Ore Geology Reviews 76 (2016) 122–139

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Evidence for SEDEX-style mineralization in the 1.7 Ga Tawallah Group, McArthur Basin, Australia

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ARTICLE INFO

Article history:
Received 30 August 2015
Received in revised form 21 January 2016
Accepted 21 January 2016
Available online 22 January 2016

Keywords:
SEDEX
Base metals
Sedimentary deposits
McArthur Basin
Tawallah Group

ABSTRACT

The Paleoproterozoic McArthur Basin (McArthur Group) of northern Australia hosts world-class sedimentary 'exhalative' (SEDEX) McArthur type Zn–Pb deposits, which are largely hosted within a sequence of 1.64 Ga pyritic carbonaceous shales deposited in an extensional rift setting. A well-known example of these is McArthur River (or Here's Your Chance [HYC] Zn–Pb–Ag deposit). The ~1.78 Ga McDermott and ~1.73 Ga Wollogorang formations (Tawallah Group) both contain carbonaceous shales deposited in similar environments. Our observations suggest the carbonaceous facies of the Wollogorang Formation were deposited under mostly euxinic conditions, with periodically-high concentrations of sedimentary pyrite deposition. The carbonaceous shales in the older McDermott Formation contain considerably less early pyrite, reflecting a mostly sulfide-poor, anoxic depositional environment. Localized fault-bound sub-basins likely facilitated lateral facies variations, which is evident from synsedimentary breccias.

The presence of evaporitic oxidized facies within the McDermott and Wollogorang formations, alongside evidence for synsedimentary brecciation in reduced shales are favourable criteria for SEDEX-style base metal deposition. Both formations overlie volcanic units, which could have been sources of base metals. Detailed X-ray petrography, new geochemical data and sulfur isotope data from historical drill cores indicate multiple horizons of stratiform and sediment breccia-hosted base metal sulfide within carbonaceous shale units, with high-grade Zn concentrations. A close association between sphalerite and ferromanganean dolomite alteration draws comparisons with younger SEDEX mineralization at HYC. Additionally, SEDEX alteration indices, used demonstrably as a vector to the younger orebodies, indicate the sedimentary rocks analyzed in this study are marginally below the ore window when compared to the overlying mineralized stratigraphy.

Our data imply that localized active circulation of metalliferous brines occurred in the Tawallah Group basin. High-grade sulfide deposition in reduced facies alteration may represent distal expressions of larger SEDEX-style deposits. Furthermore, abundant pyrite and high molybdenum in the Wollogorang Formation suggest the global oceanic sulfate concentration was sufficient by ~1.73 Ga to engender intermittent but strong bottom-water euxinia during shale deposition, thus providing a robust chemical trap for base metal sulfide mineralization.

1. Introduction

1.1. Proterozoic sedimentary exhalative (SEDEX) base metal deposits

Stratiform 'sedimentary exhalative' (SEDEX) ore deposits are major sources of base metals such as Zn–Pb–Ag ± Cu–N–Mo–Ba (Li and Xi, 2015 and references therein) and are the primary sources of Zn and Pb (Large et al., 2005). The McArthur and neighbouring Isa basins of northern Australia host numerous SEDEX deposits. The main characteristics of SEDEX deposits in the McArthur-Isa basins are, as summarised in Large et al. (2005): laminated sphalerite and galena-bearing dolomitic siltstones; stacked ore lenses separated by carbonaceous mudstones; ore deposition adjacent to major faults; Fe–Mn dolomite alteration haloes; and no obvious vent or stringer zones. A generalised genetic model for deposition is of synsedimentary base metal sulfide precipitation facilitated by exhalation of metallic basinal brines from active fault zones (Large et al., 1998; 2000 Large and McGoldrick, 2000; Large et al., 2005), or by syndiagenetic replacement of carbonate (Large et al., 1998; Ireland et al., 2004). Two distinct categories of SEDEX deposits were proposed by Cooke et al. (2000) based on the mineralizing brines, sedimentary basin and lithology type: McArthur type (oxidized brines) and Selwyn type (reduced brines). SEDEX deposits of

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http://dx.doi.org/10.1016/j.oregeorev.2016.01.007
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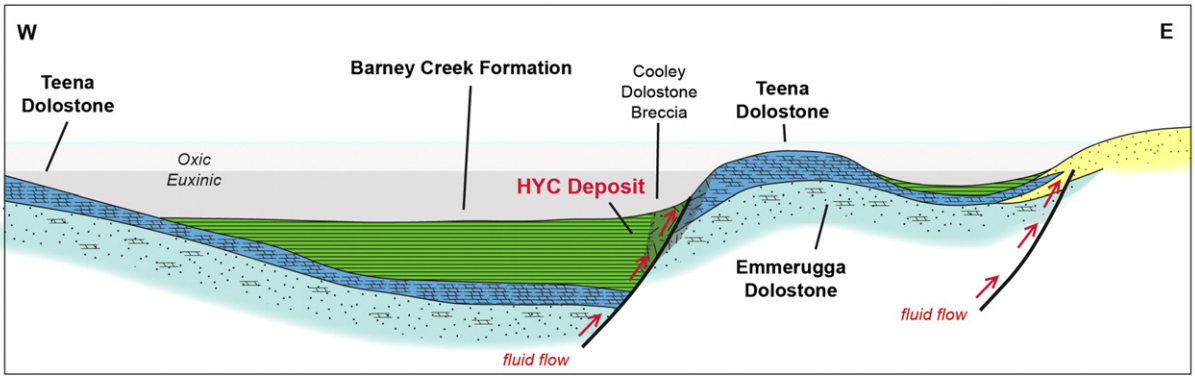

Fig. 1. Genetic model cross section of synsedimentary McArthur Type base metal sulfide SEDEX deposits, based on the geology of HYC (e.g. Large et al., 1998).

the McArthur-type typically form by the following stages (Large et al., 1998; Large and McGoldrick, 2000; Cooke et al., 2000; Fig. 1):

1. Oxidizing brines descend from surface evaporitic environments into porous and fractured basin aquifers.
2. Basinal brines leach metals from underlying volcanics.
3. Sulfate-metal-bearing oxidized brines are released along fault zones into anoxic/euxinic basin floor or shallow subsurface.
4. Base metal sulfide precipitation through bacterial sulfate reduction or by interaction with biogenic H_2S.

The major known SEDEX deposits in the McArthur Basin (Fig. 2) occur within the Barney Creek Formation of the McArthur Group (Glyde Package; Figs. 1, 3) such as the McArthur River (or Here's Your Chance [HYC]) Zn–Pb–Ag deposit (Large et al., 1998; Large and McGoldrick, 2000). The volcanic and oxidized clastic lithologies

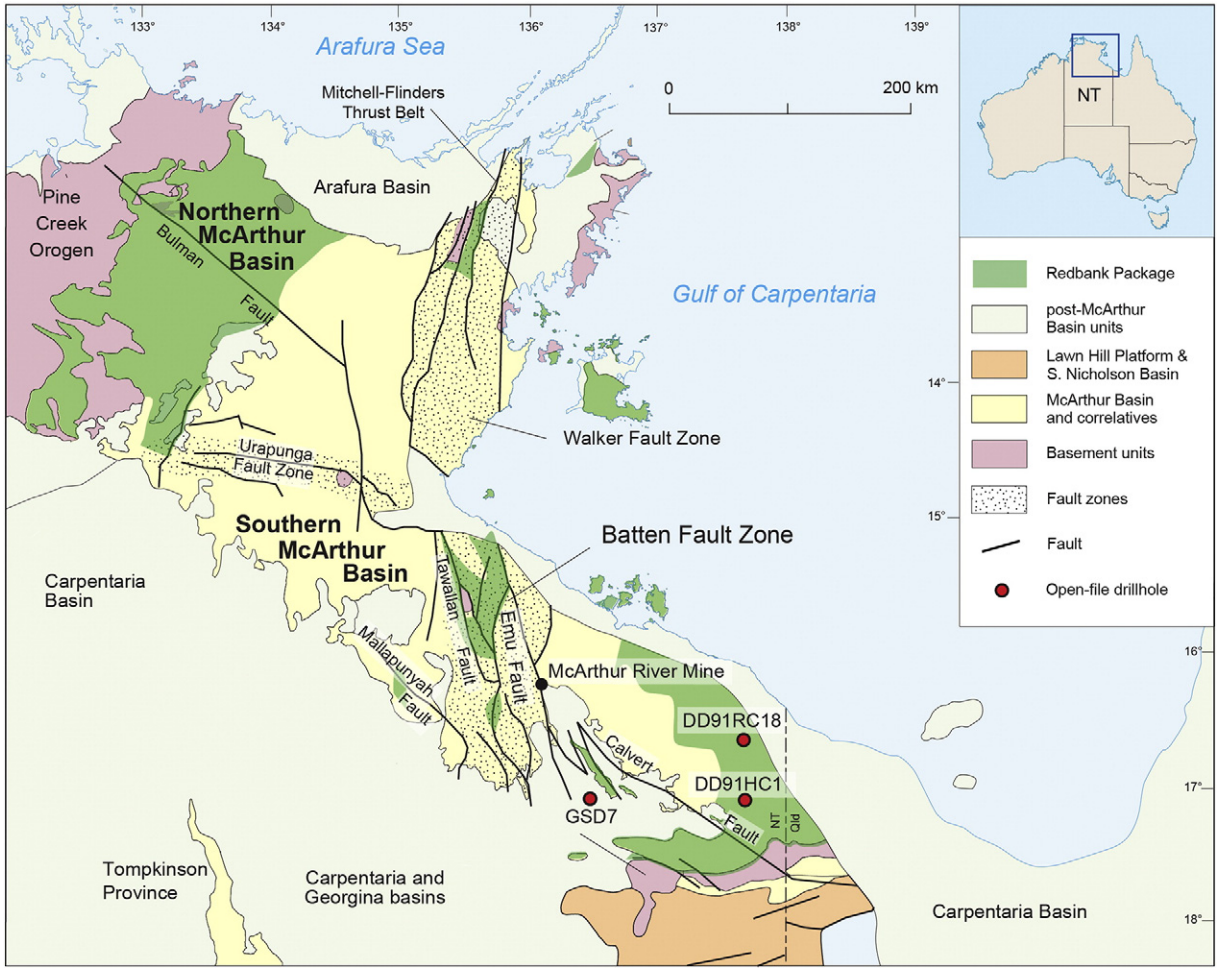

Fig. 2. Simplified geological map of the McArthur Basin of Northern Australia (modified after Ahmad et al., 2013 and references therein).