Paris Silver deposit: Pyrite trace elements and sulphur isotopes

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1. Introduction

The Paris Silver deposit, located in the Northern Eyre Peninsula (fig 1) is a shallow Ag deposit, the resource of which extends over an area of 1200 m by 400 m, to a depth of 150 m (Investigator Resources, 2013a), and contains a total resource of 9.3 Mt @ 139 g/t with 42 Moz contained silver (Investigator Resources 2017).

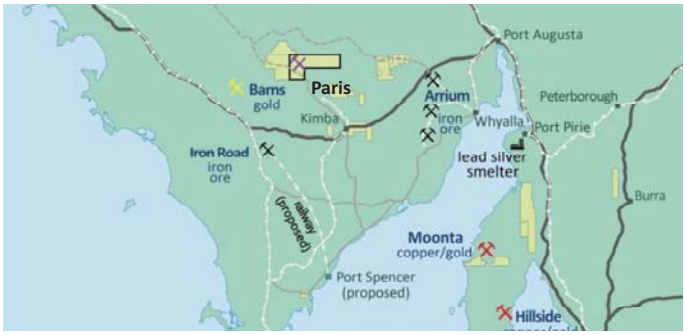

Figure 1: Location of the Paris silver deposit with respect to other deposits. (Inves. Res 2017)

2. Geology

The deposit is comprised of laterally extensive hydrothermal and volcanic breccias, fed by a largely barren central diatreme, topped by flow banded/layered volcanics, hosted by dolomitic marble and minor graphitic metasediments. The flow banded ignimbrites of the Gawler Range Volcanics are unconformably overlain by more recent sediments (silcrete, gravels, soil).

The Katunga dolomitic marble of the Hutchison Group has been metamorphosed to amphibolite facies, with a retrogressive greenschist overprint during the Kimban Orogeny, and intense isoclinal folding and faulting, occurring prior to mineralization, providing structural conduits for later metalliferous fluids (Investigator Resources, 2013). Where these fluids have interacted with the dolomite, zones of carbonate replacement mineralization have formed, with alteration minerals of pyrite, marcasite, arsenopyrite, sphalerite, galena, chalcopyrite, pyrrhotite, acanthite, jalpaite, magnetite and minor native silver, and quartz, talc and graphite gangue.

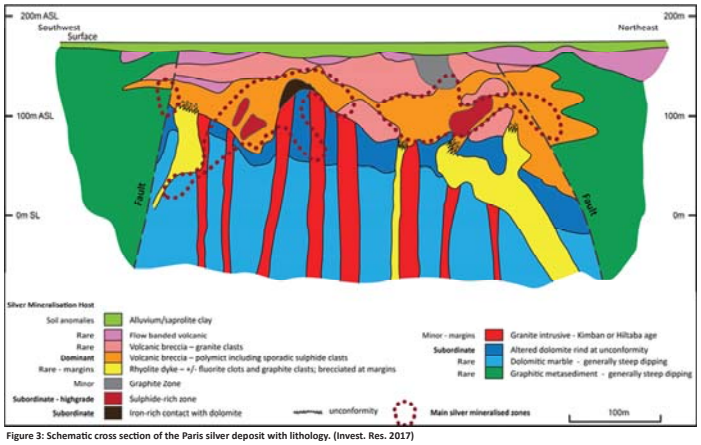

Figure 3: Schematic cross section of the Paris silver deposit with lithology. (Invest. Res. 2017)

In addition to the Katunga dolomite, the basement is also in unconformable contact with schistose to gneissic metasediments, possibly of the Sleaford Complex, and are comprised of foliated metamorphic quartz, graphite and muscovite, and secondary weathering minerals, principally kaolinite.

The emplacement of the Gawler Range Volcanics occurred prior to and during mineralization, causing formation of, in particular, the granitoid breccia, which contains granitoid clasts of 5-10 mm size, but have been reported to be up to 9 m. The graded nature of the sequences suggests that this unit may be relatable to an ignimbrite unit that occurs regionally (Parker and Flint, 2005). Yet to be dated granitic intrusives, but nevertheless interpreted to be of Hiltaba age, which exploit structural weaknesses in the dolomitic marble are thought to intrude at the same time as the early GRV (Invest. Res. 2013).

The Iron-reaction zone occurs between the altered dolomite and the volcanic breccias, and is characterized by jasperoidal iron, hematite and goethite.

The discordant breccia contains large sericite altered acid lava and graphitic metasediment fragments in a fine-grained matrix, composed of quartz, sericite, chlorite, graphite and sulphides (pyrite, sphalerite and galena) (Mason, 2012).

The polymict breccia contains mineralized massive sulphide clasts that are thought to have been sourced from sulphide veins within the altered dolomite, as the sulphide composition is similar to massive sulphide veins have been observed in the upper altered dolomite, which in some cases exhibit delamination.

A late stage of primary mineralization appears to have been dominated by a pyrite rich phase, wherein pyrite overgrowths cover earlier sphalerite, acanthite and minor native silver.

The breccias and volcanic rocks are all overprinted by intense argillic alteration, rendering most of the original rocks highly friable.

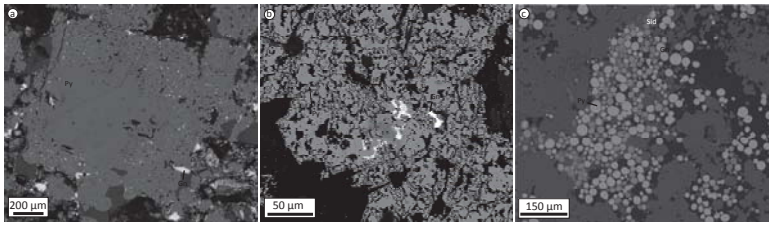

Figure 3: Backscatter election images of a) Idiomorphic pyrite; b) resorbed pyrite and c) framboidal pyrite.

3. Ore mineralogy

In descending order of abundance, the ore minerals at Paris are pyrite, galena, sphalerite, arsenopyrite, with minor chalcopyrite, pyrrhotite and a number of Ag-bearing phases, including native silver, acanthite, and subordinate jalpaite and chlorargyrite. Three main mineralized assemblages can be recognised at Paris: (i) saprolitic polymict breccia; (ii) the iron reaction zone and altered dolomite; and (iii) magnetite/sulphide veins.

Across the different lithologies at Paris, a range of pyrite textures are observed, with 4 main categories: idiomorphic pyrite, euhedral to subhedral, 50 – 500 µm grains that demonstrate varying degrees of resorption, most commonly with overgrowth of porous, inclusion rich pyrite, containing galena and Ag minerals (fig 3a); resorbed pyrite, aggregates of subhedral to anhedral grains that have been resorbed and overgrown by a later generation of pyrite (fig 3b); and framboidal pyrite, present as 10 – 20 µm framboids that occur individually and as aggregates up to ~400 µm (fig 3c).

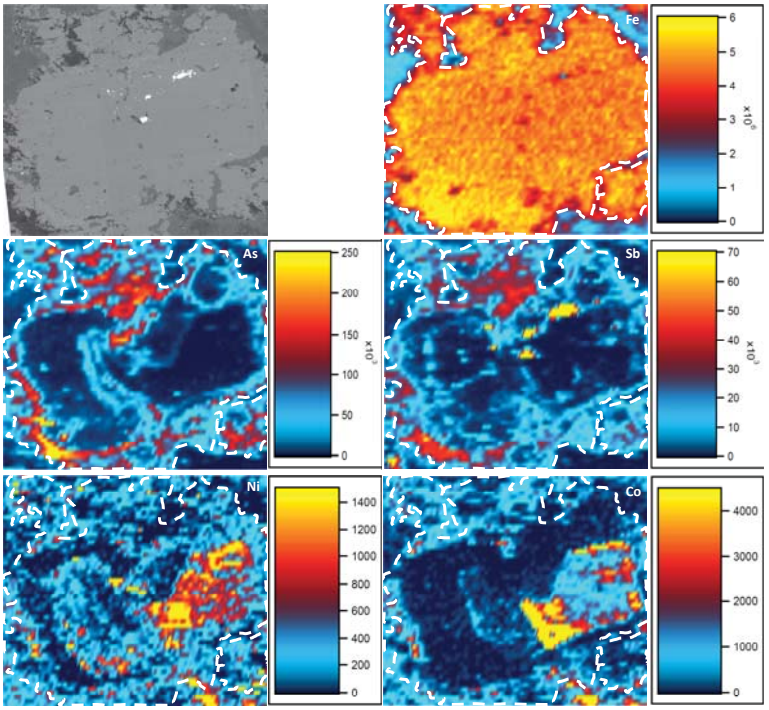

Figure 4: Backscatter electron image and LA-ICP-MS trace element maps of an idiomorphic pyrite grain. Scale is in counts per second.

4. Sulphide trace element distribution.

Silver is contained within sulphides in solid solution (particularly in galena, sphalerite and arsenopyrite), and as inclusions a few µm in size extending down to the nanoscale. Porous, inclusion-rich pyrite from the sulphide-rich breccia clasts contain an average of >10,000 ppm Ag, whereas pyrite from magnetite/sulphide veins at depth contains mean concentrations of 80 ppm Ag. Concentrations of other trace elements vary considerably with respect to texture

The idiomorphic pyrite from the altered dolomite (fig 4) is zoned with an inner Co and Ni, with an outer As and Sb zone, indicating an evolution in the source fluids.

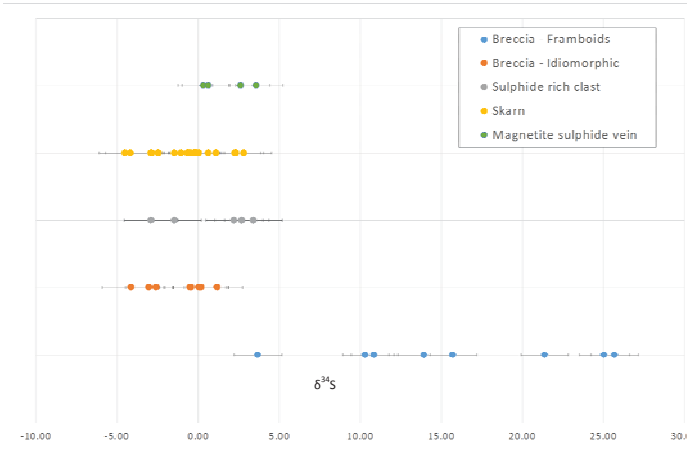

Figure 5: Sulphur isotopes for pyrite and pyrrhotite (magnetite sulphide vein).

5. Sulphur isotopes

The sulphur isotope signature for pyrite (fig 5) (breccia, sulphide rich clast and skarn) and pyrrhotite (magnetite sulphide vein) have a broadly magmatic signature, slightly negative to slightly positive per mil. The framboidal pyrite, however, has a significant spread of per mil values and is generally significantly more positive, suggesting that they were not biogenic in origin, and formed from the input of other fluid sources.

6. References

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