FTIR-MIN

Rapid, cost-effective quantitative mineralogy without the requirement of deposit-specific models is now a reality.

Traditionally, minerals are identified and even quantified visually in the field or core shed, however geologists' interpretations are subjective and thus, inconsistent.

For objective and quantitative mineral identification XRD (X-Ray Diffraction) or SEM (scanning electron microscopy) can be used, however, they are relatively expensive, technically challenging, and time-consuming processes. An economical and rapid alternative is Fourier-Transform Infra-Red (FTIR) spectroscopy.

Why quantitative mineralogy?

While determinations of elemental concentrations in rock samples are routine, quantitative mineralogy represents another valuable layer of information that is not realised in many parts of the resource cycle due to the technical, time and cost challenges of traditional XRD and SEM. Accessible quantitative mineralogy can provide useful information to equip geoscientists with a better understanding of the system that they are investigating. For example, knowing the total amount of Si in a rock will not necessarily permit an accurate estimate of the amount of quartz that is present, because reconciling elemental concentrations with mineral abundance is fraught with difficulties. Quantification of some minerals may be an effective proxy for alteration or veining, or it might be used to level geochemical concentration data.

How is it usually done?

XRD or SEM based systems are conventionally utilised for mineral quantification, however, these options are relatively costly and lengthy processes. While XRD is performed on homogenised and representative pulps, SEM is performed at the micro-scale, and is often better suited to answering highly specific mineral-element deportment questions. Modal mineralogy from petrographic analysis may also offer information, however it is still somewhat subjective, relatively expensive and suffers from scale restrictions like SEM. Currently, the length of time and cost to produce the petrography, XRD and SEM quantitative mineralogy options prevent them from being applied to every meter of drill core in a typical exploration drill hole.

How does FTIR-MIN work?

Fourier-transform infrared (FTIR) technology is a powerful analytical technique that can be used to identify and characterise minerals. This technique uses reflected light spectra collected across the near (NIR), mid (MIR) and far (FIR) infra-red spectral ranges. When the sample is illuminated with infrared radiation, it absorbs certain frequencies of light that are characteristic of its chemical composition and crystal structure.

ALS's FTIR-MIN method compares the absorption spectra with a library of known mineral spectra to identify the minerals present in the sample. Collected spectral data are fed into a mineral quantification model that uses a diverse range of thousands of real-world geological samples for which FTIR and quantitative XRD mineralogy data are available. A machine learning algorithm is used to associate the quantitative mineralogy and the FTIR spectra. With this technique, a few representative grams of homogenous, pulverised sample can be used to identify minerals based on their infrared absorption spectra.

The broad mineralogical diversity of the dataset means that robust, mineralogical quantification can be made quickly, without requiring deposit-specific calibrations or models. Ideal candidate samples represent real rocks, rather than synthetic samples or metallurgical process materials.

Currently, quantifications of 14 mineral phases (shown in Table 1), covering most of the major rock-forming minerals can be made.

QUANTITATIVE MINERAL ESTIMATES			
Quartz	Amphibole	Goethite	White Mica
Plagioclase	Pyroxene	Pyrite	Ankerite-Dolomite
K Feldspar	Calcite	Hematite	Spodumene
Magnetite	FeOx	Epidote	Kandite-Kaolinite
Biotite	Siderite	Chlorite	

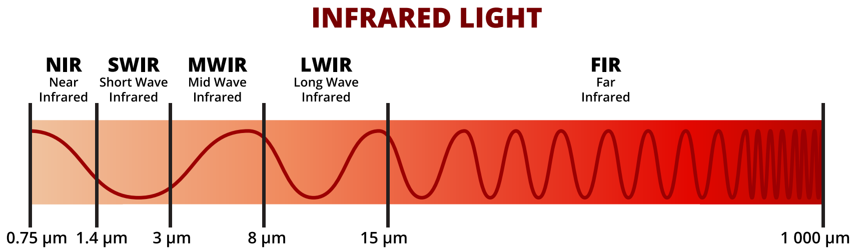
Table 1. List of minerals quantitatively reported by FTIR-MIN

What about VNIR-SWIR?

Conventional dispersive infra-red spectrometers operating in the visible and short-wave infra-red spectral ranges (VNIR-SWIR) have found widespread application in geosciences over at least the past 20 years. These instruments have delivered massive value to mineral explorers and other geoscientists due to a combination of their portability and wavelength range that identifies important hydrous mineral phases that develop during hydrothermal alteration events. Additionally, various features of the spectrum can be measured and interpreted to provide additional data. These can relate to subtle mineral composition variations – often considered to reflect different hydrothermal fluid conditions such as relative pH, redox potential and even the relative temperature of hydrothermal fluids. ALS offers this type of spectral mineralogy utilising TerraSpec® scanning and interpretation (ALS methods TRSPEC-20 and INTERP-11, packaged together as HYP-PKG).

A drawback of these instruments is that while they can "see" several important minerals, some common minerals are effectively invisible due to the limited IR range (e.g. quartz, feldspars). Furthermore, the spectral and spatial resolution provided may not make their spectra the best choice for inputs to a quantitative mineralogy model.

The FTIR-MIN method reports several minerals that are responsive in the VNIR-SWIR, currently grouping some minerals together such as white mica and chlorite. However, it is not currently capable of indicating the type of white mica (muscovite/paragonite/phengite etc) or chlorite (Mg-chlorite/intermediate-chlorite/Fe-chlorite). The same applies to other mineral groups that cannot be "seen" by VNIR-SWIR instruments, for example, plagioclase, pyroxenes and amphibole. Consequently, the FTIR-MIN and VNIR-SWIR outputs are expected to complement each other to provide even more useful data. For example, FTIR-MIN can estimate the total amount of white mica, while TerraSpec® outputs such as INTERP-11 are better placed to indicate the type and crystallinity.



What next?

Materials whose quantitative mineralogy cannot be accurately estimated will always exist. But for common rock types, composed of common minerals, FTIR-MIN represents a useful means to obtain cost-effective, objective and quantitative abundance estimates.

As more materials are added to the FTIR-MIN spectra library and additional input parameters are considered to improve classification, for example better support for Li, Cu and other critical exploration targets, the range of minerals that can be reported using FTIR-MIN is expected to broaden significantly. FTIR-MIN is anticpated to find widespread application as the "one size fits most" approach to quantitative mineralogy..

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