Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19925

Development of a new analytical strategy to determine the Hg isotopic composition in gold materials

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Mercury (Hg) is still widely used for gold extraction in artisanal and small-scale gold mines: to extract it from a lode ore or a gold-bearing sand, miners often resort to amalgamation, which consists of adding Hg. However, Hg can also be present in gold naturally (up to 800 ppm in gold-silver deposits [1]), and therefore linked to the gold deposit and its geological origin.

Hg isotopes are usually used to discriminate the origin of Hg and allows a better understanding of its biogeochemical cycle in the environment. Many factors control Hg isotopes fractionation in the environment such as biological, photoreduction processes... leading to a specific isotopic composition in the final product. This fingerprint could be used to track Hg naturally present in gold deposit from Hg used during gold extraction/amalgamation.

The aim of this work was to develop a reliable sample preparation methodology to separate quantitively Hg from Au prior to isotopic analysis. Direct measurements of Hg standard (NIST 3133) by CVG/MC-ICP-MS in the presence of gold (Au) leaded to signal suppression and Hg isotopic fractionation correlated to Au concentration due to its high reactivity with Hg. Thus, several strategies to separate Au from Hg were explored.

After acid digestion of the gold material with aqua regia ($2HCl:1HNO_3$), the Hg extraction from the matrix is divided into two steps. The first one is a redox reaction between Au and Sn to form a precipitate of gold nano-particles (Purple of Cassius). This critical step depends on the Au/Hg ratio. Excess of Sn can generate gaseous Hg leading to Hg isotopic fractionation. The second step is the volatilization of Hg from the matrix by purge and trap method adapted from Zheng et al., 2009 [2]. Recoveries obtained on Hg standards and gold samples with different Au/Hg ratios are close to 100%, suggesting that Hg is quantitatively recovered. Accurate Hg isotopes measurements in gold samples have been achieved with a precision down to 0.15‰ (as 2SD) for $\delta^{202}Hg$.

[1] A. Nikolaeva et al., 2013, Geology of Ore Deposits, 2013, 55(3), 176–184.

[2] Zheng et al., Journal of Analytical Atomic Spectrometry, 2007, 22(9), 1097-1104.