Pyrite trace element halos to northern Australian sediment-hosted Zn-Pb-Ag deposits

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Abstract. Subtle primary halos form around many sedimenthosted Zn-Pb deposits. Northern Australian deposits may also have pyrite halos, representing the first paragenetic stage of the mineralising fluids. The occurrence of trace elements within this pyrite has potential to provide vectors to the orebody or delineate mineralised from barren systems. Pyrite trace element compositions from rocks surrounding the McArthur River sediment-hosted Zn-Pb deposit, Northern Territory, Australia have been analysed by LA-ICPMS. Analysis was conducted for 25 elements. Over 95% of all pyrite analysed contained >0.10 wt% of trace elements, of which, Co, Ni, Cu, Zn, As, Sb, Ba, Tl, Pb, Mn, Mo, Ag, Bi and Sn are found in abundances significantly greater than detection limits. The host sediments contain no significant levels of Cu, Co, Ni, Pb, Zn. Concentrations of Co, Cu, Ni, Tl and Zn are significantly elevated at the orebody and hangingwall equivalent stratigraphy. As, Ba, Mo, Sb, Sn are slightly elevated at the orebody equivalent stratigraphy. Spatial distribution patterns of the trace elements are erratic, possibly reflecting variations in pH, oxidation state, or temperature across the basin at the time of formation.

Keywords. SEDEX, McArthur river, pyrite, trace elements, LA-ICPMS

1 Introduction

Primary halos to sediment-hosted Zn-Pb deposits are typically broad, but subtle and are identified from whole rock chemical variations. However, northern Australian sediment hosted Zn-Pb deposits also have close associations with highly pyritic sediments. A synsedimentary model of formation for these deposits (e.g. Large et al. 1998) predicts that this pyrite represents the first paragenetic stage produced by the mineralising fluids. Pyrite can contain measurable quantities of trace elements either as inclusions, or within the crystal lattice. This property suggests that a study of pyrite trace element contents has the potential to provide vectoring information in prospective (highly pyritic) areas or to distinguish mineralized hydrothermal systems from those that are barren.

In this study, laser ablation (LA-ICPMS) analysis of pyrite has been undertaken from systematic drill core and underground samples near the giant McArthur River deposit, Northern Territory, Australia.

2 Study area

The McArthur River deposit is the largest known example of a stratiform, sediment hosted deposit and has a geological resource of 237 Mt grading 9.2% Zn, 4.1% Pb and 41g/t Ag (Gustafson and Williams 1981). This Proterozoic age deposit has undergone minimal structural disruption and metamorphism, thus making it an ideal location to conduct such a study. Work currently in progress also involves the study of a large, low-grade sedimentary Zn-Pb system known as the Bluebush prospect, NW Queensland, Australia. This prospect covers an area approximately 10 km x 10km, with average grades of 1.0% Zn. To date, no economic mineralisation has been discovered. The Bluebush prospect will provide a comparison to the mineralised system at McArthur River.

3 Background information

This investigation builds on previous studies that recognized significant elemental and isotopic zonation around the McArthur River deposit e.g. Lambert and Scott (1973),

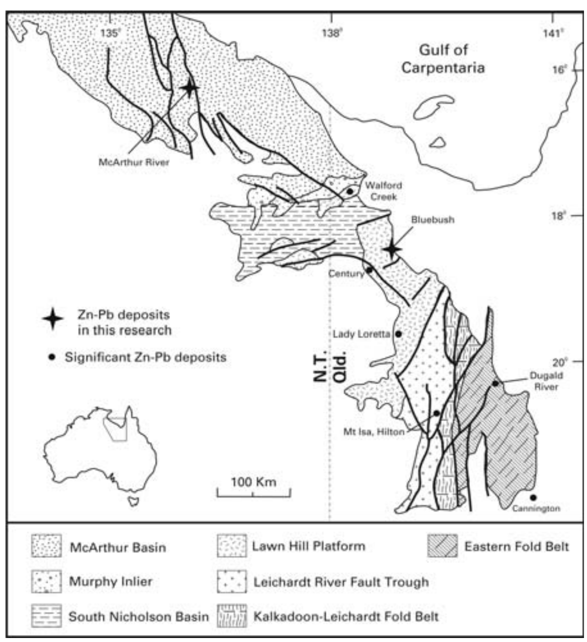

Figure 1: Map showing the location of the two deposits in this study, the location of other significant sediment-hosted Zn-Pb-Ag deposits, and the location of basins and major tectonic elements in the Carpentaria Zinc Belt. Modified from Betts et al. 2003.

Large et al. (2000) and Large et al. (2001). The results of these studies suggest that zonation of specific mineral chemistry may be present.

Many significant reviews have documented the occurrence of trace elements within pyrite (e.g. Craig and Vaughan 1990; Abraitis et al. 1994). Watson et al. 1995 have also shown the effectiveness of bacterially produced gel – a probable precursor to framboids, at absorbing trace elements.

4 Sampling strategy

Samples for this research have been collected at regular downhole intervals from drill cores 0.3, 6, 15 and 23 km away from the orebody, representing the overlying, hangingwall, orebody and underlying equivalent stratigraphy. Additional samples have been collected from underground exposures of "fringe ore". These were selected to cover significant variations in zinc content, from ore grade (~19% Zn) through to sub-economic levels (>5% Zn) along laterally continuous beds.

5 Analytical method

Analytical methods in early pyrite studies (eg Loftus-Hills and Solomon 1967) typically used wet chemical analysis of bulk mineral separates. The data was potentially compromised by inclusions of other sulphide minerals and multiple generations of sulphide deposition.

The principle analytical method used in this research is laser ablation ICPMS. Studies using other microbeam analytical methods (e.g. Cabri et al. 1985; Griffin et al. 1991; Huston et al. 1995) have limitations such as relatively large beam size, high detection limits, prohibitive costs and long analytical times compared to LA-ICPMS. Analyses to date have used an 8 - 10 µm beam, a spatial resolution of a few microns, and median detection limits for most elements less than 5 ppm. This is important considering the northern Australian deposits are characterised by fine grained sulphides.

Pyrite at McArthur River can be <5 µm and host sediment contamination needs to be considered.

The recognition and rejection of analysis compromised by inclusions can reasonably be achieved, initially by interrogation of the LA-ICPMS spectra, and confirmed by statistical analysis of the data. Invariably during LA-ICPMS, small amounts of the host sediments are ablated with the pyrite. To quantify this contribution, micro-analysis of the host sediments, adjacent to the target pyrite grains have also been conducted.

6 Results

Analysis was conducted for 25 elements. The total concentration of trace elements in pyrites was low. Over 95% of all pyrite analysed contained >0.10 wt% of trace elements, of which, Co, Ni, Cu, Zn, As, Sb, Ba, Tl, Pb, Mn, Mo, Ag, Bi and Sn are found in abundances significantly greater than detection limits.

The host rocks are typically composed of dolomite, quartz and muscovite. LA-ICPMS analysis indicates no significant levels of Cu, Co, Ni, Pb, Zn are contained within these minerals. Minor host sediment contamination of Mn, Ba, As, and possibly Sb and Tl to the pyrite analysis cannot be discounted.

Downhole plots of the pyrite trace elements indicate that Co, Cu, Ni, Tl and Zn concentrations are significantly elevated at the orebody position, relative to the hangingwall and overlying formation pyrites. As, Ba, Mo, Sb, Sn are slightly elevated at the orebody equivalent position, relative to the hangingwall and overlying formation pyrites.

Spatial distribution patterns of the trace elements are erratic. This may be reflecting variations in pH, oxidation state, or temperature across the basin at the time of formation, in turn controlling pyrite uptake of the available trace elements. Future work aims to resolve these relationships.

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