

X-RAY STUDIES OF THE IRON ORES FROM CHICALI AREA OF THE KALABAGH ORE-FIELDS

The Analysis of the Component Mineral Phases

DABIR AHMAD, M. SUALEHIN AND S.S.H. RIZVI

Physics Division, Central Laboratories, Pakistan Council of Scientific and Industrial Research, Karachi

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A detailed X-ray analysis of the Chichali ore has been undertaken in order to determine its different constituent mineral phases. This study shows that the ore contains siderite, limonite and glauconite as its major constituent components. In some samples chamosite has also been detected. Thus this ore seems to be somewhat different from those of the Kutch-Khartop and Ziarat ores in composition, but perhaps the presence of glauconite in this ore may present much the same kind of problems for the successful recovery of iron as have been experienced with the other ores.

Introduction

In continuation of the earlier investigations¹⁻⁵ on the iron ore deposits of Pakistan, the studies of the ores from the Chichali area of the Kalabagh district have been undertaken in order to determine their mineralogical composition with a view to assess their workability in steel industries. Much attention has, in recent years, been focused on the iron ore resources of this country, and as a result, detailed investigations have been carried out on the ore reserves of the Kutch-Khartop area of the Kalabagh district and also of the Ziarat area of Quetta, which until a few years back appeared to be the main iron ore reserves of Pakistan. Since 1961, however, attention has been diverted towards the Chichali ore-field, the estimated reserves of which are over 213 million tons⁶—much larger than either of the above mentioned ore resources—and are therefore of considerable importance for our potential steel industries.

The result of the investigations on the Kutch-Khartop ore have been reported in a series of papers.¹⁻⁴ These results have been of considerable value in the appreciation of the problems associated with the recovery of iron from these ores. The mean representative sample of this ore contains about 33.5% Fe, which is present in four different phases, namely haematite, siderite, limonite and chamosite. The first three of these phases are comparatively easily amenable to simple methods of reduction, but chamosite, which accounts for about 30% of the ore, is a ferruginous clay material, of composition $3(\text{Mg,Fe})\text{O}\cdot\text{Al}_2\text{O}_3\cdot 2\text{SiO}_2\cdot n\text{H}_2\text{O}$ and presents the main difficulties in the successful recovery of iron from these ores. The Ziarat ores⁶ are essentially similar in composition, with the added disadvantage that these contain even lesser percentage of iron.

The Chichali ores, having on an average about 33% Fe, have become of considerable importance

particularly because of their much higher estimated reserves, and attempts have therefore been made in this laboratory to determine their mineralogical composition with a view to assess their workability in steel industries.

Experimental

The X-ray methods have been used in the present study. Together with the mean representative sample, a few hand-picked samples were also studied in the hope that these may provide some information for the identification of particularly those phases that may be present in smaller quantities. The X-ray powder photographs of the mean and the hand-picked samples were taken using Cr-radiation with a 11.4 cm. diameter powder camera; the powder photographs of the mean sample were taken with filtered Cr K α radiation, the others being taken with unfiltered Cr-radiation. The d-values of the lines on the pattern of the mean sample together with the visual estimates of their intensities are reported in the first column of Table 1. A search through the A.S.T.M. X-ray data cards⁷ shows that most of the lines of this pattern could be explained by the powder data of iron carbonate (FeCO_3) and limonite ($\text{Fe}_2\text{O}_3\cdot \text{H}_2\text{O}\cdot n\text{H}_2\text{O}$). For confirmation, the powder patterns of these compounds were directly compared with the pattern of the mean sample: this showed satisfactory correspondence. The strongest line of iron carbonate, corresponding to $d=2.8\text{ \AA}$ is outstandingly prominent on the mean pattern, indicating thereby that this phase is present in the ore in comparatively larger proportions than limonite. However, it is significant here to note (Fig. 1) that on almost all of the patterns of the hand-picked samples, except the one shown in the middle of Fig. 1 the line of $d=2.8\text{ \AA}$ (indicated by \downarrow) is only just detectable, whereas the lines due to limonite appear much more prominently. Based on arguments similar to those made in the case of the Kutch-Khartop ores,³ it seems most

likely that iron carbonate is being gradually transformed into limonite. This transformation would effectively result in the enrichment of the ore in Fe content, and so by following this transformation through the various depths and levels of the ore-field one may hope to get some idea about the possible sources of the rich deposits of these ores.

pattern.* As can be seen from Table 1, siderite, limonite and glauconite explain most of the lines of this pattern, indicating thereby that these form the major constituent minerals of this ore.

The Hand-picked Samples.—The powder patterns obtained from the hand-picked samples are shown

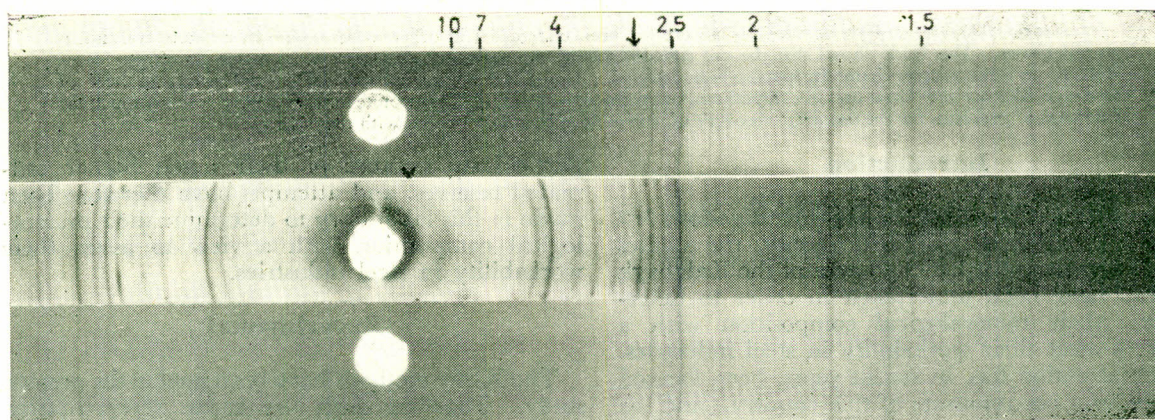


Fig. 1.—Comparison of the powder patterns of the three hand-picked samples.

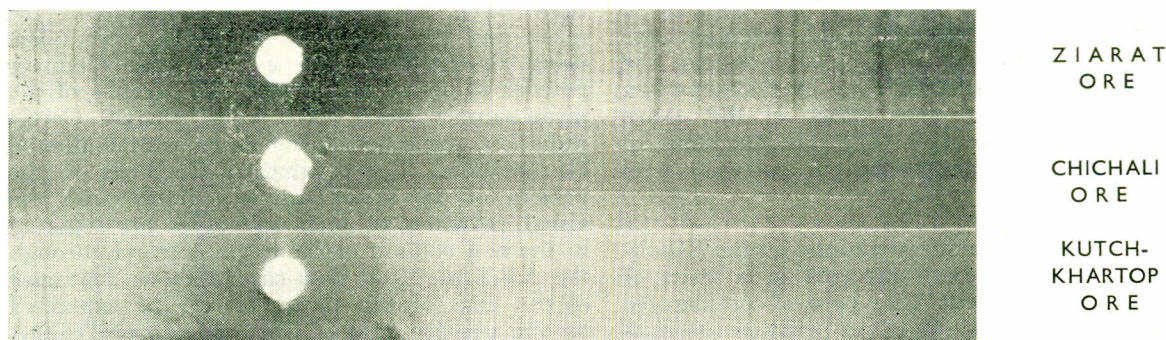


Fig. 2.—Comparison of the powder patterns of the Ziarat, Chichali and Kutch-Khartop ores.

After accounting for the lines due to iron carbonate and limonite there still remain a number of lines on the pattern of the mean sample which need to be accounted for. Most significant of them all is a diffuse line corresponding to $d=10\text{\AA}$ (seen more clearly on some patterns of the hand-picked samples and is indicated by V in Fig. 1) which has not been observed previously on any of the patterns of Kutch-Khartop and Ziarat ores (Fig. 2). From the A.S.T.M. X-ray data cards, this line indicated the presence of glauconite ($\text{K}_2\text{O} \cdot 2\text{MgO} \cdot 3(\text{Fe,Al})_2\text{O}_3 \cdot 12\text{SiO}_2 \cdot 6\text{H}_2\text{O}$), the detailed X-ray data of which are given in Table 1 and can be seen to be in reasonable agreement with the unexplained lines of the sample's

in Fig. 1. These patterns correspond with each other very closely; the X-ray powder data of the sample corresponding to the middle pattern of Fig. 1 are given in Table 1. As has been mentioned earlier, these patterns differ from the pattern of the mean sample very notably in that the strong line of iron carbonate ($d=2.8\text{\AA}$) is only just detectable on them, except on the pattern shown in the middle of Fig. 1 on which this shows up as a weak and spotty line. The conclusions

*Amongst the A.S.T.M. X-ray data cards there appear three different cards for glauconite, so only the data of the one which are in closer agreements with the pattern under study have been reported in the Table.

TABLE I.—COMPARISON OF THE X-RAY POWDER LINES OF THE IRON ORE SAMPLES WITH DIFFERENT STANDARD DATA.

Mean sample	Siderite	Limonite	Glauconite	Hand-picked sample	Chamosite	Kaolinite	Calcium carbonate
d.f.	10.00		10.0(20)	d.w. 10.00			
				d.w. 7.00	6.94(100)	7.15(100)	
				f 5.50			
f	4.50		4.9(10)	w 5.00			
s	4.18	4.18(100)	4.50(50)	m 4.52	4.64(80)		
				s 4.18			
f.w.	3.60	3.61(27)	3.67(50)	d.f. 3.72			
				d.f. 3.59	3.51(80)	3.57(100)	
w	3.35	3.39(30)	3.31(70)	m 3.35			
			3.09(20)	w.m. 3.08			3.035(100)
				w 2.95			
s	2.80	2.80(100)	2.86(20)	m.s. 2.81	2.78(50)		
m	2.70		2.68(10)	s 2.68	2.69(70)		
m	2.58	2.58(30)	2.58(100)	m 2.59			
				f 2.54		2.55(70)	
				f 2.49	2.51(70)	2.49(80)	2.49(14)
s	2.45	2.45(100)		s 2.45			
			2.40(50)	f 2.41			
f	2.36	2.36(17)		f 2.36		2.37(70)	
					2.33(10)	2.33(90)	
w	2.25	2.25(40)	2.26(10)	f 2.26		2.28(80)	2.285(18)
w	2.20	2.19(60)	2.19(—)	f 2.19			
w	2.15	2.13(20)	2.14(20)	f 2.15	2.13(50)		
f	2.01		2.00(20)	f 2.00			2.095(18)
w.f.	1.975	1.95(20)		w.f. 1.975		1.985(70)	
				f 1.925			1.91(17)
				f 1.89			1.88(17)
				f 1.87			
f	1.81	1.79(7)	1.83(20)	f 1.81			
m	1.74		1.82(10)	f 1.74	1.77(40)		
m.s.	1.725	1.73(40)	1.72(80)	s 1.725			
f	1.69	1.69(20)	1.66(50)	w 1.69			
				w 1.67			
						1.659(80)	
f	1.61	1.60(20)		w.m. 1.61		1.616(70)	
m	1.57	1.56(60)		m 1.57	1.56(60)		
m	1.52	1.50(11)	1.52(100)	m 1.52	1.53(40)		
			1.50(20)		1.48(20)	1.486(90)	
w.m.	1.46	1.45(40)		w 1.46			
w	1.425	1.43(8)		w.f. 1.425	1.43(20)		
				f 1.40			
			1.38(10)				
f	1.365	1.35(9)		f 1.365			

The numbers within the parenthesis following the d-values for the standard patterns represent their intensities. The lines below 1.35 A.U. have been omitted. The notations for the intensities have the following meanings:- s=strong, m=medium, w=weak f=faint, d=diffuse.

that could be drawn from this observation have already been discussed in the preceding paragraphs. Another notable feature of this pattern (the middle pattern of Fig. 1) is the appearance of a somewhat diffuse line of $d=7.0 \text{ \AA}^\circ$ which can be identified to correspond with one of the strong lines of kaolinite and/or chamosite patterns. The standard powder data of chamosite and the strong lines of kaolinite (of intensity equal to or

greater than 70) are given in Table I. It may be observed, from this Table, that two of the strong lines of kaolinite, corresponding to d-values of 2.33 and 1.49 \AA° , are missing on the pattern of the hand-picked sample—these absences have been carefully checked on the actual photograph. This observation suggests that kaolinite, if at all present, must be in very small quantities. The standard data of chamosite, on the other

hand, gives much better agreements favouring thereby the possibility of the presence of chamosite in this ore sample. Besides these phases, there appear to be present small quantities of other less important phases as well, one of which is calcium carbonate.

In Fig. 2 a comparison has been made of the powder patterns of the three ore samples, viz. those of the Chichali, Kutch-Khartop and Ziarat areas, in order to see at first glance the general compositional variations of these ores. It can be seen quite evidently that the powder patterns of the Chichali and Kutch-Khartop ores have many common features, which is in accord with what one should have expected from the knowledge of the component mineral phases of these ores, which are given in Table 2 for ready reference.

TABLE 2.—COMPONENT MINERAL PHASES OF THE CHICHALI, KUTCH-KHARTOP AND ZIARAT ORES.

Ores	Main phases	Other phases
Chichali ores	Siderite, Limonite, Glauconite	Chamosite, Kaolinite, Calcium carbonate
Kutch-Khartop ores	Siderite, Haematite, Limonite, Chamosite	Kaolinite, Bobimite, Quartz
Ziarat ores	Haematite, Chamosite	Bobimite, TiO_2 , $MgCO_3 \cdot 3H_2O$

Discussion

The Chichali ore consists of three iron-bearing phases, namely siderite, limonite and glauconite and has much in common with those of the Kutch-Khartop ores, except for the important difference in that this contains a fair proportion of another iron-bearing siliceous mineral, glauconite. On leaching this ore with water, fine particles were observed to be left in colloidal suspension, the X-ray powder photographs of which revealed that these were not different from the rest of the mass, and suggested thereby that the ore components were all very finely distributed. Thus

it appeared that this ore would present very much the same kind of problem in the successful recovery of iron, as have been experienced with the Kutch-Khartop ores.

As has been mentioned earlier, one of the hand-picked samples of the ore indicated the presence of chamosite also in smaller quantities. That some samples from the Chichali area should contain chamosite as well appears somewhat interesting. The Chichali ores belong to the same belt of ore ranges of the Kalabagh district of which Kutch-Khartop ore-field forms a part. It is therefore, not unlikely that there should be some relationship between these ores, and therefore the compositional variation of these ores, as one goes along from one part of the ore-field to the other, should form an interesting study by itself.

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