An Isotopic Investigation of the Environment of Deposition of the McArthur Mineralization

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Additional measurements of \( {^{34}}S / {^{32}}S, {^{13}}C / {^{12}}C \) and \( {^{18}}O / {^{16}}O \) ratios in metallic sulphides, carbonates and organic residues suggest a mode of genesis of the McArthur deposit generally consistent with geological and geochemical evidence. A very stable marine environment is indicated by the constant values for \( \delta^{13}C \) and \( \delta^{18}O \) observed throughout the entire deposit. However, \( {^{34}}S \) contents of pyrites varied by 25%, in a manner consistent with the water depths and sulphate availability postulated for the McArthur environment.

Introduction

The winning of base metals from the sulphides of the McArthur lead-zinc-silver deposit has not yet been shown technically to be an economically viable project. However, the size and potential of the deposit, together with the excellent degree of preservation of mineral textures and the availability of specimens ensure a continued interest in the deposit, if only at this stage as a possible precursor of other, metal-producing, metamorphosed ore-bodies such as Mount Isa or Broken Hill. Since the publication of results obtained from a limited study of sulphur isotope distributions in the McArthur lead-zinc-silver deposit (Smith and Croxford 1973), new geological and geochemical data (Plumb and Brown 1973; Murray 1975; Lambert and Scott 1973) have provided a better understanding of the geological environment in which the McArthur deposit and enclosing sedimentary formations accumulated. The revised stratigraphy has been clearly presented in diagrammatic form by Plumb and Brown (1973). In postulating the existence of a series of basins and sub-basins in the McArthur region, Murray (1975) introduced the concept of a retaining reef and back-reef lagoonal environments. Age differences have precluded the total acceptance of this view by Plumb and Brown (1973), but certainly the Cooley Dolomite Member, whether an algal reef or a carbonate bank, appears to have played a significant role in the formation, or at least the delineation, of the H. Y. C. Member. It is now widely accepted that:

(a) during the Carpentarian, predominantly shallow water conditions prevailed throughout the McArthur Basin except in the Bulburra Depression, where a downwarping of a shallow trough in the sea floor gave increased water depth;
(b) the bituminous and highly pyritic H. Y. C. Member containing the McArthur deposit accumulated within the Bulburra Depression. Approximately 5000 m of shallow-water carbonate-rich sediments accumulated in the trough;
(c) the Cooley and H. Y. C. Members are contemporaneous;
(d) the eastern limit of the McArthur Basin is presently delineated by the Emu Fault (Fig. 1), although the original eastern limit is unknown;
(e) the sulphides within the McArthur deposit itself originated from primary chemical sediments on the sea floor.

Since isotopic measurements are particularly valuable environmental indicators, the initial sulphur isotopic study (Smith and Croxford 1973) has been expanded to provide further information on the environment in which the various sedimentary formations of the McArthur Group accumulated and, in particular, that in which the H.Y.C Member was deposited. Consequently, a number of drill core samples were collected from sediments, stratigraphically above and below and adjacent to the McArthur deposit. These were isotopically analysed for $^{13}$C/$^{12}$C ratios in preserved organic residues; for $^{13}$C/$^{12}$C and $^{18}$O/$^{16}$O ratios in carbonate species; and for $^{34}$S/$^{32}$S ratios in pyrite from both physically undisturbed sediments and associated slump breccias.

The distribution of metals and sulphur, and the isotopic composition of sulphur in the heavily mineralized V121 Cross Cut Section of the McArthur deposit have been described by Croxford and Jephcott (1972) and by Smith and Croxford (1973) respectively. The material examined was generally representative of the sulphides from the entire H.Y.C. Member and, except for the inclusion of some data from the slump breccias, no new details are given here on the McArthur deposit itself.

**Experimental**

**Sample Selection**

Samples from the drill cores BMR 1, BMR 2, Ie 115 and Te 115 and the V 121 cross shaft were examined. The geographical locations of these samples are shown in Fig. 1. The stratigraphic positions from which individual specimens were selected and the inter-relationships between such samples relative to the known features of the main basin are shown diagrammatically in Fig. 2 and listed in Table 1.

In most cases, analytical data on the specimens examined, or on rocks from the immediate vicinities have been published (Croxford and Jephcott 1972; Lambert and Scott 1973).

**Analytical Procedure**

Apart from reported traces of chalcopyrite (Croxford 1968), pyrite is the only sulphide