RELATIONSHIP BETWEEN THE SPECIFIC MAGNETIC SUSCEPTIBILITY AND THE IRON PLUS MANGANESE CONTENT OF CHLORITE

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ABSTRACT

The specific magnetic susceptibilities of eleven chlorites were calculated from their chemical compositions and also measured by means of the Frantz isodynamic separator. The calculated values indicate a linear relationship between the specific magnetic susceptibilities and the total iron-plus-manganese content of chlorities. This relationship may be expressed by the equation $C = 0.12 + 0.559 \cdot 10^{-6} \chi_m$ where C is the total iron-plus-manganese expressed as FeO plus MnO, and χ_m is the mean calculated specific magnetic susceptibility. The measured values for eight of the chlorites follow this relationship, but those for the remaining three chlorites deviate from it by substantial amounts.

INTRODUCTION

Although it has been known for some time that the magnetic susceptibility of ferromagnesian silicate minerals varies considerably with composition, these factors have been correlated for only a few species (Akimoto *et al.*, 1958, Frost, 1960, Nagata *et al.*, 1957, Syono, 1960, and Vernon, 1961). The accepted method of making such correlations is to measure the magnetic susceptibilities of analysed samples with either a magnetic balance or a calibrated Frantz isodynamic separator. Since no such correlations have been reported for chlorites the writer measured the specific magnetic susceptibilities of eleven chemically analysed samples as part of a broader project dealing with this mineral (Petruk, 1964).

EXPERIMENTAL METHOD

The chlorite samples were crushed and sized. The $-100 + 200$ mesh fractions were passed through a Frantz isodynamic separator at low amperage settings to remove ferromagnetic impuritites. The specific magnetic susceptibilities of the sized and cleaned samples were

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then measured at room temperature using the separator calibrated according to the method devised by McAndrew (1957). The measurements were made by altering the current and transverse slope until substantially equal weights of material flowed down each chute.

Chemical Compositions of the Chlorites

The chemical compositions of the chlorites and their structural formulae calculated according to Foster (1962) are given in Tables 1 and 2 respectively.

Table 1. Chemical Compositions of Chlorites Studied

Element	Clark	61	3058	1	3	Ch-65	M.P.	15-4	F-137	F-149	F-88
SiO_2	31.62	29.45	27.80	26.60	24.80	29.61	22.20	24.50	21.17	23.22	22.24
TiO_2	0.31	0.60	1.01	0.30	0.90	0.35	1.00	—	0.07	0.03	—
Al_2O_3	16.10	13.32	19.55	21.80	21.00	22.85	27.00	16.32	20.02	17.45	17.05
Fe_2O_3	2.00	—	4.62	2.80	3.90	2.86	3.70	7.45	9.88	4.09	13.38
Cr_2O_3	0.15	—	—	—	—	—	—	—	—	—	—
FeO	2.69	22.18	20.73	23.30	22.90	31.50	32.50	31.46	33.48	38.90	26.26
MgO	33.93	23.18	19.40	15.60	15.60	10.30	1.00	4.59	3.10	4.54	4.10
MnO	0.10	0.81	0.87	0.60	0.60	0.36	0.40	3.33	0.45	0.01	5.42
H_2O	13.16	—	—	—	—	—	9.80	11.36	10.63	10.89	10.05
H_2O-	—	—	—	—	—	—	—	—	0.57	0.80	0.98

Note: All the chlorites, with the exception of the one designated M.P. are described more fully in Petruk (1964).

Table 2. Structural Formulae of the Chlorites ($X_Q Y_4 O_{10}(OH)_8$)

Atom		Clark	61	3058	1	3	Ch-65	M.P.	15-4	F-137	F-149	F-88
Y	Si	3.00	3.01	2.71	2.69	2.57	2.82	2.42	2.82	2.43	2.69	2.54
	Al	0.97	0.94	1.22	1.29	1.36	1.15	1.50	1.18	1.57	1.31	1.46
	Ti	0.03	0.05	0.07	0.02	0.07	0.03	0.08	—	—	—	—
Total Y		4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
X	Al	0.83	0.67	1.02	1.33	1.21	1.53	1.96	1.03	1.14	1.06	0.84
	Fe^{3+}	0.15	—	0.33	0.21	0.31	0.20	0.30	0.62	0.85	0.36	1.15
	Fe^{2+}	0.21	1.89	1.69	1.97	1.99	2.51	3.54	3.03	3.21	3.75	2.51
	Mg	4.80	3.53	2.81	2.34	2.41	1.46	0.16	0.75	0.53	0.78	0.70
	Mn	—	0.07	0.07	0.05	0.05	0.03	0.04	0.33	0.04	—	0.53
	Q	5.99	6.16	5.92	5.90	5.97	5.73	6.00	5.76	5.77	5.95	5.73

Calculation of Specific Magnetic Susceptibilities

As a check on the susceptibility measurements it is desirable to calculate the approximate susceptibilities from the chemical analyses.

For paramagnetic compounds containing Fe^{3+}, Fe^{2+}, and Mn^{2+} the specific susceptibilities at 20° C may be calculated using the following equation derived by Chevallier & Mathieu (1958).

$$\chi_1 = 423.6 \cdot 10^{-6}(27.6\,x + 34.6\,(y + z)) \quad (1)$$
$$\chi_2 = 423.6 \cdot 10^{-6}(30.6\,x + 34.6\,(y + z)) \quad (2)$$

where χ_1 and χ_2 are the minimum and maximum calculated specific susceptibilities respectively (in e.m.u./gram), and x, y and z are the ionic concentrations (gram ions/gram) of Fe^{2+}, Fe^{3+} and Mn^{2+} respectively. The values for the calculated specific magnetic susceptibilities are given in Table 3, and the relationship between these values and the total iron-plus-manganese in the chlorites studied is shown as a straight line in Figure 1. This relationship may also be expressed by the equation $C = 0.12 + 0.559 \cdot 10^{-6}\ \chi_m$, where C is the weight per cent of FeO + MnO, and χ_m is the mean calculated specific magnetic susceptibility.

Measured Specific Magnetic Susceptibilities

The measured specific magnetic susceptibilities of the eleven chlorites are included in Table 3 and are shown plotted in Figure 1.

Table 3. Compositions and Magnetic Susceptibilities of the Chlorites

Sample	Total FeO + MnO (Fe_2O_3 converted to FeO)	Concentrations of magnetic ions (gm.ions/gm of chlorite)			Calculated specific magnetic susceptibilities (e.m.u./gm)			Measured specific magnetic susceptibilities (e.m.u./gm)
		Fe^{2+} $\times 10^{-4}$	Fe^{3+} $\times 10^{-4}$	Mn^{2+} $\times 10^{-4}$	χ_1 $\times 10^{-6}$	χ_2 $\times 10^{-6}$	χ_m $\times 10^{-6}$	$\chi \times 10^{-6}$
Clark	4.50	3.74	2.50	0.01	8.1	8.5	8.3	7.4
61	22.93	30.87	—	1.14	39.8	43.7	41.7	37.7
3058	25.76	28.85	5.78	1.23	44.0	47.7	45.8	39.4
1	26.42	32.43	3.51	0.85	44.3	48.4	46.3	52.0
3	27.01	31.87	4.88	0.85	45.7	49.7	47.7	40.8
Ch-65	34.43	43.84	3.58	0.51	57.3	62.8	60.0	56.0
M.P.	36.23	45.23	4.63	0.56	60.5	66.2	63.3	61.0
15-4	41.54	43.79	9.33	4.69	71.7	77.3	74.5	98.5
F-137	42.82	46.60	12.37	0.63	73.5	79.5	76.5	96.0
F-149	42.59	54.14	5.12	0.01	70.8	77.7	74.3	98.3
F-88	43.74	36.55	16.76	7.64	78.5	83.1	80.8	76.8

*$\chi_m = \frac{\chi_1 + \chi_2}{2}$.

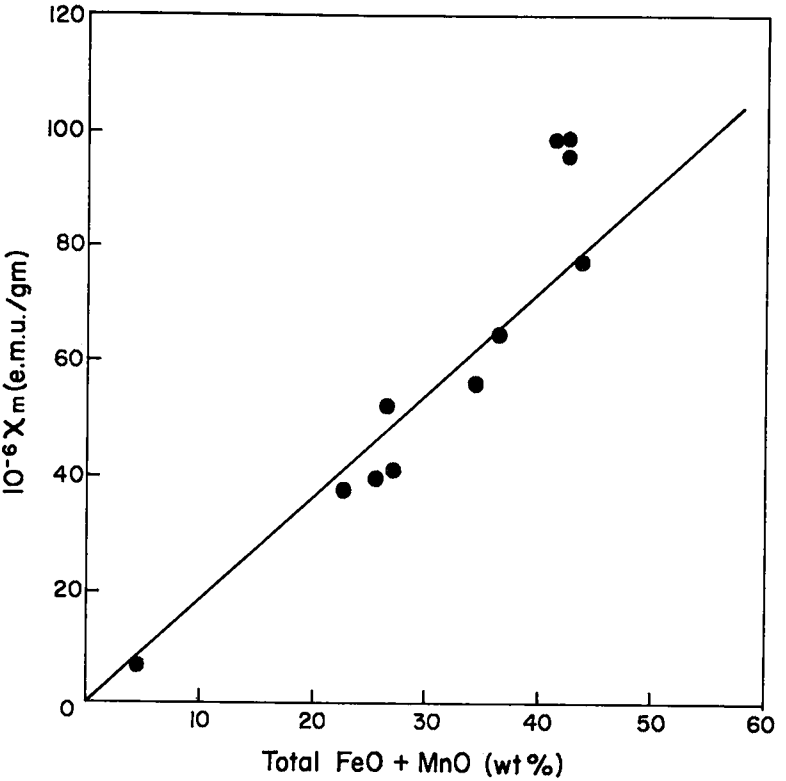

FIG. 1. Relation between χ_m and the total Fe (as FeO + MnO) for the chlorites in Table 3. The points represent measured values of χ; the line corresponds to the linear equation $C = 0.12 + 0.559 \cdot 10^{-6}\chi_m$.

DISCUSSION

A comparison of the calculated and measured values for the specific magnetic susceptibility shows that the specific magnetic susceptibility may be used as an indication of the total iron-plus-manganese content of chlorite. It is to be noted, however, that although good correlations were obtained for eight of the chlorites, the measured values for three of the iron-rich varieties are significantly larger than the calculated ones. The reason for this discrepancy is not known, but one possibility is that the samples contain trace amounts of ferromagnetic impurities.

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