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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 61-59

**SUITABILITY OF LOW GRADE MANGANESE
ORES FROM GHANA FOR PRODUCING
FERROALLOYS BY ELECTRIC SMELTING**

IR 61-59

by

G. E. VIENS, R. A. CAMPBELL & R. R. ROGERS

EXTRACTION METALLURGY DIVISION

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JUNE 16, 1961

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SUITABILITY OF LOW GRADE MANGANESE ORES FROM GHANA
FOR PRODUCING FERROALLOYS BY ELECTRIC SMELTING

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G. E. Viens^{*}, R. A. Campbell^{**} and R. R. Rogers^{***}

SUMMARY OF RESULTS

The results of the chemical analysis and mineralogical examination of three ores from Ghana, are given. Reasons are given for concluding that

- (1) standard ferromanganese could not be produced from any one of these ores by the ordinary commercial electric smelting method.
- (2) standard ferromanganese probably could be produced from any one of these ores by a multi-stage electric smelting method which, however, would be considerably more expensive than the ordinary commercial method.
- (3) there is a bare possibility that silicomanganese containing standard proportions of manganese and silicon could be produced from a combination of ores 1 and 3, by the ordinary commercial method.
- (4) it is quite possible that such a silicomanganese would have too high a phosphorus content for ordinary commercial use.

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INTRODUCTION

In November, 1960, the following shipments of manganese ore were received from Ghana for experimental purposes:

Ghana Mn No. 1 (2 crates)

Ghana Mn No. 2 (2 crates)

Ghana Mn No. 3 (3 crates)

These were referred to in a letter dated October 6, 1960, received by the Deputy Minister, Department of Mines and Technical Surveys, Ottawa, Canada, from Mr. F. E. V. Smith, National Research Council, P. O. Box M32, Ministerial Branch Office, Accra, Ghana.

The present report gives an account of (1) the preparation of the ore samples prior to the experimental work, (2) the results of their chemical analysis, and (3) the results of their mineralogical examination. This is followed by a discussion as to the suitability of the ores for the production of ferroalloys by electric smelting. It is assumed of course that the three ore shipments were representative samples of the materials in the ore deposits.

EXPERIMENTAL WORK

Preparation of Experimental Samples

Each shipment of ore was crushed to $-1/2$ inch and then sampled for analysis. Part of the same sample was used in the mineralogical examination. Although it was necessary to crush all

three of the ores to obtain the desired particle size, the products from the crushing of No. 2 and 3 contained much larger proportions of fine particles than did that from the crushing of No. 1. For this reason No. 2 and 3 were considered to be much less satisfactory than No. 1 from the standpoint of smelting.

Chemical Analysis

The chemical analyses of the ore samples from the three shipments are given in Table 1.

TABLE 1
Analysis of Manganese Ores

Shipment	Analysis (%)							
	Mn	Fe	SiO ₂	CaO	MgO	P	Mn/Fe	L. O. I.
No. 1	38.6	9.7	9.3	0.4	0.04	0.2	4.0	13.0
No. 2	13.5	6.1	47.4	0.6	0.2	0.1	2.2	9.3
No. 3	23.0	4.8	33.8	0.3	0.2	0.1	4.8	11.6

Mineralogical Examination

The report of the complete mineralogical examination of these three ore shipments will be available within the next month, and copies will be sent to the National Research Council of Ghana and to the Geological Survey of Ghana. However, it may be pointed out here that the following minerals were found in the ore shipments:

Main	} Minerals	Cryptomelane	$\text{KMn}_8\text{O}_{16}$
Manganese		Lithiophorite	$\text{Li}_2(\text{Mn}^{11}, \text{Co}, \text{Ni})_2\text{Al}_8\text{Mn}_{10}^{\text{IV}}\text{O}_{35} \cdot 14\text{H}_2\text{O}$
		Pyrolusite	MnO_2
		Quartz	
		Kaolin	
		Goethite	
		Garnet-spessartite	

No phosphorus-containing minerals were observed.

DISCUSSION

Suitability of Ores for Ferroalloy Production

In Table 2 the common manganese ferroalloys are listed along with their manganese/iron ratios.

TABLE 2

Manganese/Iron Ratio in Manganese Ferroalloys

Ferroalloy	Manganese/Iron Ratio
Standard ferromanganese	4.8 to 6.8
Medium carbon ferromanganese	4.7 to 7.0
Low carbon ferromanganese	6.6 to 10.0
Silicomanganese (1.8 to 20% silicon)	3.9 to 8.2
Spiegeleisen	0.2 to 0.4
Silicospiegeleisen (8 to 15% silicon)	0.37 to 0.45

Our experience has shown that the recovery of iron in the production of these alloys is higher than that of manganese; accordingly, the manganese/iron ratio in the furnace charge should be even higher than that in the ferroalloys to be produced.

This fact, and the manganese/iron ratios in Tables 1 and 2 show definitely that the first three alloys listed in the latter table could not be produced from any of the three submitted ores by present-day standard smelting procedures. However, on the basis of our experience, it is believed that these alloys could be produced from any one of these ores by a multi-stage smelting process.

Unfortunately such a process would be considerably more expensive than the process used commercially at the present time. Accordingly such a process could only be used under special conditions, for instance if the ore and/or the electric power should be available at an unusually low price.

On the basis of manganese/iron ratio, it is doubtful if silicomanganese could readily be produced from ore No. 3 and it is even less likely that it could be produced from ore No. 1. On the other hand, there is a little more chance that silicomanganese could be produced from a blend of ores 1 and 3 by the standard smelting method.

Obviously either of the last two alloys in Table 2 could be produced from any one of the three ores submitted, if an appropriate quantity of iron ore were to be added to the furnace charge. However, it should be pointed out that the selling price of these alloys would be comparatively low, and the demand for them would be less than for the higher alloys.

One other possibility should be mentioned. Judging by the literature, a considerable amount of very high grade manganese ore (manganese/iron ratio up to 600) occurs in or near Ghana. If a comparatively small quantity of such ore were to be blended with any one of the submitted ores, but particularly No. 1, then any of the manganese ferroalloys could be produced by standard smelting methods.

One of the more important contaminants in manganese ferroalloys is phosphorus. As shown in the enclosed report (Mines Branch Research Report R 19) an ore containing 0.06% phosphorus gave a silicomanganese containing 0.2% phosphorus when smelted in our 250 kva furnace; also a slag containing 0.4% phosphorus, when smelted, gave a silicomanganese containing 1.6% phosphorus. Thus, ore from shipment No. 1 might be expected to give a silicomanganese containing 0.8% phosphorus, and No. 2 and No. 3 ores one containing 0.4% phosphorus. Values of phosphorus less than 0.4% are preferred by the consumers. As far as we are aware, there is no commercial method of obtaining a low-phosphorus ferroalloy from a high-phosphorus raw material.

Other Considerations

It should be pointed out that the properties of the ore are not the only important considerations when deciding whether or not to install a commercial smelting plant. The following are points which

also must be considered:

- (1) the size of the ore deposits
- (2) the distance between the ore deposits and the source of electric power
- (3) the distance that the reductant would have to be transported.

It may be added that high grade coke would not be required as reductant, since lower grade carbonaceous material would be satisfactory.

CONCLUSIONS

It is concluded that, using these particular ores, the production of a suitable grade of ferromanganese at a suitable price would be very difficult. It is barely possible that silicomanganese could be produced more readily, using a combination of No. 1 and No. 3 ores; however the success of such a project would depend partly on how low a phosphorus content could be obtained in the product.

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