

CHEMICAL VARIATIONS IN THE BISHOPVILLE ENSTATITE ACHONDRITE

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The enstatite achondrites are coarse-grained monomict breccias consisting of large (up to several cm) angular fragments set in a groundmass of smaller grains (1). One way to look at such rocks is to analyze a large number of small samples. Trends in chemical variations between the many samples should reveal information about the homogeneity of the meteorite. Bishopville, a relatively low metal, high plagioclase enstatite achondrite, was used to evaluate this approach. Twenty-two separate samples ranging in weight from 0.25 to 3.2 g were taken from the specimen of Bishopville in the Arizona State University meteorite collection. Sampling was done to cover representatively the surface of the meteorite: nine samples of the large white enstatite crystals (clast) and thirteen samples of the gray material that composes the bulk of the meteorite (matrix) were collected.

The samples were analyzed using the instrumental neutron activation analysis facilities at NASA/Johnson Space Center. Results obtained for Fe, Na, Cr, Co, Ni, Sc and REE abundances for the clast and matrix samples were examined (Table I). All of these elements show wide variations in abundance, indicating that the meteorite is very inhomogeneous at the scale sampled. Starting with the REE, the data was examined for correlations between pattern shape and the type of sample (clast/matrix). Next, the type of pattern and the type of sample were both correlated with the abundance levels of the other elements determined. Finally, the amount of mixing between the components was determined.

The REE patterns divided into two groups. One, Group 1, was fairly homogeneous, consisting of relatively flat patterns at abundances between 0.3 and 0.9 x chondrites (Fig. 1). A second, Group 2, had irregularly shaped patterns with abundances ranging from 0.01 to 0.5 x chondrites (Fig. 2). The two pattern groups corresponded roughly to matrix and clast respectively.

Looking at the other elements determined, it was found that they all divided roughly into the same two groups as the REE. Sodium showed the best correlation of abundance with pattern type. Samples with Na abundances >0.95% were Group 1 and <0.7% were Group 2. Interestingly, the one pattern with a negative Eu anomaly (E in Fig. 2) has the lowest Na abundance. All of the Group 1 samples had iron contents >0.3% and the majority of the Group 2 samples were low Fe (<0.3%). One notable exception was the sample with the highest Fe content (6.3%), which is seen as pattern W in Figure 2. Nickel, Co and Cr also divided into the two categories, with high abundances in Group 1 and low abundances in Group 2. However, the division was not as clear cut as for iron and sodium.

Using the major element analysis done on a few of the samples, a norm was determined and from this the amount of mixing that occurred was calculated. The calculation determined that the Fe component varied from 0% to 2% in the samples, with one at 9% Fe. The Fe component was principally kamacite, as shown by a strong correlation of Ni with Fe, but traces of three other opaque phases seen petrographically (2,3) can be identified by chemical variations in the abundances of Cr (daubreelite), Co (schreibersite), and excess Fe (troilite). Since plagioclase occurs as oligoclase (2) and is the only major Na-carrying phase, Na is correlated with plagioclase content. The samples vary from 4% to 58% plagioclase.

Sodium, Fe and the REE's occur primarily in the matrix, and as a result, purely chemical means can be used to divide the enstatite achondrites into the

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textural clast/matrix division, and to determine the amount of mixing between the various components. The clasts have low abundances of Fe (opaques), Na (plagioclase) and REE, but are inhomogeneous because of minute opaque inclusions in the enstatite crystals (1) and/or bits of matrix included as a part of the sample. The REE in the matrix are surprisingly homogeneous, despite wide variations in the other elements in this groups and particularly in comparison to clast REE. The REE carrying phase is apparently present in the matrix and occurs as a component that has mixed with the matrix material only. If the matrix formed from broken up clast material, the matrix should have REE patterns similar to those of the clast, which it does not. What this phase could be is yet to be determined. Recent work on oldhamite, the best candidate for this phase, has shown the levels of Ce and Nd to be insufficient to account for the variations in the REE between clast and matrix (4).

Table I. Neutron Activation Analysis data for Bishopville.

Sample	Fe	Na	Co	Cr	Ni	Sc	Ca
GROUP 1							
V	0.365	1.167	1.51	300.7	41.2	7.6	
L	1.070	0.973	9.62	402.3	167.9	7.4	0.21
P	0.952	2.287	12.76	119.3	537.1	6.89	
F	0.620	1.515	3.01	127.1	146.9	7.48	
G	0.606	1.137	4.77	352.5	76.5	7.6	0.56
H	0.526	1.803	2.89	398.4	80.7	7.1	
M	0.869	1.232	3.68	441.8	84.82	7.57	
Q	0.396	1.531	1.30	239.5	-	6.9	
S	0.950	1.446	7.62	422.7	156.1	7.79	
U	0.326	0.936	1.15	213.4	40.5	8.6	
O	0.670	1.439	5.36	382.6	114.5	8.47	0.79
C	0.285	0.399	1.58	226.2	63.2	5.78	
GROUP 2							
X	0.642	0.377	4.11	365.8	98.6	7.1	
W	6.29	0.838	128.7	120.7	862.3	10.07	
R	0.256	0.688	1.48	247.8	25.76	8.08	
A	0.196	0.674	0.99	92.87	28.11	7.39	
D	0.139	0.311	0.754	116.4	-	6.1	
E	0.114	0.062	0.661	184.4	-	5.5	
B	0.104	0.132	0.573	118.0	-	5.4	
J	0.957	0.399	1.60	311.5	-	6.51	0.11
N	0.458	0.581	0.596	792.7	-	6.7	
T	0.199	0.37	2.84	108.3	64.15	9.01	

References: (1) Reid A.M. and Cohen A.J. (1967) *Geochim. Cosmochim. Acta*, **31**, pp. 661-672. (2) Watters T.R. and Prinz M. (1979) *Proc. Lunar and Planet. Sci. Conf. 10th*, pp. 1073-1093. (3) Wasson J.T. and Wai C.M. (1970) *Geochim. Cosmochim. Acta*, **34**, pp. 169-184. (4) Woolum D.S., Burnett D.S., Murrell M.T., Benjamin T., Maggiore C. and Rogers P. (1982) *Meteoritics*, **17**, #4. (In press).

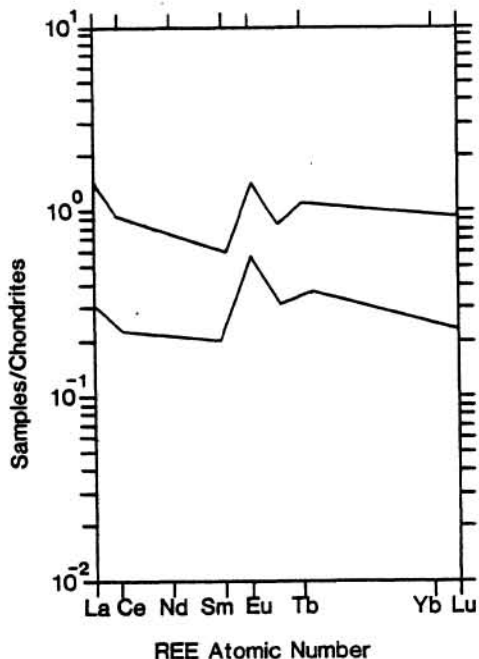


Figure 1. REE range for the 12 samples in Group 1.

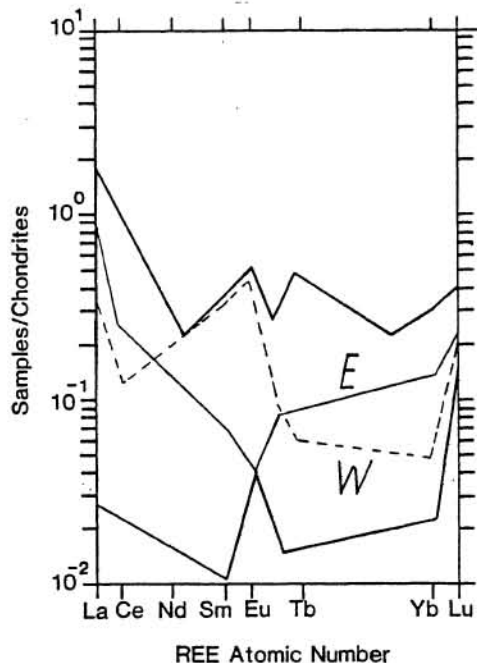


Figure 2. REE range for the 10 samples in Group 2.