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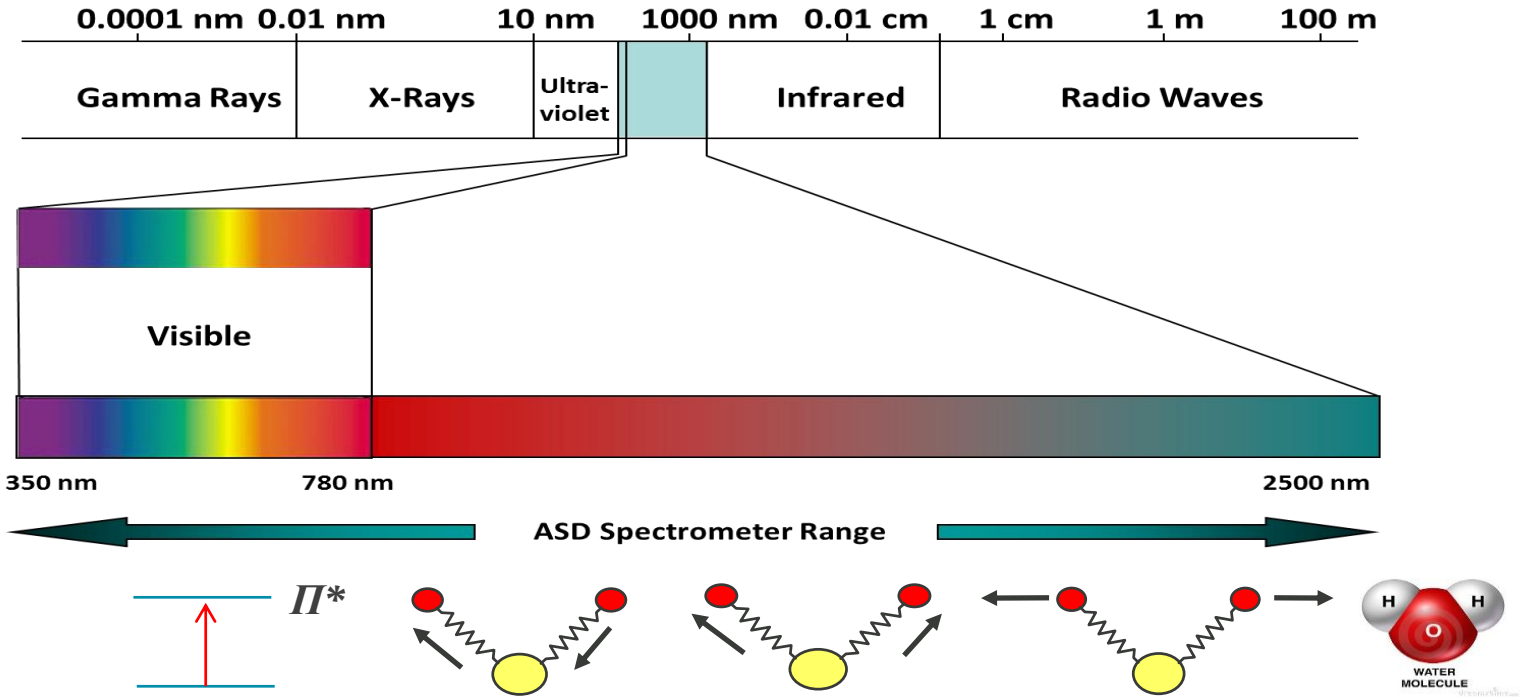
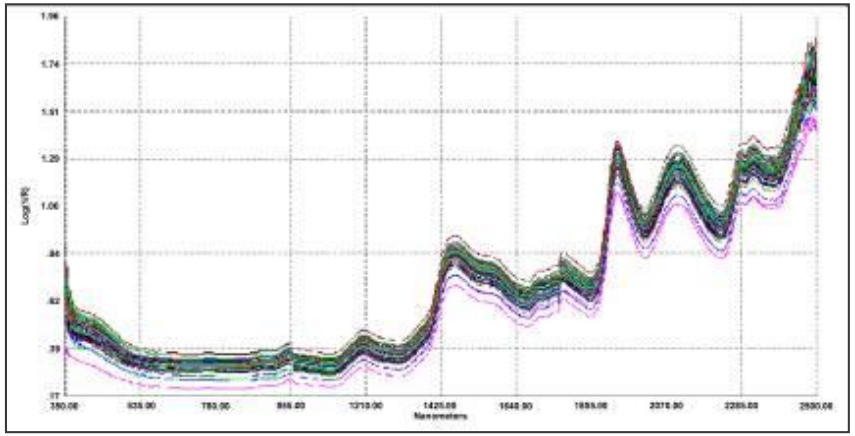
NIR FOR RESOURCES EXPLORATION

Robert Cocciardi-Sales Representative
Malvern Panalytical

NEAR INFRARED - HOW DOES IT WORK?

NIR spectra is similar to a fingerprint. Every material has its own unique spectral signature





Electronic transitions Molecular Vibrations: Overtones and Combinations

NIR is a secondary measurement – “calibrated to a primary technique”

NIR SPECTROMETER

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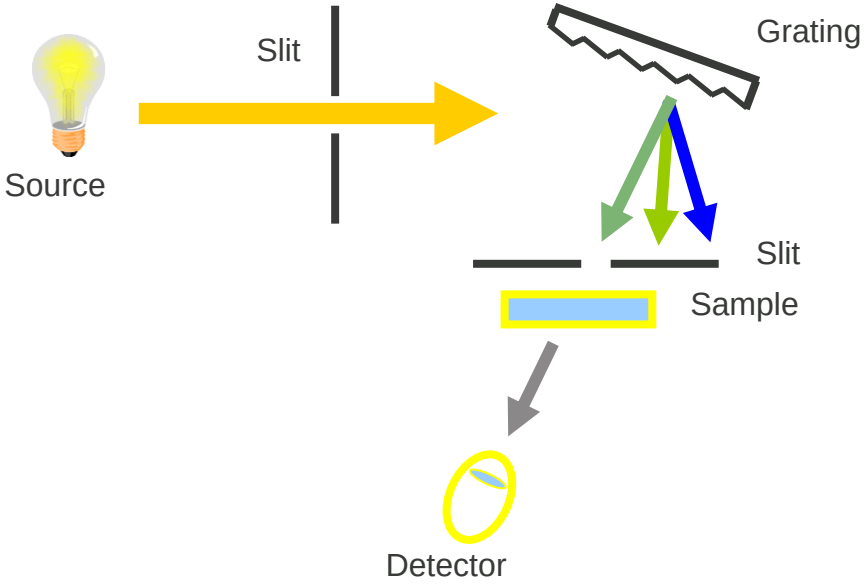
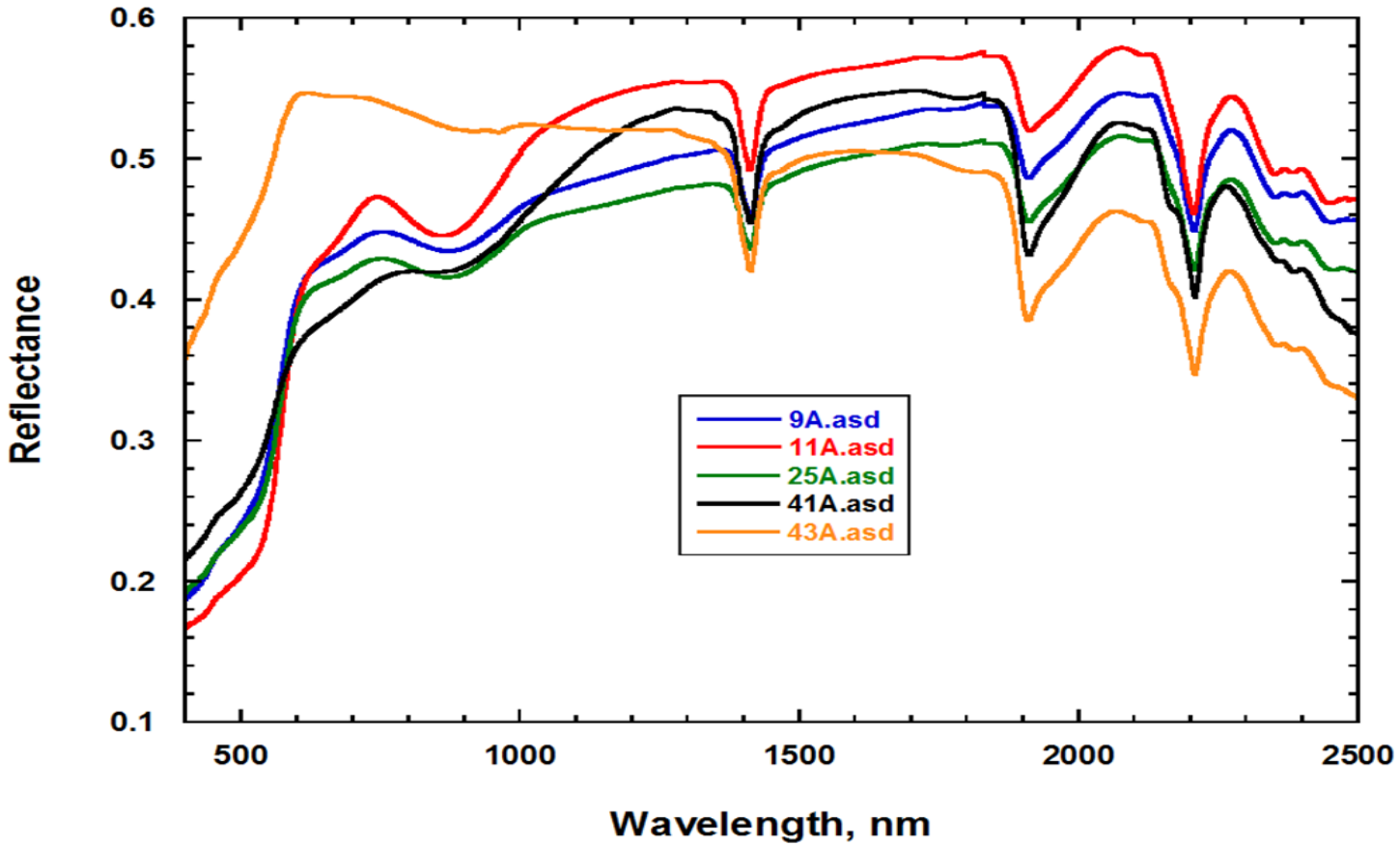
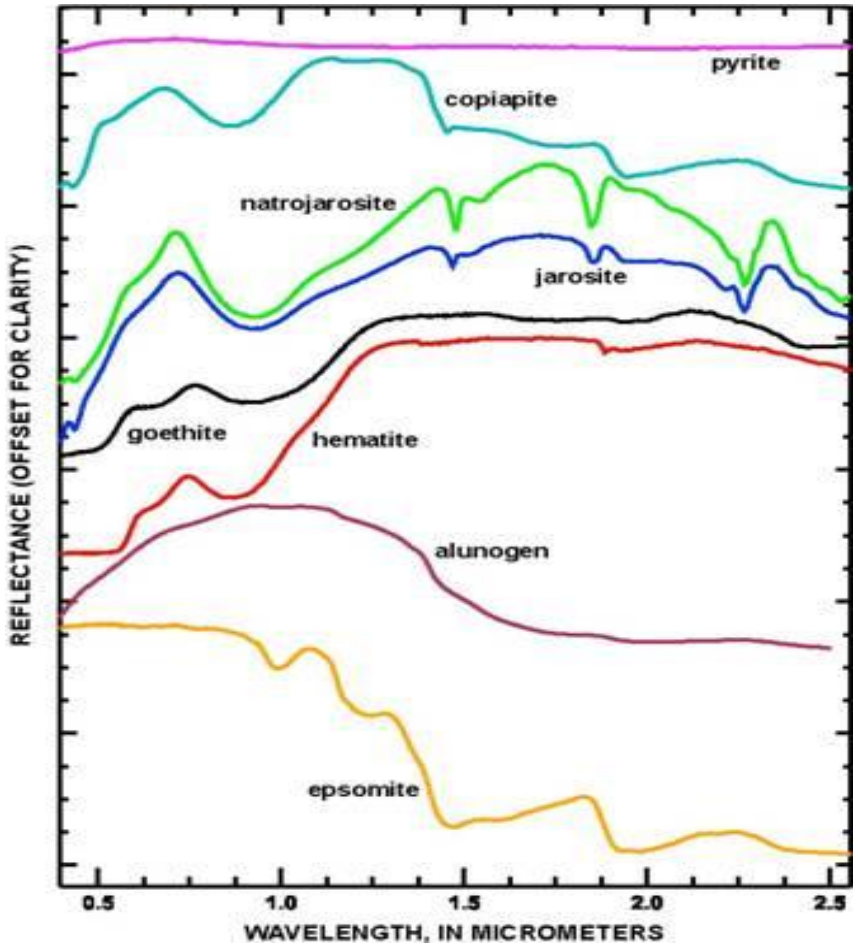
A spectrometer is an instrument that measures light intensity vs wavelength

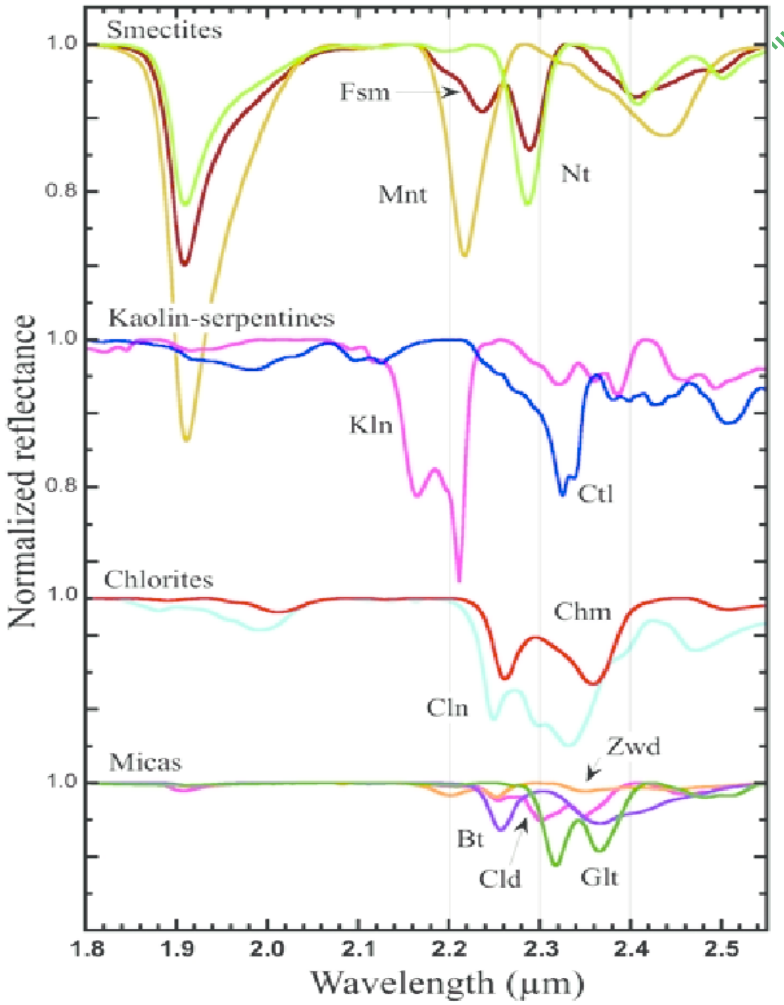




SPECTRAL MINERALOGY

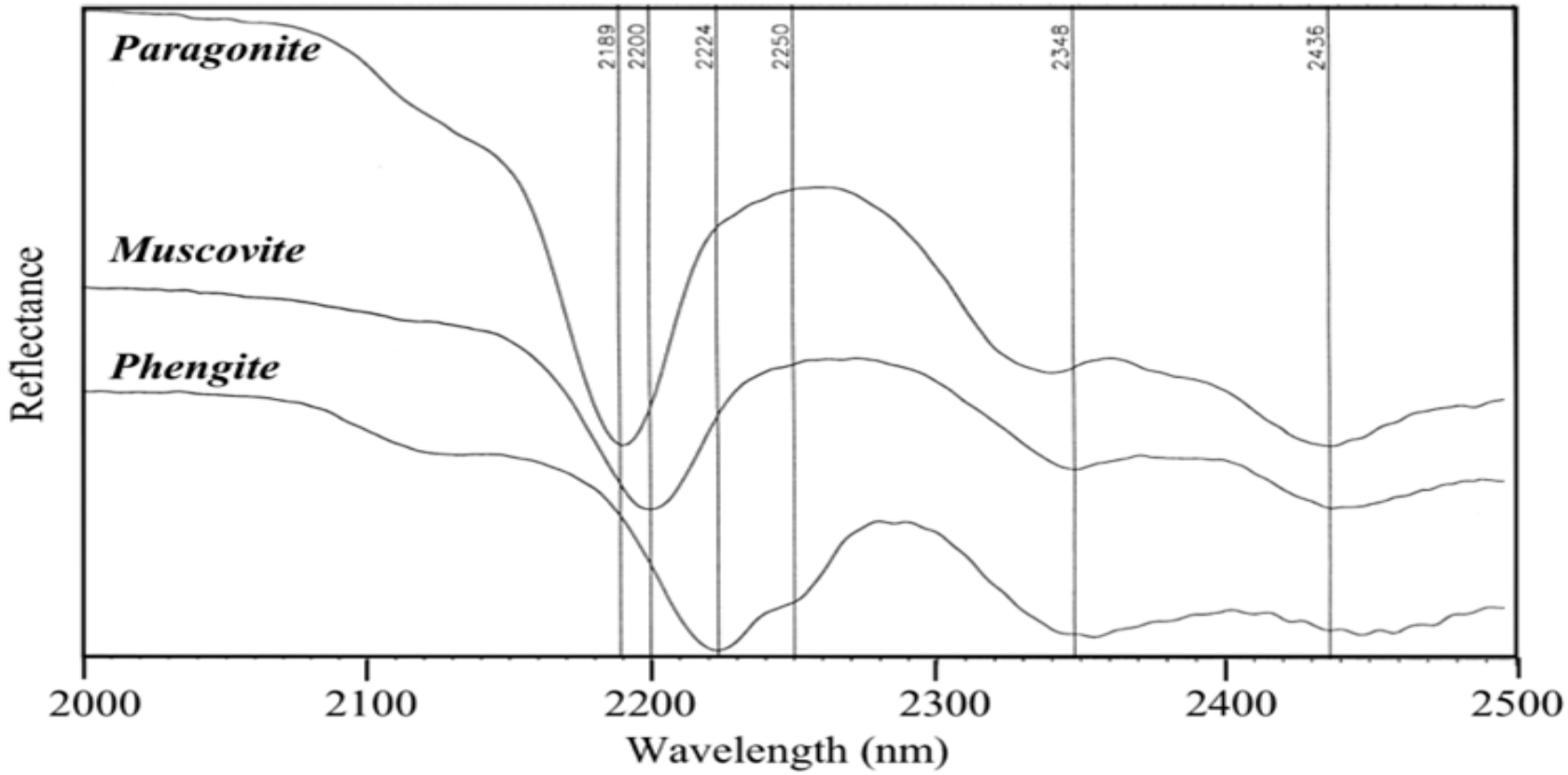


https://speclab.cr.usgs.gov/earth.studies/Utah-1/sir5241txto_bredit.html



https://www.researchgate.net/publication/236137008_Reflectance_and_Emission_Spectroscopy_Study_of_Four_Groups_of_Phyllosilicates_Smectites_Kaolinite-Serpentines_Chlorites_and_Micas

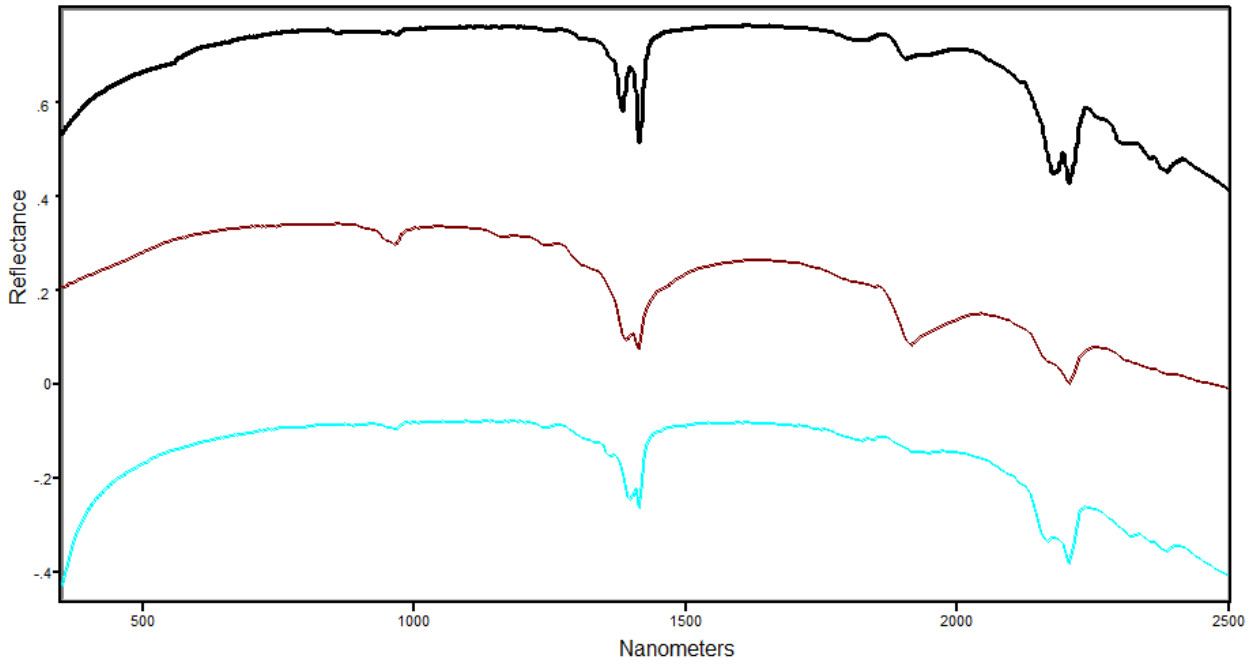
SPECTRAL MINERALOGY



- Paragonite = Na - $Al_2(OH)_2(AlSi_3O_{10})$
- Muscovite = K - $Al_2(OH)_2(AlSi_3O_{10})$
- Phengite = K - $(AlMg)_2(OH)_2(SiAl)_4O_{10}$

COMPARISON OF CLAYS

- Below is a plot of Dickite, Halloysite and Kaolinite
- Same chemistry but different spectra due to crystallinity!



$(Al_2Si_2O_5(OH)_4)$

NIR-MINERALOGY

- Mineralogy = Good
  - ➢*NIR can detect the subtle shifts indicative of changing mineralogy, crystal lattice structure, color centers*
- Clays = Really Good
  - ➢*Clays are really important in alteration zone mapping (exploration) as well as in ore recovery processes (production).*
  - ➢*Phyllosilicates = Really Good*

More Specifically…. These are good

- Hydroxyl (OH)
- Carbonate (CO_3)
- Minerals with transitional metals and an oxygen
  - *Ex: Cu, Fe, Ni*

- Dark minerals = not too good
  - ➢*NIR has a tough time detecting some dark minerals since they absorb light. Ex: Coal*
- Clear minerals = not too good
  - ➢*NIR has a tough time detecting some clear minerals since lights passes through them. Ex: Quartz*
- Elemental = NO!
  - ➢*Minerals not Elements! NIR is complimentary technology for elemental analysis*

NIR-MINERALOGY

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- Examples of Classes of Minerals analyzed using the TerraSpec:
  - *Clay minerals*
  - *Talc*
  - *Oxides*
  - *Hydroxides*
  - *Sulfates*
  - *Carbonates*
  - *Hornblende and amphibole*
  - *Muscovite*
  - *Chlorites and serpentines*
  - *Biotite*
  - *REE minerals*
  - *Ammonium minerals*
  - *Epidote, Apatite, Topaz, and tourmalines*
  - *Hydrous silicates (opal, beryl, and zeolites)*

NIR SPECTROSCOPY IN MINING EXPLORATION

TerraSpec: NIR Mineral Analyzers

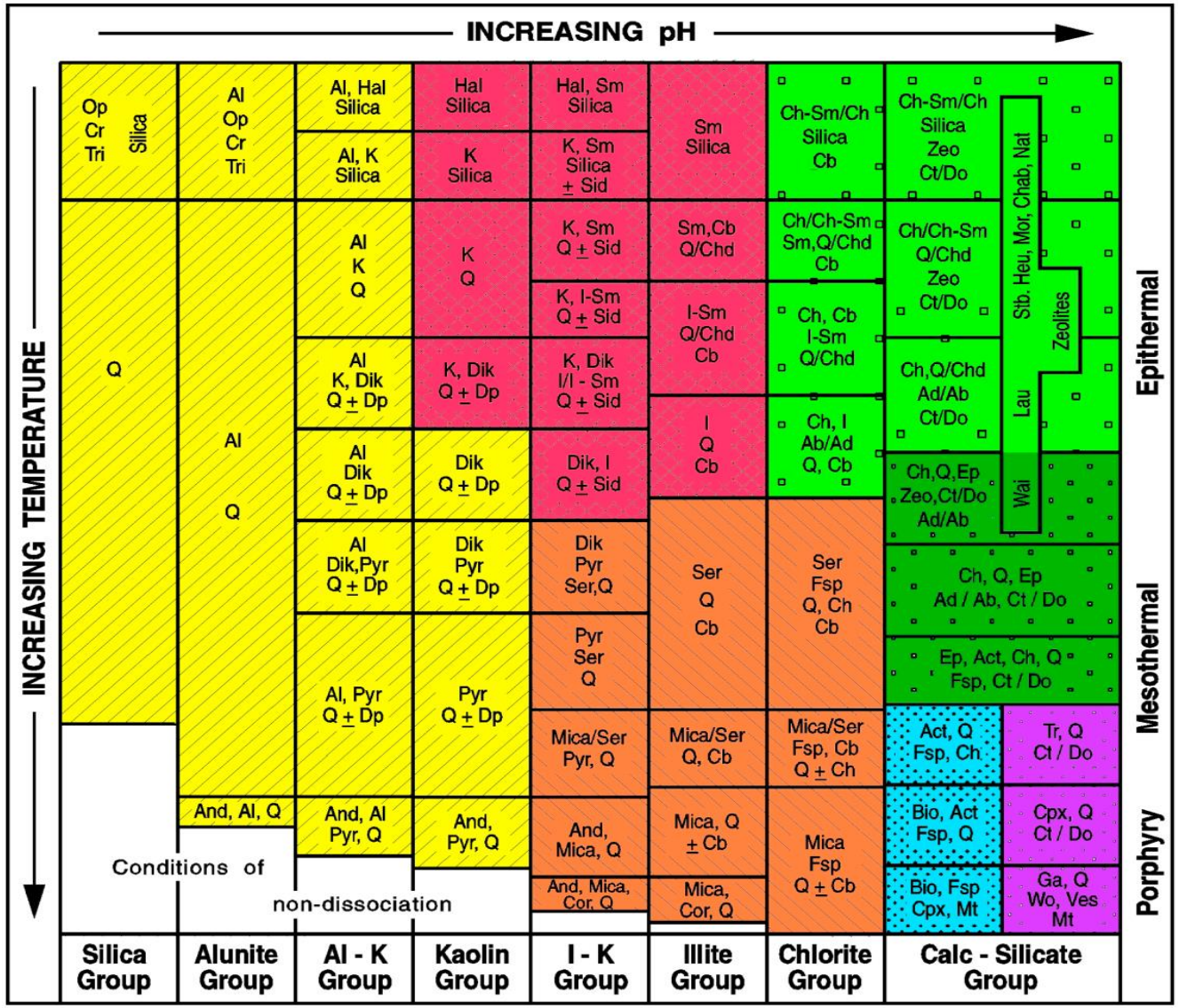
TerraSpec 4 Hi-Res

TerraSpec Halo

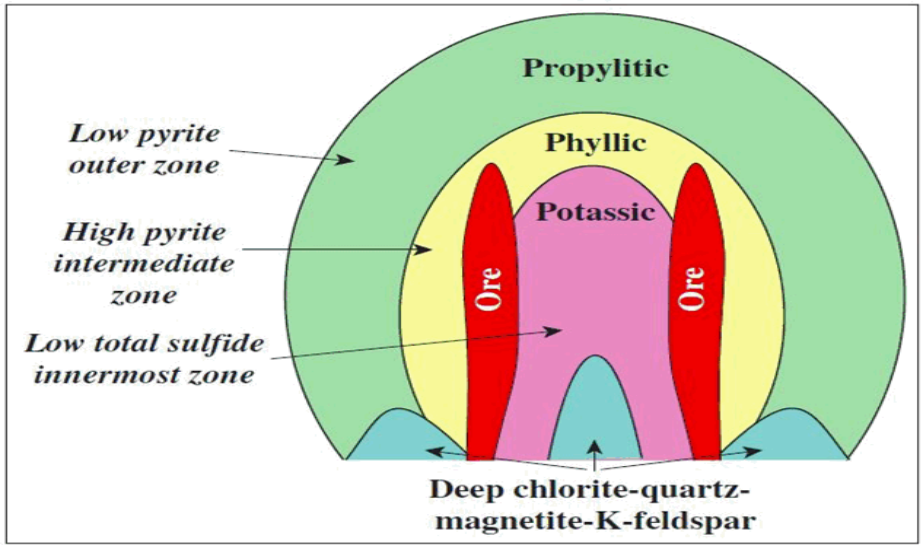
Benefits of using TerraSpec Mineral Analyzers:

- Map the mineral halos that are indicators of economic deposits
- Analyze 100's of samples a day (rapid technique)
- Supplements X-Ray Diffraction (XRD), QEMSCAN and other measurement data
- Can give both qualitative and quantitative information
- TS Halo has its own in-house library (150+ minerals) while TS4 Hi-Res needs to be used with **TSG** or **AiSIRIS**

MINERALOGY CAN IDENTIFY THE ORE BODY

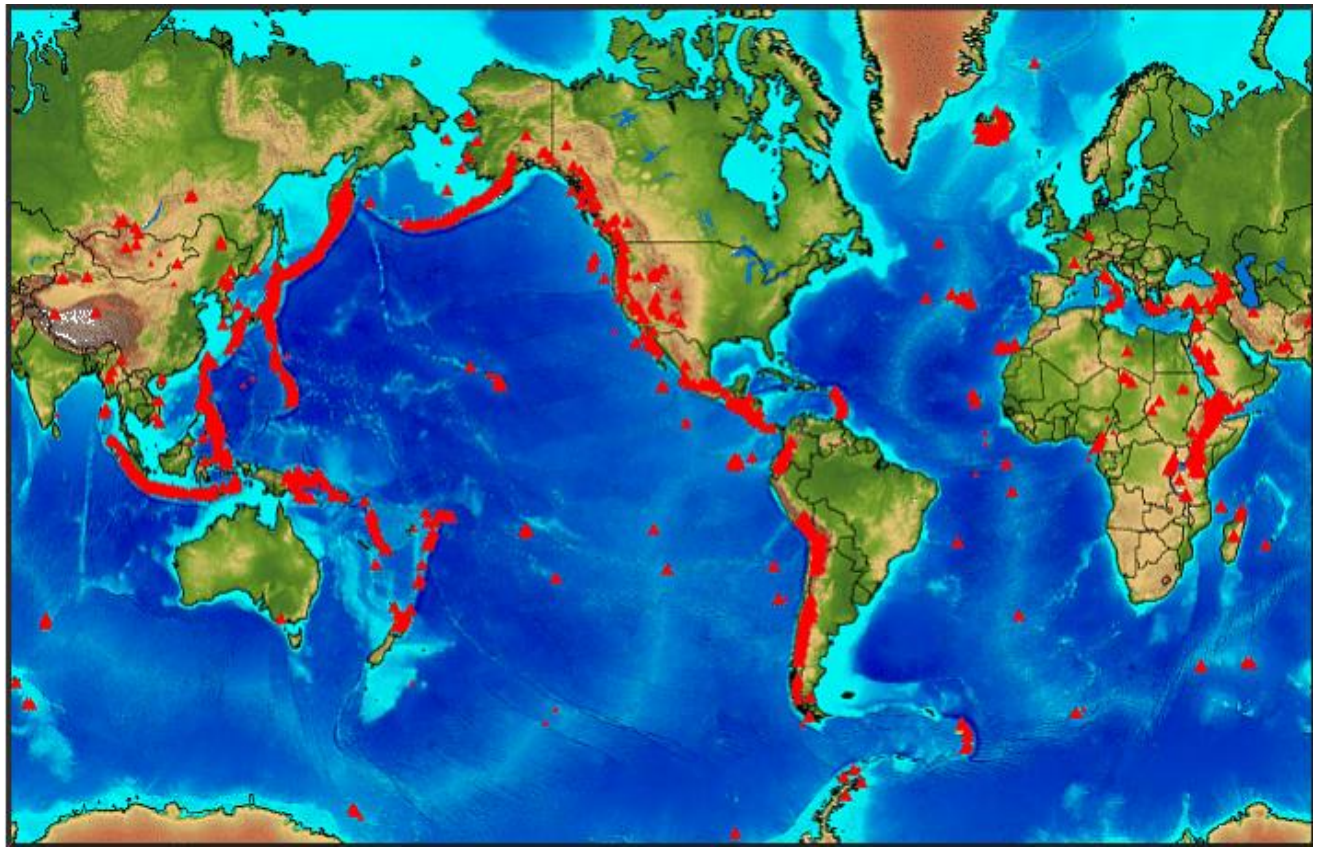


- Advanced Argillic
- Argillic
- Phyllic
- Sub Propylitic
- Propylitic
- Potassic
- Skarn



TYPICAL DEPOSIT TYPES THAT CAN BE MEASURED

- **Epithermal**
  - *Ores precipitated from fluids; hydrothermal*
  - *Shallower deposit when formed*
  - *Ex: Comstock Lode, NV*
- **Porphyry**
  - *Magma cooled at different rates*
  - *Deeper deposit when formed*
  - *Ex: Bingham Canyon, UT*



NIR IN MINING EXPLORATION: CORE LOGGING

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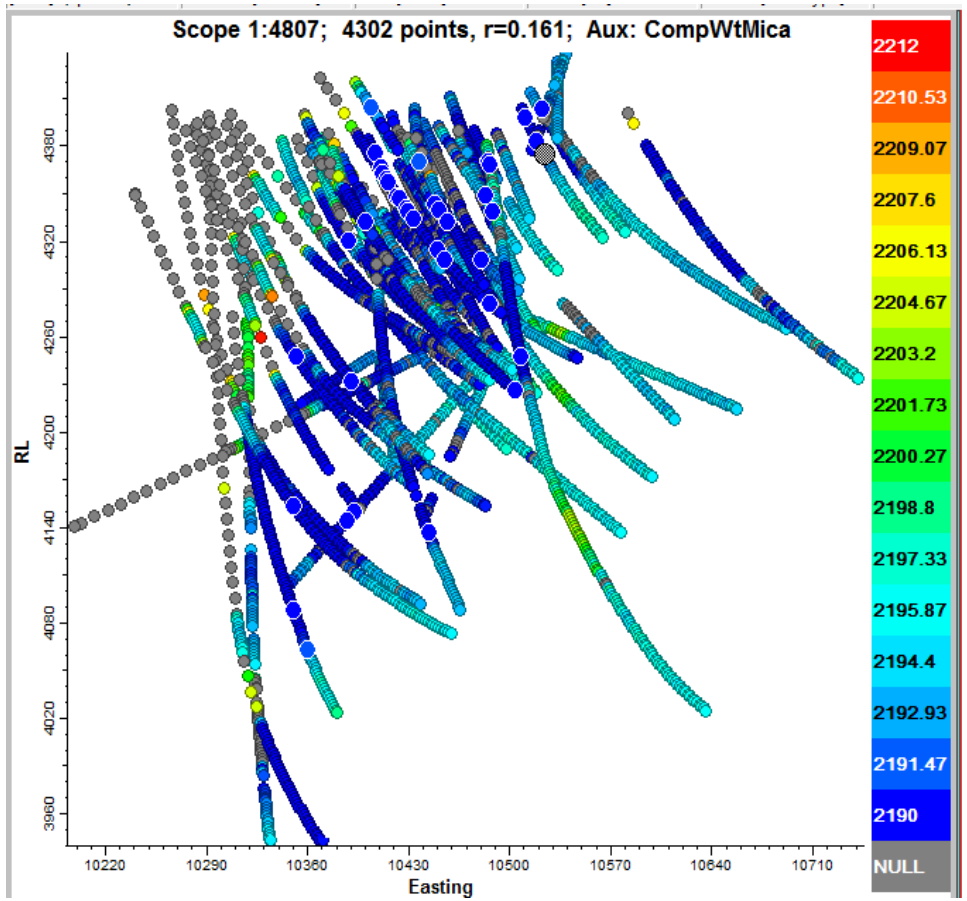
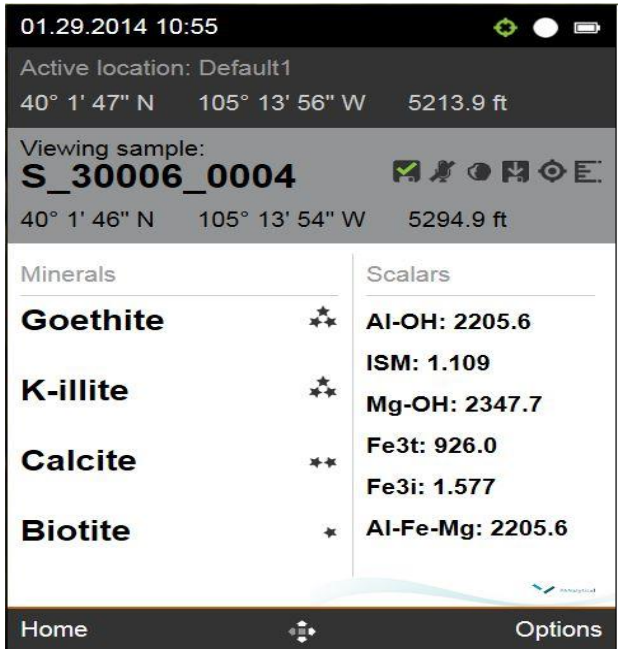
The alteration mineralogy of exploratory drill cores is measured as a function of depth and is then plotted to better understand the patterns of alteration as they relate to mineralization.



TERRASPEC HALO



Features/Benefits:

- Extensive mineral library, over 700 spectra from over 150 minerals.
- Full Range: 350 – 2500 nm
- Built in GPS
- Automatic white referencing
- Audio recorder
- Easy to use: Technician-level use
- Full Day Battery life
- Map the minerals that are indicators of economic deposits

Results Display:

- HALO identifies up to 7 mineral matches from its mineral database and reports the top 4. (Halo Manager displays all 7 matches.)
- HALO also computes the corresponding mineral scalars and reports the top 7
- Spectral viewer

TERRASPEC 4

TerraSpec 4 Hi-Res

Potential Applications:

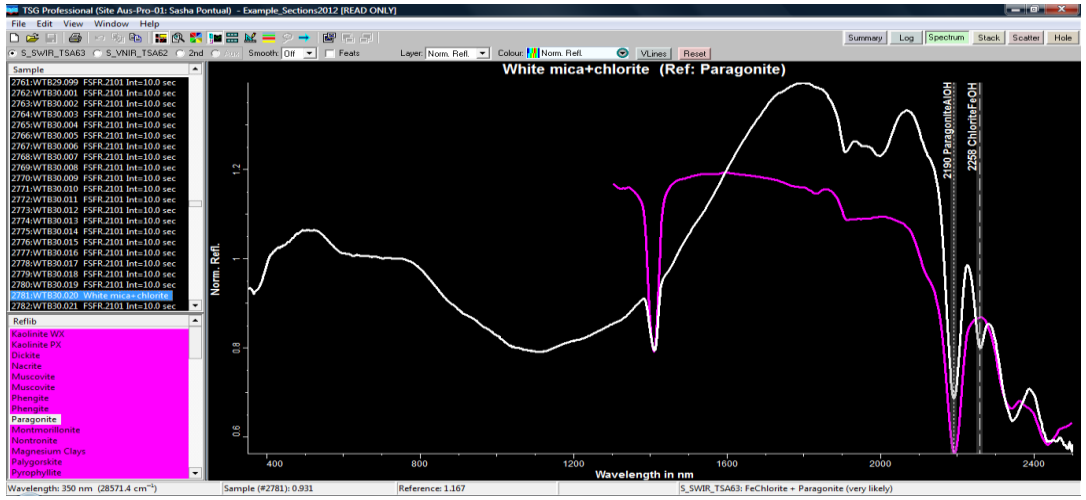
- *Mapping the Halo's, finding economic deposit*
- *Blast hole chip analysis*
- *Block modeling*
- *Understanding ore body variability and mineralization*
- *Clay minerals characterization in flotation and heap leach processes*
  - *Heap leach and flotation processes can be adversely affected by ore composition*
  - *Swelling clays interfere with heap leach process, quantification of swelling clays, ex: smectite, CEC.*
  - *In flotation processes, some clay minerals remain bound to the metal, which makes it more difficult for the metal of interest to be recovered (i.e., float to the top).*

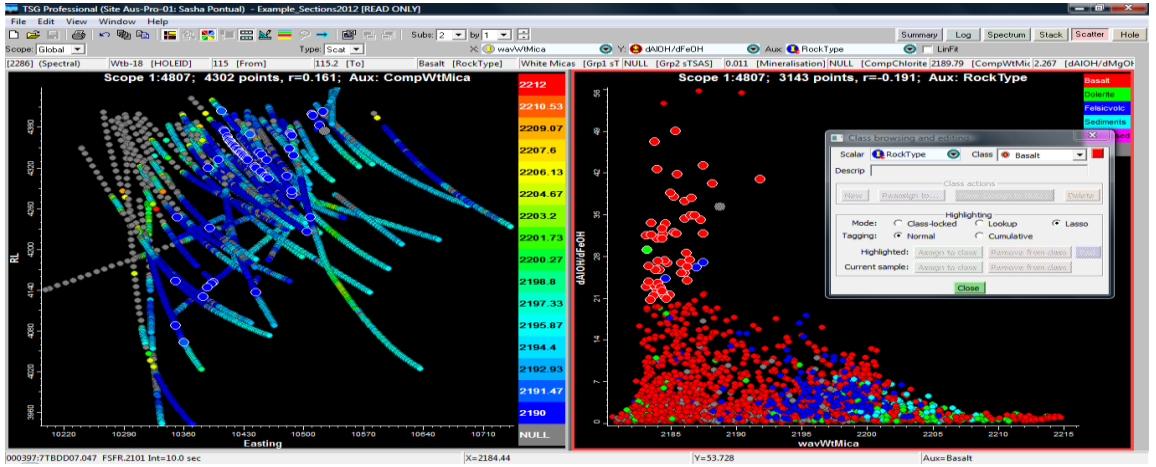
THE SPECTRAL GEOLOGIST SOFTWARE - TSG

- The Spectral Geologist (TSG, CSIRO, Australia) is a specialized processing and analysis software package that analyzes field or laboratory **TerraSpec** spectrometer data.

- TSG allows spectral data to be easily analyzed in the context of your project geology and geochemistry. This will contribute directly to understanding the alteration and mineralization relationships in the study area.

- Can create custom scalars to relate sample crystallinity





QUANTITATIVE ANALYSIS

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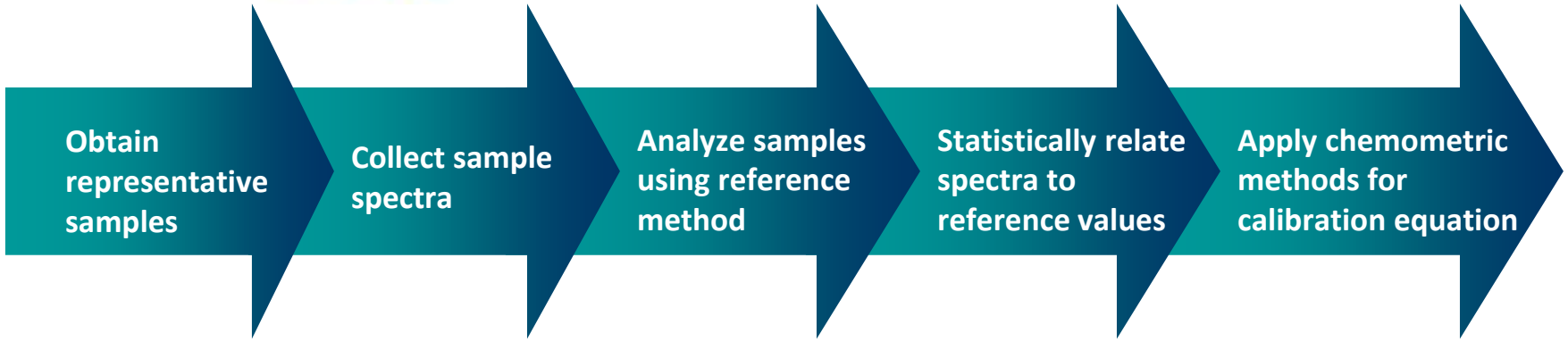
SUMMITCAL

SumitCAL Solutions Team has the expertise and experience required to perform the calibration process



The accuracy is no better than the quality of the reference method!

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