Highlights and Breakthroughs

Analyses under the curve, identifying how invisible gold is held in pyrite

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ABSTRACT

When laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) analyses of pyrite plot below the gold solubility line on a gold vs. arsenic plot and have relatively flat counts on laser ablation time-resolved output graphs, it is often interpreted that the gold is held within the pyrite structure. The study by Ehrig et al. (2023, this issue) shows, using a combination of LA-ICP-MS spot analyses of gold in pyrite, transmission electron microscopy, and electron backscatter diffraction that this is not necessarily the case. Furthermore, they use these same techniques to identify how trace elements, including gold, are remobilized in pyrite during deformation and metamorphism.

Keywords: TEM, gold, arsenic, nanoparticles

A link has been made between the amount of gold and arsenic in pyrite. Reich et al. (2005) found that the maximum amount of gold that can be contained in the pyrite structure can be defined by a maximum solubility curve on a gold vs. arsenic plot where gold in pyrite with concentrations above the curve must be held as nanoparticles. However, it is not clear whether the gold/arsenic ratios that plot below the curve are held within the pyrite structure or as nano-inclusions that are not in high enough abundance to make the analyses go above the solubility curve. Laser ablation time-resolved output graphs can be used to distinguish between structurally held gold and micro-inclusions because if there are distinct peaks, it can be concluded the gold is present as nano-inclusions. However, if the counts are relatively consistent, it is often interpreted that the gold is held within the pyrite structure, although it has been noted that it is possible that they are in uniformly distributed nano-inclusions.

What Ehrig et al. (2023, this issue) have achieved is to utilize transmission electron microscopy (TEM) and electron backscatter diffraction (EBSD) to investigate how gold was held in pyrite that had LA-ICP-MS spot analyses with gold concentrations under the gold solubility line and with relatively flat counts of gold on laser ablation time-resolved output graphs (i.e., a situation where gold would often have been interpreted to be held within the pyrite structure; Ehrig et al. 2023). Importantly, they present data from both the LA-ICP-MS scale and the TEM scale so it can be understood how the latter data can inform the interpretation of the former data. What they found was that indeed gold is held within a variety of nano-inclusions, including electrum, tellurides, and Bi and Pb minerals. This shows that conclusions cannot be made on how gold is held within pyrite if it plots under the gold solubility line. This is important as pyrite trace element content is used, among other things, to understand past fluid compositions, and if the gold is held within different mineral phases, the partition coefficient of gold into these other phases will have a bearing on the interpretation of the composition of the original fluid, rather than the partition coefficient of gold into pyrite.

Furthermore, Ehrig et al. use their results to track how gold content is affected by metamorphism. This, too, contains important information as pyrite trace element content has been argued to be preserved during metamorphism until lower- to mid-greenschist facies. This is largely based on interpretations of pyrite texture in different ore systems. The observations of Ehrig et al. give some evidence of how trace elements in pyrite are affected by deformation, which will aid in both interpretation of empirical data in the future and the design of experiments to better understand the mobility of trace elements in pyrite during metamorphism and deformation. This is important because pyrite is often invoked as a source of gold in orogenic gold systems (Large et al. 2011) and how and when these trace elements are released has significant bearing on understanding the source of the gold, fluids, and subsequent formation of these ore deposits.

In conclusion, this paper gives important empirical observations demonstrating that despite LA-ICP-MS analyses below the gold solubility line and flat gold laser ablation output graphs, the gold is held within nano-inclusions, and it is not held within the pyrite structure. This shows that while analyses that plot above the curve can be interpreted to be free gold inclusions, it cannot be known that analyses that plot below the curve show structurally bound gold. Furthermore, the paper provides interesting information regarding how gold is remobilized during deformation.

REFERENCES CITED


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