# Ore mineralogy and geochemistry in the M2 orebody, Challenger, SA: Implications for gold distribution and remobilisation

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**Abstract**

The Challenger gold deposit, northwest Gawler Craton, South Australia, underwent granulite-facies metamorphism during the Sleafordian orogeny. Since its discovery, debate has focused on the genetic history of the Challenger deposit and whether the mineralisation is metamorphogenic (syn-orogenic) or metamorphosed (pre-metamorphic precursor). Unlike other studies that have targeted the silicate assemblages in the wallrock to understand ore evolution, the present study attempts to unravel part of the genetic history from the ore minerals themselves, specifically from the main ore minerals (löllingite, arsenopyrite and pyrrhotite) and various trace minerals. The study is also the first which has been able to access the entire strike of the M2 orebody, which forms the mainstay of current exploitation. One goal of the work was to establish if distinctions could be made between mineralogy and textures in the M2 orebody and those in distinct high-grade areas of the deposit.

By integrating microscopy, electron probe analysis, determination of trace element distributions in ore minerals by laser-ablation ICP mass spectroscopy (LA-ICP-MS), electron back-scatter diffraction (EBSD) and transmission electron microscopy of pyrrhotite, the study has established that grain-scale remobilisation of lattice-bound gold to form visible gold took place by mineral-fluid interaction via coupled dissolution-reprecipitation reaction. This is in addition to the melt-assisted remobilisation of Au, which is considered to account for the high-grade ore. The study shows that the ore mineral assemblage in M2 ore is broadly similar to that of M1, except that there are some significant differences with respect to the association of gold; Au-Ag-Te associations appear to be more important in M2 than Au-Bi associations described in earlier publications.

The LA-ICP-MS data show that tens of ppm Au are retained in the löllingite lattice, but that coexisting arsenopyrite is a very poor host for invisible Au. The trace element contents of the two minerals in different textural settings can help to constrain the metamorphic development of the ore. Furthermore, the pioneering attempt to use EBSD to study associations of löllingite and arsenopyrite show promise for relating gold remobilisation to deformation. Mineral assemblages and trace element signatures observed in the present study are consistent with a precursor, zoned, epithermal-style deposit.

The mineral inventory of the Challenger deposit has been expanded by the identification of several telluride minerals previously unreported from Challenger (hessite, petzite, hedleyite, volynskite), as well as greenockite, scheelite and gahnite. Two less-common pyrrhotite types (3C and 1C) are also reported. The presence of Ag-rich electrum, sub-microscopic gold at reaction fronts between arsenopyrite and löllingite, 'invisible' gold in löllingite, and the presence of graphite in the M2 ore, all carry implications for mineral processing and gold recovery.

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