

1981/27. A sulphur isotope study of the Chester massive pyrite deposit, western Tasmania.

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#### Abstract

$\delta^{34}\text{S}$  values of massive and disseminated pyrite from the Chester mine have a limited range of +0.4 to -3.9 per mil (mean -1.8 per mil). Such values are abnormally low for stratiform volcanogenic massive sulphide deposits which typically have a range of +1 to +20 per mil. The low values are probably due to a greater contribution of magmatic sulphur to the hydrothermal fluid than for most other volcanogenic deposits.

#### INTRODUCTION

The Chester mine is situated on the eastern flank of Mt Kershaw, approximately 8 km north of Rosebery [CP581634]. It is a stratiform, volcanogenic massive sulphide deposit consisting of massive pyrite, interbedded pyrite and chert and disseminated pyrite occurring at the northern end of an elliptical hydrothermal alteration zone within a predominantly pyroclastic sequence of felsic pyroclastic rocks and chert, with minor rhyolitic lava (Stevens, 1974; Collins *et al.*, 1981, p.89). The deposit contains an estimated 2.5 million tonnes of 40% pyrite and is characterised by an almost complete absence of copper, lead and zinc sulphide minerals. However, a study of the cobalt and nickel contents of the pyrite has shown a genetic affinity to other pyrite-sphalerite-galena-chalcopyrite massive sulphide deposits in western Tasmania (Collins *et al.*, 1981, p.97).

#### SULPHUR ISOTOPES

A sulphur isotope study was undertaken to allow further comparison of this deposit with other stratiform volcanogenic deposits. Eleven samples of pyrite were selected from the samples previously analysed for their trace element contents (see Collins *et al.*, 1981, Table 6 for sample details). The analysed pyrite concentrates contained more than 95 mass% pyrite. The combustion of the pyrite to liberate  $\text{SO}_2$  and the mass spectrometry were undertaken at the University of Tasmania.

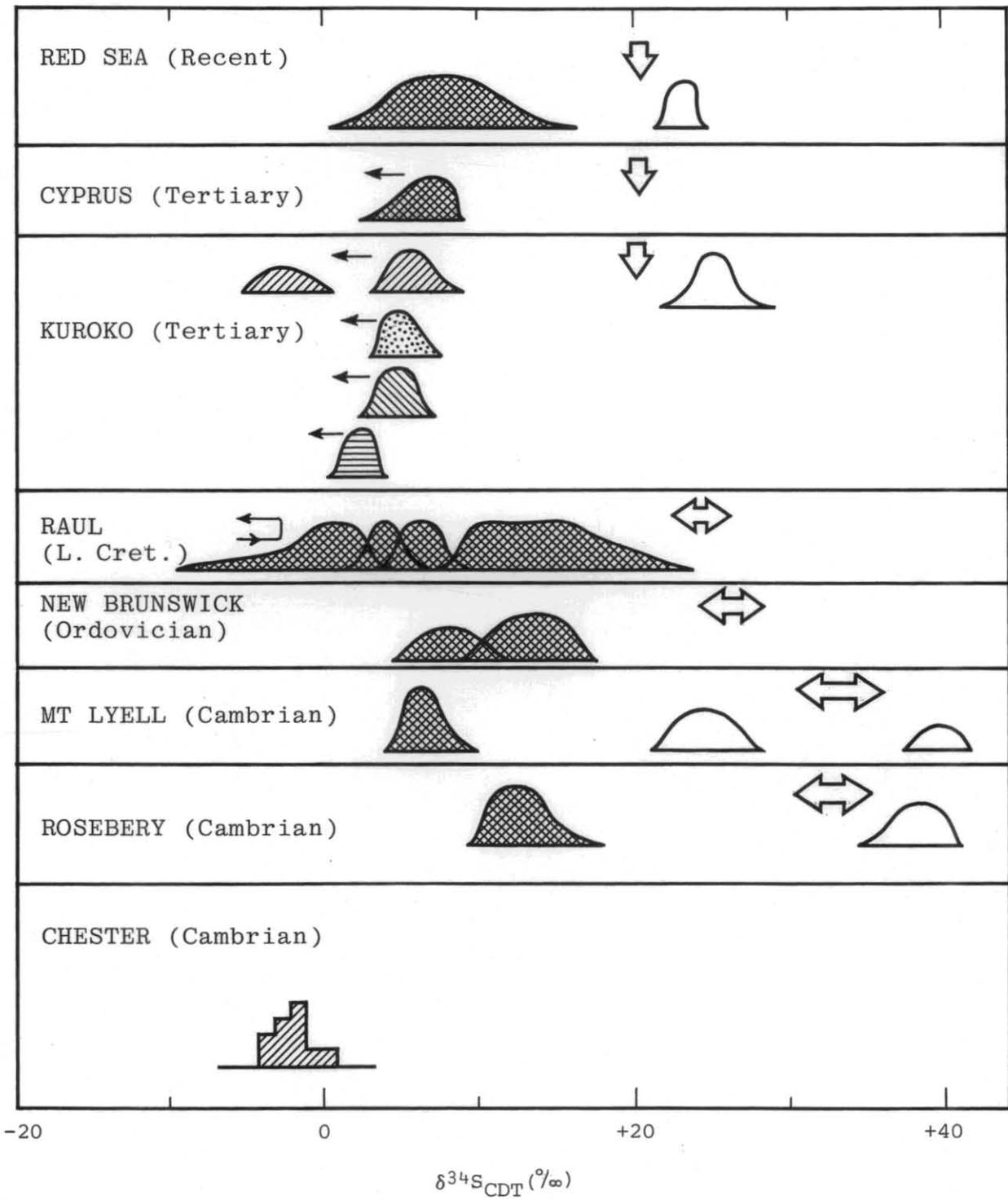
#### Results

The  $\delta^{34}\text{S}$  values of the massive and disseminated pyrites have an extremely limited range of -0.9 to -3.0 per mil, with an average of -1.85 per mil (Table 1). A sample of colloform pyrite [740752] has a slightly lower value of -3.9 per mil, and pyrite in an agglomerate [740750] has a slightly higher value of +0.4 per mil.

A sample of the coarse-grained disseminated pyrite at the South Chester prospect, situated approximately 0.5 km south of the Chester mine, has a  $\delta^{34}\text{S}$  value of -1.8 [740765], which is the same as the average of the massive and disseminated pyrite.

#### DISCUSSION

The  $\delta^{34}\text{S}$  values of sulphides in stratiform massive sulphide deposits that occur in volcanic terrains and which are thought to have formed at the seawater-rock interface by precipitation from hydrothermal solutions related to submarine volcanism are typically positive with a range of +1 to +20 per mil (fig. 1; Ohmoto and Rye, 1979). Sulphides in volcanogenic



- |   |                           |  |                    |
|---|---------------------------|--|--------------------|
| → | Trend toward later stage  |  | FeS <sub>2</sub>   |
|   | Seawater                  |  | ZnS                |
|   | Sulphates                 |  | CuFeS <sub>2</sub> |
|   | Sulphides (excluding PbS) |  | PbS                |

5 cm

Figure 1. Comparison of the Chester pyrites with a schematic presentation of sulphur isotopic data of some other stratiform massive sulphide deposits associated with submarine volcanism. Diagram based on Figure 10.13 of Ohmoto & Rye (1979).

deposits in western Tasmania, such as at Mt Lyell and Rosebery, conform to the trend and have  $\delta^{34}\text{S}$  values ranging between +4 to +10 per mil and +10 to +18 per mil respectively (Solomon *et al*, 1969). Some stratabound volcanogenic deposits show a trend of decreasing  $\delta^{34}\text{S}$  values of sulphides upward in the stratigraphic section (e.g. Kuroko, Cyprus and Raul deposits) and values in the range -1 to -6 per mil occur at the very late stages of mineralisation in some of the Kuroko deposits (Kajiwara, 1972; Ohmoto and Rye, 1979).

Thus the  $\delta^{34}\text{S}$  values of the Chester pyrites are comparable only to the final stages of mineralisation of some of the Kuroko deposits (e.g. Shakani No 1 deposit, Kajiwara, 1972). This late stage mineralisation, the red-coloured Fe-chert zone, is composed of cryptocrystalline quartz and hematite with minor pyrite, carbonate, sericite and chlorite, and occurs as a thin bed (approximately one metre thick) in the uppermost part of an ore body (Matsukuma and Horikoshi, 1970; Horikoshi and Sato, 1970). Although the  $\delta^{34}\text{S}$  values are similar, the morphology and colour of the Fe-chert zone and the occurrence of hematite are totally unlike the pyrite-chert mineralisation at Chester.

Similar low  $\delta^{34}\text{S}$  values with a range of -10 to +3 per mil have been measured for disseminated pyrite and chalcopyrite in andesitic pyroclastic rocks in the stratigraphic footwall of the Raul deposit, Peru (Ripley and Ohmoto, 1977). The sulphides in this basal unit comprise less than 1% of the rock which contrasts with the distribution of the pyrite at Chester where it commonly exceeds 50% of the rock. Thus, despite similarities in the  $\delta^{34}\text{S}$  values they are not readily comparable because of differences in the morphology, distribution and relative stratigraphic positions of the sulphide minerals at Raul and Chester.

A possible origin for the low  $\delta^{34}\text{S}$  values at Chester is from a combination of sulphur produced by reduction of seawater sulphate through reactions with hot volcanic rocks and sulphur from igneous sources as proposed for the Raul and Kuroko deposits (Ripley and Ohmoto, 1977; Ohmoto and Rye, 1979). The lower  $\delta^{34}\text{S}$  values at Chester, probably reflect a greater magmatic component than at Raul and Kuroko. The low values are unlikely to result from any contribution from diagenetic sulphur produced by bacterial reduction of seawater sulphate which is generally much lighter with  $\delta^{34}\text{S}$  values of less than -10 per mil. The host rocks for most stratabound volcanogenic deposits are generally too poor in organic carbon content and the temperature of deposition much too high to allow bacterial activity at the site of sulphide deposition (Ohmoto and Rye, 1979).

The Chester deposit also contrasts with the parallel variation between the average  $\delta^{34}\text{S}$  values of sulphides and contemporaneous seawater which Sangster (1968) noted to be characteristic of stratabound volcanogenic deposits. The average depletion of the Chester pyrites relative to Cambrian sea water with an assumed value of +32 per mil (fig. 1) is approximately 34 per mil, which is double the average of 17 per mil noted by Sangster (1968). This difference is much greater than the Mt Lyell and Rosebery deposits which also show an enhanced depletion with average  $\delta^{34}\text{S}$  values of sulphides approximately 25 per mil and 20 per mil respectively lower than contemporaneous sea water (fig. 1).

#### CONCLUSION

The  $\delta^{34}\text{S}$  values of the massive and disseminated pyrite at the Chester mine have a range of +0.4 to -3.9 per mil, which are abnormally low for stratiform volcanogenic massive sulphide deposits. Although similar values

have been measured for sulphides in the final stages of mineralisation and in the host rocks of some other volcanogenic deposits, such low values have not been observed in the main massive sulphide mineralisation of this type of deposit. In this respect and in its almost total lack of copper, lead, and zinc sulphides, the Chester deposit appears unique among volcanogenic, massive sulphide deposits.

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Table 1. *SULPHUR ISOTOPIC COMPOSITION OF PYRITE FROM THE CHESTER MINE*

<i>Sample No.</i>	<i>Description</i>	$\delta^{34}\text{S}_{\text{CDT}} \text{‰}$
740746	Pyrite interbedded with chert	-2.6
740748	Massive pyrite	-3.0
740750	Chert-pyrite agglomerate	+0.4
740752	Colloform pyrite	-3.9
740754	Massive pyrite	-1.2
740755	Disseminated pyrite	-1.4
740756	Disseminated pyrite	-2.2
740758	Intergranular pyrite and quartz	-1.3
740763	Disseminated pyrite	-2.2
740764	Disseminated pyrite	-0.9
740765	Coarse-grained disseminated pyrite	-1.8

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