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8. Applied Mineralogy: Extractive and Metallurgical Processes

MINERALOGY OF BENEFICIATION PROBLEMS INVOLVING FLUORSPAR CONCENTRATES FROM CARBONATITE-RELATED FLUORSPAR DEPOSITS

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The World's three largest producers of fluorite from carbonatite-related fluorite ore deposits are located at Okorusu, Namibia, Amba Dongar, India, and Mato Preto, Brazil. Beneficiation problems involving fluorite concentrates from those three deposits share some similar aspects that are related to their mineralogy. The most important of these problems involves their phosphorus, silica, and lime contents.

Because the fluorite-depositing hydrothermal fluids were partly or largely derived from carbonatite sources, and carbonatites typically are rich in phosphorus, carbonatite-related fluorite deposits are expectably characterized by significant amounts of phosphorus minerals, especially apatite. Apatite may occur as free particles and especially as particles locked with fluorite. The presence of apatite in fluorite concentrates may contribute significant amounts of phosphorus, a deleterious constituent in fluorite concentrates used in the steel-making industry.

Fluorite concentrates from some carbonatite-related fluorite deposits are characterized by significant amounts of silica. The silica occurs in the form of quartz, potash feldspar, and sericite. Quartz occurs as free particles and particles locked with fluorite. Quartz was deposited late in the paragenetic sequence and typically fills small vugs between the fluorite crystals. Potash feldspar formed during early potassic fenitization associated with the magmatic carbonatite emplacement. Potassic feldspar forms intricate intergrowths with fluorite that result in locked feldspar-fluorite particles in the fluorite concentrates. The potash feldspar is intensely altered to sericite.

Fluorite deposits that occur within a carbonatite host, such as some deposits at Mato Preto, may have the grades of their fluorite concentrate diluted by the presence of calcite. The calcite commonly is present as binary locked calcite-fluorite particles.

Although the beneficiation problems concerning fluorite concentrates from carbonatite-related fluorite deposits may be effectively studied by petrographic and ore microscopic techniques, cathodoluminescence microscopy is uniquely suited to the rapid recognition and study of the minerals involved in these problems.

CHARACTERIZATION OF PRIMARY GOLD FROM SALAMANGONE, AP, BRAZIL

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Three samples from Salamangone primary ore were studied as a part of an economic feasibility study. Applied mineralogical studies were carried out through mineral separations coupled to cyanidation and amalgamation tests, with support of chemical and mineralogical analysis - optical microscopy, SEM and XRD. The objectives were to define the gold association and distribution, identify the presence of fortuitous "cyanicides" minerals, as well as to suggest a preliminary process flowsheet and the gold recovery potential.

The ore presented an average grade of 12.6 ppm. After grinding it below 0.6 mm the gold recovery for the amalgamated heavy fraction was 61% with the following distribution - 40% as free gold, 11% in locked particles with silicates, 7% locked with sulphides and 3% with quartz plus sulphides. Cyanidation tests performed from float fractions and amalgamation residues showed that an additional 27% of the gold content could be recovered - 15% associated with silicates and the others 12% to sulphides. The unrecoverable gold portion represents 8% - 5% associated with silicates and 3% with sulphides. Cyanicides minerals were not found.

A process flowsheet could be established without any other mineral or metallurgical processes tests. Later on, the operation of industrial plant showed a total, as well as individual gold recoveries for the gravity and cyanidation circuits, very close to the predicted values from the applied mineralogy studies.

DETERMINATION OF REFRACTORY GOLD DISTRIBUTION BY MICROANALYSIS, DIAGNOSTIC LEACHING AND IMAGE ANALYSIS

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A refractory gold deposit recently discovered in Northern Finland has disseminated gold-bearing pyrite and arsenopyrite in graphite-bearing albitite host rock. The minor ore minerals include chalcopyrite, sphalerite, tetrahedrite, gersdorffite, galena, bournonite and rutile.

Ore and concentrate samples were studied under polarising microscope using reflected light. To reveal the texture of pyrite and arsenopyrite the samples were etched with KMnO_4 dissolved in concentrated sulfuric acid with etch times of 1-2 minutes.

The diagnostic leach tests show that only a minor part of the gold is in cyanide leachable form, i.e., free gold. Most of the gold is liberated in nitric acid leach, which means that it is bound to pyrite and arsenopyrite as inclusions or as "invisible" gold.

The relationship between arsenopyrite and pyrite in the concentrate was determined using image analysis of backscattered electron images. Optical image analysis was used for determination of the grain size distribution of the concentrates.

As result of the rare-phase search runs with EPMA a total of 111 gold grains were located in the polished sections of ore samples and concentrates. The grains have a large compositional variation from silver bearing gold to electrum and Au-Ag amalgam.

In the EPMA trace Au analyses, the average gold content in pyrite (n=192) is 46 ppm, the average Au content in arsenopyrite (n=135) is 279 ppm. The SIMS analyses average 69 ppm Au in pyrite (n=16) and 217 ppm Au in arsenopyrite (n=22).

Based on cyanide leach results, trace analyses and image analysis the calculated average percentages of gold in the concentrate are: free gold 4.1%, gold in pyrite 22.7% and gold in arsenopyrite 73.2%.

USING SCANNING ELECTRON MICROSCOPY TO STUDY BIOLOGICAL MINERAL DEPOSITS

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Examination of thin sections of breast tissue are the second stage of identifying tumors after mammography. The sections often exhibit mineral deposits among the cells and cellular products. The significance of these deposits and their potential to aid the diagnosis and treatment of patients are not yet fully explored nor understood.

We have investigated the use of SEM/BSE with EDS/WDS to study the morphology and composition of the deposits in situ, that is in association with other tissue components. We utilized standard laboratory thin sections but removed the paraffin and did not polish the samples. Five samples, selected from 152 breast tissue specimens collected at Yale in 1994, showed deposits in a variety of tissue sites. The microcalcifications were imaged and range in size from less than 1 μm to over 40 μm . The larger size mineral material was recognizable as calcium oxalate but the predominant mineral form in the calcifications was calcium phosphate as tiny spherules and spherulitic aggregates.

Because of the small size and rough surface the energy spectra results varied widely but we elected to calculate Ca/P ratios for multiple analyses on each type. The results showed that the Ca/P of the microcalcifications are comparable to normal calcium phosphate deposits in bone, and other pathologic deposits. However two distinct types of deposits were identified: those in the ducts of the tissue and those in the matrix. The ducts had higher Ca/P ratio material although the reproducibility of the measurements suggests that the mineral may not be a homogeneous phase, even when a single aggregate is examined.

We suggest that the mineral reflects the composition of the biological environment in which it is precipitating. It appears that SEM may be a useful and effective technique to document the reactions of cells under different conditions and may help in clinical diagnosis and treatment.