MINERALOGY AND S^{34}/S^{32} RATIOS OF SULFIDES ASSOCIATED WITH KIMBERLITE, XENOLITHS AND DIAMONDS.

Hsiao-ming Tsai: Department of Geosciences
Yuch-ning Shieh: Purdue University
Henry O.A. Meyer: West Lafayette, Indiana 47907

The mineralogy of sulfides from eclogite xenoliths and inclusions in diamond, and the S^{34}/S^{32} ratios of sulfides from several eclogites and other crustal xenoliths in kimberlite have been studied:

1) Sulfides in thirteen eclogites (griquaites) from various localities, including Premier, Roberts Victor, Jagersfontein, Bobbejaan and Obnazhennaya (Siberia) have been examined. These sulfides are generally round in shape and often occupy interstitial positions relative to the silicate grains. The most common assemblage observed is an intergrowth of pyrrhotite-pentlandite surrounded by chalcopyrite rim. A similar assemblage has been previously descirbed by Frick (1973), Vakhrushev and Sobolev (1973) and Meyer and Boctor (1975). However, in this study, we have also observed a small amount of chalcopyrite occurring as very fine exsolution lamellae in pyrrhotite. Nickeliferous pyrrhotite is common, and also found in association with this phase is Ni-pyrite (or Ni-marcasite). One sample from Roberts Victor appears identical to that described by Desborough and Czamanske (1973), but the new low nickel phase identified by them is probably Ni-bearing pyrrhotite. Pentlandite usually occurs as oriented exsolution lamellae in pyrrhotite and is present in various abundances. Some of the pentlandite is Co-bearing with cobalt contents of up to 3.6 wt.%. Monosulfide$_{ss}$ is present in only one specimen. Textural relations indicate the original presence of immiscible sulfide melts having various bulk compositions. Subsequent re-equilibrium at lower temperatures accounts for the present phases and form of the intergrowths. One unique assemblage in a garnet xenocryst from Premier consists of granular aggregates of pentlandite, chalcopyrite, magnetite and silicates. Minor lamellae of pentlandite are present in some of the chalcopyrite, while pentlandite is generally free of exsolution lamellae. The silicates are interesting in that they consist of andradite, ilvaite [$CaFe_2(FeOH)(SiO_4)_2$] and needle-shaped secondary chlorite. Pyrite observed in two samples from Bobbejaan and Roberts Victor is probably secondary, based on the presence of the well-formed crystal outlines. Analyses of major mineral phases mentioned above are presented in Tables 1 (sulfides) and II (silicates).

2) Examination of sulfide inclusions in diamonds from Premier, Finsch and Koffiefontein reveals two important features: One is that the occurrence of sulfides as inclusions is much rarer than previously anticipated, most of the black

inclusions appear to be graphite. The second feature is the presence of a variety of sulfide assemblages, including pyrrhotite-pentlandite intergrowths with or without minor chalcopyrite; pyrrhotite-chalcopyrite intergrowths with minor pentlandite; Ni-rich pentlandite-magnetite with possible minor chalcopyrite; and pentlandite-chalcopyrite. The intimate association of these intergrowths and the small size have made it difficult to obtain satisfactory microprobe analyses. One notable difference between sulfides in diamonds and in eclogites is the much rarer occurrence of chalcopyrite in diamond than observed in eclogite. Pyrite is present in one diamond from Koffiefontein.

3) S^{34}/S^{32} ratios have been determined for sulfides in crustal and eclogitic xenoliths and discrete crystals of sulfide from Premier, Finsch, Koffiefontein, Roberts Victor and Bobbejaan. The results are shown in Fig. 1. Most pyrite-bearing crustal xenoliths as well as a secondary pyrite in a Bobbejaan eclogite give results suggestive of sedimentary origin of the sulfur (δS^{34} ranging from -37.3 to +15.1). Discrete pyrite from Premier kimberlite gives δS^{34} to be +1.3, suggesting the sulfur may be of magmatic origin. Chalcopyrite/pentlandite and pyrrhotite/pentlandite assemblages from Premier and Roberts Victor samples of supposed mantle origin give δS^{34} values of +0.2 and +2.1, respectively. These results support the inference that sulfur of mantle origin has a δ-value close to zero.

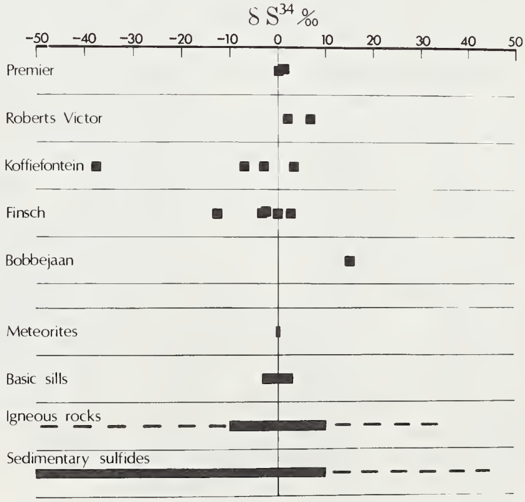

Figure 1 δS^{34} – values of sulfides from kimberlites and associated xenoliths. Also included are the variations of δS^{34} for common rock types in nature (after Thode et al. 1961)

References

1. Frick (1973). Contrib. Mineral. Petrol., 39, 1-16.
2. Vakhrushev and Sobolev (1973). Int. Geol. Rev., 15, 103-110.
3. Meyer and Boctor (1975). Contrib. Mineral. Petrol., 52, 57-68.
4. Desborough and Czamanske (1973). Am. Mineral., 58, 195-202.
5. Thode, Monster and Dunford (1961). Geochim. Cosmochim. Acta, 25, 150-174.

Table I. Representative analyses of major sulfide minerals.

	Pentlandite		Pyrrhotite		Chalcopyrite		Pyrite	
Fe	27.2	33.9	56.1	61.6	30.5	30.4	46.4	44.7
Ni	38.1	28.3	2.15	0.00	0.00	0.08	0.00	1.61
Cu	0.00	0.00	0.00	0.07	33.6	33.8	0.07	0.18
Co	0.82	3.36	0.13	0.01	0.09	0.03	-	0.50
S	33.7	34.3	41.3	37.5	36.3	35.2	53.4	53.1
Total	99.8	99.9	99.7	99.2	100.5	99.5	99.9	100.1

Table II. Representative analyses of silicates.

Oxide	Andradite	Ilvaite
SiO_2	37.2	30.1
TiO_2	0.02	0.00
Al_2O_3	5.47	0.09
Cr_2O_3	0.00	0.00
FeO*	21.8	51.8
MgO	0.09	0.20
CaO	32.4	13.90
MnO	0.21	1.64
NiO	0.13	0.00
Na_2O	0.00	0.00
K_2O	0.00	0.00
Total	99.3	97.7 (+OH)

* All Fe reported as FeO