

INDICATOR MINERAL PROCESSING

INTRODUCTION

The SGS Minerals Services diamond services group has a long history dating back to the early 1990s. We provide a wide range of services and the materials processes vary widely, ranging from till and alluvial samples, to beach sand and bedrock samples. As a result there are a variety of flowsheets for different types of starting material. The basic flowsheet (shown below) is designed to recover as wide a range of indicator minerals as possible, including the recovery of diamonds and gold grains.

SAMPLE PROCESSING

Typically, samples are wet screened after weighing. If geochemical analysis of the sample matrix is also required, all or part of the sample may be dried and screened to remove the -0.18 mm material to ensure recovery of the clay sized and finer material which can be critical as the host of mobile elements and a carrier of geochemical signals. Sample sizes can vary dramatically from a few hundred grams to 50-100 kg. Often samples may have been pre-screened in the field to remove $+2$ mm material to reduce transportation costs. An attrition mill may be used for sample disaggregation, particularly for clay rich samples that may be indurated to some degree. Rock samples (usually 5 -20 kg) submitted for indicator mineral recovery are stage crushed to passing 2 mm; stage crushing will tend to yield a higher proportion of intact mineral grains. After screening, the sample goes directly to heavy liquid separation.

Standard screen sizes for till samples are 0.85 mm and 0.25 mm. The screened $-0.85+0.25$ mm fraction is dried before being fed to a Wilfley table fitted with a slurry pump to re-circulate the tails. The table set up parameters can be adjusted by an experienced operator to ensure that the complete heavy mineral train is collected. If quality control (QC) tests indicate inadequate heavy mineral recovery, the table tails will be processed through a Permroll magnet to recover any remaining magnetic minerals that might normally report to the heavy mineral concentrate. The indicator mineral processing lab has access to an array of magnetic and electrostatic instruments that may be used for specific mineral separation processes.

The heavy mineral portion may then be acid washed prior to drying and processing in methylene iodide diluted to a specific gravity (SG) of 3.1. Tetrabromoethane may be used if a lower specific gravity is preferred. After removal of ferromagnetic minerals with a hand magnet, the concentrate is divided into two fractions by screening at 0.5 mm. If the concentrate is large, 30 g will be riffled out to speed processing. The remainder is processed at client request or if the indicator mineral content is low. A Frantz magnetic separator divides the sample into paramagnetic and non-magnetic mineral fractions for the picking lab. This separation helps indicator mineral picking as ilmenite and chromite will be concentrated in the paramagnetic portion while the nonmagnetic portion (also containing weakly paramagnetic grains) will contain garnet, chrome diopside, olivine and other silicates. At each stage of the process, reject portions of the sample are dried, weighed and stored.

INDICATOR MINERAL SELECTION

SGS picking laboratories use high quality stereo microscopes with a variable 10 to 50 times zoom lens and daylight halogen fibre optic light sources. Questionable grains are checked by a scanning electron microscope (SEM) equipped with an energy dispersive system (EDS). An automated x-ray diffraction system is also available. While recovery of the full suite of kimberlite indicator minerals including diamond constitutes the bulk of the workload, our mineralogists have worked on projects that require recovery of a variety of minerals, including base metal indicators, gold grains for morphological study, zircons for mineral provenance studies, tourmaline from lamproites and rutile from gold deposits. Occasionally some of these studies will require processing of fractions >0.85 mm or <0.25 mm. Gold and PGE minerals can be concentrated by using a Superpanner to process silt sized (<0.063 mm) fractions.

Description of kimberlite indicator mineral surface textures is also part of the services offered. Descriptive parameters include mineral type, form, shape, luster, clarity, surface texture and the degree of corrosion for chromites. Surface texture reports may be augmented by digital SEM images or photomicrographs.

QA/QC

Quality Assurance procedures include standard operating procedures for all aspects of the process and training and monitoring of staff. ONLINE LIMS is used for detailed worksheets, batch and sample tracking including weights and labeling for all the products from each sample.

Quality control procedures include:

- Sample spiking with synthetic diamond SG 3.52
- Table tails audit with heavy liquids to verify complete heavy mineral recovery
- Balance and screen calibrations
- Quality control repicking of 50% of samples
- Checking of picked indicator minerals by a mineralogist
- SEM-EDS checking of questionable grains (generally ilmenite).

ELECTRON MICROPROBE ANALYSIS

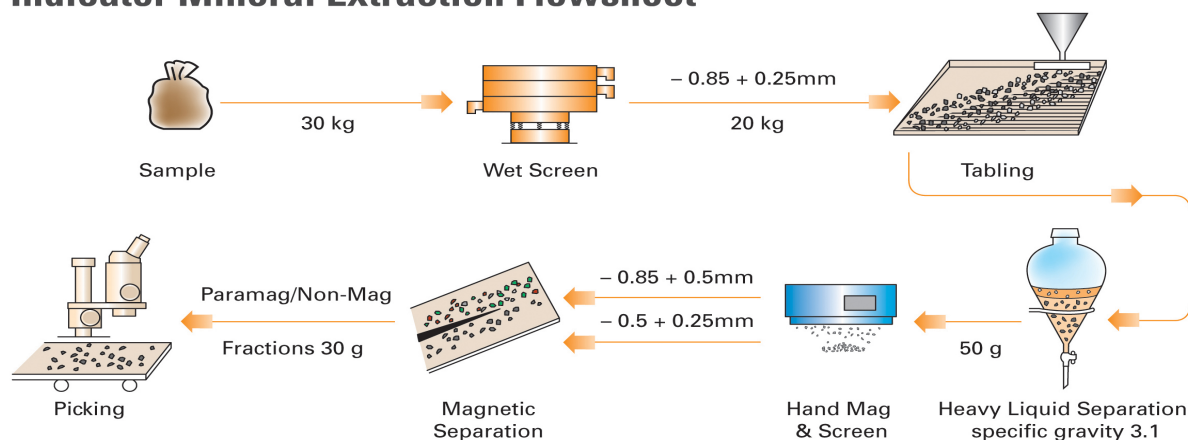
Indicator mineral chemistry is determined with a JEOL 733 Superprobe (one energy & four wavelength dispersive spectrometers with PET, LiF, TAP, DLE crystals) that has calibrations specifically for diamond indicator minerals. Calibrations are based on well known standards (e.g. from the Smithsonian & SPI) from a wide range of natural and synthetic minerals. Typically, it is recommended that 50-100 grains of key indicator minerals are analyzed per sampled lithology. The SGS Minerals Services facility has a fully equipped section preparation lab on site for the preparation of high quality polished and thin sections for microbeam analysis and optical study in both reflected and transmitted light. Grain selection procedures include backscattered electron (BSE) imaging of altered diamond indicator minerals grains to analyze the non-altered core parts of chromite and ilmenite grains relevant to diamond forming conditions.

Frequent quality control (QC) checks (up to 30% of the analytical run) carried

out as part of the routine electron microprobe analytical protocol include: 1) silicate and oxide check standards similar in composition to the diamond indicator minerals, 2) blank checks (such as Na in synthetic rutile) and 3) duplicate grain analysis in a second run. Other quality assurance (QA) checks include measurements of some elements by two different spectrometers and wavelength dispersive crystals with a comparative analysis to identify systematic errors. Previously analyzed minerals may also be used as QC checks; compositions are verified at other microprobe facilities. We participate in the Open University GeoPT round robin for microprobe labs. Laser ablation ICP-MS analysis is also available.

Interpretation of mineral chemistry has been carried out for a number of projects including thermobarometric calculations using the single pyroxene method and the Ni-in-garnet method. For bedrock samples, these interpretations will usually be accompanied by a petrographic study using standard optical methods as well as SEM BSE imagery for detailed characterization of groundmass minerals and textures.

Indicator Mineral Extraction Flowsheet



MICRODIAMOND EVALUATION

SGS has several large caustic fusion laboratories for microdiamond extraction and characterization. Microdiamond recovery by caustic fusion is now a key part of the process for diamond exploration. Minimum recommended sample sizes are 24 kg per specific lithological unit. Sample aliquots of 5 - 8 kg in size are dissolved in molten caustic soda in stainless steel fusion pots heated in kilns to 500-600° C. The molten mix is poured onto 0.105 mm screens and the residue is then washed and treated with acids leaving a small concentrate which is picked for diamonds. Microdiamond counts and weights are reported for each size class using a root-two progression of square mesh sieve sizes from 0.105 mm up in accordance with the CIM guidelines. Individual stones are measured (X,Y,Z dimensions), and described in terms of colour, clarity, percentage preservation and stone morphology. Key quality control procedures consist of spiking samples with synthetic diamonds and duplicate picking of the sample residues. Recovery of kimberlite indicator minerals from the caustic fusion residues is carried out on occasion for some clients. The caustic fusion attack does not completely dissolve many refractory minerals such as picro-ilmenite, chromite, garnet, zircon and corundum and these may be picked for further study.



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