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MINERALOGICAL AND SOME OTHER PROPERTIES OF CHROMITE FROM MALA KAND AREA

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A study has been made on Chromite from Malakand area. Its geology, chemical composition, X-ray diffraction, differential thermal analysis, petro-graphic analysis and specific gravity are presented. The associated minerals are antigorite, chrysotile, olivine, chlorite, iddingsite and serpophite. Chemically the ore contains 38.85 to 53.15% Cr_2O_3 with permissible amount of silica and iron oxide for the manufacture of chrome and chrome-magnesite refractories.

INTRODUCTION

Refractory grade chromite occurs in many parts of Baluchistan. Considerable amount of the ore occurs at some localities of Saplaitorghar and Khanozai of Muslimbagh, Chagai Kharan [1] and in the northern flank of Zhob Valley around Muslimbagh[2]. The chromium to iron ratio in these areas is around 2.6:1. Some work has already been done on chemical and mineralogical compositions of chromites by Ali etal[3]. The purpose of the present study is to evaluate the Malakand Chromite for refractory purposes as this deposit is centrally placed in a rapidly developing region of Pakistan. Moreover this deposit is the second largest in Pakistan[4]. Detailed investigations including chemical, microscopic, differential thermal analysis and some other studies were carried out to find out the possible use of the ore in refractories.

Occurrence. The preliminary geological account of the area is given by Hussain[5]. According to him, the area is composed of Ultramafic rocks where three larger and a few smaller out-crops are present making an elongated belt of about 13 by 3 miles. The Ultramafic body is composed mostly of Harzburgite nearly ¾ of the mass; with small conformable out-crops of the dunite in which chromite occurs as distinct primary layers. Gabbroic rocks are also seen along the northern contact. In the altered Gabbroic rocks, rodingite occurs at stringers [6].

The hand specimens, the ore is medium to rather coarse-grained. It is a black lumpy and loose to compact rock and often elongated to develop primary layering with serpentine, Olivine and other gauge meterials.

The microscopic study shows that 30-90% of chro mite is generally present in the rocks. The associated minerals are antigorite chrysotile, Olivine, Chlorite, iddingsite and serpophite. The rocks are fine to medium-grained where medium grained material is generally chromite and they are usually anhedral to subhedral in form. The grains are usually loosely packed in some rocks while in others these are closely packed to give a dense structure to the rock. As seen in hand specimens some chromites also exhibit layering, conspicuous, pull-apart and occasional microfolding.

Chromite. The grains of chromite are generally anhedral in shape; their size is generally from 0.4 to 1mm, but occasionally some rocks have 1-4 mm coarse grains (Nos. 1,2,6, & 7). The colour of the grains is brown and reddish brown which shows the composition to be picotitic (Nos. 1,2,5,6 & 7). In most of rocks the grains are fractured and along the fractures, the chromite is altering to maghemite. In some grains alteration to maghemite is also very common at the rims and intensity of alteration is much more along the cracks which obtain a thickness of 0.15 mm, 0.6 mm, 0.5 mm, 0.3 mm, 0.25 mm and 0.35 mm in sample Nos. 5,7,4,6,1 and 2 respectively. In some rocks the grains of chromite contain inclusions of Olivine and antigorite (Nos. 1,2,3,4,5, and 6). In some rocks the cracks are quite regular.

Maghemite. It is an alteration product of chromite which is dense black and is conspicuously developed along cracks and on the edges. The intensity of alteration depends on the width of dense black material which is from 0.15 mm to 0.6 mm in the rock grains of all the samples. It is present in small amount in the grains of all the samples but grains of sample Nos. 1,2 & 4 have almost double the amount of this mineral.

Olivine. It occurs as very fine to as much as 0.6 mm and some times upto 1 mm anhedra. It is colourless and shows a higher relief than its alteration products antigorite and chrysotile. In sample Nos. 4 &7, the Olivine alters to iddingstie. Some of the Olivine grains in smaple No. 6 show vacinal twinning. There is great variation in the amount of ths mineral. Sample Nos. 1,2, & 7 have very small amount of Olivine in their grains whereas grains of sample No. 5 & 6 have almot double the amount. However, sample Nos. 3 & 4 have still a greater amount of Olivine in their grains.

Antigorite. It is present as very fine leaf-like grains with low interference colour and non-pleochroic. It is found almost equally distributed in small amounts in the grains of all the samples.

Chrysotile. It occurs as thin veinlets all along Olivine grains and shows bipartite structure. It is found in the grains of sample Nos. 2,3,4,5 & 7 in very small amounts, while sample No.4 has slightly greater amount.

Serpophite. The very low bi-refringent material enclosed in the cross-fibres of chrysotile bears the properties of serpophite. It is present in small amounts in the grains of sample Nos. 1,6 & 7.

Iddingsite. Alightly pleochroic from light brown to brown material in veinlet is iddingsite. It occurs closely alongwith Olivine in sample No. 7. It is present in very small amounts in the grains of smaple No.7 only.

Chlorite. It is present only in sample No. 7 in a very small amount. It is slightly pleochroic in low-birefringent flakes.

Bastite. It is present only in sample No.2 in a very small amount. It is an alteration product of pyroxene where the traces of cleavages and its form are preserved.

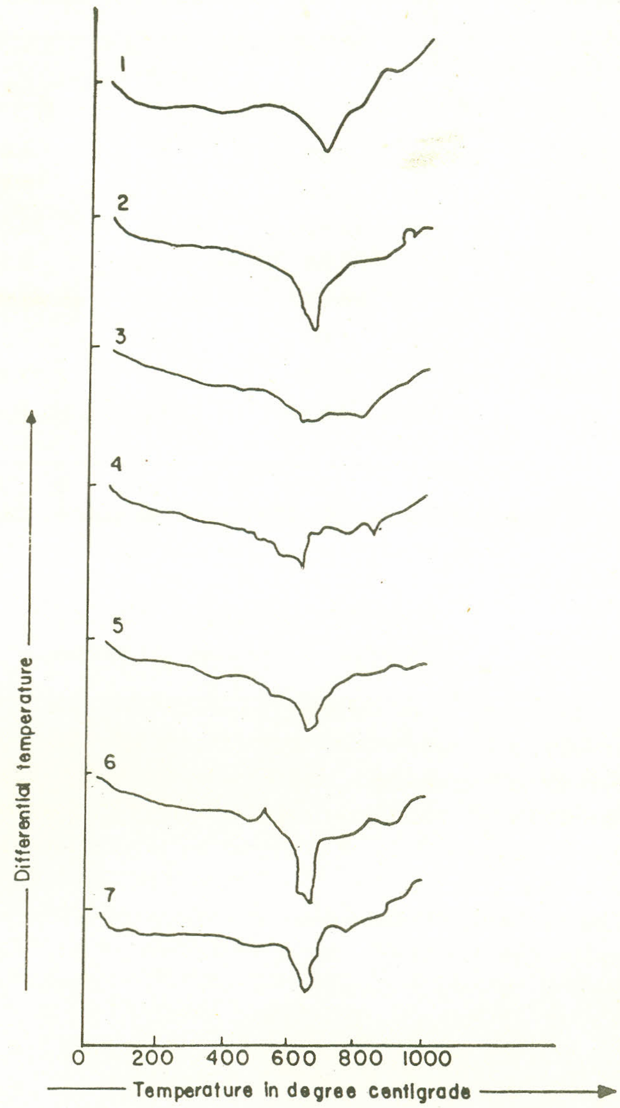

Fig. 1.

EXPERIMENTAL

The chemical analysis of the ore presented in Table 1 were done by the routine methods described by Scott's Standard Methods of Analysis [7] and were checked in the light of the improved method of Bilgrami and Ingamells [8].

Porosity, bulk density and specific gravity were determined using 1-3 inch pieces of the ore. The specific gravity of the powdered samples were determined by using specific gravity bottle. The results are given in Table 2.

Differential thermal analysis (DTA) was carried out on powdered samples (100 mesh) after being dried at 110°. The smaples were heated at the rate of 250°/ hour upto a temperature of 1000°. The restults are given in Fig. 1.

X-ray photographs were obtained of the powdered mounts of the chromite samples to confirm the microscopic results. For this purpose a 19 cm Camera was used. The radiation being Cr unfiltered with a voltage of 35 KV and current of 15 . Three sample Nos. 2,5, & 6 were selected for this purpose on the basis of variations in their chemical composition but having similar X-ray pattern. The minerals present were identified by comparison with the d' values as given in the ASTM File (1963). A composite data is presented in Table 3.

The thin and polished sections of the ore were studied under the microscopic to observe the possible mineral phase.

RESULT & DISCUSSIONS

Seven physically different samples of the ore were studied regarding their chemical composition (Table I). The

Table 1. Chemical analysis of chromite ore

Sample No. 1		2	3	4	5	6	7
SiO_2%	1.56	2.03	1.84	1.78	2.01	2.35	1.98
Al_2O_3%	14.32	12.90	16.11	15.62	17.32	16.89	10.15
FeO%	10.41	10.63	12.32	8.56	11.49	10.85	11.54
Fe_2O_3%	3.94	3.04	0.57	1.24	0.59	3.85	2.81
Cr_2O_3%	40.17	43.66	48.89	50.63	42.17	38.85	53.15
CaO%	1.00	0.16	0.15	Tr	0.26	0.72	Tr
MgO %	23.80	22.16	17.32	20.02	23.02	22.32	17.60
I/Loss	3.82	2.98	1.36	3.01	2.80	1.98	1.12

Table 2. Porosity, bulk density and sp. gravity

Property	Malakand Chromite	Baluchistan Chromite	Shetland Chromite
Porosity	4.31	–	4.1 – 5.3
Bulk Density	3.512	–	2.99
Sp. Gravity	3.732	4.32	3.15 – 3.22

chief oxides determined being SiO_2, Cr_2O_3, FeO, Fe_2O_3, Al_2O_3, MgO and CaO. Geo-chemical work on chromite has been reported by Malhotra *et al* from Muslimbagh (Hindo bagh) Pakistan.[9]. According to Malhotra the Chrome ore with less than 8% SiO_2 and 20% Fe_2O_3 is preferred for chrome magnesite refractories. According to Budnikov the chromite ore for refractories should not have more than 6.481% SiO_2, 1.0-1.5% CaO and Fe_2O_3 not over 16%[10]. According to the chemical composition as shown in Table 1 the SiO_2 content of the samples varies from 1.56 to 2.35% and the Cr_2O_3 varies from 38.85 to a maximum of 53.15% in the whole ultramafic body. The Cr_2O_3 contents in sample Nos. 1,2,5 & 6 being from 38.85 to 43.66% while sample Nos. 3,4, & 7 have higher Cr_2O_3 content ranging from 48.89 to 53.15%. The amount of FeO in sample Nos. 1,2,3,4,5,6 & 7 lies between 10.40 and 12.32% whereas sample No.4 has 8.56% FeO. The Fe_2O_3 contents in sample No. 1,2,6 & 7 are found between 2.8 and 3.95% while sample Nos. 3,4 and 5 have much lower FeO varying from 0.57 to 1.24%. The CaO content in all the samples is very low whereas the MgO in sample Nos. 1, 2,5 and 6 ranges from 22.16 to 23.02%. Sample Nos. 3,4 & 7 have 17.32, 17.60 and 20.02% of MgO respectively. As far as the chemical composition of the ore is concenred it may be suitable for chromite containing refractoreis because it can not make a great amount of the low melting magnesium silicates and monticellite on account of low silica and lime contents. Silica is calculated as serpentine (3 MgO. $2SiO_2$) which is not over 4.70% in the ore. According to Lynam and Nichlson[11] the chemical composition alone of chromite does not give a clear indication about its suitability in refractories. The DTA curves of the chromite samples were, therefore, obtained.

Porosity, bulk density and specific gravity of the ore were determined and given in Table 2. The comparison of our data with those described byLymam *et.al*[12] shows that our samples have fairly high values of these properties confirming the presence of low amount of gangue material like Serpentine (Antigorite) etc.

Banerjee and Ramesam[13] have described that the spinel constituent of the chrome ore does not undergo thermal changes on heating to a temperature of 1000°. Howie & Lakin[14] have, however, given peak temeprature around –600° and +800° due to the presence of gangue mineral chrysotile, antigorite and chlorite. The magnestie gives one endo-thermic peak between 650 and 680° [15,16]. The thermal curves of our samples are given in Fig.1. Only one dominant endothermic peak at about 695, 665, 630, 625, 650, 660 and 650° is found in sample Nos. 1,2,3,4,5,6 and 7 respectively which may be an indication of the presence of silicate minerals like antigorite, chrysotile, chlorite serpophite, and magnesite. The minor additional peak at about 800° given by sample No. 3 and 4 Is probably due to the presence of chromium chlorite or chlorite alone. As the chrysotile gives higher endothermic values than antigorite it may be concluded that all the samples are rich in antigorite with the exception of sample No. 1 which has an exothermic peak at 850° indicating higher percentage of chrysotile than other minerals in the sample [17]. Sample Nos. 1,5,6 & 7 having endothermic peak at 500° shows the presence of some goethite. The thermal curve at 780° obtained in case of sample No.6 is suggestive of the presence of little amount of pyrophyllite in additon to antigorite.

Table 3. X-ray diffraction of chromite ore

Radiation Cr-Unfiltered Current 15mAmp Voltage 35 KV

'd' values of chromite ore				A.S.T.M. 'd' values							
				Chromite				Magnesite			
F	7.0	MW	1.54								
F	5.5	MS	1.47	M	4.82	W	0.979	S	2.742	W	1.0669
MW	4.75	VF	1.43	M	2.95	MW	0.96	W	2.503	VW	1.051
WF	3.6	F	1.40	S	2.52	W	0.931	VW	2.318	MW	1.0145
WF	3.22K β	F	1.39 K β	W	2.40	W	0.873	M	2.102	W	0.9134
M	2.92	W	1.315	MS	2.07	M	0.850	W	1.939		
MW	2.75 K β	M	1.265	MW	1.69	W	0.815	VW	1.769		
S	2.5	W	1.25	S	1.60	MW	0.805	MW	1.70		
VF	2.40	MW	1.20	S	1.46			W	1.510		
W	2.28 K β	MF	1.188	W	1.40			W	1.488		
MS	2.08	W	1.61	W	1.31			W	1.476		
F	2.00			M	1.26			W	1.371		
VF	1.86			W	1.20			W	1.354		
MW	1.76 K β			W	1.16			W	1.338		
MW	1.69			W	1.11			W	1.252		
MW	1.61			M	1.10			MW	1.238		
M	1.60			W	1.04			MW	1.110		

Three sample Nos. 2,5, & 6 were subjected to the X-ray powder diffraction technique. The results are given in Table 3. Our chromite ores have strong 'd' values at 2.50; medium strong at 2.08 and 1.47; and medium at 2.92 1.60 and 1.265. The corrosponding ASTM 'd' values for chromite are strong at 2.52, 1.60, 1.46; medium strong at 2.95, 2.07, 1.10, and 0.850. On comparison of these values of our ores with the ASTM values, it may be concluded that the ores have the major spinel FeO, Cr_2O_3. The standard ASTM 'd' values of magnesite are strong at 2.75 and medium strong at 1.68. Medium weak 'd' values at 2.75 and 1.69 in the samples are suggestive of the presence of some magnesite.

CONCLUSIONS

1. The Chemical composition of the ore reveals that it contains a small amount of the low melting silicate minerals.

2. The data of low porosity, high specific gravity and bulk density of the ores show that it obtains a low amount of gangue material.

3. The petrographic data of the ore show that it contains very small amount of different silicate minerals.

4. The D T A curves show that the ore contains a small amount of antigorite (Serpentine) chrysotile, chlorite, goethite and serpophite etc. with a comparatively higher amount of magnesite.

5. The X-ray diffraction result shows the presence of FeO. Cr_2O_3 as the major spinel with a small amount of magnesite.

On the basis of the above results it may be concluded that the chromite ore investigated is of good quality and it may be successfully utilized for the development of high quality chrome and Chrome-Magnesite refractories.

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