Joseph Nelen
and Brian Mason

The Estherville Meteorite

The Estherville meteorite fell near the town of the same name in eastern Iowa on May 10, 1879. It belongs to the small class of mesosiderites, and is one of only six that were observed falls. The material is particularly suitable for research since it was collected immediately after the fall and has not suffered from the weathering that has seriously deteriorated most other mesosiderites. No complete chemical analysis has been published of the silicate material of this meteorite, hence the present investigation.

Material was taken from specimen number 1722 in the meteorite collection of the United States National Museum of Natural History. The material was crushed to pass through a 50-mesh sieve, and nickel-iron particles were removed with a hand magnet. This procedure evidently failed to remove all the included metal, since 0.14% Ni was determined in the analysed sample; using the figure of 8.57% Ni in the metal phase of Estherville (Powell 1970), this corresponds to 1.6% of nickel-iron. The analysed sample also showed 1.05% S, equivalent to 2.88% troilite. From the total iron determined by analysis the appropriate amounts were allotted to nickel-iron and troilite, and the remainder is reported as FeO. The analysis is set out in Table 1, together with partial analyses of Estherville silicates by Powell (1970) and Jérome (1970). Powell's data were obtained by X-ray fluorescence analysis; Jérome's data by semimicro wet chemical analysis except for Cr_2O_3, obtained from instrumental neutron activation anlysis.

The normative mineralogical composition calculated from the analysis is (in weight percent): pyroxene ($En_{71}Fs_{25}Wo_4$), 72.6; plagioclase (An_{89}), 18.4; troilite, 2.9; nickel-iron, 1.6; tridymite, 1.6; chromite, 1.1; whitlockite, 0.7; ilmenite, 0.5. This is consistent with the observed mineralogical composition, except that a little olivine (estimated 2%) is present; the amount of modal pyroxene is therefore less than normative pyroxene by about 2%, and the amount of modal tridymite will be somewhat greater than the 1.6% in the norm. Modal chromite and ilmenite will be somewhat less than the normative amount, because some chromium and titanium are combined in the pyroxenes. Fuchs (1967) has shown that the whitlockite in Estherville is accompanied by stanfieldite, $Ca_4Mg_3Fe_2(PO_4)_6$.

Estherville is a polymict breccia, and different samples of the silicate material are likely to give somewhat different analyses. This certainly explains, at least

Joseph Nelen and Brian Mason, Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

TABLE 1.—*Analyses of silicate material of the Estherville meteorite*

Constituent	*Chemical analyses (weight percent)*		
	*1**	*2**	*3**
SiO_2	50.03	55.42	
TiO_2	0.29	0.43	0.29
Al_2O_3	6.24	8.44	7.10
Cr_2O_3	0.76		0.95
FeO	12.27	11.80	18.68
MnO	0.51	0.47	0.43
MgO	18.88	14.16	17.40
CaO	5.18	5.62	5.50
Na_2O	0.22		0.26
K_2O	0.02		0.02
P_2O_5	0.31	0.74	
FeS	2.88		
Fe	1.46		
Ni	0.14		
Total	99.19		
FeO/FeO+MgO (mole percent)	26.8	31.9	37.6

* Column *1:* Analyst, Joseph Nelen.
Column *2:* Powell (1970).
Column *3:* Jérome (1970).

in part, the discrepancies between the different analyses in Table 1. The FeO/FeO + MgO molecular percent given by Jérome's analysis is too high to be consistent with the average composition of the pyroxenes; probably his sample contained some troilite and nickel-iron whose iron was determined and reported as FeO. The SiO_2 figure in Powell's analysis appears to be somewhat too high; he gives a figure of 10.1% for normative tridymite, which is considerably higher than the amounts we have observed.

Literature Cited

Fuchs, L. H.
1967. Stanfieldite, a New Phosphate Mineral from Stony-Iron Meteorites. *Science,* 158:910–911.

Jérome, D. Y.
1970. *Composition and Origin of Some Achondritic Meteorites.* Thesis, University of Oregon.

Powell, B. N.
1970. Petrology and Chemistry of Mesosiderites. I. Textures and Composition of Nickel-Iron. *Geochimica et Cosmochimica Acta,* 33:789–810.