

CHAPTER SEVEN: S-ISOTOPE GEOCHEMISTRY

Most magmatic sulphide ore (e.g. at Kambalda, Voisey's Bay, Noril'sk, Petchenga) are thought to have formed by assimilation of external S from the country rocks. A similar model has been proposed by Buchanan et al. (1981) for the Platreef on the farm Tweefontein. S-isotopic analyses may be used as tracers to detect the contamination. The mantle is taken to have a $\delta^{34}\text{S}$ value of $\sim 0 \pm 3$ ‰ and any substantial deviation from these values is interpreted to be due to assimilation of country rock sulphur with $\delta^{34}\text{S}$ values that differ from the mantle values (Ripley, 1999).

Buchanan et al. (1981) carried out S-isotopic analyses on 9 samples of the Platreef on the farm Tweefontein, where the floor rocks are formed by calcsilicate, banded ironstone and argillaceous sediments. In the present study, I provide new S-isotopic data on 12 samples, covering the three Platreef layers and the floor rocks on the farm Townlands. This was done to i) make a comparison of the S-isotopic composition of the Platreef along strike ii) determine the role of crustal contamination in the formation of the Platreef, and iii) determine whether the different platiniferous layers of the Platreef underwent different degrees of contamination.

The samples were analysed at Indiana University, Bloomington, U.S.A. Analytical results are presented in Table 7.1 and analytical procedures are given in Appendix I. Sulphur isotopic compositions are reported in standard δ notation relative to VCDT (Vienna Cañon Diablo Troilite).

Sample	$\delta^{34}\text{S}$ (‰VCDT)	Rock unit
P2	5.7	Upper Platreef
P3	10.1	Upper Platreef
P6	6.0	norite sill
P11	2.6	Middle Platreef
P15	5.3	Middle Platreef
P19	4.0	Middle Platreef
P25	7.3	Lower Platreef
P26	9.3	Lower Platreef
P28	16.9	hornfels
P30	14.2	calcsilicate
P31	15.2	hornfels
P32	15.3	hornfels

Table 7.1: S-isotopic analyses of samples from the Platreef and its floor rocks.

It is notable that all the samples have positive $\delta^{34}\text{S}$ values. The highest values are found in the hornfels and the calcsilicate, which have broadly similar S-isotopic signatures. The $\delta^{34}\text{S}$ signature of the Platreef is compared to other mafic/ultramafic intrusions around the world in Fig. 7.1. The Uitloop, Cape Smith, Kabanga, Mellon, Noril'sk and Muskox intrusions all contain a large contribution of sedimentary sulphide due to assimilation of country rock. It is also important to note that the Lower Platreef and the Upper Platreef have higher $\delta^{34}\text{S}$ (average 8 ‰) compared to the Middle Platreef (average 4 ‰), confirming the whole rock chemical data that showed high K_2O and CaO contents in the Lower and Upper Platreef which could not be explained by variation in pyroxene and plagioclase contents.

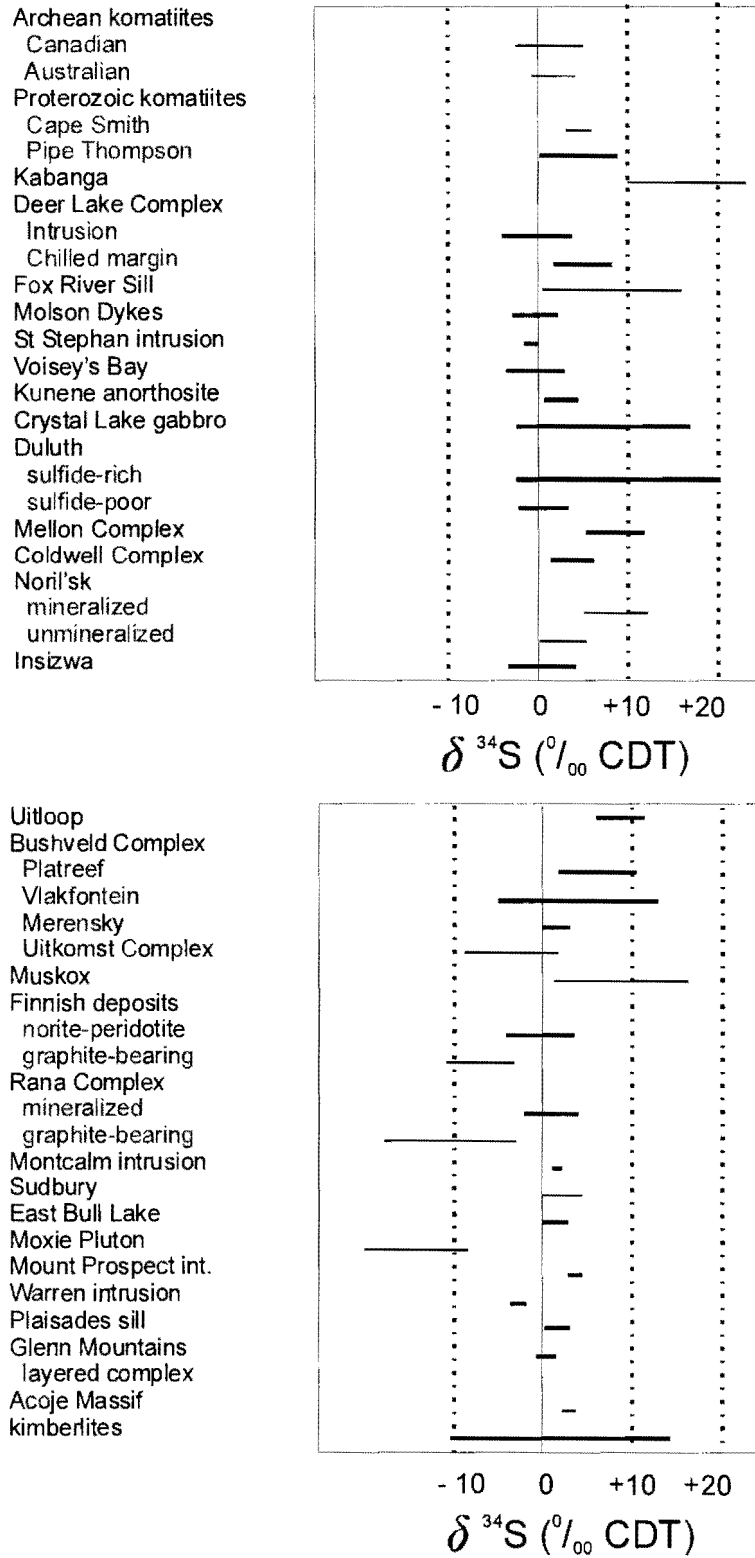


Fig. 7.1: $\delta^{34}\text{S}$ values of selected mafic/ultramafic intrusions in the world (modified from Ripley, 1999). Kabanga data from Maier (unpublished), and Uitloop data from Touvila, (personal communication).

Buchanan et al. (1981) reported $\delta^{34}\text{S}$ values of 6.3 to 9.2 per mil from the Platreef on the farm Tweefontein. These are comparable to the $\delta^{34}\text{S}$ isotopic signatures for the Platreef on the farm Townlands, suggesting the sulphides could have formed by assimilation of the same contaminant. Pyroxenite sills some 1 km in the floor rocks below the Platreef, and hosted by dolomite, also show a strong positive $\delta^{34}\text{S}$ isotopic signatures (Tuovila, personal communication).

In addition to variation between the different Platreef layers on Townlands, the data also suggest some systematic variation within the individual Platreef layers. There is a trend of an increase in the $\delta^{34}\text{S}$ values towards the base within the Middle and Lower Platreef, a phenomenon that can possibly be explained by enhanced assimilation of crustal sulphur towards the floor of each intrusion, perhaps by means of continued degassing of the floor rocks during crystallisation of the Platreef.

The high $\delta^{34}\text{S}$ values of the analysed hornfels are of note. Buchanan et al. (1981) report $\delta^{34}\text{S}$ values of -11.6 to +7.8 per mil for the Pretoria shales, and Cameron (1982) reports mostly significantly negative $\delta^{34}\text{S}$ values for the Transvaal metasediments south of Johannesburg. This could indicate significant localized variation in the S isotopic signatures of the Transvaal Supergroup, or it may reflect a change in the S-isotopic signature of the shales in the Northern limb due to the intrusion of the Platreef and associated devolatilisation (notably loss of light S). Further work is clearly necessary to constrain this question. The analyses of calcsilicate interpreted to represent interlayers in the Pretoria Supergroup gave a $\delta^{34}\text{S}$ value of 14.2 per mil which is heavier than the Malmani dolomite analysed by Buchanan et al.,

1981, which has a $\delta^{34}\text{S}$ value of 7.1 per mil. The hornfels and calcsilicates of the Silverton formation probably formed in shallow water depths of between 30 and 100 m (Eriksson and Reczko, 1998) i.e. in slightly oxidizing conditions that could explain the elevated $\delta^{34}\text{S}$ values. Alternatively, the heavy S-isotopic signature may be the result of devolatilisation of light S.

In summary, the S-isotopic data support a model whereby shale and dolomite were engulfed by the intruding Platreef magma and the xenoliths reacted with the hot magma releasing the contained sulphur. The released crustal sulphur caused S-supersaturation in the magma and segregation of an immiscible sulphide melt enriched in heavy S. This suggests that sulphidation is an important factor controlling sulphide precipitation in the Platreef on the farm Townlands and elsewhere.

Importantly, the data support the mineral and whole rock major and trace element chemical data indicating that the different layers of the Platreef may represent distinct magma injections, intruding as sill-like bodies.