ZINC-BEARING CHROMITE

M. Donath, *Bergakademie, Freiberg, Saxony.*

The October 1929 issue of the American Mineralogist published a paper by L. W. Fisher, entitled "Chromite: Its Mineral and Chemical Composition." On the strength of an extensive study of more than 150 analyses, Fisher distinguishes four chemically different groups which in turn have four subdivisions. Most varieties of chromite can be classed in his groups IIa, IIIa, and IIIc, which have the following chemical compositions:

(IIa) $FeO \cdot Al_2O_3 \cdot Cr_2O_3$
(IIIa) $FeO \cdot MgO \cdot Al_2O_3 \cdot Cr_2O_3$
(IIIc) $FeO \cdot MgO \cdot Fe_2O_3 \cdot Al_2O_3 \cdot Cr_2O_3$

In his conclusions, Fisher makes the statement that "various members of the spinellid group are isomorphous with each other, but all the members cannot be arranged in a definite isomorphous series," and that "chromite does not contain zinc and cannot be a true variant of a series which contains gahnite."

The writer had the opportunity of making a study of chromite deposits, including a detailed microscopic investigation of various ores from 22 different occurrences from all parts of the world. In two cases, in ore from Ramberget and Värnäsfjeld, near the Island of Hestmandö, Norway, zinc was found as an isomorphous mixture in chromite. This fact is all the more noteworthy as these very occurrences are considered as "standard" types of chromite deposits, in various text books such as Lindgren, Beck, and Beyschlag-Krusch-Vogt. The physical and chemical characteristics of the zinc-bearing chromite are dealt with in detail in the following paragraphs.

Macroscopically the color of the ore is much like that of ordinary chromite, its luster, however, being considerably higher. The mineral has no cleavage. The streak is blackish-brown, being obviously different from that of pure chromite. The hardness varies from 6 to 7; the specific gravity was found to be 4.5. The magnetic properties of the ore are remarkable; even small particles show polar magnetism.

Studies of thin sections and polished sections of zinc-bearing chromite afford the observation of more distinguishing features.

Polished sections of ore from Hestmandö were remarkably easy to make, and a good polished surface was obtained after sufficient preliminary grinding with very fine emery. On the polished section the color of the ore is like that of ordinary chromite and no difference could be found after various etching tests. Polarized light, however, is affected by the mineral, causing anisotropism, although only to a slight degree. This is the most remarkable point of difference for distinguishing zinc-bearing from ordinary chromite. In thin sections the mineral is absolutely opaque, even in exceedingly thin slides, which is another distinguishing feature.

These physical properties (streak, color, hardness, optical behavior), being different from those of ordinary chromite, induced the writer to obtain a complete chemical analysis of the ore.

The material for the analysis was carefully selected ore from the occurrence at Ramberget. Two thin sections and two polished sections were prepared from the specimen used for the analysis, as a check on the homogeneous character of the ore. These sections showed all the above mentioned physical properties.

Minute inclusions of some silicate were detected in the ore, varying in size from 3 to 60 microns, the average being between 10 and 20 microns. These particles consisted of olivine and a very little plagioclase. The carefully powdered ore was separated from the small amount of silicate by means of a magnet. Although this method afforded a fairly clean separation, it was impossible to remove all silicate grains intergrown with ore of an approximate size of less than 10 microns. Experiments attempting to remove these traces of silicates by means of centrifugal force were unsuccessful on account of the minute size of the inclusions.

The results of the chemical analyses of the ore, prepared as described above, were as follows:

	Analysis I Per cent	Analysis II Per cent
Fe_2O_3	50.49	50.28
Cr_2O_3	41.48	41.84
Al_2O_3	0.35	0.76
MnO	Trace	Trace
NiO	Trace	Trace
MgO	4.68	4.88
ZnO	2.62	2.21
SiO_2	1.74	1.45
	101.36	101.42

In order to facilitate a comparison of the results, the values of the analyses were calculated as spinellid components. The silica was accounted for as contained in olivine. The value for $FeO \cdot Fe_2O_3$ may not be quite accurate, as FeO was not determined in the analyses. Thus a possible isomorphous admixture of Fe_2O_3 may have escaped the computation.

In the following are the values calculated from analysis II:

61.61%	$FeO \cdot Cr_2O_3$
18.62%	$MgO \cdot Fe_2O_3$
8.48%	$FeO \cdot Fe_2O_3$
6.55%	$ZnO \cdot Fe_2O_3$
1.06%	$MgO \cdot Al_2O_3$
2.39%	Olivine
98.71%	

In order to obtain values for the zinc-bearing chromite free of silicates, the latter were computed as $(Mg_2SiO_4)_{90} \cdot (Fe_2SiO_4)_{10}$, and percentage values were calculated for the pure ore:

63.96%	$FeO \cdot Cr_2O_3$
19.33%	$MgO \cdot Fe_2O_3$
8.80%	$FeO \cdot Fe_2O_3$
6.81%	$ZnO \cdot Fe_2O_3$
1.10%	$MgO \cdot Al_2O_3$
100.00%	

The above analysis classes the Hestmandö ore with the members of the spinellid group, belonging to the subdivision of the chromium spinels on account of the high content of Cr_2O_3.

It is distinguished from ordinary chromite by a considerable admixture of MgO, ZnO, Al_2O_3 and Fe_2O_3. The presence of ZnO as an isomorphous admixture in the subdivisions of chromium spinels is entirely new.

Since it is known that compounds of the structure of the spinellid group may be dimorphous, an *x*-ray investigation became necessary to explain the optical behavior of the mineral.

The *x*-ray photograph was taken after the method of Debye-Scherrer, with a revolving camera of 5.7 cm. diameter. For reference an *x*-ray picture was also taken of a pulverized single chromite crystal from Svilare, near Ueskub, Macedonia.

The results, given by the number and the intensity of the lines, were as follows:

Ore from Ramberget, Hestmandö Time of exposure 2160 milliampere-minutes		Chromite from Svilare Time of exposure 2250 milliampere-minutes	
Angle of reflection	Intensity	Angle of reflection	Intensity
19°21′	medium to weak		
20°42′	medium to weak	20°30′	weak
22°54′	strong	23°00′	strong
25°00′	weak	25°30′	very weak
27°48′	medium	28°00′	weak
33° 9′	medium	33°00′	weak
34°12′	medium		
36°36′	medium		
37° 6′	strong	37°36′	medium
41°00′	strong	41°30′	strong
49°21′	very weak		
54°27′	very weak		
62°42′	very strong	63°54′	strong
67°42′	strong	69° 6′	strong

The photographs show the same isometric lattice in both ores. The larger angle of reflection of the Svilare ore, compared with the Ramberget ore, indicates a distinct change of the parameter.

Summarizing the results of the investigation of the chromite from Ramberget, we may characterize the ore as a new member of the chromite group, distinguished by a high percentage of Cr_2O_3 and a noticeable isomorphous admixture of MgO, FeO, ZnO, and Fe_2O_3. The *x*-ray investigation showed an isometric lattice. Thus the anisotropism of the mineral has to be accounted for as an optical anomaly, due to the isomorphous admixtures, causing irregularities in the fine structure of the mineral.