TIMA Bright Phase search –
Tracking gold losses using SEM based automated mineralogical system

Gold ores are usually considered as low grade when compared to common base metal ores. The gold content commonly ranges from 2 ppm to 10 ppm. It can only exceptionally reach values as high as hundreds and thousands ppm. Recovering of such a small quantities from often very variable ores is a matter of complex beneficiation process with many ways of possible losses. Quality control is thus extremely important in order to maintain the profitability of particular mining site. Automated SEM based mineralogical analysis is virtually the only tool which is able to asses not only the gold quantity in the tailings but also its relationship to other minerals allowing to identify possible causes of gold losses. A general example will be described in following text.

Methods

The TESCAN Integrated Mineral Analyser (TIMA) was used for acquiring the data (see Fig. 1). It is a SEM based automated mineralogical solution capable of automated identification and quantification of minerals present in the sample. The system also provides further texture related information like a grain size, mineral association, liberation degree and others in addition. Mineral classification relies on X-ray spectra (EDS) and backscattered electron (BSE) signal primarily, although other signals like secondary electron (SE) and cathodoluminiscence (CL) can be also used to provide further information about the sample. The data were acquired by using an accelerating voltage of 25 kV and a beam current of 5 nA in a high vacuum mode. The working distance was set to 20 mm. The applied pixel spacing was 2 µm.

The processing waste was obtained from a minor gold producer in Europe in a form of a loose powder. The sample represents a week average tail from the processing plant. The mass of sample was subsequently reduced using laboratory splitter from initial 0.5 kg to about 10 g sufficient to create three epoxy mounts. The epoxy mounting was performed under vacuum conditions in order to remove any gaseous bubbles from the curing epoxy. The block surface was grinded and polished and finally also coated with 10 nm of carbon. This conductive layer allowed the actual SEM imaging and EDS mapping.

▲ **Fig. 1:** TESCAN Integrated Mineral Analyser (TIMA FEG)

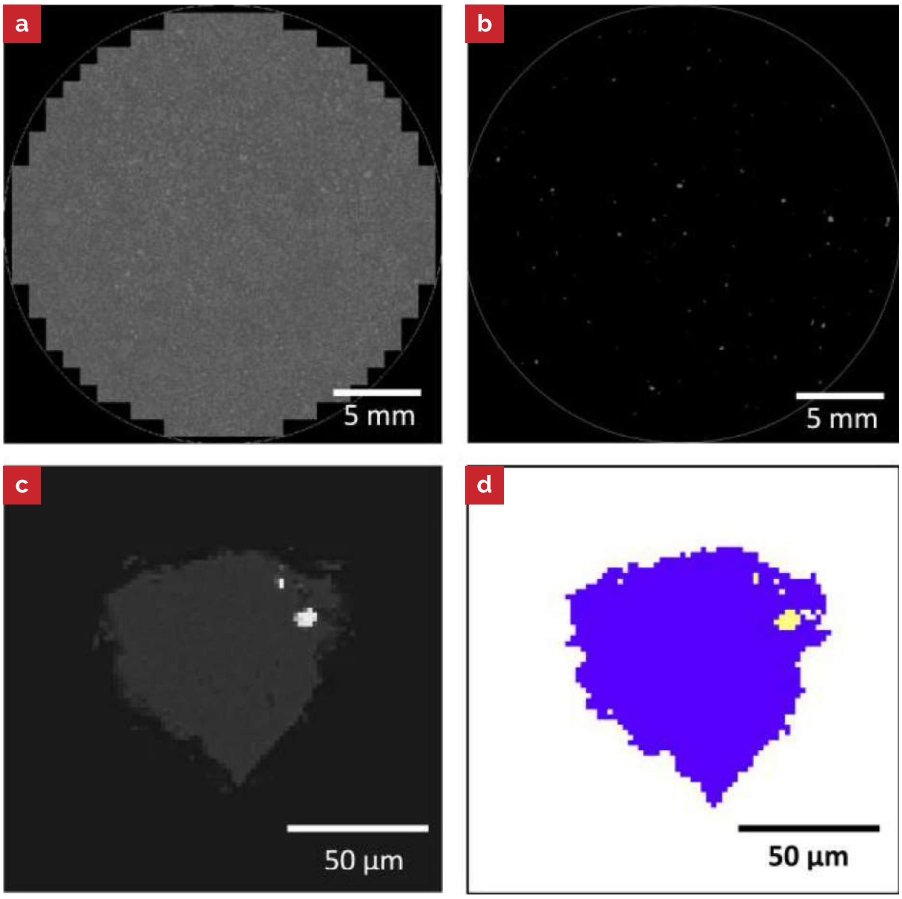
Bright Phase search

TIMA software provides three software modules for data acquisition and processing – Modal Analysis, Liberation Analysis and Bright Phase Search (BPS) module. Each of them is designed to be used for a specific task. The first two modules can be applied in a general way virtually on any sort of geological samples in order to get information about mineral abundance and related textural data. BPS module is more suitable for cases in which the mineral of interest constitutes only a small part of the sample and it is formed by heavier elements providing BSE contrast against gangue minerals.

Typical uses involve characterization of PGM, gold and REE ores. The BPS module provides association information on the mineral of interest and so it does not acquire data only from the mineral of interest but it scans the whole particle containing it. Mineral locking can be easily studied as a result.

TIMA is capable of distinguishing the mineral particles from the epoxy based on the different BSE signal (so called BSE thresholding). As for the BPS-which was specifically used for the gold tailings sample under study-the threshold is set to a higher value than in the case of Modal and Liberation analysis. In this way TIMA avoids not only to epoxy but

also to minerals with lower than specified value of BSE signal shortening the acquisition time from hours to minutes provided the mineral of interest is only scarcely present.
The processed gold ore was generally rich in sulphides (galena, sphalerite, pyrite, chalcopyrite etc.) which consequently occur even in tailings. Application of high BSE threshold was necessary in order to only focus on gold and minimize the time of acquisition. The level was set to 90, which should be sufficient to distinguish gold from galena. Subsequent analysis revealed that the gold was relatively rich in silver (up to 20 %) which lead to a drop of BSE signal below the limit. The BSE threshold was decreased to 80 and a phase filter which uses X-ray spectra in addition to BSE level was applied (see Fig. 2a, 2b). The system thus acquired data only from particles containing gold and did not take the galena into the account.



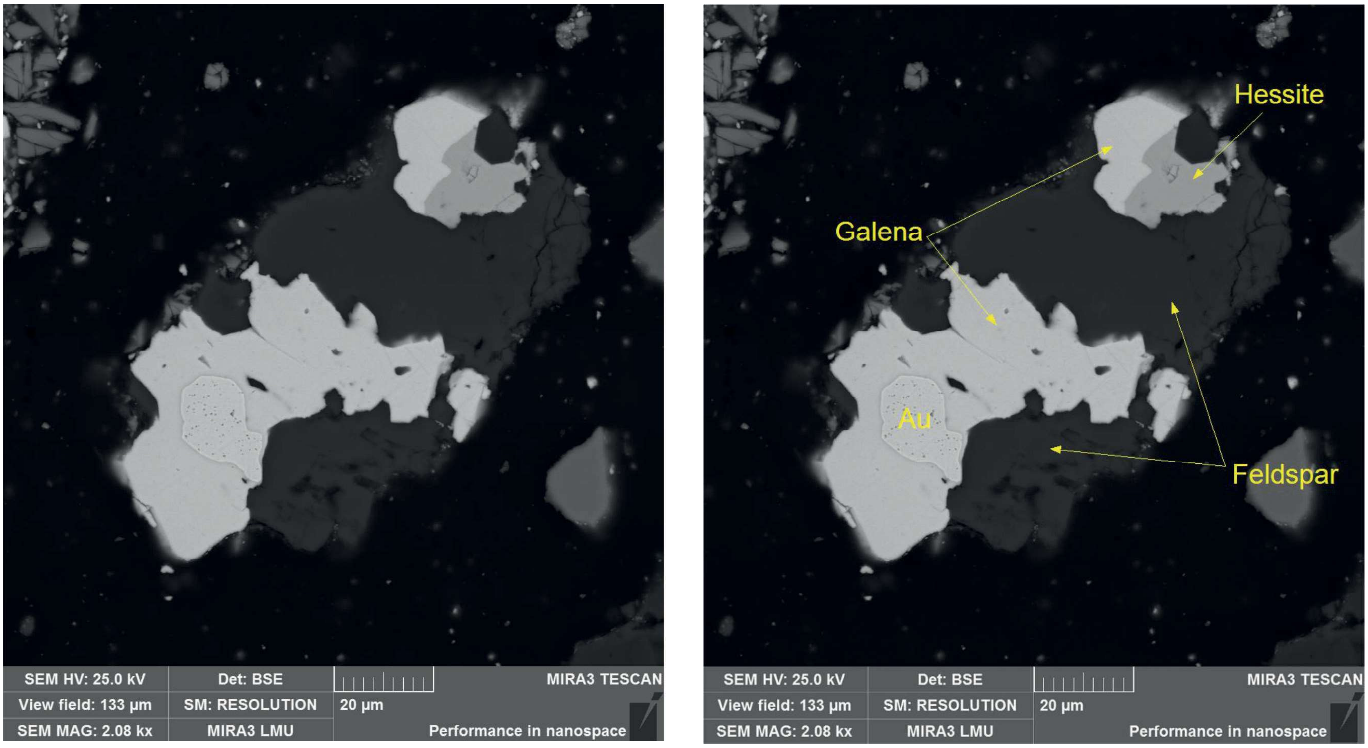
▲ **Fig. 2:** a) BSE image of the sample, b) Particles containing phases with BSE signal above relative value 80, c) BSE image of gold hosting quartz particle, b) Particle phase map obtained by TIMA.

Results

The study revealed that gold is present only in very small amounts which comply well with the fire assay results (<1 ppm). Only five gold hosting particles were found among 1.5 million of gangue particles. The gold passing processing plant to the tailings is relatively fine grained. It was found that the gold size varies from 1 to 5 microns. It is associated with quartz which encloses it completely (see Fig. 2c, 2d). The processing plant relies on collection of sulphides which typically enclose gold in the primary ore (see fig. 3). The gold forms less than 5 % of gold containing particles and it belongs to the first liberation class forming less than 10 % of the particles surface. The gold is not collectable by the flotation as a result.

▲ **Fig. 3:** Specimen of primary sulphide rich ore containing visible gold. .

applications@tescan.cz



▲ **Fig. 4 (a,b):** Gold in contact association with galena (concentrate sample).

Conclusion

Traditional approaches relying entirely on fire assays of different size fractions would not allow the identification of the exact cause of gold occurring in tail. Even more, attempts to find the gold grains using common SEM would have only a limited chance of success because of the widespread galena with similar BSE signal. Using the TIMA BPS module with phase filtering can provide a direct answer within several dozens of minutes. Similar approach is not restricted to tailings. It can be applied to characterize any low grade ore. The full potential of TIMA can be exploited especially when combined with the system of automated sample loading - AutoLoader (see Fig. 4). The AutoLoader has a capacity of 100 samples which allows TIMA to work continuously in a 24/7 regime.

▲ **Fig. 5:** TIMA equipped with the AutoLoader.