hardening) by repeated heating in beds of glowing charcoal, carburization *en masse* of iron is difficult to achieve in the open air. The classical process as was practised in Sheffield for the production of cemented steel (blister steel) involved the heating of bars of wrought iron packed in separated layers, and surrounded by charcoal in air-tight 'converting pots' heated to 1100°C and kept at that temperature for 7 to 10 days according to the carbon content desired; the heating of crude-iron pieces in the presence of unburnt carbon enveloped in a clay casing to a high temperature would lead to the production of a steel of some sorts.

References

1. WERTIME, T. A. *The coming of the Age of Steel.* Chicago, University of Chicago Press, 1962. Chapter 2, p. 44.

2. ANON. New process reduces iron ores with carbon monoxide. *Iron Age*, 30th Jan., 1958.

Author's Reply

What Dr Siff presents as hypothesis (2) is correct in itself, but the production of carbonless (carbon-free) iron was probably not desirable in a primitive society, since this type of iron is too soft for the making of good tools and weapons.

I recommend a reformulation of hypothesis (2) so that it reads as follows: They were less knowledgeable in the art of the production of iron with a *controlled* low or high carbon content.

It should also be pointed out that all the statements made and the hypotheses given in the paper under discussion refer to the technology of the *South African* Iron Age only, and not necessarily to those in other parts of Africa such as Central, East, and West Africa.

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