Sulphide mineralization in Blinman 2 drill hole of Frontier Exploration Limited

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At the invitation of Professor E. A. Rudd I have made a preliminary study of the mineralogy and sulphur isotopic composition of sulphide minerals in Blinman 2.

Samples of sulphide mineralization were selected, after a comparison of the core with the drill hole log prepared by Mr. G. Weste, in an attempt to obtain representative material. The downhole depths and stratigraphy of the samples (based on the stratigraphic interpretation by Dr. W. Preiss, letter of 12 July 1991 to Professor Rudd) are as follows.

1035.06 - 1035.12m	
1035.12 - 1035.18m	
1211.60 - 1211.76m	Tapley Hill Formation
1386.07 - 1386.18m	
1439.91 - 1440.03m	
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1623.83 - 1624.05m	
1626.72 - 1626.83m	
1626.87 - 1627.13m	Wilyerpa formation
1718.32 - 1718.50m	
1750.96 - 1751.13m	
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2004.62 - 2004.72m	Bolla Bollana Tillite equivalent

Mineralogy

Pyrite is the most abundant sulphide mineral in most of these samples, but chalcopyrite is significant in some. Pyrite is particularly common within siltstones in the sequence and is finely laminated and framboidal (Plate 1a), closely resembling biogenic pyrite formed during early diagenesis in modern detrital sediments. The process involved in formation of pyrite in modern sediments is illustrated in Figure 1 (Berner, 1984). Pyrite forms during shallow burial as a result of the reaction of detrital iron minerals with H_2S. The H_2S is produced by the reaction of interstitial dissolved sulphate by bacteria using sedimentary organic matter as a reducing agent and energy source. As shown in Figure 1, the initial product of this reaction is not pyrite but metastable iron monosulphide.

Preservation of the framboidal textures in the pyrite indicates that the rocks have not been subjected to significant grades of metamorphism. Euhedral pyrite crystals growing across the layers of fine grained framboidal pyrite have also been observed in some samples. The layers of framboidal pyrite can be traced through the euhedral crystals (Plate 1b). These crystals would appear to have developed during late diagenesis or very low grade metamorphism. Chalcopyrite is a minor component only in the laminated mineralization and occurs as small irregularly shaped patches.

Slightly coarser grained pyrite and chalcopyrite are found in the porosity of sand and conglomerate layers (Plate 2a). Other less common textural types are coarse pyrite crystals, up to 0.5cm, in vughs in a carbonate vein (1626.87 - 1627.13m) and irregularly shaped patches of chalcopyrite, up to 1.5 x 1cm, also within carbonate veins (1623.83 - 1624.05m, Plate 2b).

Sulphur Isotopes

The results of the sulphur isotope analyses are shown in Table 1 and Figure 2. Data from Lambert et al. (1980, 1987) for sulphides from the Tapley Hill Formation are shown in Figures

3 and 4 for comparison. Figure 5 shows typical distributions for biogenic sulphides (Ohmoto and Rye, 1979).

The Tapley Hill Formation values from Blinman 2 are highly enriched in ^{34}S (17.7 to 40.4 ‰) and are in keeping with the data of Lambert al. Bacterial reduction of contemporaneous seawater sulphate to H_2S to form biogenic pyrite, according to the mechanism explained above, would require a $\delta^{34}S_{sulphate} \approx 40‰$, considerably higher than the expected value for Late Proterozoic seawater sulphate (Claypool et al., 1980). As interpreted by Lambert et al., this suggests the development of isotopically heavy residual sulphate in a restricted environment.

The analyses of samples from the Wilyerpa Formation (3.7 to 25.9‰) show some overlap with those of the Tapley Hill Formation but overall are much less ^{34}S enriched. The values are typical of the range expected for biogenic sulphides formed from "normal" Late Proterozoic seawater sulphate in a shallow marine environment closed to sulphate supply (Figure 4). These data are of considerable interest in that they assist in explaining the anomalously heavy isotope values found in the Tapley Hill Formation and should contribute to an understanding of the sedimentary environment of both the Wilyerpa and Tapley Hill Formations. The sulphur isotope data suggest that the depositional environment became restricted during deposition of the Wilyerpa Formation, with reduction of seawater sulphate and consequent pyrite formation leading to the development of the heavy residual sulphate involved in subsequent formation of sulphides in the Tapley Hill Formation. Obviously this hypothesis is based on a small data set and would need to be tested with further analyses, not only from Blinman 2 but also on a regional scale.

References

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Lambert, I. B., Donnelly, T. H., and Rowlands, N. J., 1980: Genesis of Upper Proterozoic stratabound copper mineralization, Kapunda, South Australia. Mineral. Deposita, 15, 1-18.

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TABLE 1: Sulphur isotope analyses, Blinman 2.

Sample	Mineral	δ34S(‰)
1035.06 - 1035.12m	pyrite	17.7
1035.12 - 1035.18m	"	40.4
1211.60 - 1211.76m	"	17.7
1386.07 - 1386.18m	"	26.1
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1623.83 - 1624.05m	chalcopyrite	25.9
	pyrite	20.7
1626.72 - 1626.83m	"	14.4
1626.87 - 1627.13m	"	17.4
	"	9.3
1718.32 - 1718.50m	"	4.9
	"	6.3
	"	4.2
1750.96 - 1751.13m	chalcopyrite	5.5
	pyrite	3.7
	"	6.0
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2004.62 - 2004.72m	"	19.6

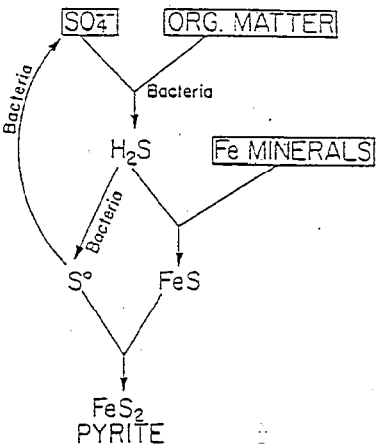

FIG. 1. Diagramatic representation of the overall process of sedimentary pyrite formation.

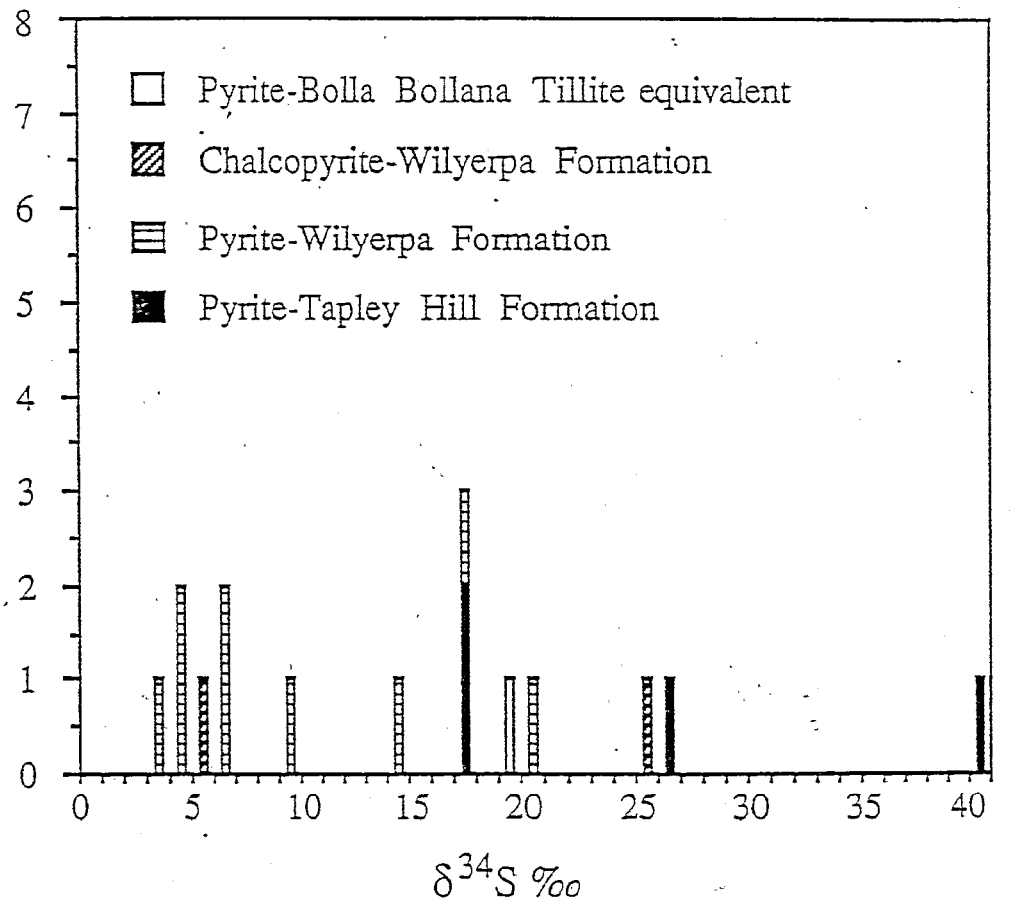

Fig.2. $\delta^{34}S$ values of sulphide minerals in Blinman 2.

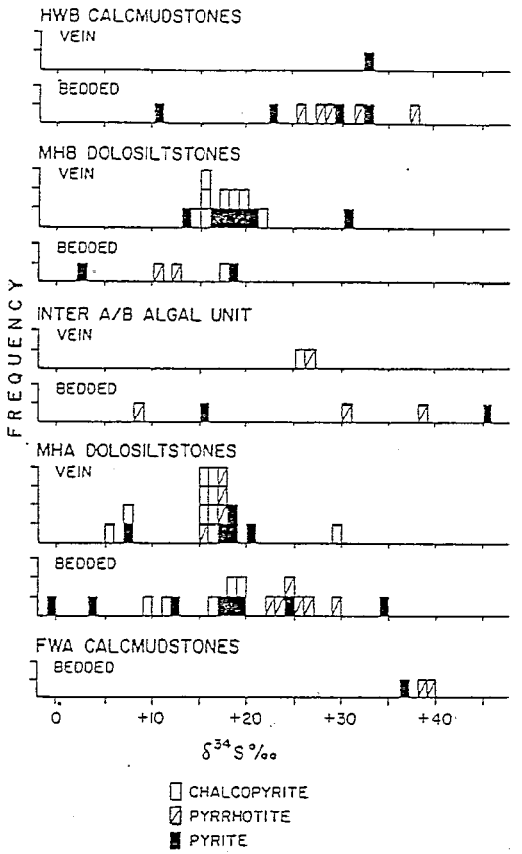

Fig. 3. $\delta^{34}S$ values for individual units of the Kapunda Mine Series.

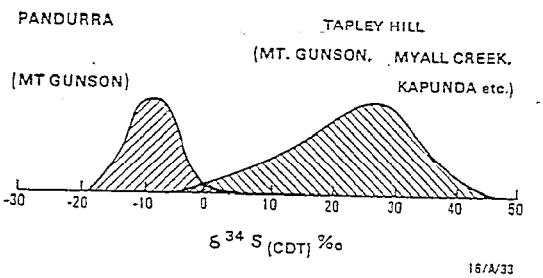

FIG. 4. Distributions of $\delta^{34}S$ values for copper deposits along the Pandurra Formation-Whyalla Sandstone unconformity, and for sulfides in the Tapley Hill Formation.

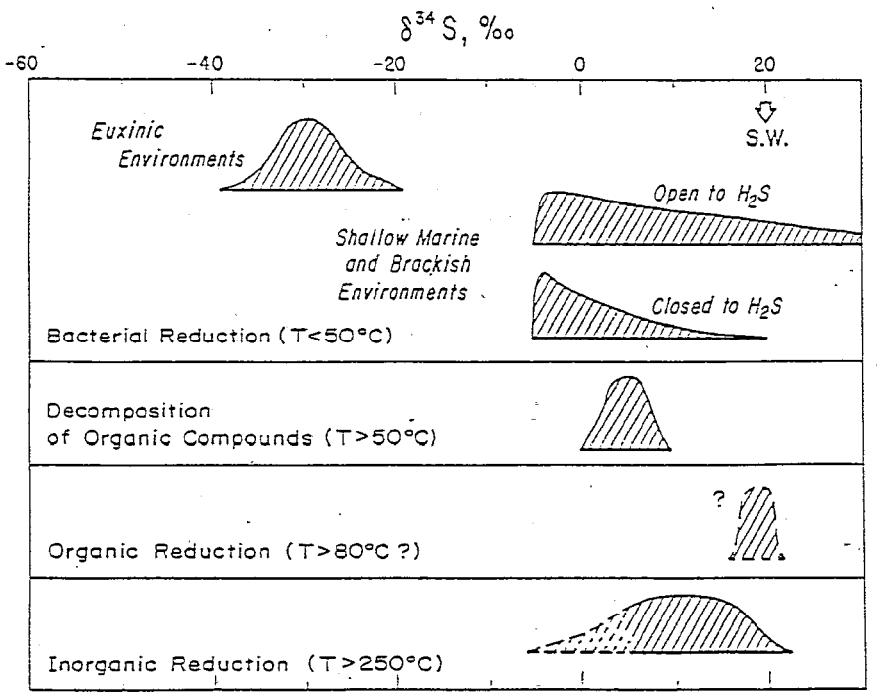

Fig. 5 Distribution pattern for $\delta^{34}S$ values of H_2S and sulfide minerals when sulfate of $\delta^{34}S = +20‰$ is reduced by various mechanisms. SW is sea water.

Plate captions

1a: Framboidal pyrite, Wilyerpa Formation (1718.32 - 1718 50m). Width of photograph = 0.3mm.

1b: Euhedral pyrite crystal with framboidal pyrite inclusions, Wilyerpa Formation (1718.32 - 1718 50m). Width of photograph = 1.0mm.

2a: Pyrite with minor chalcopyrite deposited in porosity in sand layer, Tapley Hill Formation (1386.07 - 1386.18m). Width of photograph = 0.5mm.

2b: Carbonate vein with coarse chalcopyrite, Wilyerpa Formation (1623.83 - 1624.05m). Width of photograph = 2.0mm.