Preliminary Results of Airborne Hyperspectral Surveys in Nunavut

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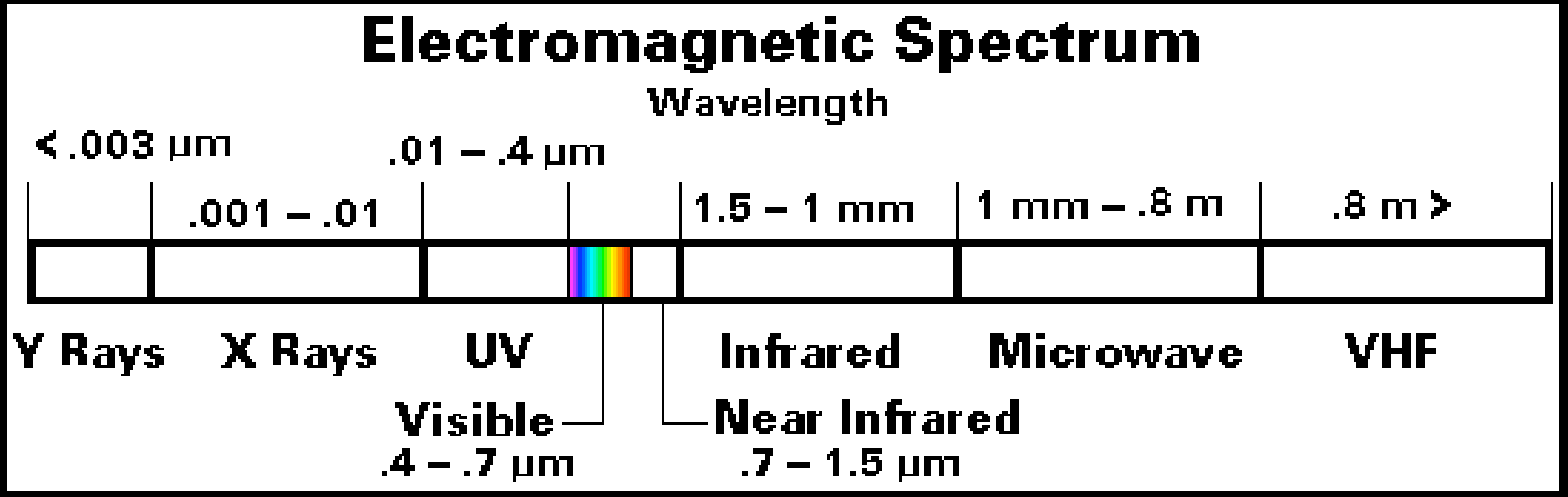
Outline

- Overview of remote sensing
- Hyperspectral basics
- Challenges for remote sensing in Nunavut
- 2009 hyperspectral Nunavut surveys
- Other (than mining) hyperspectral applications

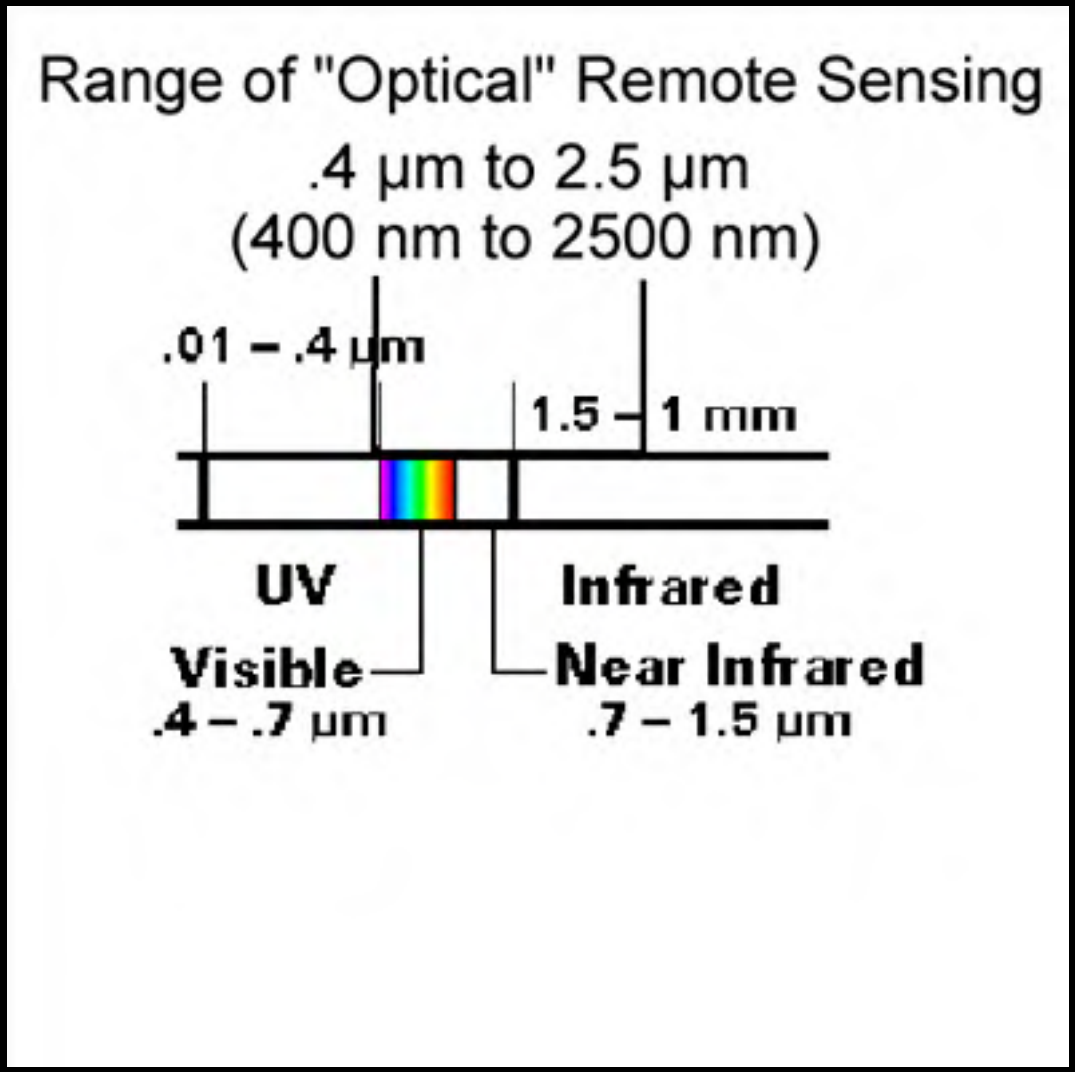
What is Remote Sensing?

- The measurement of reflected and emitted electromagnetic radiation
- The primary energy source is the Sun

Wavelengths



Wavelengths



What Does Remote Sensing Do?

- Identification of surface materials and features
  - Minerals
  - Structures
  - Vegetation
  - Water quality

Comments

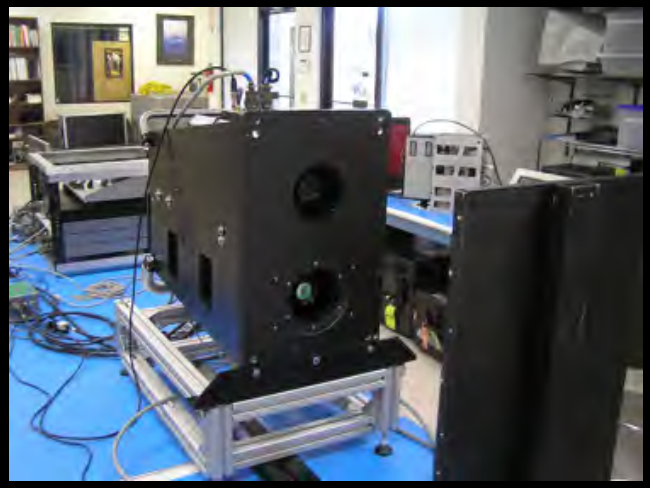
- Some aspects of remote sensing are qualitative (photointerpretation)
  - Structural interpretation
  - Textural mapping (i.e., cover/bedrock)
- Some aspects are quantitative (digital classification)
  - Mineral/alteration mapping
  - Water quality assessment
  - Vegetation mapping

Hyperspectral Imaging is a Quantitative Remote Sensing Method

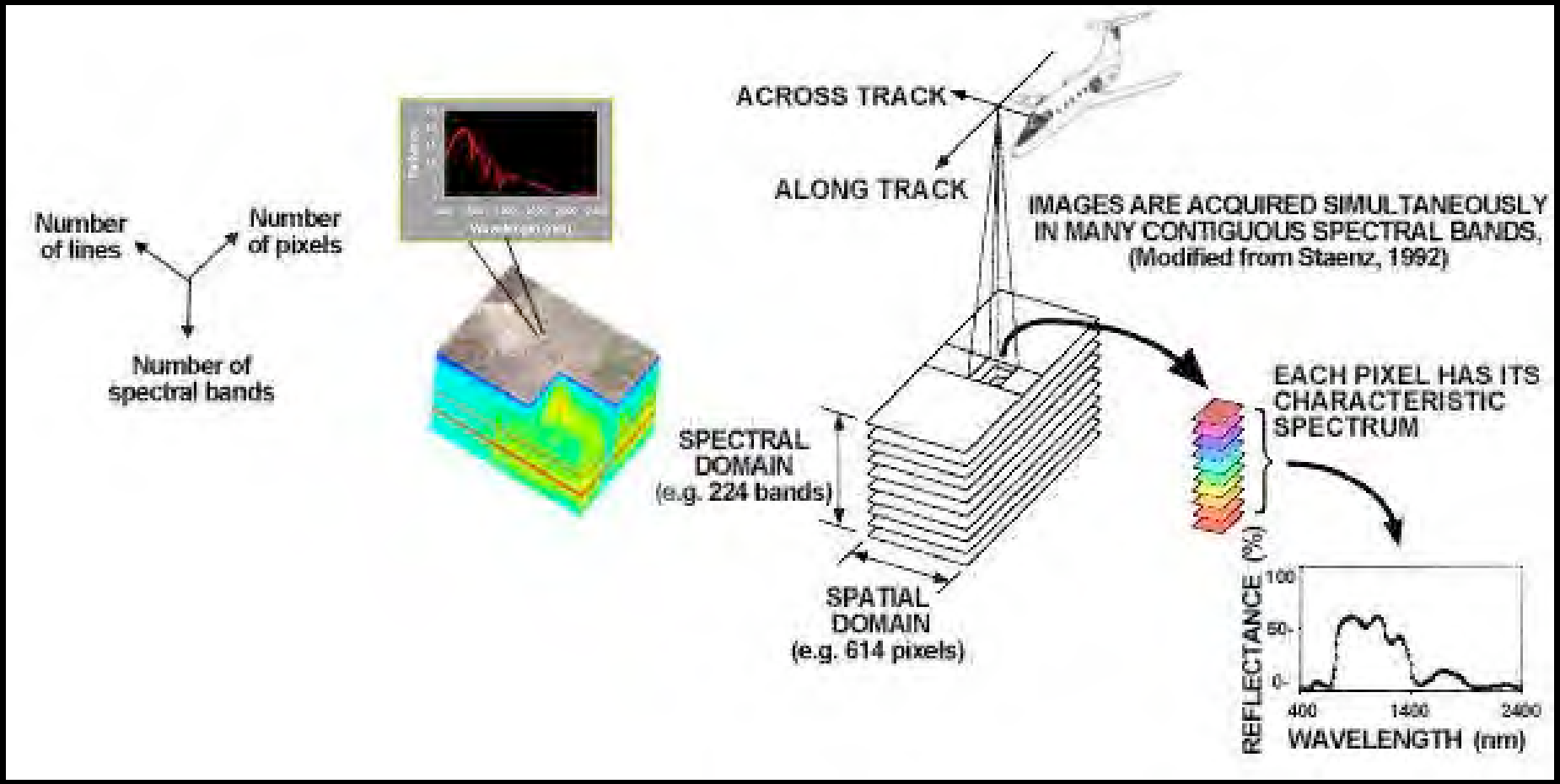
Remote Sensing Technology 1900 to 2010

Photogrammetry → Digital Imagery

Hyperspectral

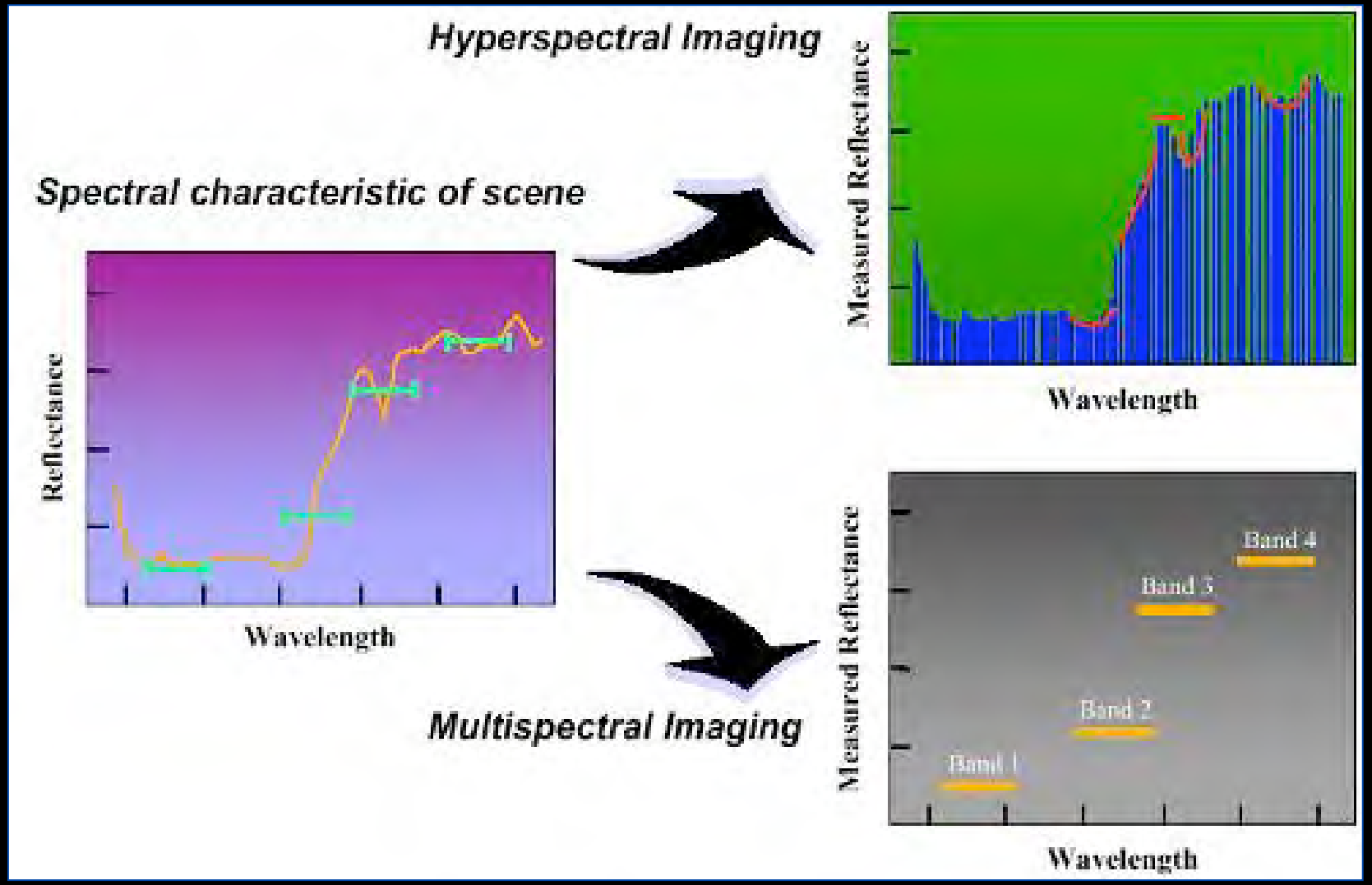


Hyperspectral Concept



Source: CCRS http://www.ccrs.nrcan.gc.ca/ccrs/misc/issues/hyperview_e.html

Hyperspectral vs Multispectral



Comments

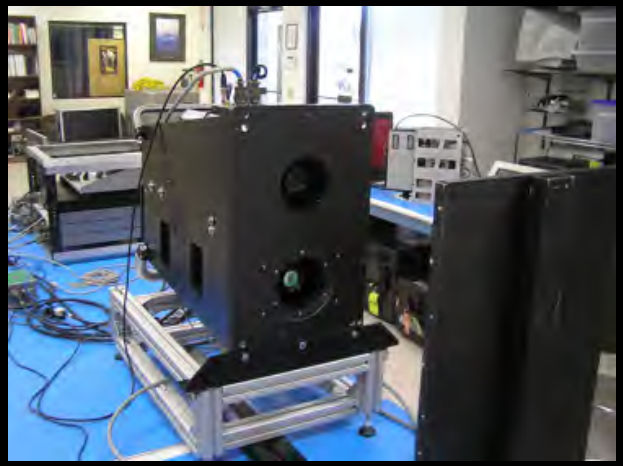
- The increasing interest in airborne hyperspectral data has been driven by the wide use of field spectrometers
  - ASD Terraspec and PIMA
  - “The method works on outcrops and core, can we get these data from the air?”
- Geophysical methods attempt to avoid the surface
- Geologic methods grossly under sample the surface
- Remote sensing fills the gap by providing spatially dense surface information
- *Hyperspectral imaging is currently ONLY an airborne technique*

Hyperspectral Instruments

AVIRIS

HyMap

Spectir HST

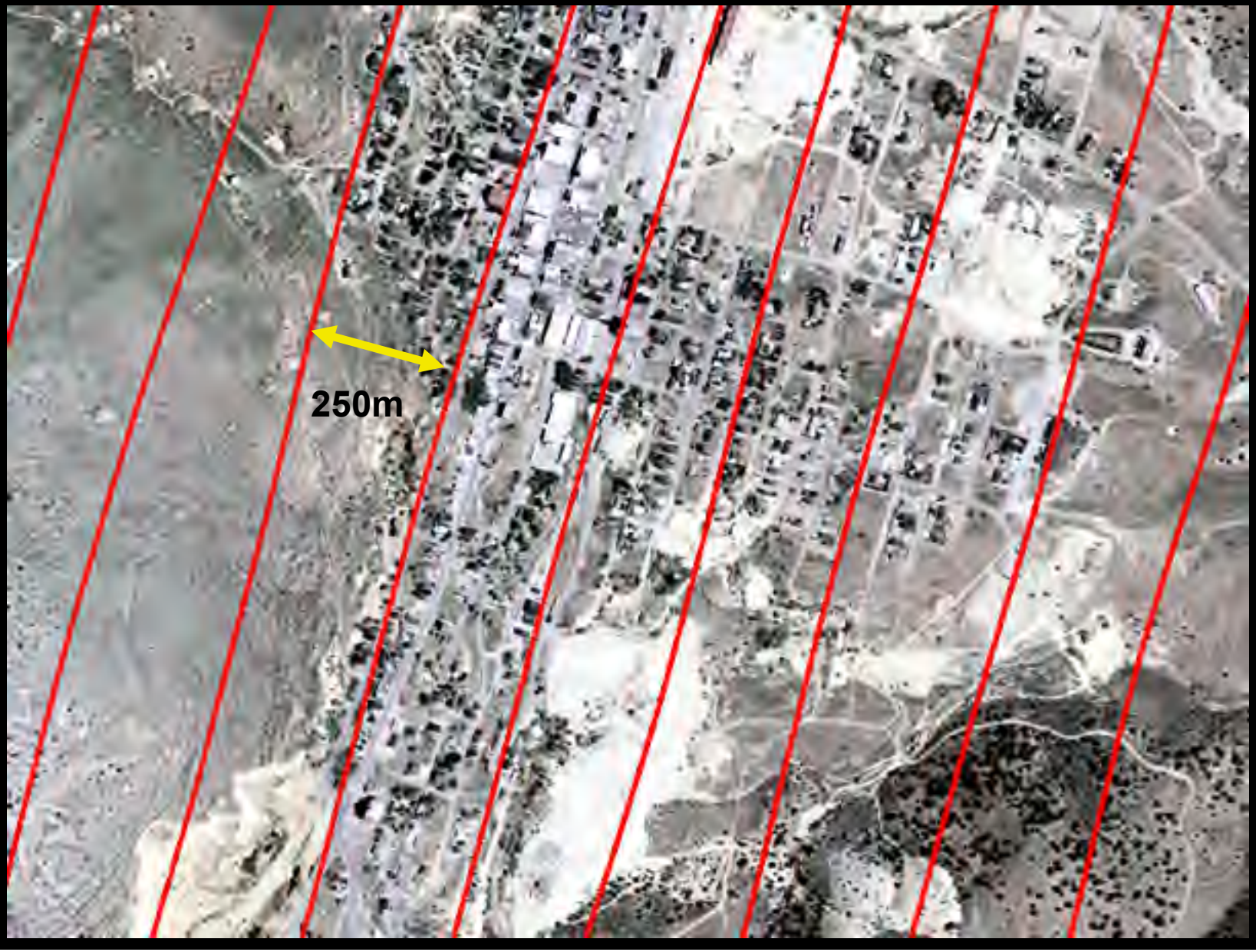


Prospectir

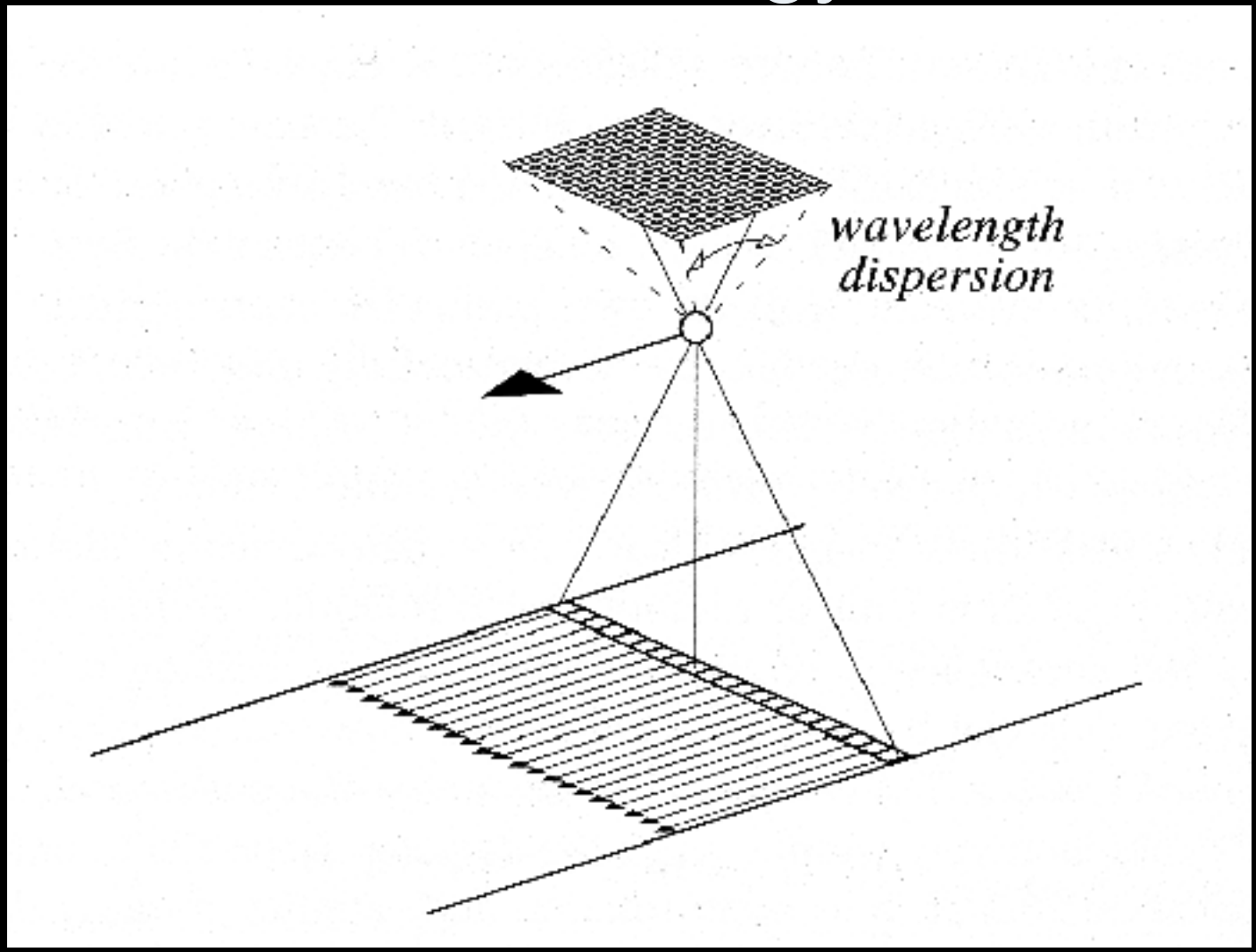
Hyspex

TASI - Thermal

Flight Lines for 1 Meter Resolution Data



Hyperspectral Pushbroom Technology

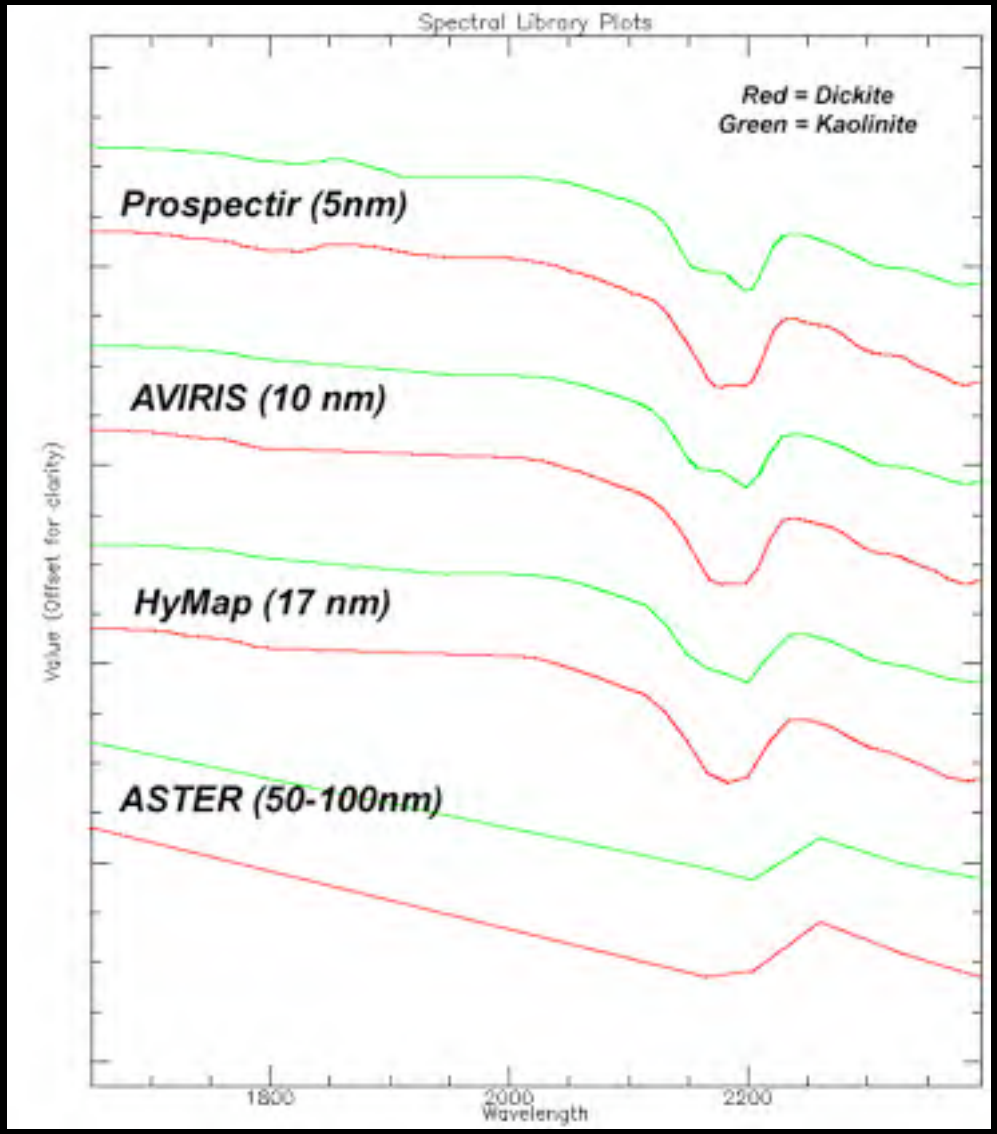


From: Schowengerdt, R.A., *Remote Sensing Models and Methods for Image Processing 2nd Edition.* 1997

Acquisition

- Ground resolution is a function of altitude and IFOV
  - For 1 milliradian instrument: 1m @1000m AGL
  - Swath width varies
  - Swath sidelap is normally 30%
- Aircraft needs a photographic port
  - Typical - Cessna 310 (200Km/Hr)
  - Pressurized may be used with a crystal window
- Typical return to line is 7 minutes
- Productivity depends on survey geometry – 20Km line = 50% productivity
- Survey day is 4 hours – Solar Noon +- 2 hours
- Cloudless days are required!

Spectral Resolution



Spatial Resolution

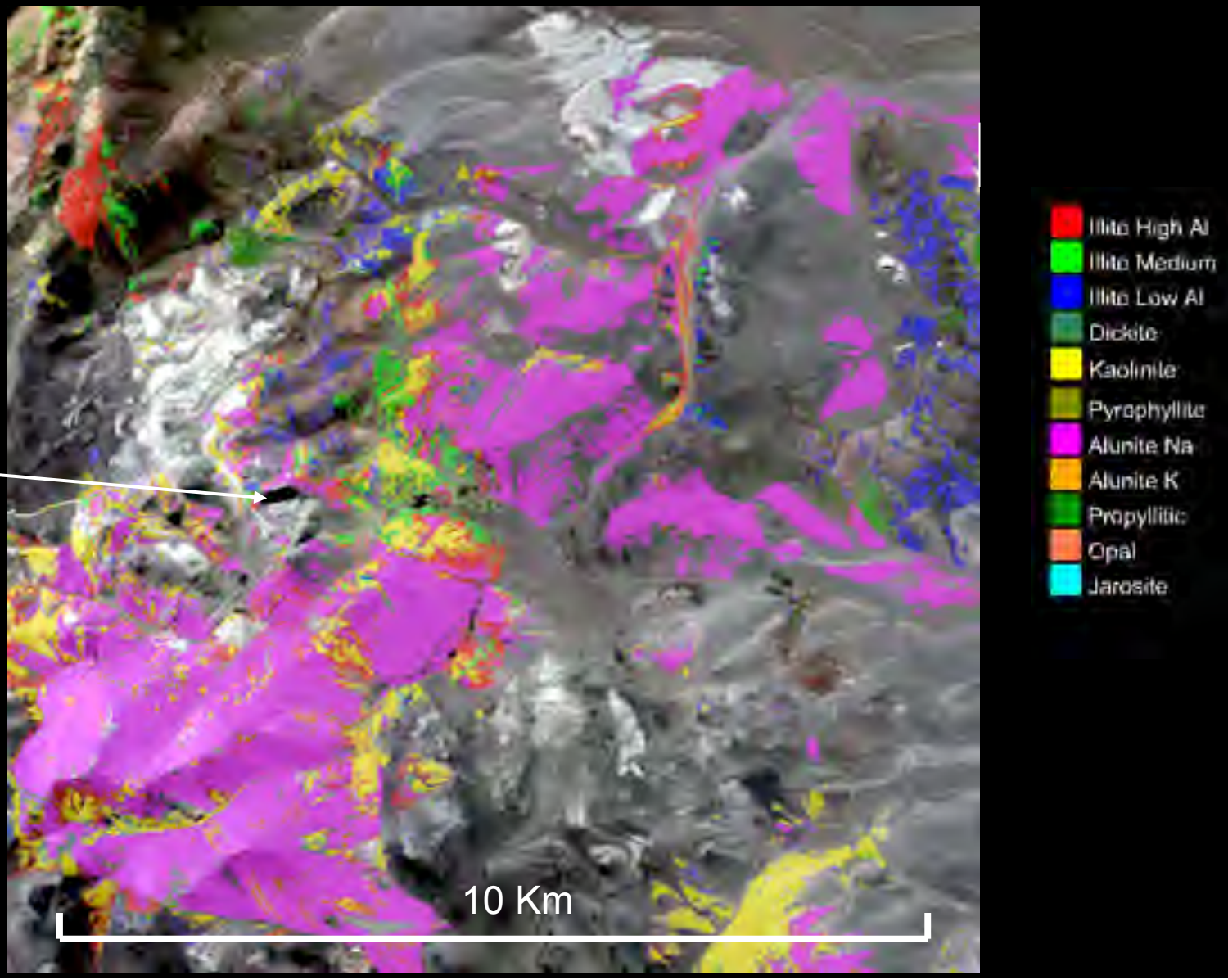
1 Meter

5 Meters

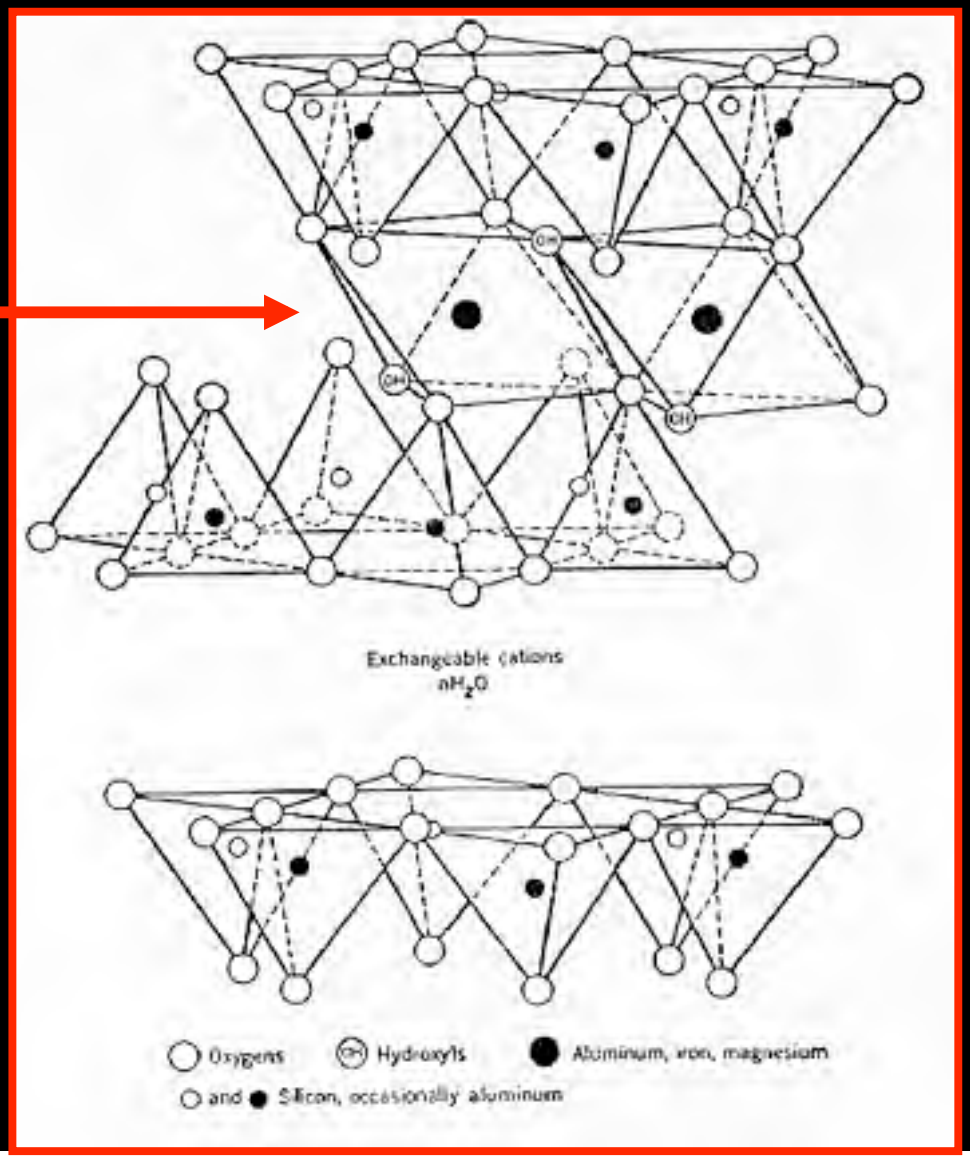
What Does HSI Do?

- Remote identification and mapping of mineral species
  - Phyllosilicates
  - Sulfates
  - Oxides
  - Carbonates
- Tectosilicates are the next step

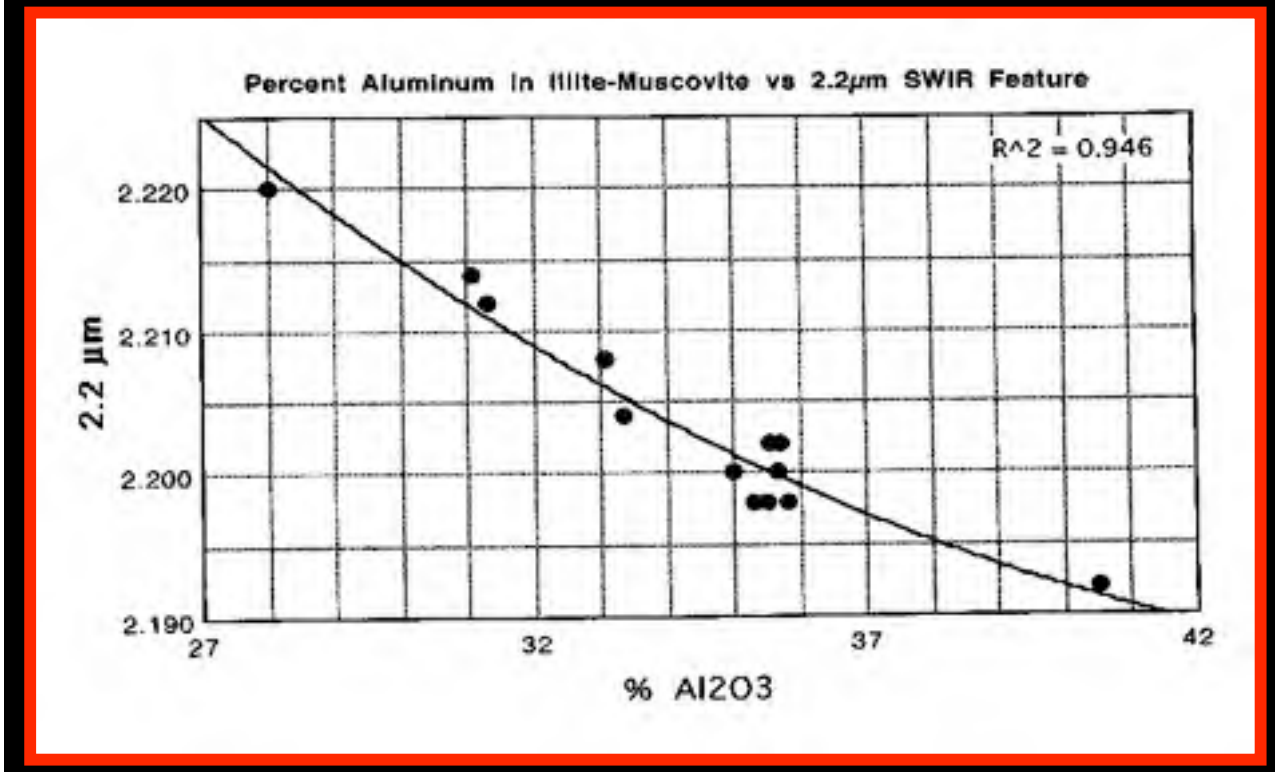
Results (In a Perfect World!)



Illite (Sericite) Chemistry

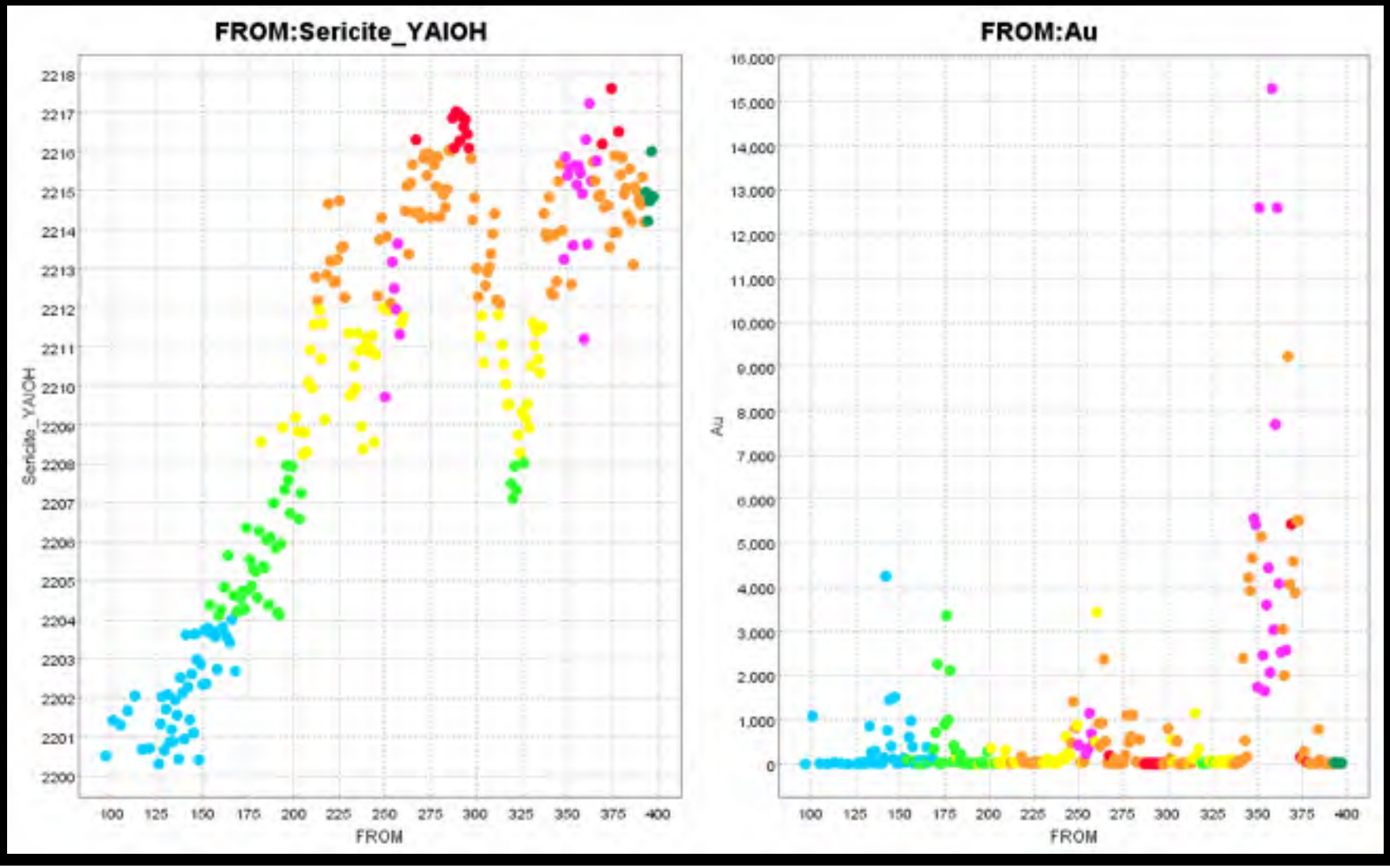


Shift in Wavelength tracks Aluminum composition



Lower the wavelength higher the Aluminum content

Hanging Wall Illite/Sericite Example



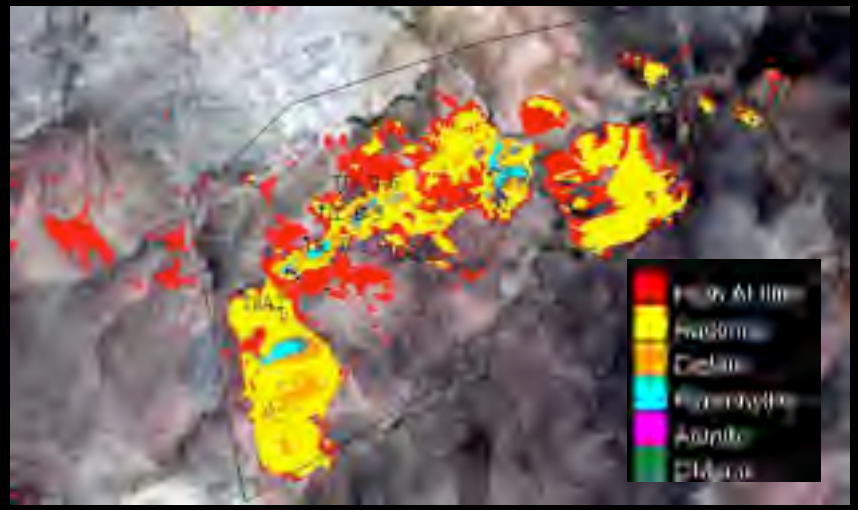
First Rule of ALL Remote Sensing - VISA

V – Visibility	The mineral must be optically visible
I – Identifiable	The mineral must be identifiable
S – Signal	The signal from the mineral must be strong enough to be differentiated from noise
A – Abundance	There must be enough mineral to be seen

Challenges for Remote Sensing in Nunavut

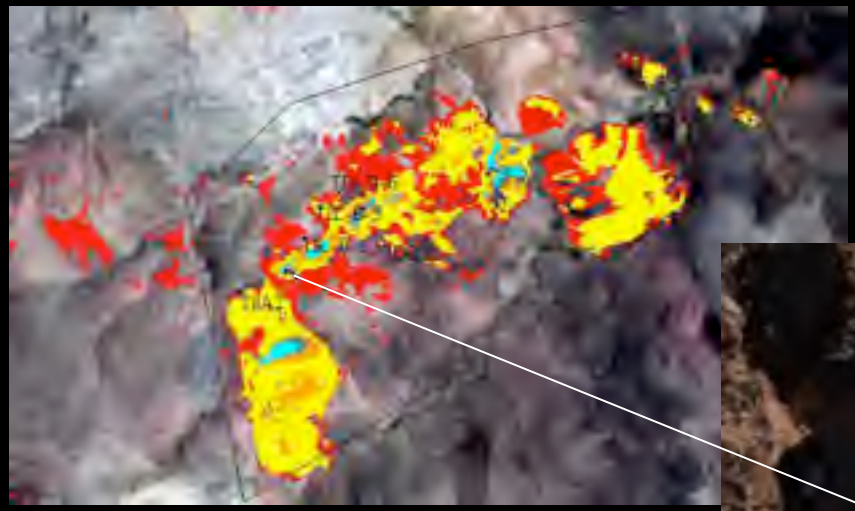
V – Visibility	Vegetation and till cover, we have to have CLEAR sky!!
I – Identifiable	Best for epithermal and porphyry alteration
S – Signal	Dark rocks are a problem
A – Abundance	Lichen may cover a high percentage of outcrop

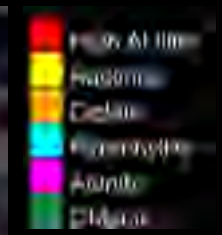
Does Age Matter?



Proterozoic
Epithermal
Style Alteration
In Morocco

Does Metamorphism Matter?





Pyrophyllite
After
Alunite?

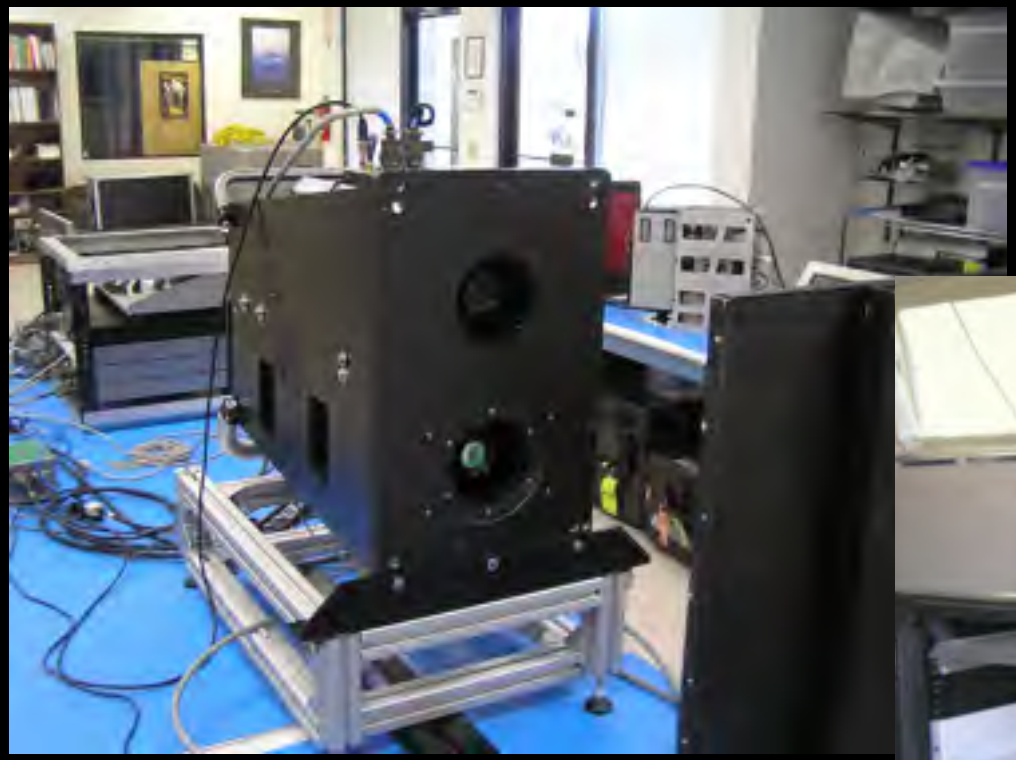
Hyperspectral Initiatives in 2009

- CNGO/GSC/Newmont
  - Hackett River Survey
  - Hope Bay Survey
- Government of Nunavut Departments of Economic Development & Transportation, and Environment
  - Caribou Inventory Proof of Concept Survey

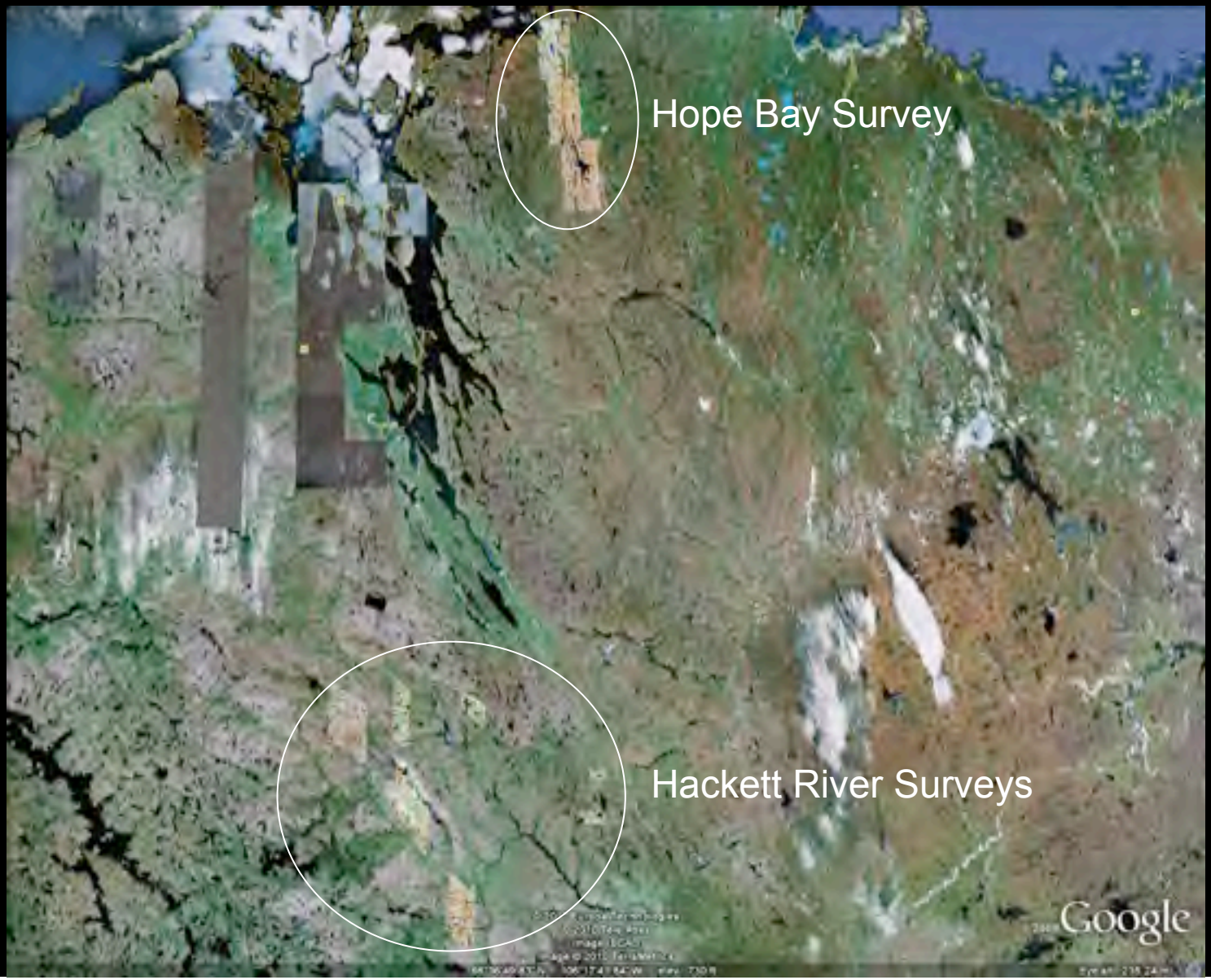
Survey Instrumentation

- Hackett River and Hope Bay
  - Spectir LLC “Prospectir” Instrument
  - Modified Specim AISA “Eagle/Hawk” Dual Camera System
  - Visible to Shortwave IR (400 nm to 2500 nm)
  - 4 nanometer to 6.3 nanometer spectral resolution – 357 channels
  - 1 meter and 3 meter ground resolution
  - Owned and operated by Spectir LLC of Reno, Nevada

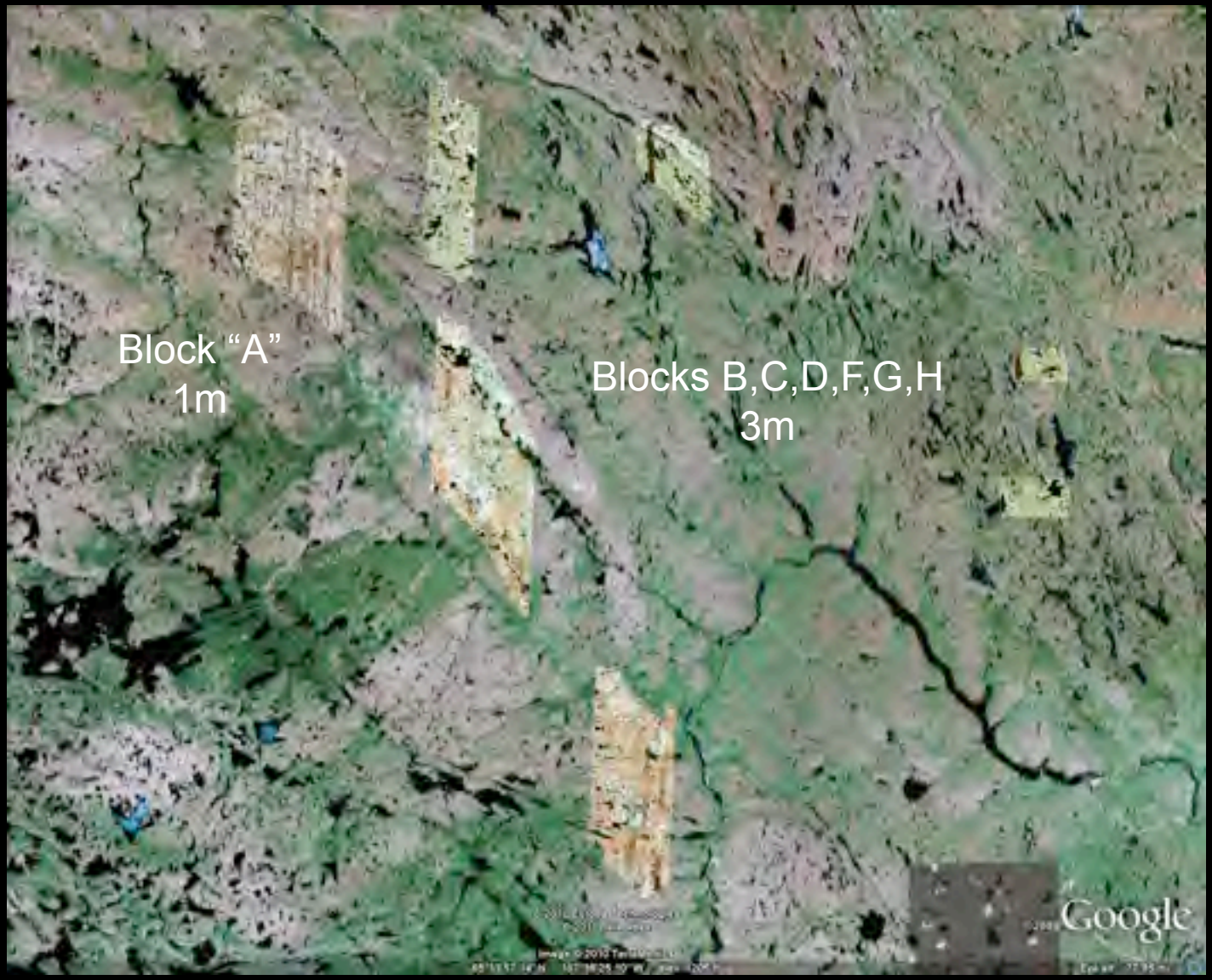
Survey Instrumentation - Prospectir



Hackett River and Hope Bay



Hackett River



Hackett River

Hackett River

Hackett River

Hackett River

Hackett River

Hope Bay

Hope Bay

Hope Bay

Hope Bay

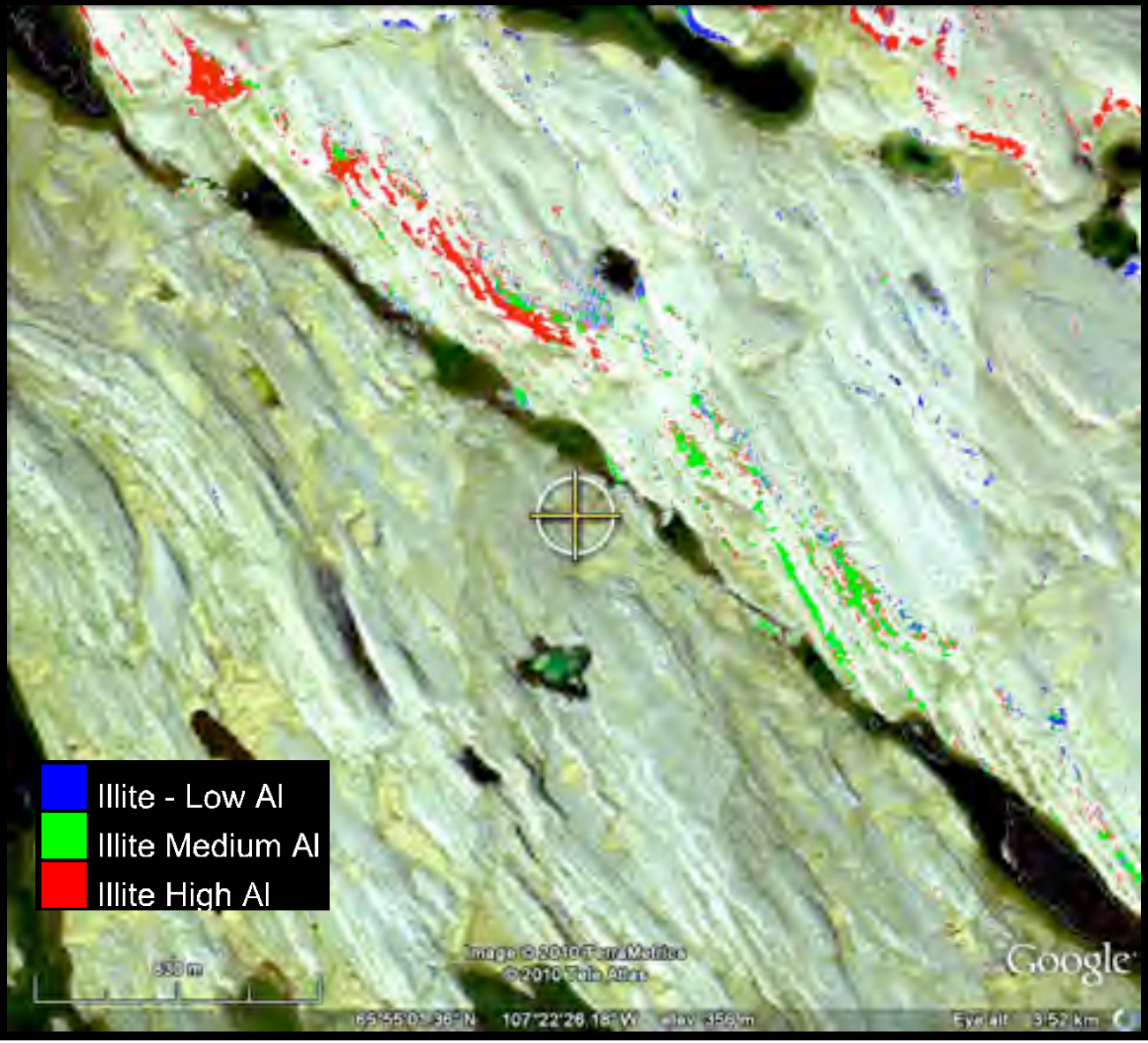
Hope Bay

Hope Bay

Work So Far

- Flight lines were mosaiced (Level 2)
  - Hackett: 150 flight lines @ 1.5 Gb to 4.5 Gb / flight line
  - Hope Bay 59 flight lines @ 1.5 Gb to 1.9 Gb / flight line
- Preliminary mineral maps were generated
  - Predominantly illite family with Al variations
  - Issues with carbonates, chlorite, actinolite

Illite Map



Issues

- Poor exposure in many places – expected
- Vegetation signal in most pixels
- Signal issues: low sun angle/energy, dark rocks, spectral artifacts
- Spectral artifacts are making some minerals difficult to identify – atmospheric or vegetation?

Important Points

- The preliminary mineral maps are a rough guide (but necessary)
- The “success” of these missions will not be known until field mapping and followup is done
- Field followup is critical to refine the mineral maps and focus on important mineralogies

General Conclusions

- Exposure is better near the coast
  - Hope Bay mineral mapping is better than Hackett River
  - At Hope Bay the results are better closer to the coast
- We can map bedrock mineralogy at high latitudes under certain conditions

Hackett and Hope Bay Final Points

- Hyperspectral data provides spatial complete documentation of the conditions of, *and material on*, the surface
- In sensitive areas it is a definitive baseline of the pre-mining condition of the ground
- The Hackett River and Hope Bay data will provide fodder for exploration and future Arctic research

Caribou Inventory

- Proof of concept study generated and funded by the Territory of Nunavut
- Can caribou be identified and inventoried using hyperspectral technology?
- Study was carried out near Durango Colorado over contained elk herds
- Access to elk was provided by the Elk Research Institute (ERI)

Why?

- Inventory method might be developed that is automatic/semi-automatic
- Hyperspectral data collection is high altitude (500 m +) – *no impact on herd behavior*

Study Methodology

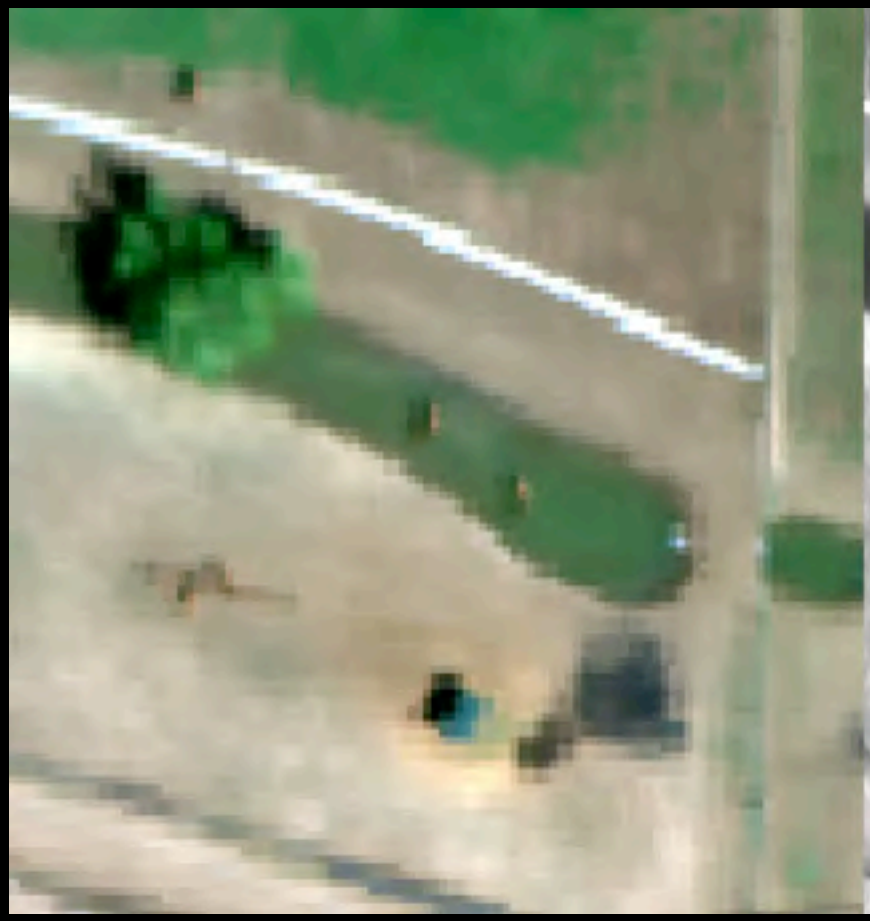
- Fly variable spatial resolution data over elk herds
- Utilize visible-shortwave infrared and thermal infrared sensors
- Supplement hyperspectral data with a high spatial resolution camera (Redlake) for direct identification of elk

Survey Instrumentation

- Caribou Inventory Proof of Concept
  - Spectir LLC, Aerospace Corp “Prism Duce”
  - Prospectir plus
    - SEBASS Thermal Infrared Hyperspectral System – 128 channels
    - High resolution B&W “Redlake” digital camera
  - Flown by Aerospace Corp with Aerospace and Spectir operators onboard
  - ½ meter, 1 meter, and 3 meter resolution
  - (5 cm, 10 cm, and 30 cm for Redlake)

Survey Instrumentation – Prism Duce

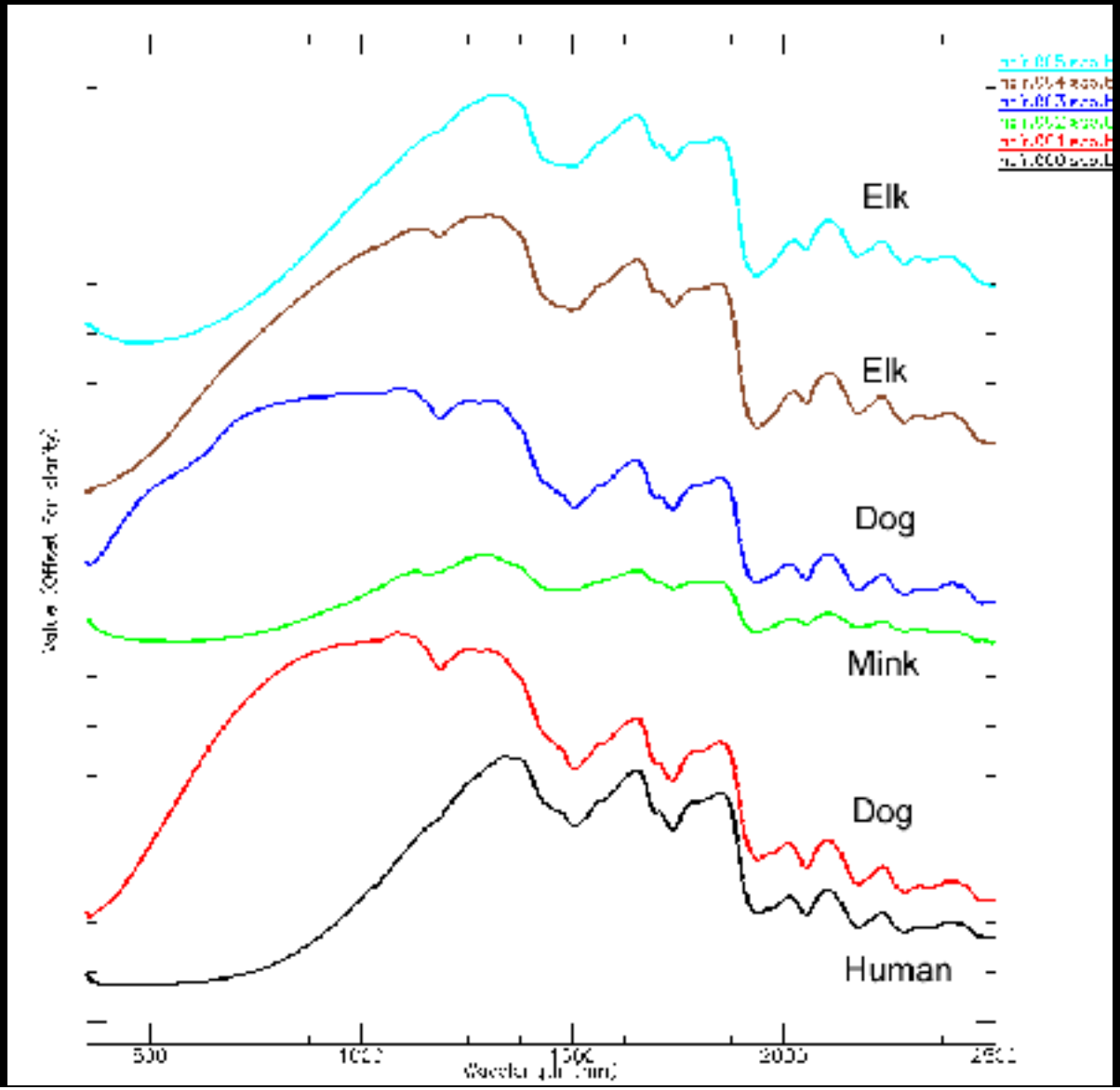
Hyperspectral and High Resolution Imagery



1/2 meter hyperspectral

5 cm Redlake

Spectroscopy of Animal Fur



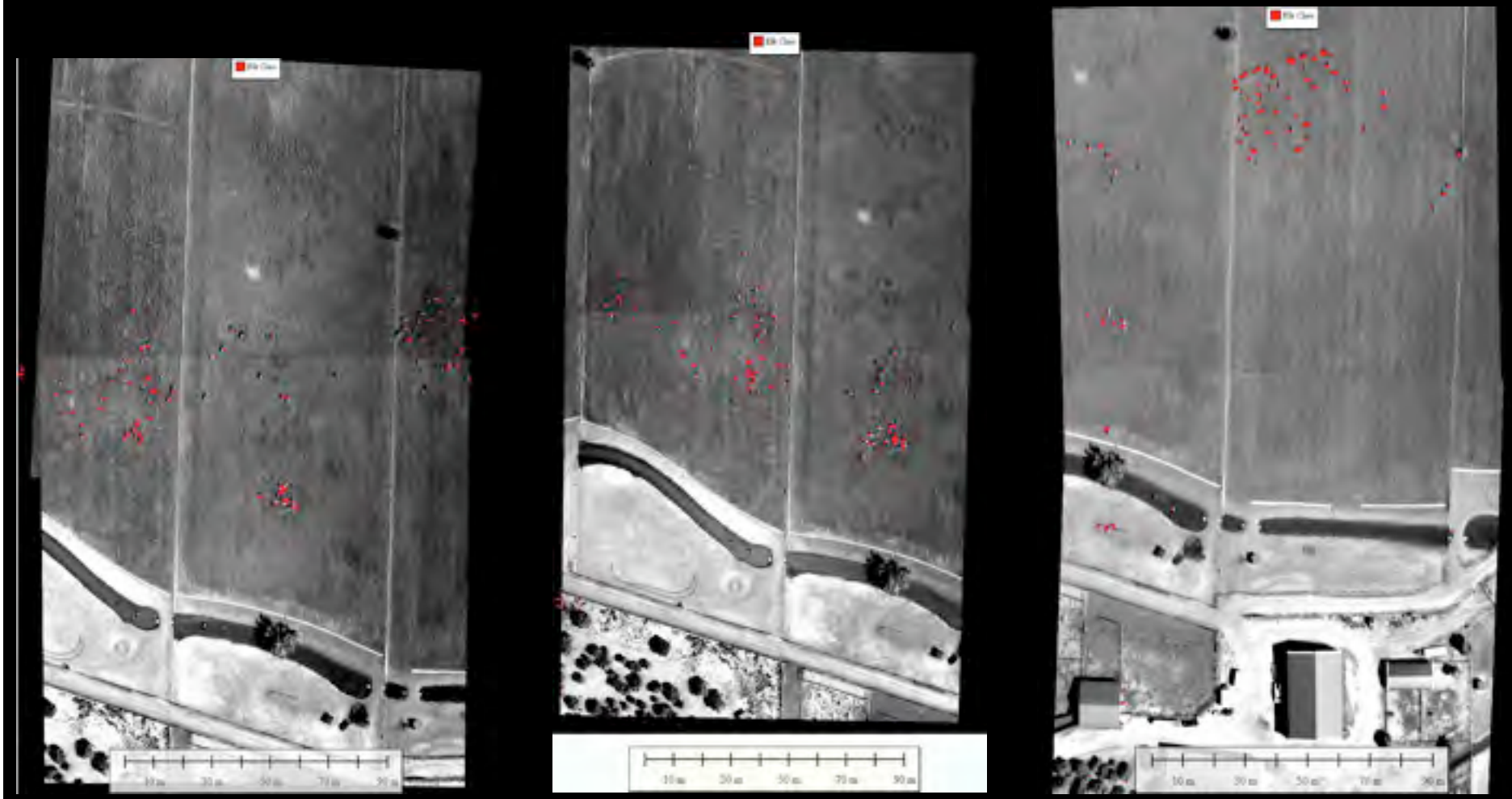
Survey Location

Survey Location

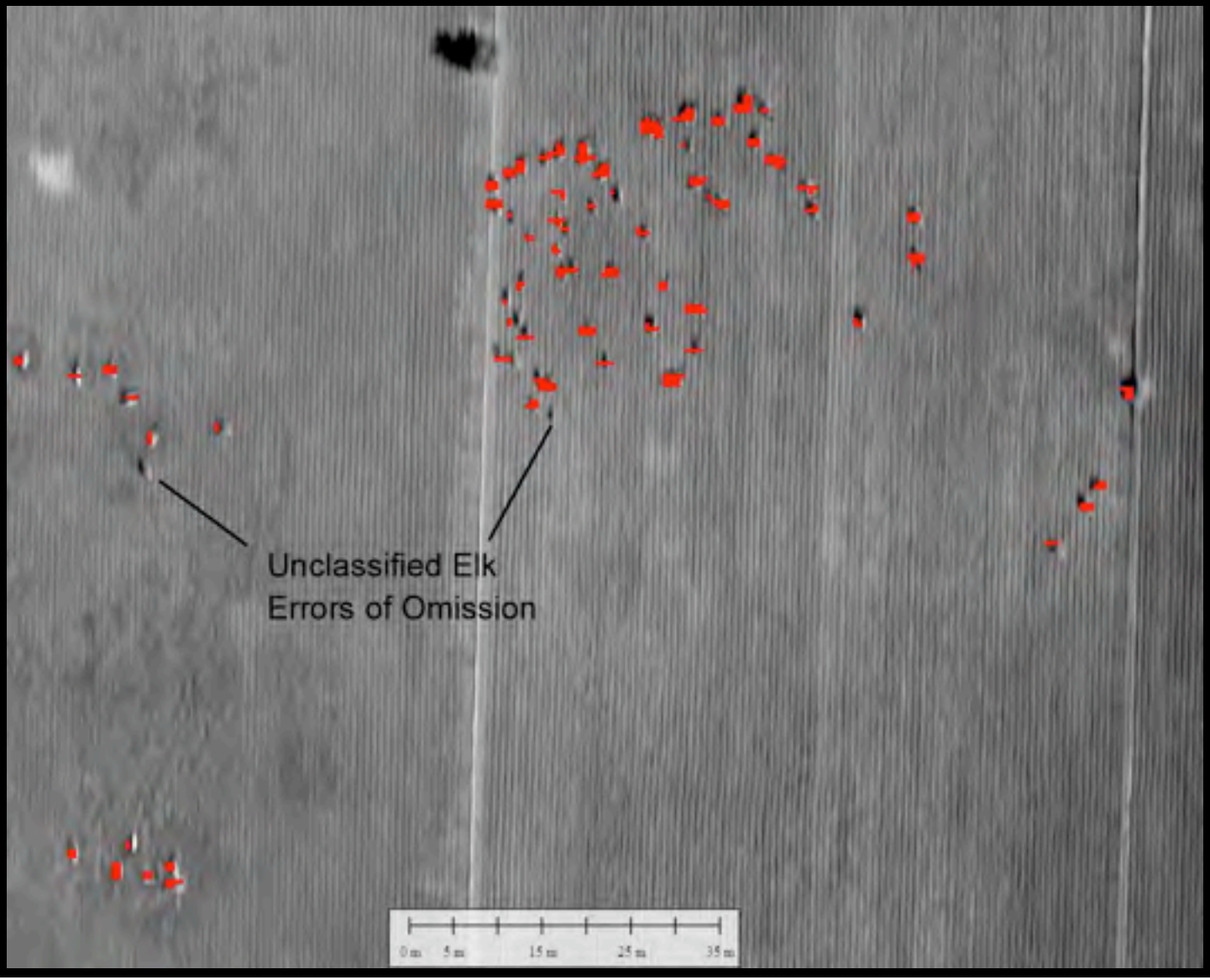
Survey Location

ERI Facilities

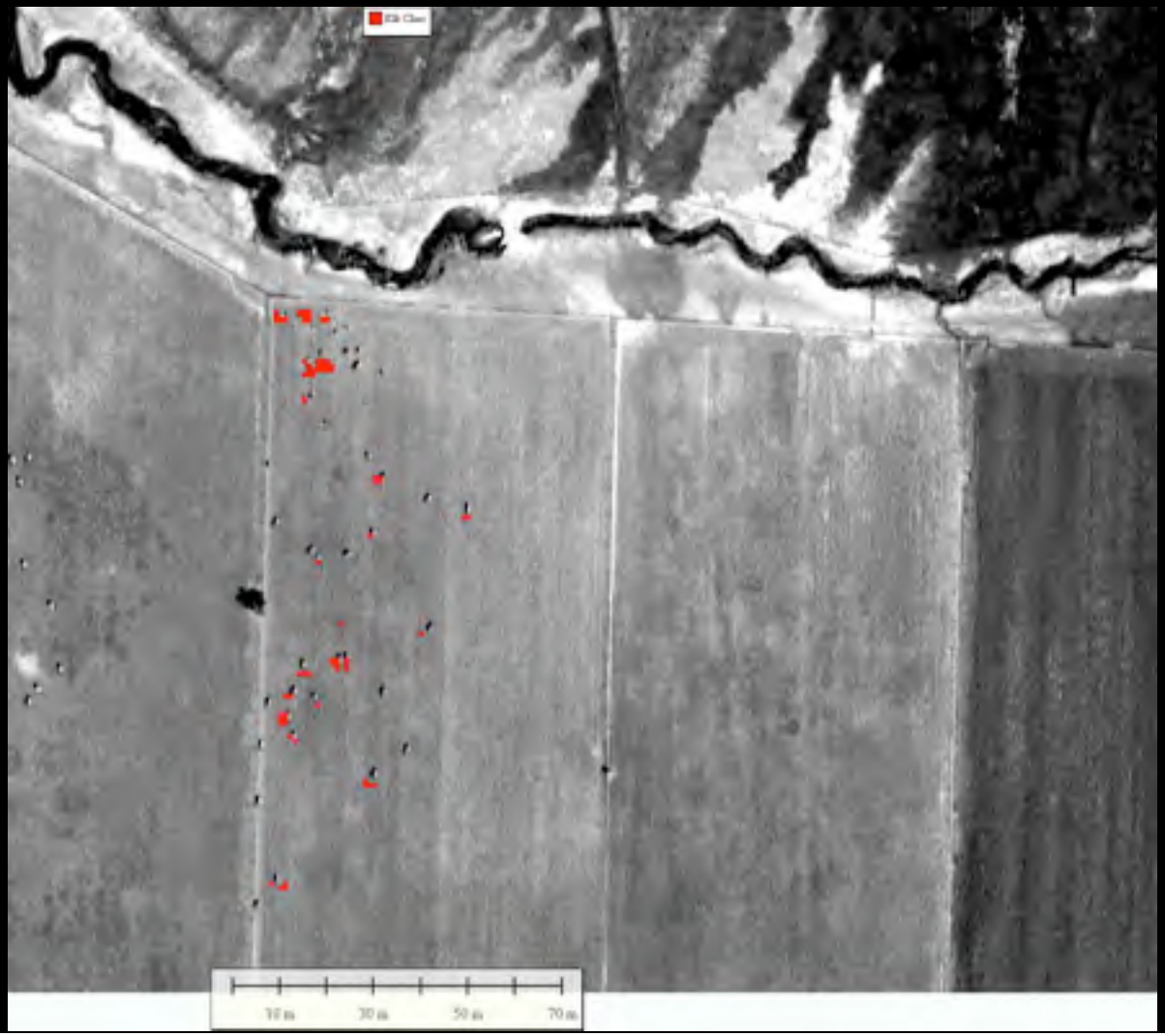
Results – Prospectir ½ Meter



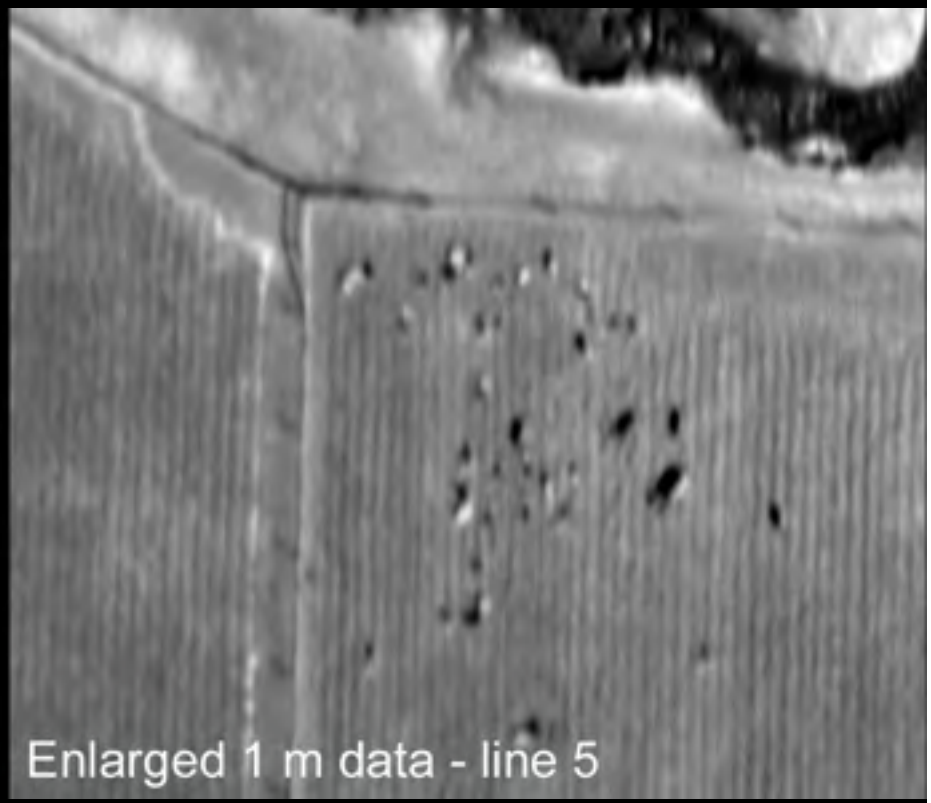
Closeup



Results Prospectir 1 Meter



Closeup



Conclusions

- Animal fur has a characteristic spectral fingerprint
- At ½ meter resolution elk can be accurately mapped and inventoried
- Accuracy degrades rapidly at lower resolutions when individuals are scattered
- Airborne hyperspectral measurement at 1/2m resolution had no impact on elk behavior in the study

Thank You