Lateral Variability of Sedimentology, Mineralogy and Geochemistry in the HYC Zn-Pb-Ag deposit, Northern Territory, Australia; *implications for ore genesis*.

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I Abstract

An understanding of the lateral variability of sedimentology, mineralogy and geochemistry at HYC has the potential to contribute to improved ore genesis models, and to facilitate better mine planning and grade control at the McArthur River Mine. HYC is the largest of the north-Australian Proterozoic sediment hosted stratiform base metal deposits (>230 mT @ >12%Zn), and is hosted by the reduced sub-wave base marine carbonate-siliclastic Barney Creek Formation.

Macroscopic planar sulphide laminae consist of variable intergrowths of two distinct sphalerite and pyrite phases, galena, arsenopyrite, quartz, ankerite and dolomite, and disguise significant microscopic textural complexity. Sphalerite 1 (sp1) and pyrite 1 (py1) are paragenetically early, fine grained and volumetrically dominant in the deposit, whereas sphalerite 2 (sp2) occurs as late stage, relatively coarse grained replacement of carbonates, and pyrite 2 (py2) is coarse grained, volumetrically minor, and is the last sulphide phase to form. The deposit friuge is characterised by systematic changes of microscopic sp1 texture with concommitant stratigraphic thinning and declining base metal grade that is unrelated to the distribution of iron. Characteristic anastamosing microscopic textures are explained by pelagic fallout of pyrite crystallites from the water column (py1) with simultaneous seafloor precipitation of basemetal sulphides (sp1).

Sheet-like mass flow deposits that separate ore lenses and dilute ore at HYC exhibit rapid lateral transition from erosive boulder-bearing debris flows to non-erosive normally-graded turbidites. Turbidites formed by elutriation of fines into a turbid flow that followed and outran the primary debris flows. Plastically deformed sulphidic intraclasts and sulphidic matrices of these breccias are texturally and isotopically identical to *in-situ* laminated sulphide ore, and constrain mineralisation to the upper few metres of the unconsolidated marine sediments.

Nodular carbonates occur on all preserved fringes of the deposit, and are the direct lateral equivalent of the mineralised stratigraphy. The S/C ratio of unmineralised siltstone reveals primary differences in shallow diagenetic processes between the nodular and laminar sulphide ore facies. Bacterially triggered carbonate precipitation probably took place at shallow depth during base-metal mineralisation, and resulted in Fe-Mn-calcite nodule formation in a zone concentric about the local depocentre. Dolomitisation and partial replacement by sphalerite (sp2) occurred shortly after nodule formation, as modified ore fluids permeated the sediment pile. The $\delta^{13}C$ of these carbonates is consistent with that of detrital carbonates in the host unit, which indicates that oxidised organic carbon (a major product of inorganic sulphate reduction) was not incorporated into the nodular carbonates.

The $\delta^{34}S$ values of sp1 and py1 are heavier in the deposit centre (5-8‰) than in the deposit fringe (0 to -2‰). This suggests a gradient of ^{34}S fractionation concentric around the focus of mineralisation, interpreted to be largely due to bacterial processes that were limited spatially by physicochemical gradients in a stratified water body. Fine grained pyrite textures closely resemble contemporaneous microfossils and microbially laminated pyritic sediments elsewhere, and confirm the presence of a prolific benthic microbial fauna spatially related to the mineralising system. Sp2 defines a $\delta^{34}S$ population (mean = 9.3‰) that is distinct from, and always heavier than coexistent sp1, interpreted to arise from partial closed-system sulphate reduction in the sediment pile.

The textural, geochemical and sedimentological data demonstrate that the stratiform HYC Zn-Pb-Ag deposit at McArthur River is a vent-distal sedimentary exhalative deposit, in which the contemporaneous benthic microbial fauna played an important role in mineralisation. The HYC sub-basin was probably not significantly more extensive than the deposit, and restriction of the water body, including 'plugging' of the northern end by a fanglomerate wedge, were crucial to establishment of a stratified aqueous environment amenable to extreme concentration of metals. Metalliferous fluids were introduced into the basin via hydrothermal pluses from a structural conduit related to the Emu Fault.

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III Contents