GOLD BALANCE

SUBMICROSCOPIC GOLD: A CRITICAL ASPECT OF REFRACTORY GOLD ORES

The extractive metallurgy of gold and silver is controlled and often complicated by mineralogical factors such as

- particle size
- mineral associations
- coatings
- presence of cyanicides, oxygen consumers and preg-robbers.
- presence of refractory gold and silver minerals
- locking of submicroscopic gold in sulfide mineral structures

Understanding the deportment of gold locked in pyrite, arsenopyrite or other minerals in either gold ores or mill products is critical to troubleshooting low gold recovery. Submicroscopic gold is a major form of gold in many refractory ores, particularly Carlin-type ores and some epithermal gold ores.

SGS Minerals Services can quantify the presence of microscopic and submicroscopic gold in the various minerals in a sample, using techniques such as QEMSCAN, and combine this data to generate a gold balance. This quantifies free milling and refractory gold contents for:

- conceptual scoping studies
- flowsheet development
- pre-feasibility testing and piloting
- process audits
- process troubleshooting

SUBMICROSCOPIC GOLD CARRIERS

Pyrite and arsenopyrite are the two major carriers of submicroscopic gold in many refractory ores. Other submicroscopic gold carriers include chalcopyrite, loellingite, marcasite, iron oxide minerals (in oxidized ores or calcines), realgar and clay minerals.

In refractory ores, pyrite and aresenpyrite often occur in three morphological types: coarse grained, fine grained and blastic or porous. The concentration in each type of sulphide mineral is different and usually varies from ore to ore and so must be determined individually for each deposit and perhaps within each ore-type in a deposit.

Zoning is a common textural feature of these ores. Often, the gold content of the rim or outer zones is higher than that of the core. These relationships must be quantified to fully understand the impact of refractory gold on an ore.

PROTOCOLS AND PROCEDURES

To determine the character of refractory gold and a mass balance between refractory and free-milling gold in a sample, a sequence of separations and analyses are performed to provide a complete overview of the mass balance of gold in the sample. While the protocol is complex, the sizing, pre-concentration and final concentration steps are crucial to yielding a sample large enough to be both statistically valid and still able to quantify the gold present in the sample.

Conceptualized flowsheet showing protocols used to determine microscopic and submicroscopic gold is as follows:

This protocol can be divided into several components:

MICROSCOPIC GOLD STUDY BY CONVENTIONAL ANALYSIS (FRACTIONS A, B1, C)

This study characterizes the gold in fractions A, B1 and C (above) by conventional analysis which includes multipour fire assay, optical microscopy or image analysis. From these data, the grind fineness and possible response of this fraction of ore to conventional gold recovery techniques can be predicted, as well as any major mineralogical factors that may affect gold and silver metallurgy.

SUBMICROSCOPIC GOLD STUDY BY SIMS (FRACTION B2) (REFRACTORY GOLD)

This study characterizes the gold in fraction B2 (above). This is the submicroscopic or refractory gold component of the sample. For each major gold-bearing sulfide mineral (mainly pyrite and arsenopyrite), the gold content is determined by multipour fire assay and Secondary Ion Mass Spectrometry (SIMS). Gold distribution in the sulphide minerals can also be determined by SIMS. Normally, 25 analyses (including pyrite and arsenopyrite) are done per sample. From these data, the nature of the refractory gold and its distribution are determined.

GOLD BALANCE (FRACTIONS A, B1, B2, C)

This reconciliation allows the percent microscopic gold vs submicroscopic gold to be calculated. To do this, fractions A, B1, B2 and C must be analysed. Approximately 0.5 – 5 kg of sample is required to determine a gold balance, depending on the gold grade.

OTHER POSSIBLE STUDIES

Other studies such as cyanide leaching tests or acid digestions can be performed, depending on the ore and problem being addressed

SECONDARY ION MASS SPECTROMETRY (SIMS)

Secondary ion mass spectrometry (SIMS) is an important tool in investigating refractory gold balances because of its unique ability to detect and map submicroscopic gold in minerals such as pyrite and arsenopyrite. In particular, it has a

- small beam size: ~20 μm;
- low detection limit - 0.3 – 0.5 ppm for Au
- shallow beam-sampling depth (0.5 – 1μm)

SIMS can perform individual particle analysis, depth concentration profiling and element mapping. SIMS in-depth concentration profiling can be used to discriminate colloidal gold and solid solution gold in sulphide minerals. SIMS mapping will show the location and distribution of submicroscopic gold in host minerals, gold that is invisible under the optical microscope and scanning electron microscope. Submicroscopic gold can occur as discrete particulates as little as <0.1 μm in diameter within host minerals such as pyrite and arsenopyrite.

CONTACT INFORMATION

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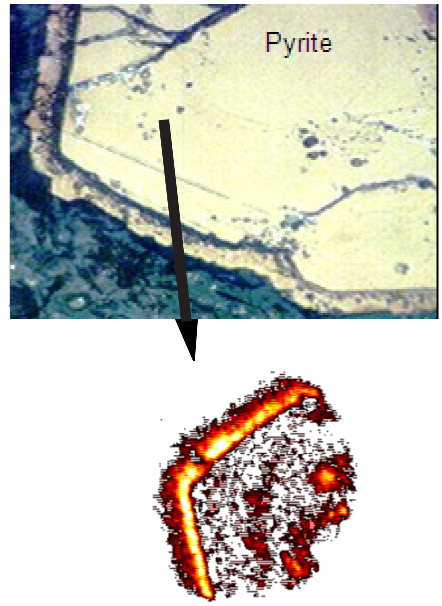

Pyrite containing zones of arsenic (red) and 0.5-130 ppm gold (yellow).