

## 32. SULFUR IN LEG 37 BASALTS

A.J. Naldrett, A.M. Goodwin, and T.L. Fisher,  
Department of Geology, University of Toronto, Toronto, Canada

### INTRODUCTION

Sulfur is being continuously transported from the mantle to the crust in solution in basic magmas. The solubility of sulfur in such magmas is a function of a number of variables including the composition of the magma (particularly its FeO content), the temperature, oxygen fugacity, and sulfur fugacity (Haughton et al., 1974; Shima and Naldrett, 1975; and the discussion in Naldrett and Goodwin, in preparation. In the paper just referenced, Naldrett and Goodwin report some of the results of a continuing study of sulfur in Archean volcanic rocks, demonstrating in particular the importance of the FeO content of the rocks. This present study has given us the opportunity to compare the sulfur content of young volcanic rocks, derived directly from the mantle, with ancient ones.

### METHOD

Sulfur was determined on a Leco automatic sulfur titrator and National Bureau of Standards, Standard Reference Material 10G, Bessemer Steel, was used as a standard to calibrate the titrations. Two control samples were analyzed several times on each day on which the equipment was used in the course of this and other sulfur studies. Statistics indicating the precision achieved in analyzing these controls are given by Shima and Naldrett (1975).

### RESULTS

Our results are incorporated in the main tables of geochemical data (Chapters 2-5, this volume). Because our earlier results on Archean rocks emphasized the importance of iron content, we have compared here the sulfur content of those Leg 37 samples containing 7 to 9 wt % FeO with those containing 9 to 11 wt %. Mean values for sulfur and FeO, and median values for sulfur are compared in Table 1 with the results obtained by us for 23 samples dredged from the mid-Atlantic Ridge at 45°N (Aumento, 1970) and with samples of similar FeO content from the Archean Blake River Group of the Abitibi belt, Ontario (Naldrett and Goodwin, in preparation). Looking first at the Leg 37 samples, little difference is apparent between the two sets of data. The positively skewed distribution of the data, as demonstrated by the mean being approximately twice the median, is consistent with our Archean data which approximate a log normal distribution.

In Figure 1 the sulfur content is plotted against total FeO content for each of the samples for which major element analyses were available to us. In their study of the Blake River Group, Naldrett and Goodwin showed

that the median sulfur contents of the different rock classes approximated very closely to a smooth curve when plotted in this way and this is shown in the figure. Median sulfur values for the two subdivisions of Leg 37 rocks and for 45°N rocks are also plotted against mean FeO in this figure and demonstrate the much lower sulfur content of the young rocks. This is also brought out by comparison of the means given in Table 1.

If the basalts were not carrying additional sulfur as immiscible droplets, that is, if they were either undersaturated or only just saturated, and if our results represent original sulfur contents unaffected by later redistribution, phenocryst-bearing samples would be expected to contain less sulfur than phenocryst-free samples. Accordingly, in Table 2 we compare the mean sulfur content of those rocks described in the shipboard report as moderately to highly phyric with those described as aphyric to sparsely phyric. The means of the two groups are very similar and the more highly phyric basalts have a slightly greater sulfur content.

### DISCUSSION AND PRELIMINARY CONCLUSIONS

1) The sulfur content of Leg 37 basalts is similar to that of basalts dredged from the Mid-Atlantic Ridge at 45°N and very much lower than that of rocks of similar FeO content from the Abitibi greenstone belt.

2) Basing their conclusions on a study of pillowed oceanic basalts, Moore and Fabbi (1971) suggested that the glassy rims preserved more juvenile sulfur than the pillow interiors and that their rocks were originally saturated with a sulfur content of the order of 900 ppm. In the single pillow studied by us, we found that the outer 20-40 cm averaged about 300 ppm sulfur and that in the interior the sulfur was erratically distributed with six very low and very high value, averaging altogether about 250 ppm.

3) Sulfur values in our study vary widely between rock samples only a few centimeters apart. We do not regard this as primary variation but think that the sulfides must have suffered considerable redistribution subsequent to the initial crystallization of their host rocks. This raises the question of how much may have been removed or added altogether. At present we are in no position to answer this question. If Moore and Fabbi are correct concerning the sulfur-saturated nature of oceanic basalts, both the Leg 37 and 45°N rocks must have lost 2/3 to 3/4 of their initial sulfur. Once the results of further petrographic and mineralogical studies of Leg 37 rocks are available to us, we may be able to relate sulfur content to degree of alteration and, by restricting ourselves to the very freshest rocks, estimate the initial sulfur content at the time of extrusion.

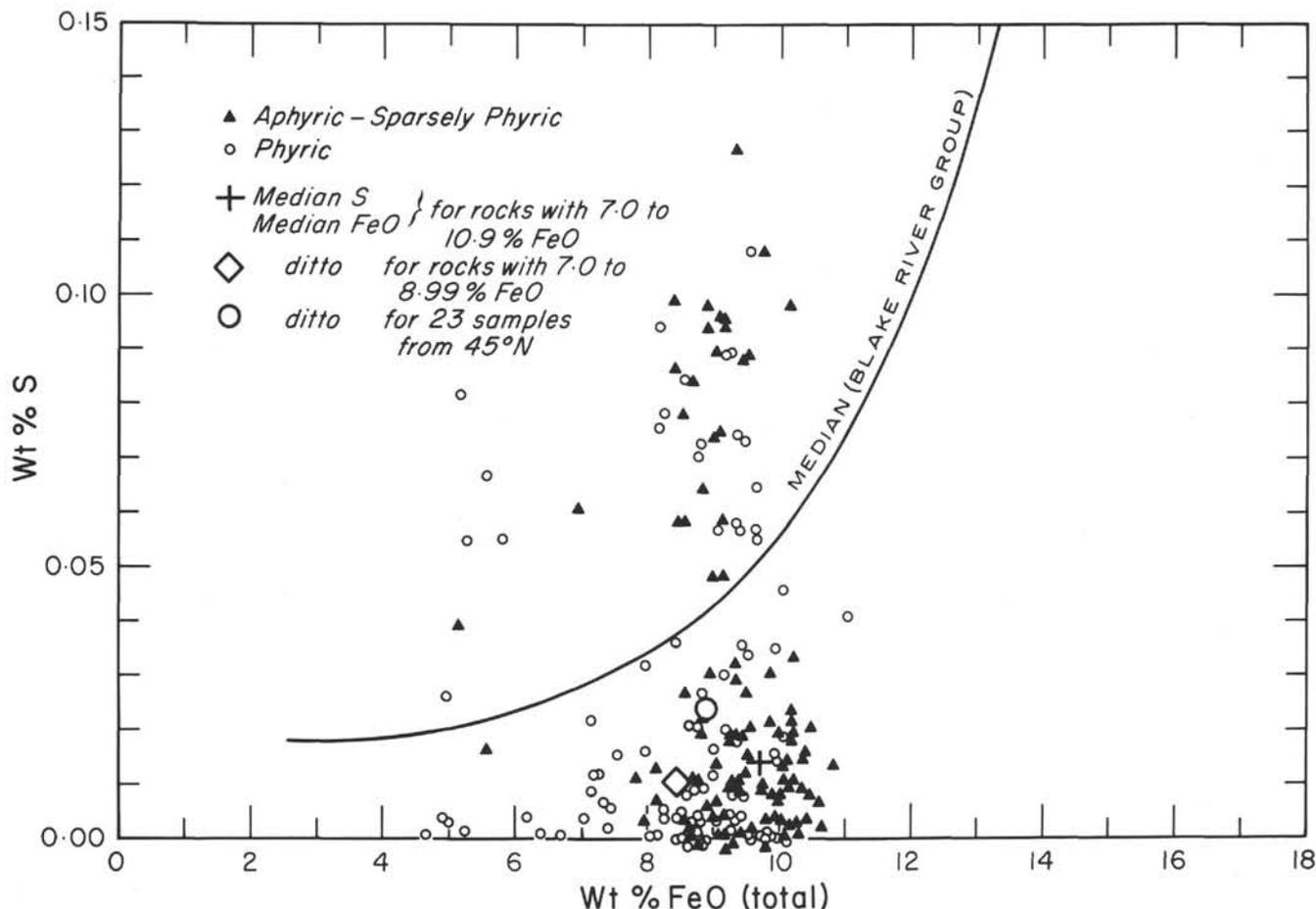


Figure 1. Plot of weight percent sulfur against weight percent total FeO for all rocks for which major element analyses were available. The line labeled Median (Blake River Group) is taken from Naldrett and Goodwin, in preparation.

TABLE 1  
Comparison With Other Areas

	Leg 37 Samples			Blake River Group
	7.00%-8.99% FeO	9.00%-10.99% FeO	45°N	Al-Rich Basalts
No. of Samples	69	123	23	181
Mean FeO (wt %)	8.45	9.64	8.93	8.97
Mean S (ppm)	250 (308) <sup>a</sup>	255 (296) <sup>a</sup>	320 (389) <sup>a</sup>	976 (1986) <sup>a</sup>
Median S (ppm)	106	131	230	500

<sup>a</sup>Figures in parentheses after mean S values are standard deviation.

TABLE 2  
Effect of Phenocryst Concentration

	Aphyric to Sparsely Phyric	Moderately to Highly Phyric
No. of Samples	54	64
Mean S (ppm)	248	284

## REFERENCES

- Aumento, F., 1970. Petrological, geochemical and geophysical studies of rocks dredged from the Mid-Atlantic Ridge at 45°N: Atlantic Oceanographic Lab Data Series, 1970-5-D, v. 1, 2.
- Haughton, D.R., Roeder, P.L., and Skinner, B.J., 1974. Solubility of sulfur in mafic magmas: *Econ. Geol.*, v. 69, p. 451-467.
- Moore, J.G. and Fabbi, B.P., 1971. An estimate of the juvenile sulfur content of basalts: *Contrib. Mineral. Petrol.*, v. 33, p. 118-127.
- Naldrett, A.J. and Goodwin, A.M., in preparation. Sulfur in the Blake River Group of the Abitibi Greenstone Belt.
- Shima, H. and Naldrett, A.J., 1975. Solubility of sulfur in an ultramafic melt and the relevance of the system Fe-S-O: *Econ. Geol.*, v. 70, p. 960-967.