GEM

A STRAGEY for PRODUCING PREDICTIVE BEDROCK MAPS of CANDA'S NORTH

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Geological Survey of Canada

GEMS (Geomapping for Energy and Minerals) – Remote Predictive Mapping (RPM) - OBJECTIVES

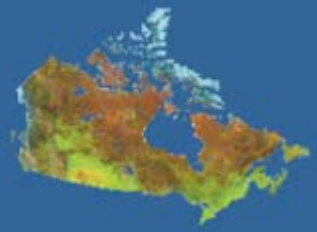
- Produce bedrock, surficial (associated posters) and mineral potential maps of poorly mapped areas of Northern Canada
- Provide support for regional mapping
- Promote the OPERATIONAL use of RPM in poorly mapped areas ("white spaces")
- (changing the mapping paradigm)

  - training and mentoring

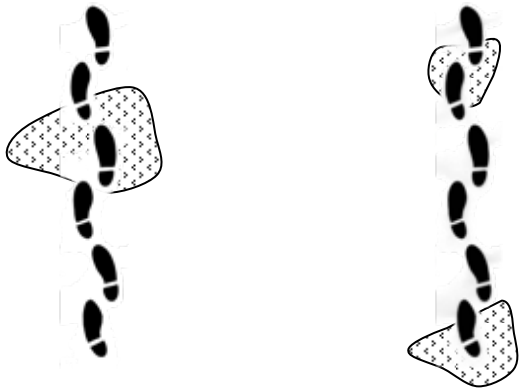
- R & D activities

  - prepare for new satellites and up coming satellites (i.e. hyperspectral)

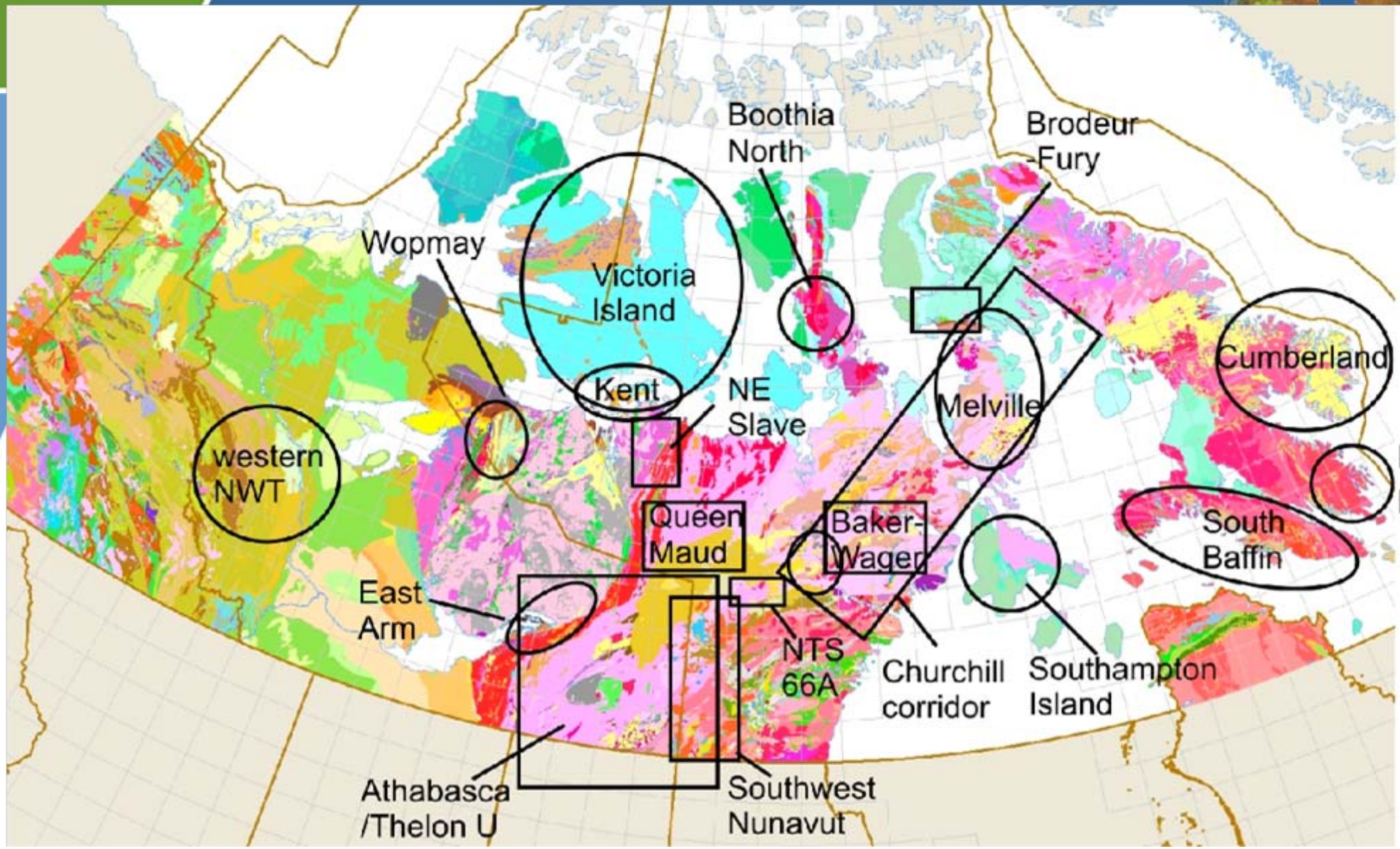
Why RPM?



- Canada is a very large, densely-vegetated and glaciated country
- We can not walk everywhere…..
- and where we walk we often can not see the rocks ….
- As a result there is lots of ‘white space’
- Remotely sensed data can be effectively
- used to map geological features across this
- ‘white space’



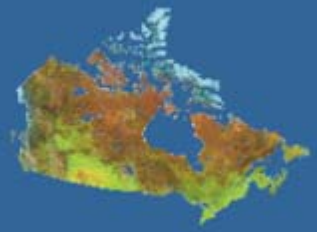
Project Areas



Methodology development for remote predictive mapping - RPM

- Remote Predictive Mapping **comprises:**
- the compilation and interpretation (visual and/or computer-assisted) of a variety of geoscience data to produce predictive maps that are integrated with existing legacy geologic data; these maps contain structural, lithologic, geophysical and surficial information for the field geologists before the start of field work.
- ongoing contribution to the **regional mapping** process through upgrades to the predictive geological maps by repeated integration of newly acquired field and laboratory data.
- the predictive maps may also serve as first-order geologic maps in areas where field mapping is not feasible – **"White Space Mapping"**
- RPM is not a replacement for fieldwork! – help us map more efficiently and cover large areas quickly – broaden our mapping coverage

The RPM process

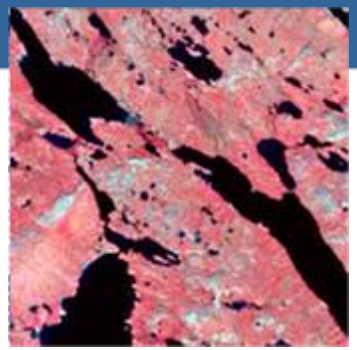


- Define Mapping Focus and Environment
- Data Acquisition
- Data Compilation and registration
- Data processing, Image Enhancement and Information Extraction
- Data Analysis and Interpretation; generation of predictive maps
- Field Logistics and planning
- Validation
- Improvement of predictive maps based on field and laboratory data

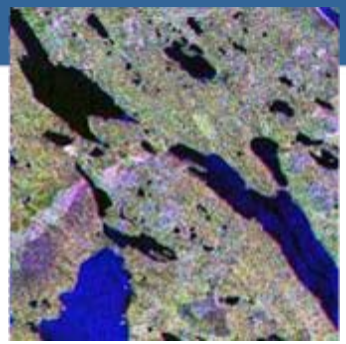
Note: *Red indicates those steps for which further method development by RPM team is warranted*

Data

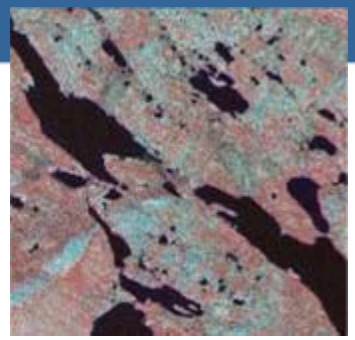
- Remotely sensed
  - Landsat TM
  - Radarsat
  - Aster
  - Hyperspectral
- Geophysics
  - Magnetics
  - Gravity
  - Seismics
  - MT
- DEMS
- Geochemistry
- Field observations



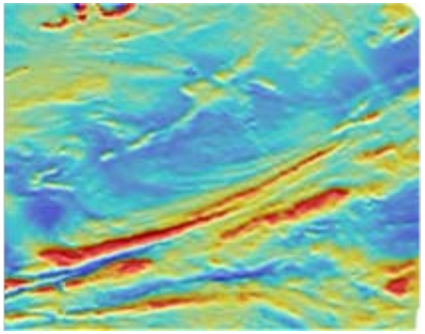
LANDSAT TM – 432(RGB)



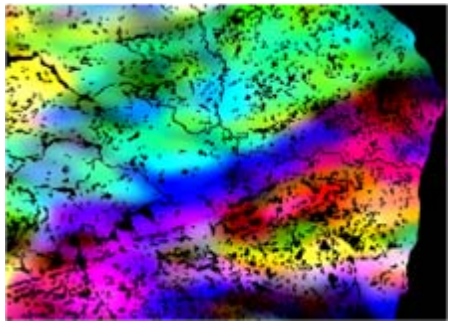
RADARSAT – RGB



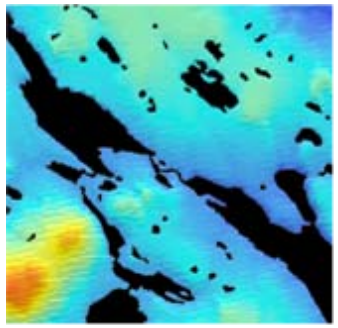
LANDSAT TM and RADARSAT



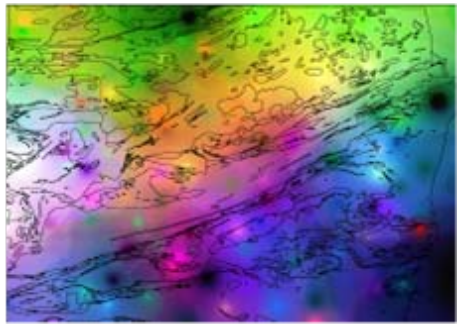
Magnetic – shadow enhanced



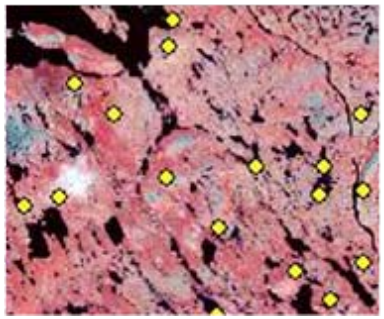
Gamma ray ternary image



DEM

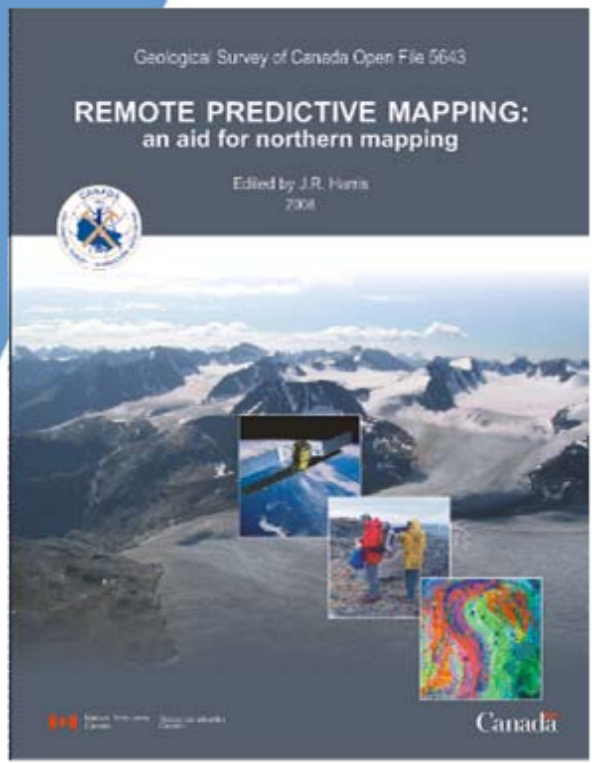


Gamma ternary image – ground measurements



Field observations

RPM - OUTPUTS



GSC Open File
5643

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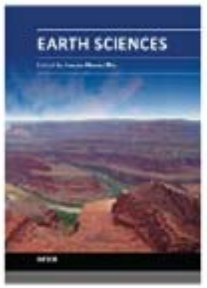
Special Issue on RPM
in CJRS

+

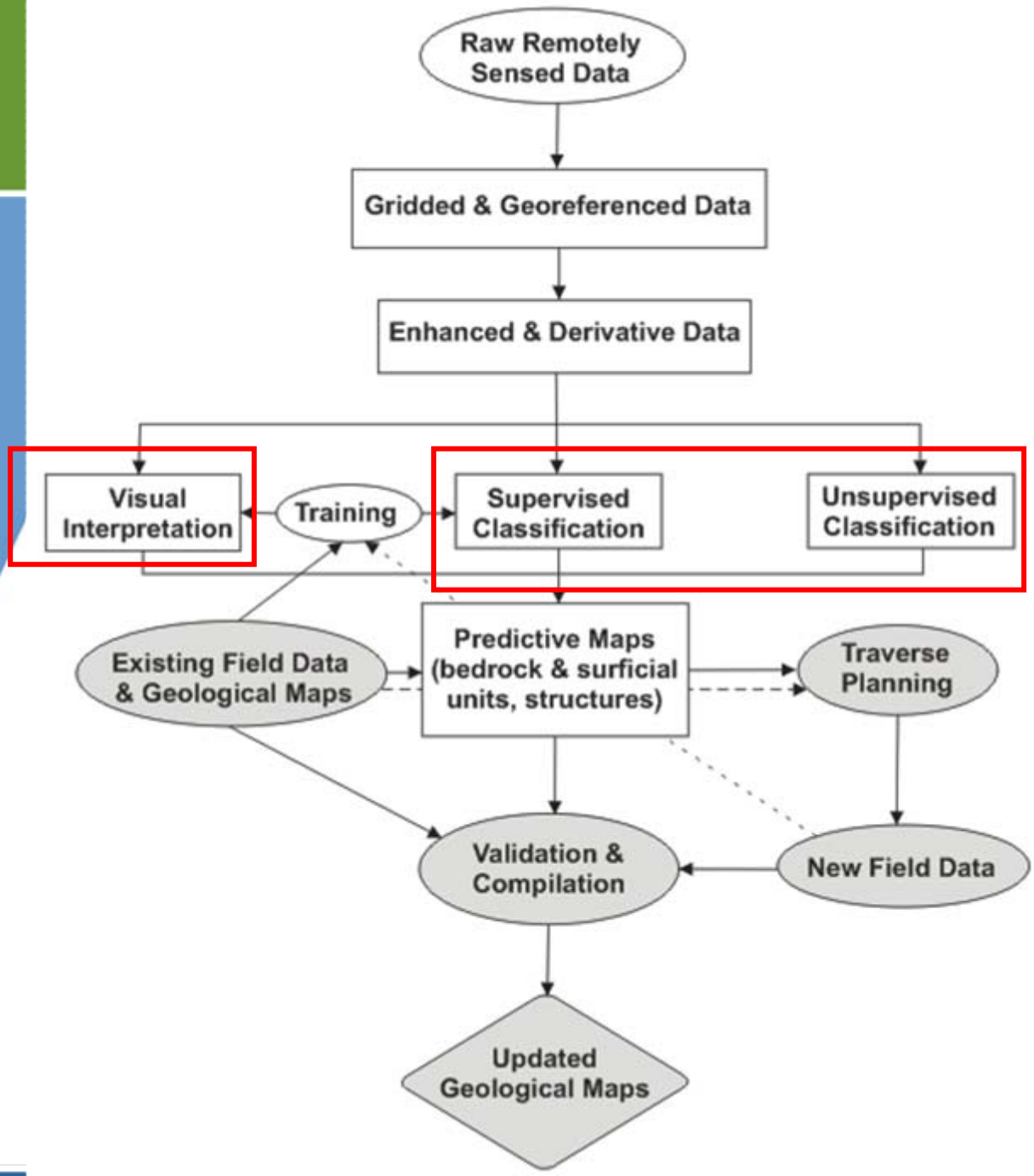
Geoscience Canada
A new series on RPM

Various scientific papers
(CJRS, CJES, IJRS)



Edited by: Imran Ahmad Dar

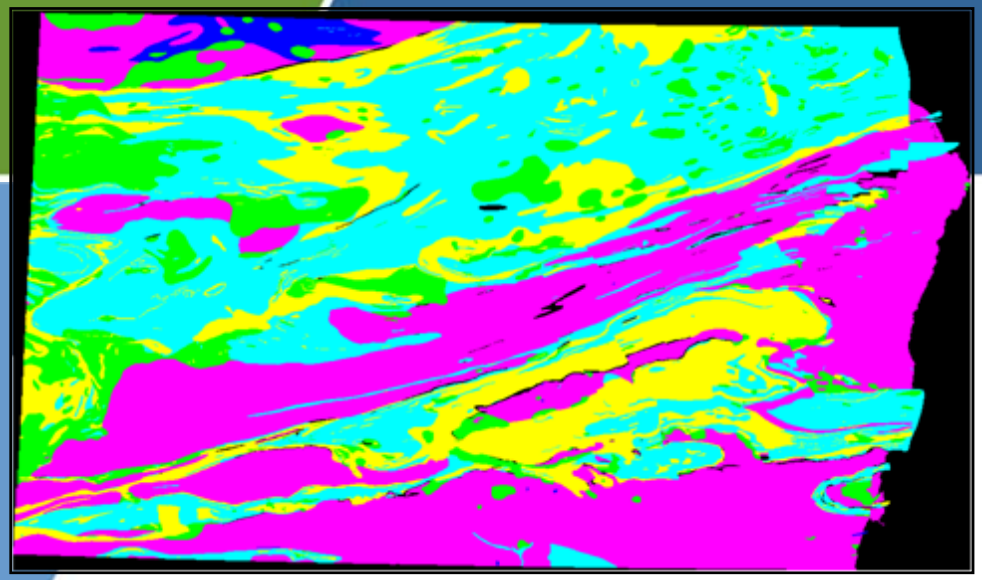
ISBN 978-953-307-861-8
Publisher: InTech
Publication date: February 2012



How is RPM carried out?

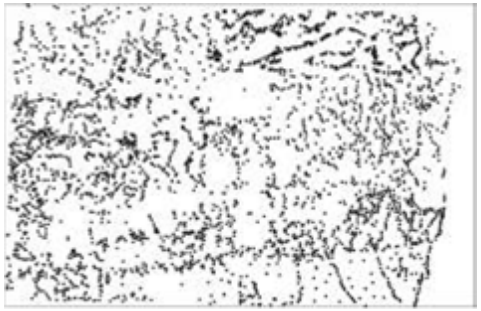
The shaded part of the flow diagram represents the traditional geological mapping process whereas the un-shaded part represents the RPM Component.

…Computer assisted approach to making a predictive map – supervised classification



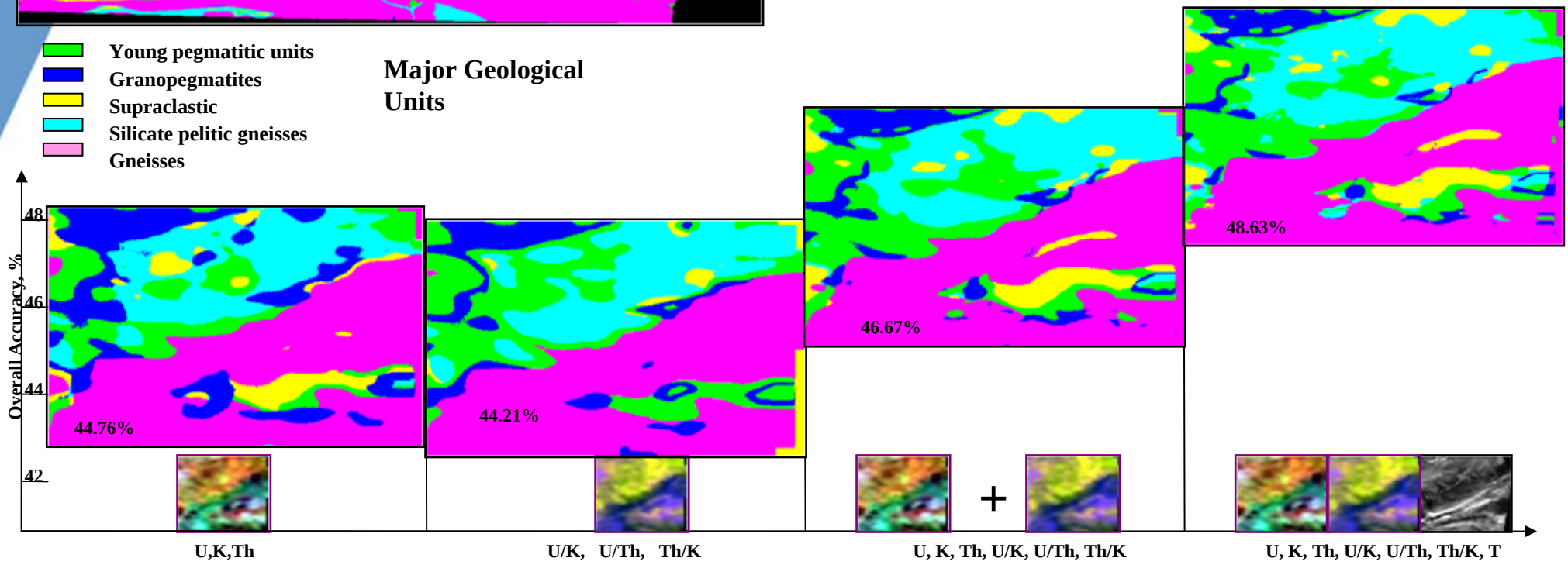
Training Sites:

- 226
- 36
- 1153
- 1794
- 936

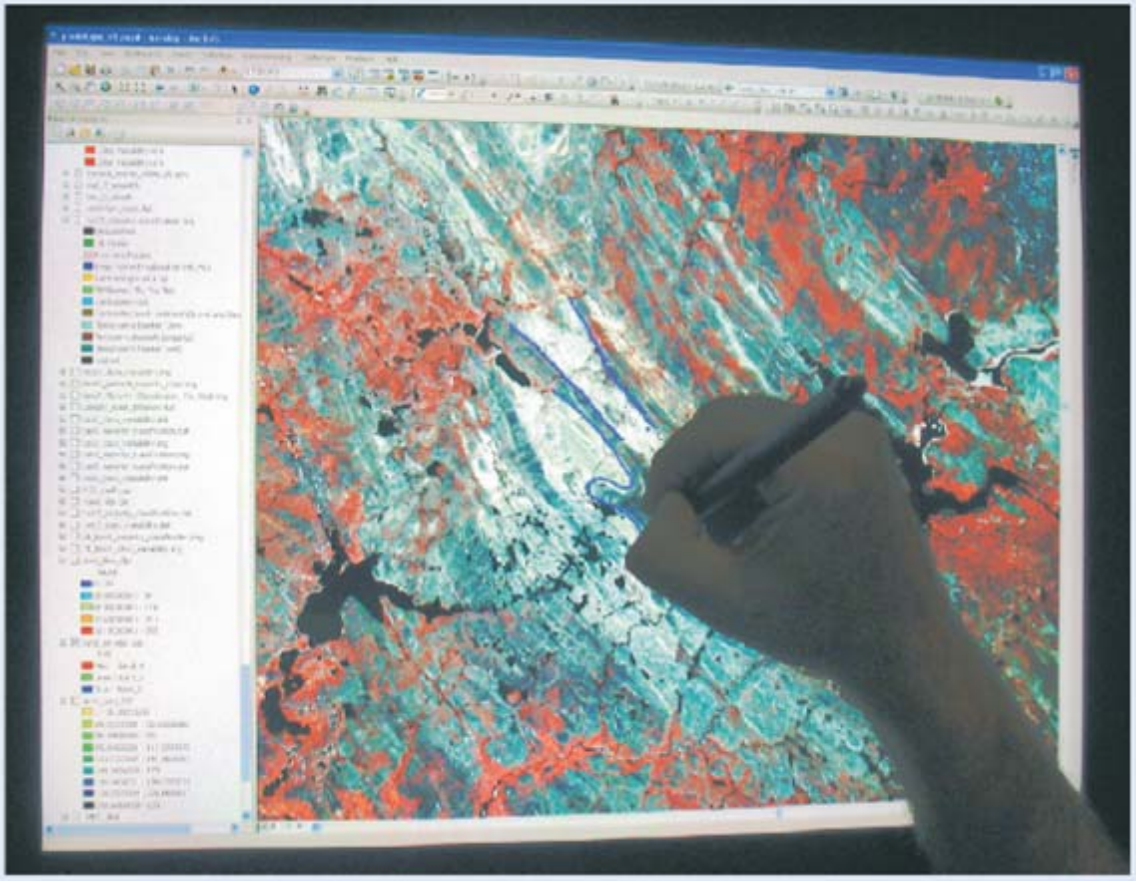


- Young pegmatitic units
- Granopegmatites
- Supraclastic
- Silicate pelitic gneisses
- Gneisses

Major Geological Units



Visual Interpretation



Visual Interpretation using a touch-sensitive screen within ARCGIS in concert with the capabilities of the geodatabase

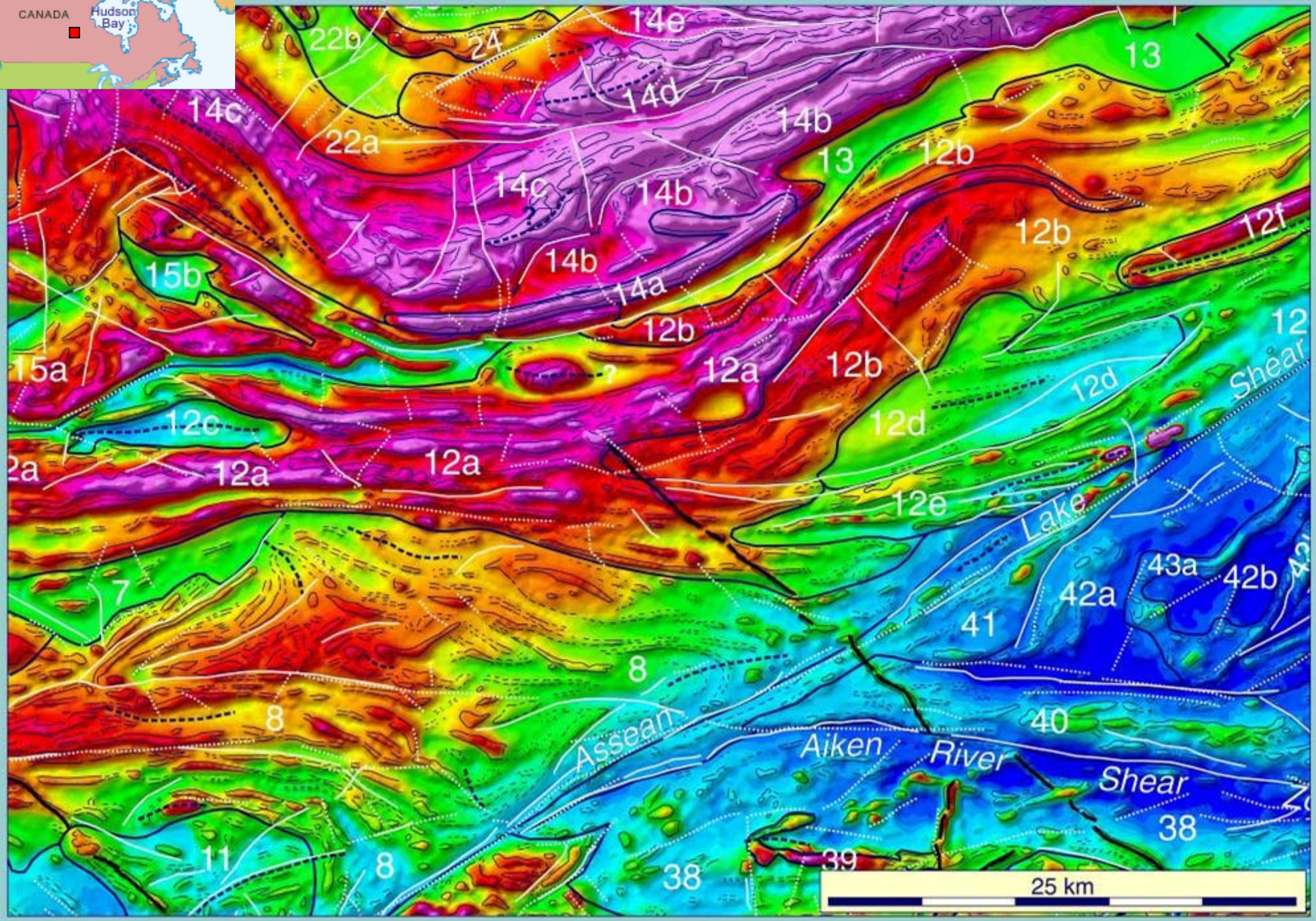
- GEODATABASE_DEVELOPMENT
  - structural interp
    - <all other values>
    - type
    - bedding trends, foliation, fold traces
    - distinct gamma ray boundary
    - distinct magnetic boundary
    - distinct spectral boundary
    - esker
    - frature, fault, variable age
    - interprered fold axis
    - magnetic / spectral / topographic
    - photogeologic evidence for a fault
    - potential shear zone
    - stream- lined landform
  - RPMUnits
    - <all other values>
    - RPMUnit
    - RPM sedimentary cover, unit 1
    - RPM sedimentary cover, unit 2
    - RPM structural domain 1, unit 1
    - RPM structural domain 1, unit 2
    - RPM structural domain 1, unit 3
    - RPM structural domain 1, unit 4
    - RPM structural domain 1, unit 5
    - RPM structural domain 2, unit 1
    - RPM structural domain 2, unit 2
    - RPM structural domain 2, unit 3
    - RPM structural domain 2, unit 4
    - RPM structural domain 2, unit 5
    - RPM structural domain 2, unit 6
    - RPM structural domain 2, unit 7

1. Why Visual Interpretation

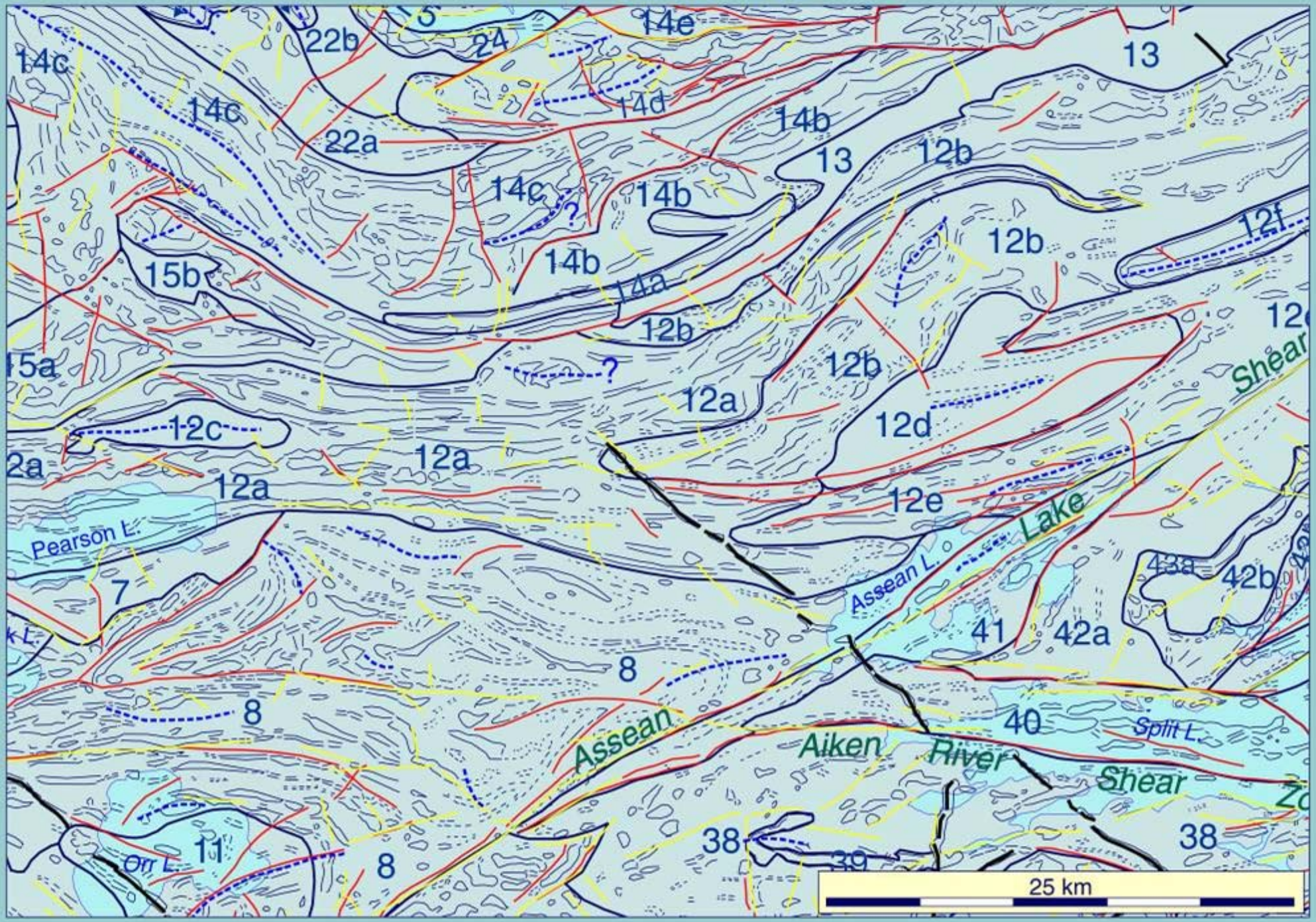
Additional advantages in context of operational RPM

- Relatively easy to get acquainted with
- Evolves naturally from photogeology
- Evolutionary learning experience

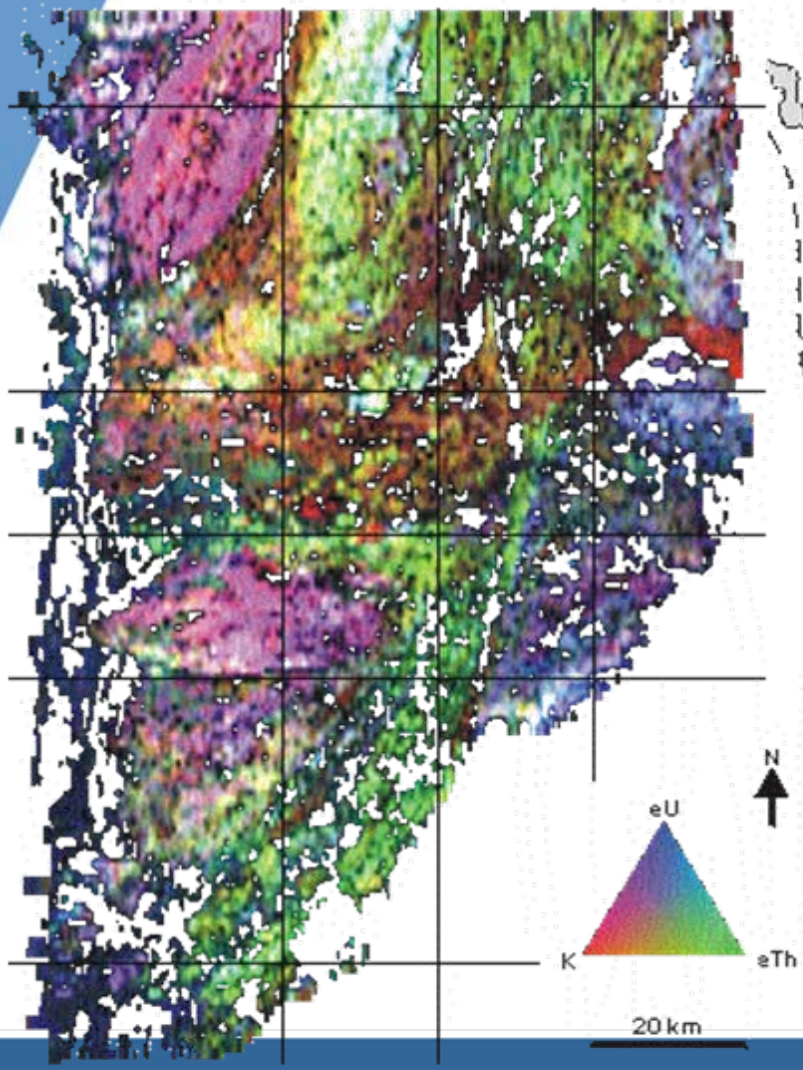
Total Magnetic Field with Interpreted Geology
Assean Lake Area

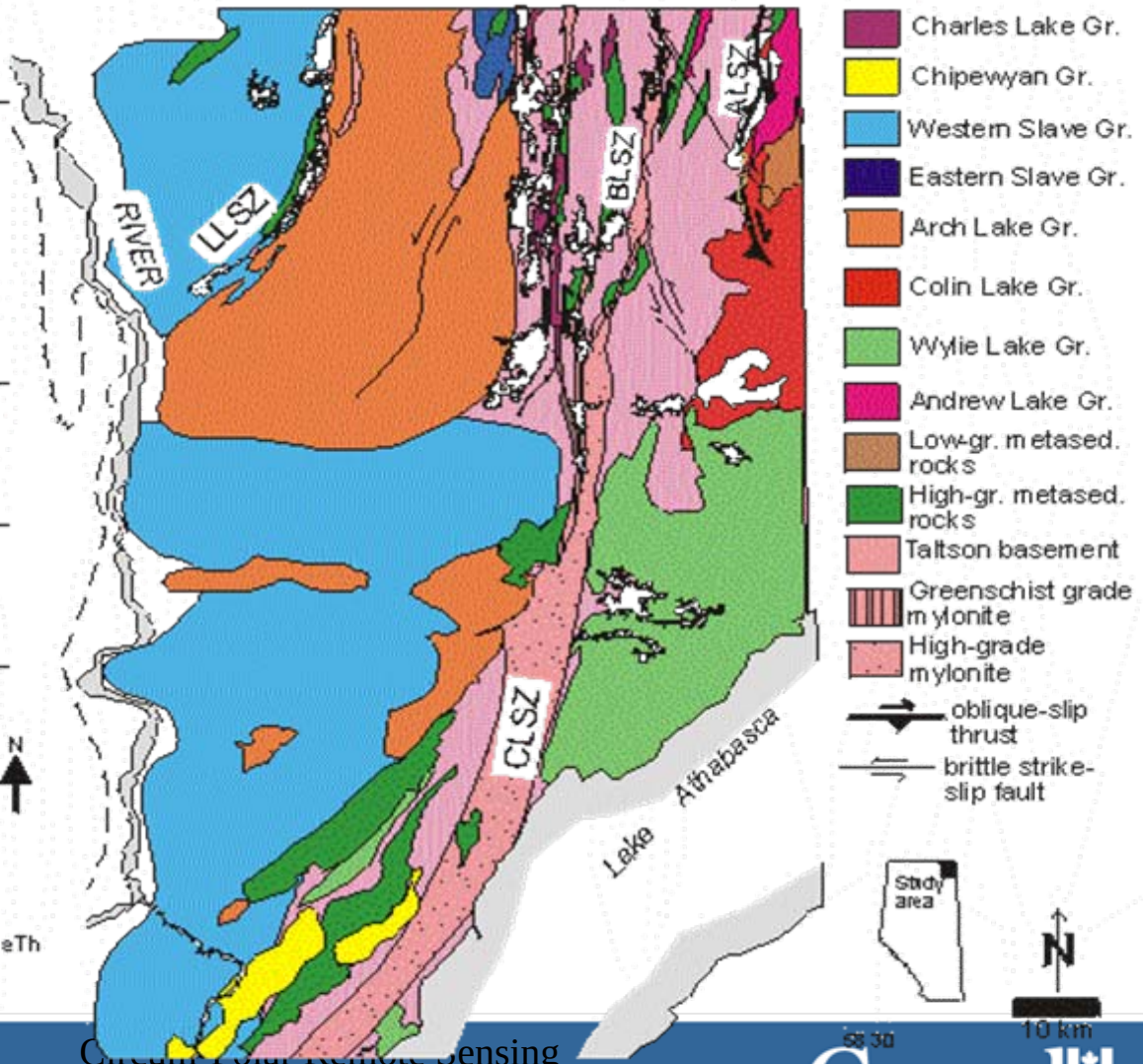


Geology Interpreted from Magnetic Data
Assean Lake Area

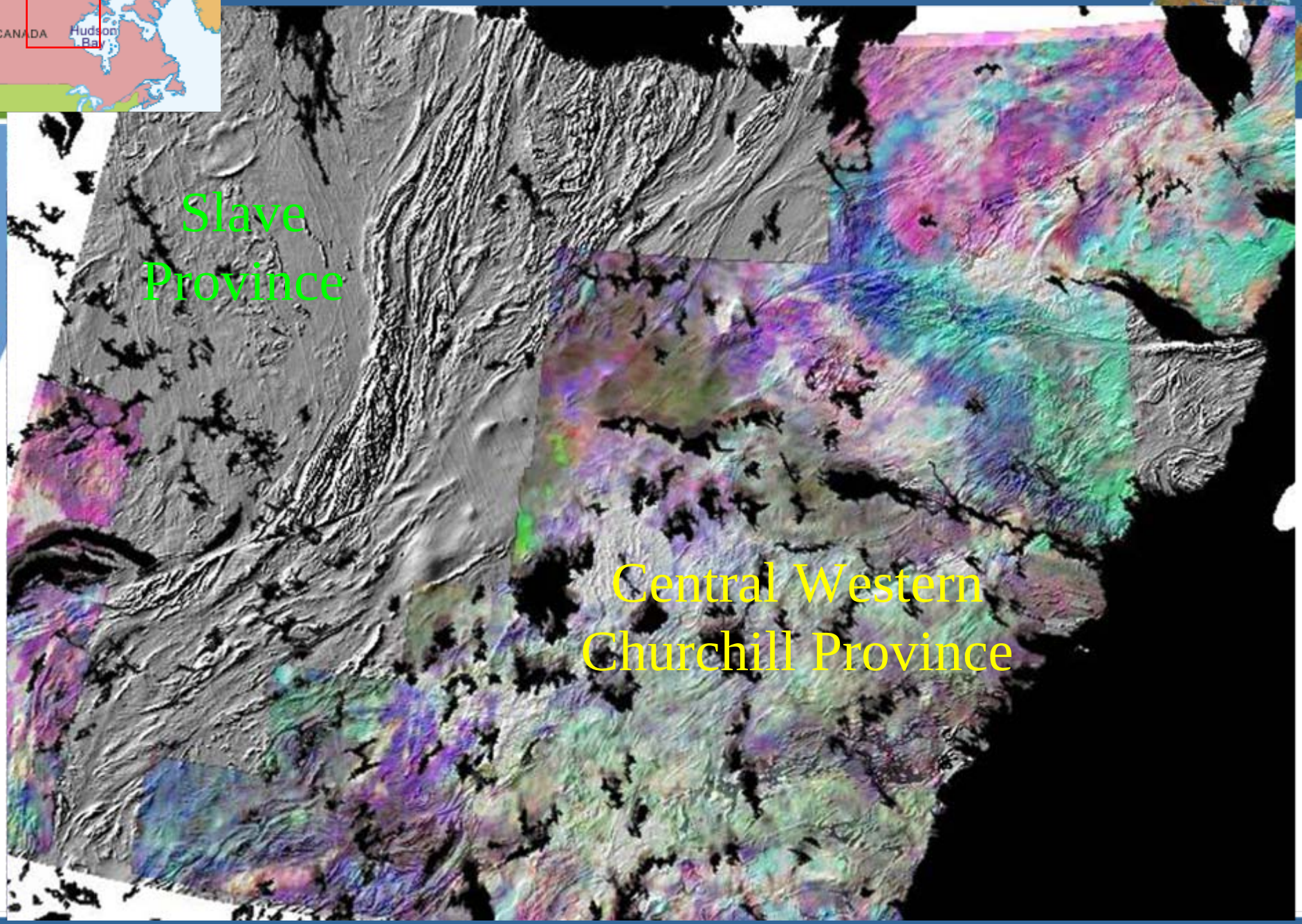


Gamma Ray Spectrometer Data



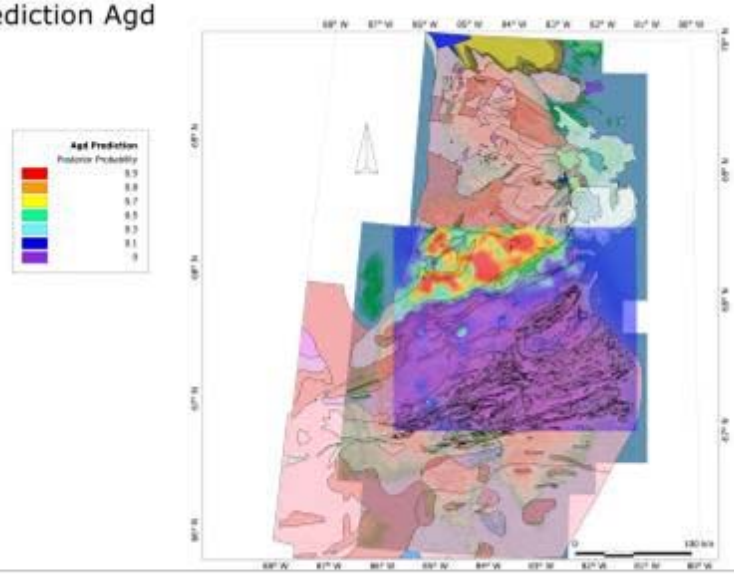


FUSED – Shaded Magnetics and Gamma (ternary)

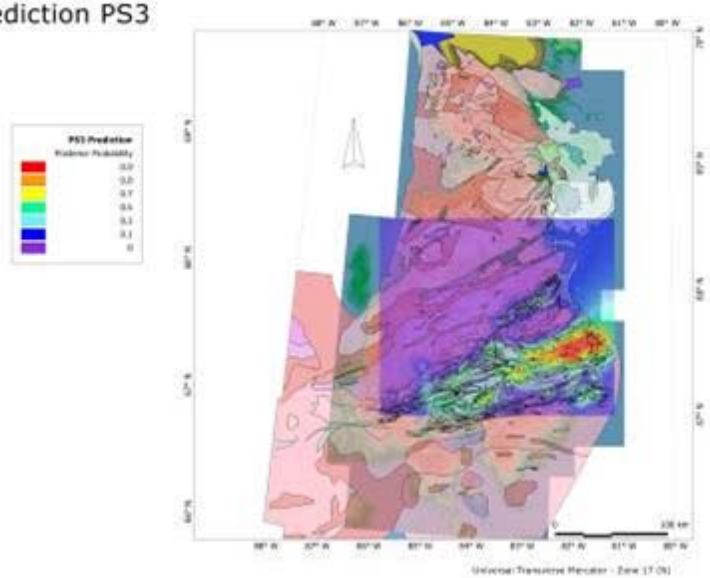


Lithological Prediction using Geochemical (lake-sed)

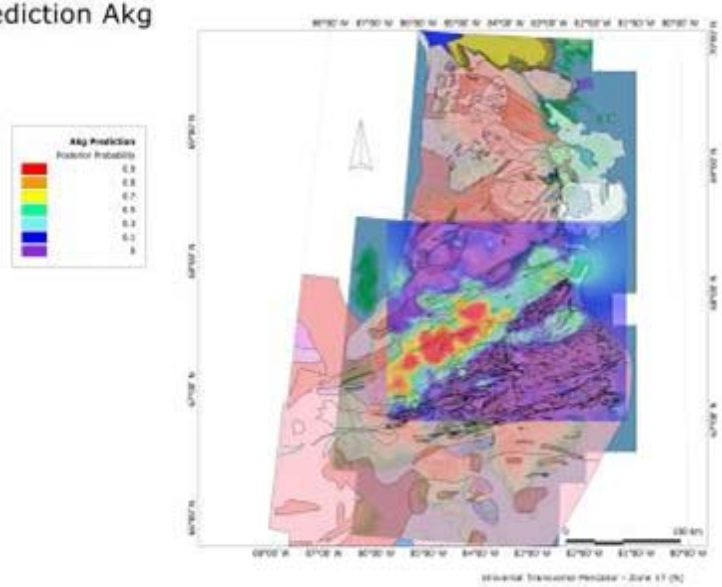
Prediction Agd



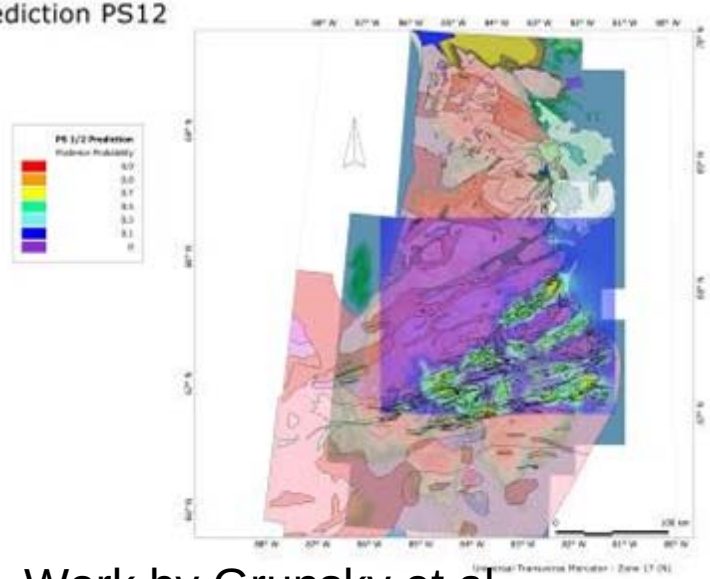
Prediction PS3



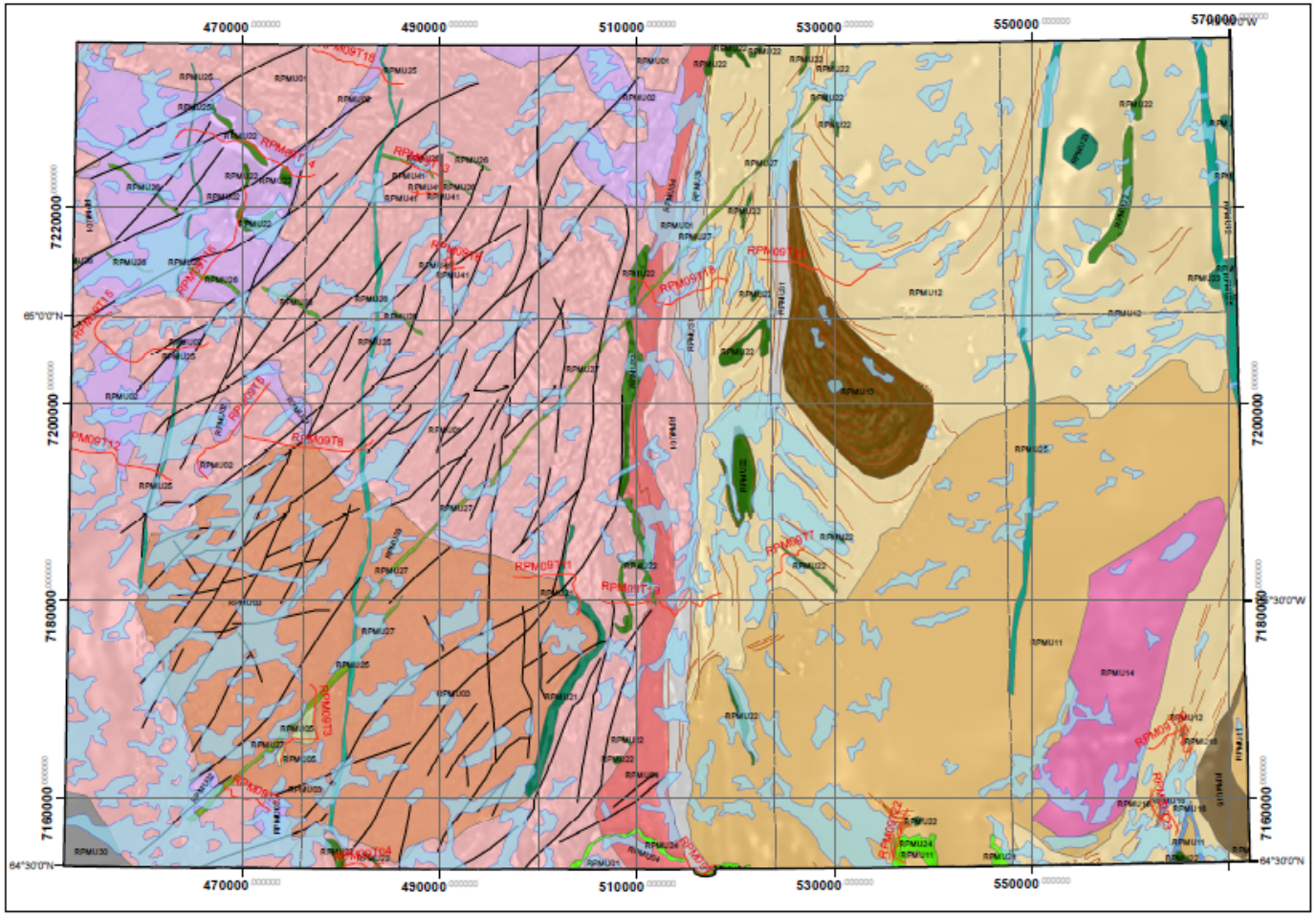
Prediction Akg



Prediction PS12



Work by Grunsky et al



Remote Predictive Map

NTS sheets 86C, 86B (west), 86F south, 86G, southwest

E. Schetselaar, 1 June 2009

N

A predictive map of The GBMZ

RPM structures

fault

foliation

RPM09T35 Suggested field traverse to ground truth RPM interpretation access route based on monoscopic aerial photograph interpretation

Kilometers

0 5 10 20 30 40

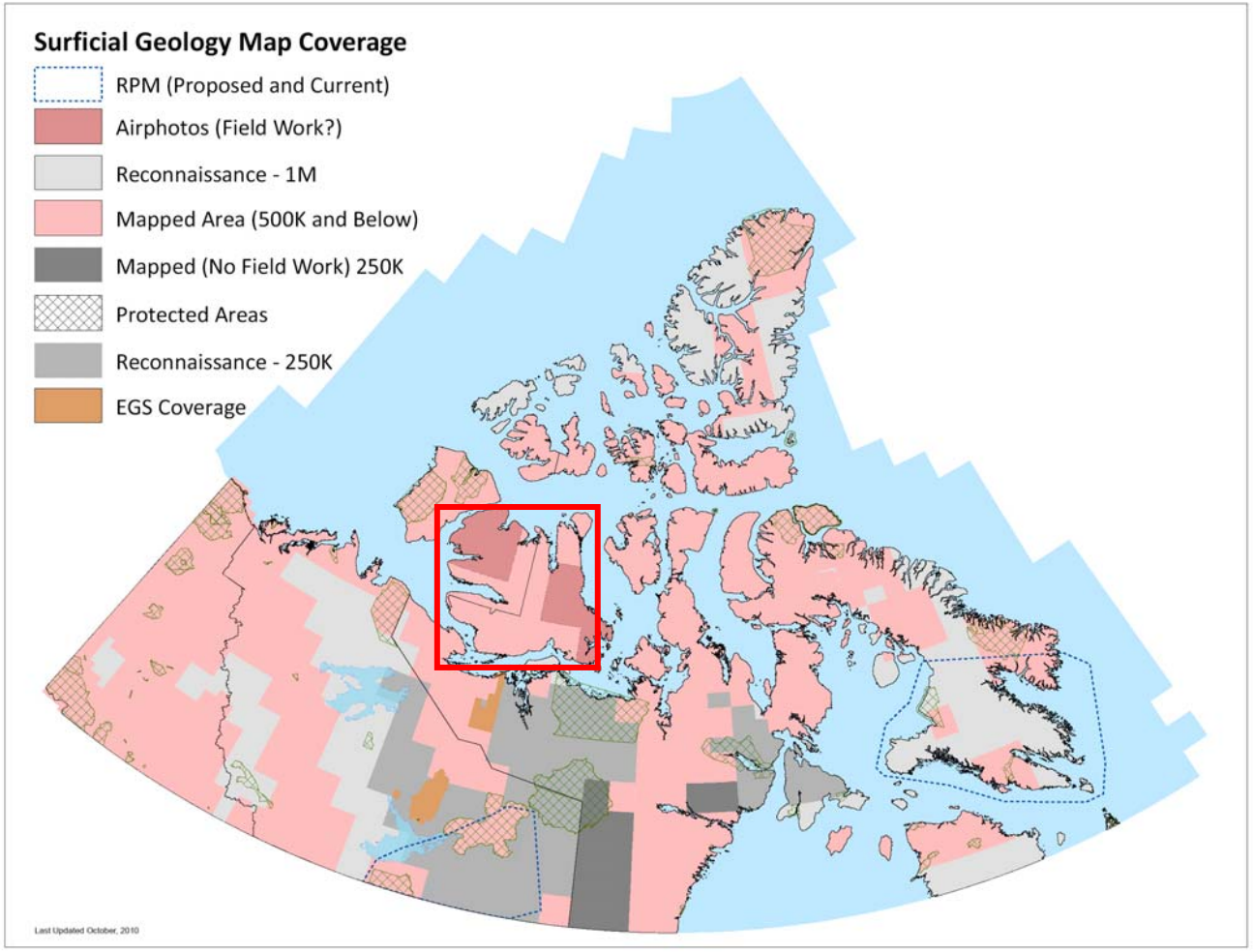
RPM units with their tentative lithologic interpretations

RPMU05	Mafic sills interleaved with supracrustal rocks
RPMU11	Undivided Proterozoic/ Archean granitic / supracrustal rocks (Snare Grp) with abundant granitoid intrusions
RPMU12	Undivided Proterozoic/ Archean granitic rocks / supracrustal rocks (Snare Grp)
RPMU13	Unidvided granitoid/mafic gneisses (Slave inlier)
RPMU14	Undivided granitoids/ granitoid gneisses with some supracrustal rocks
RPMU15	Supracrustal rocks (Yellowknife Grp)
RPMU16	Carbonate/mafic unit (Snare Group)?
RPMU17	Proterozoic undivided supracrustal rocks (Snare Group)
RPMU21	Mafic/intermediate intrusive rock
RPMU22	Mafic intrusive rocks (gabbroid)
RPMU23	Mafic/intermediate intrusive rock (circular int.)
RPMU24	Diabase intrusions (Hottah sills)
RPMU25	NS trending diabase dykes
RPMU26	NW-SE trending diabase dykes (sills?)
RPMU27	NE-SW trending diabase dykes
RPMU30	Phanerozoic cover
RPMU31	High-strain zone (mylonite) with undivided protoliths
RPMU41	Fault-controlled Fe-alteration
RPMU01	Granitoids (mainly granite)
RPMU02	Granitoids (mainly granite) potentially with some supracrustal rocks
RPMU03	Granitoids (mainly granite) Th-rich phase
RPMU04	Granitoids (potentially strained)

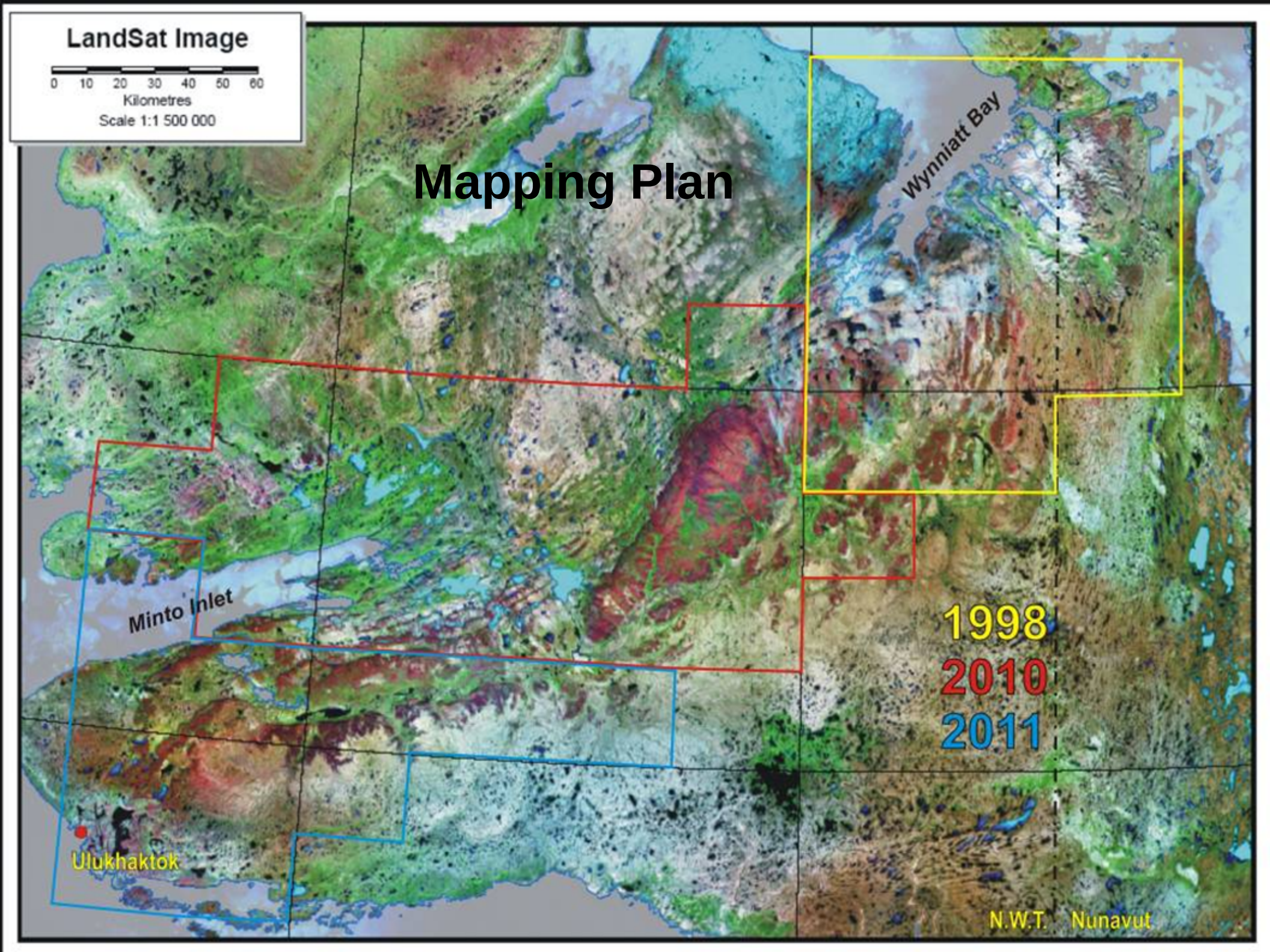
background: high & medium resolution magnetic vertical derivative grey scale images

REGIONAL MAPPING EXAMPLE

VICTORIA ISLAND

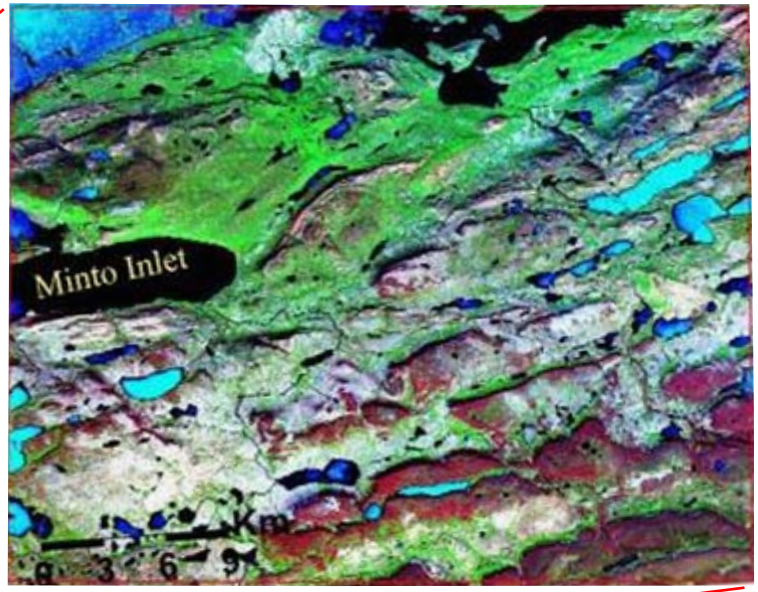


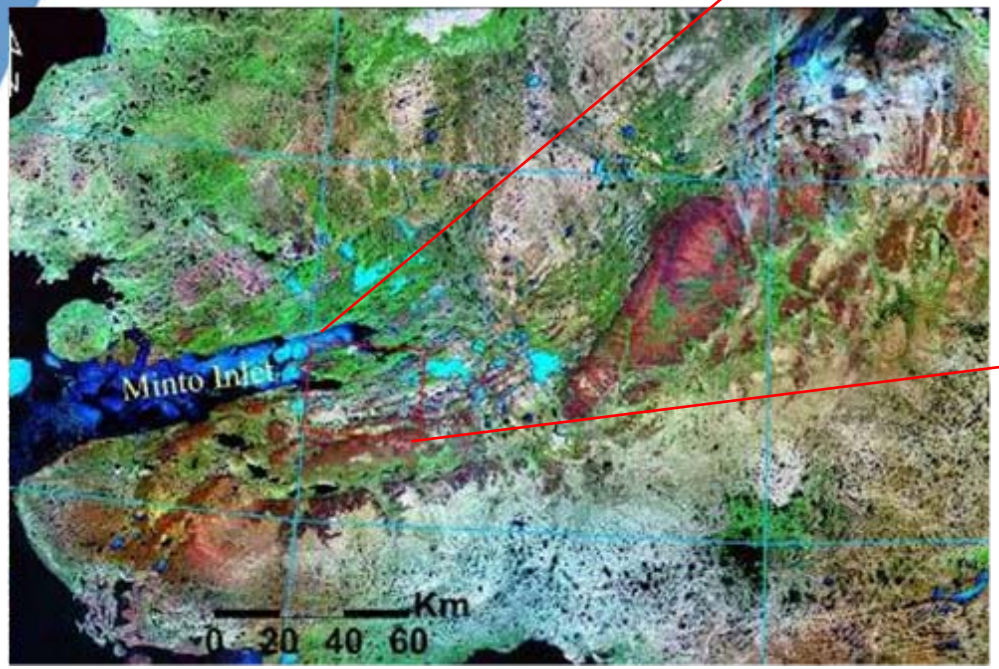
IJRS and Geoscience Canada


LandSat Image
0 10 20 30 40 50 60
Kilometres
Scale 1:1 500 000
Mapping Plan
Wynniatt Bay
Minto Inlet
1998
2010
2011
Ulukhaktok
N.W.T.
Nunavut

Scaling-up study area NTS 87H/05

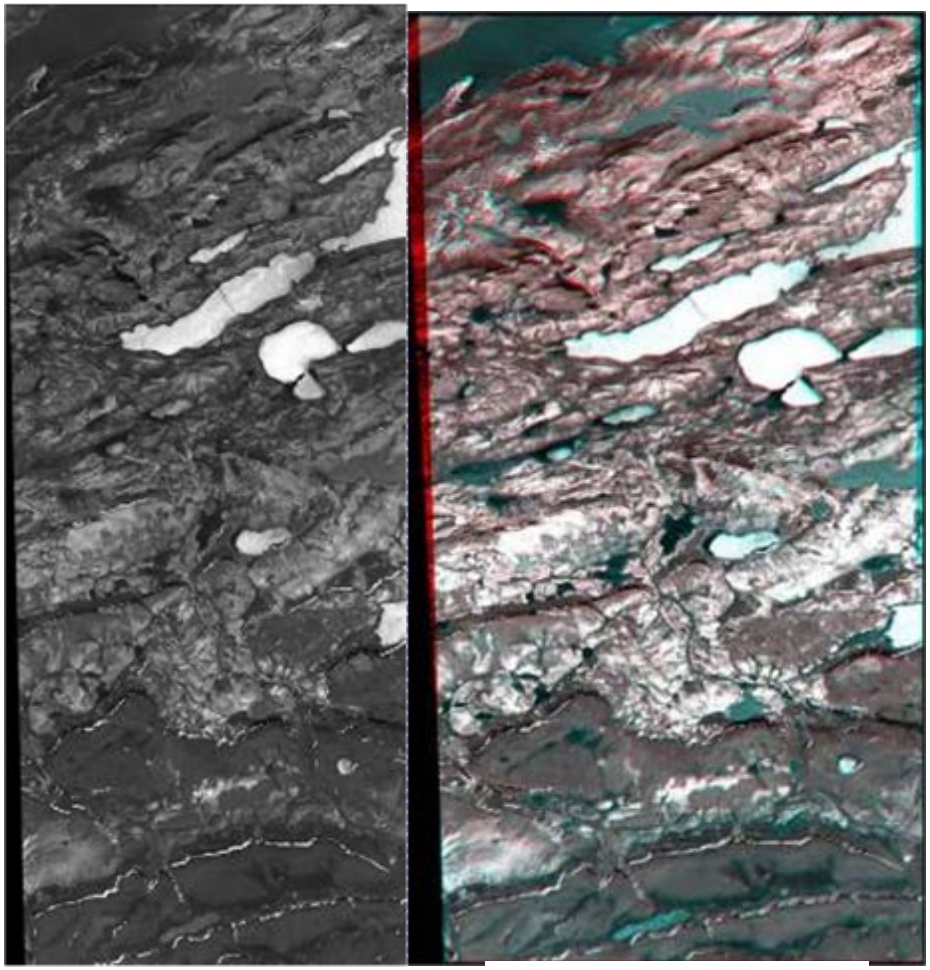
NTS87H/05





Landsat 742 FCC

Geo-Eye -Stereo Capability



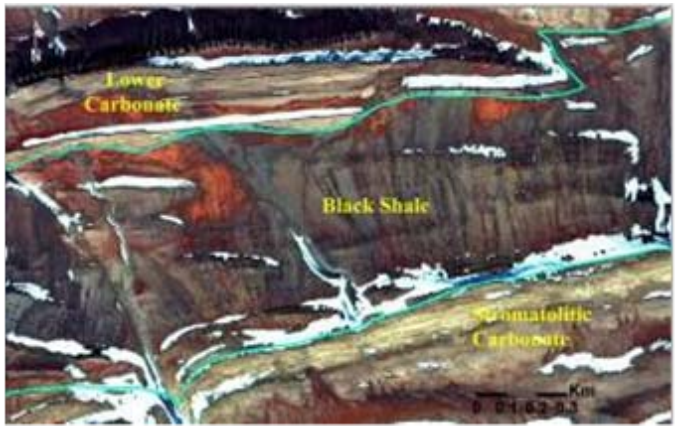
Left image

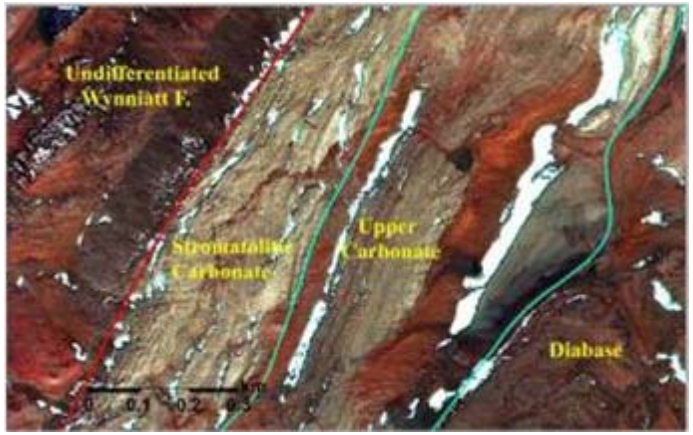
Anaglyph of
Epipolar image pairs

DEM

Wynniat Formation subdivision

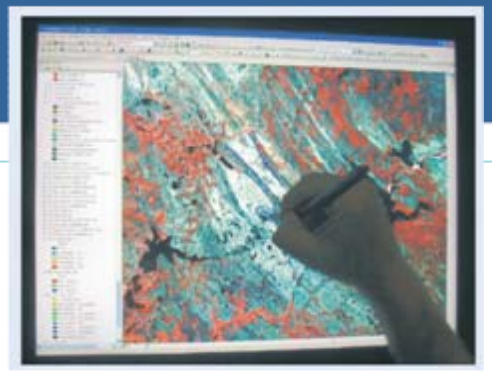
With the aid of recent reconnaissance-level field observations Wynniatt Formation was divided into four sub-units (members) and these are recognized throughout most of the map area.



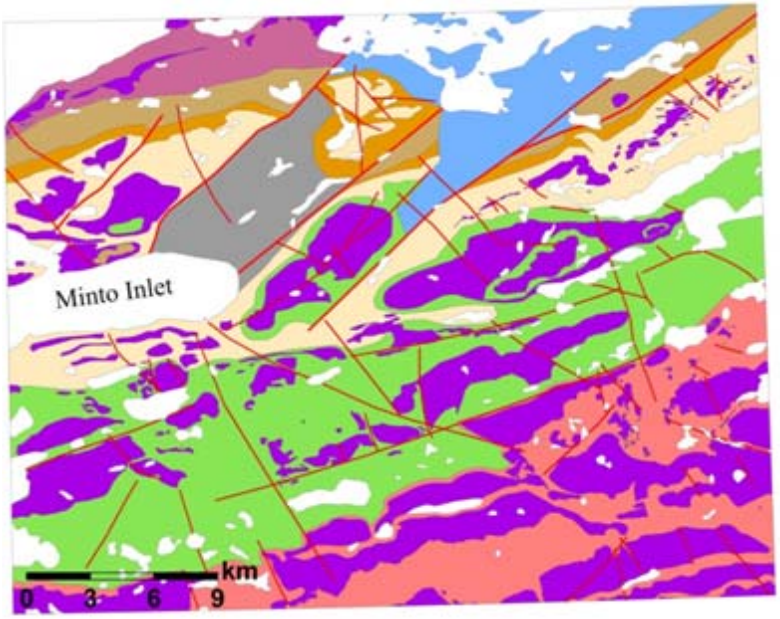


The high spatial and spectral resolution of GeoEye image allowed to resolve subtle colour and texture differences between massive stromatolitic dolostones and overlying and underlying dolostones containing fine-grained interlayers (upper & lower carbonate members).

Predictive bedrock map…..

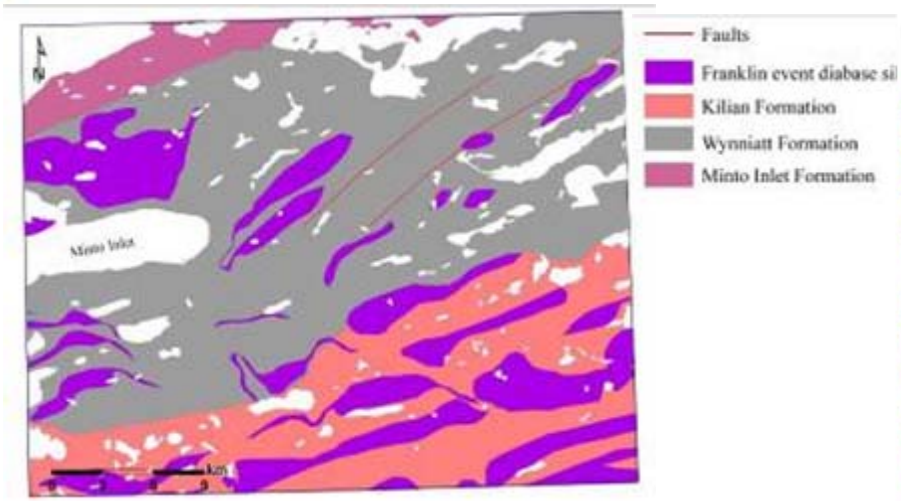


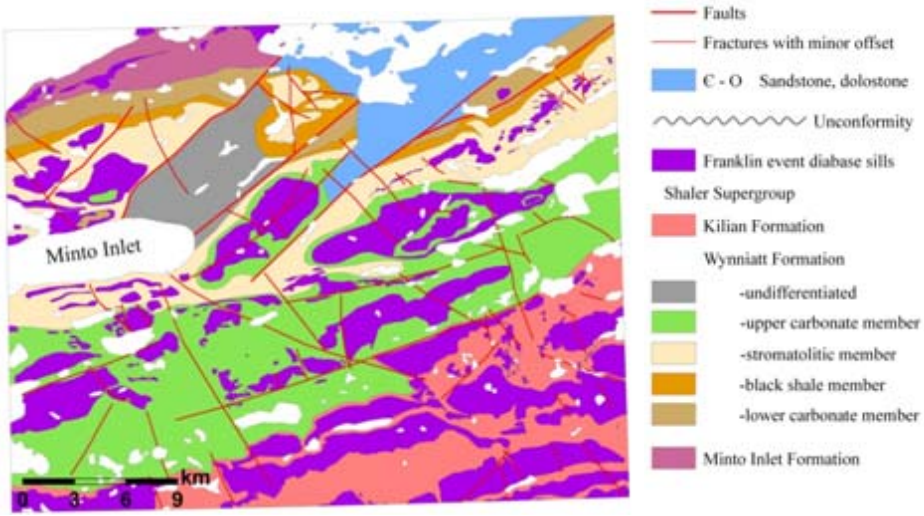
321 color composite GeoEye image of the area



Geology, interpreted from 3D stereo visualization of GeoEye images and field observations

Predictive vs. legacy geological map…

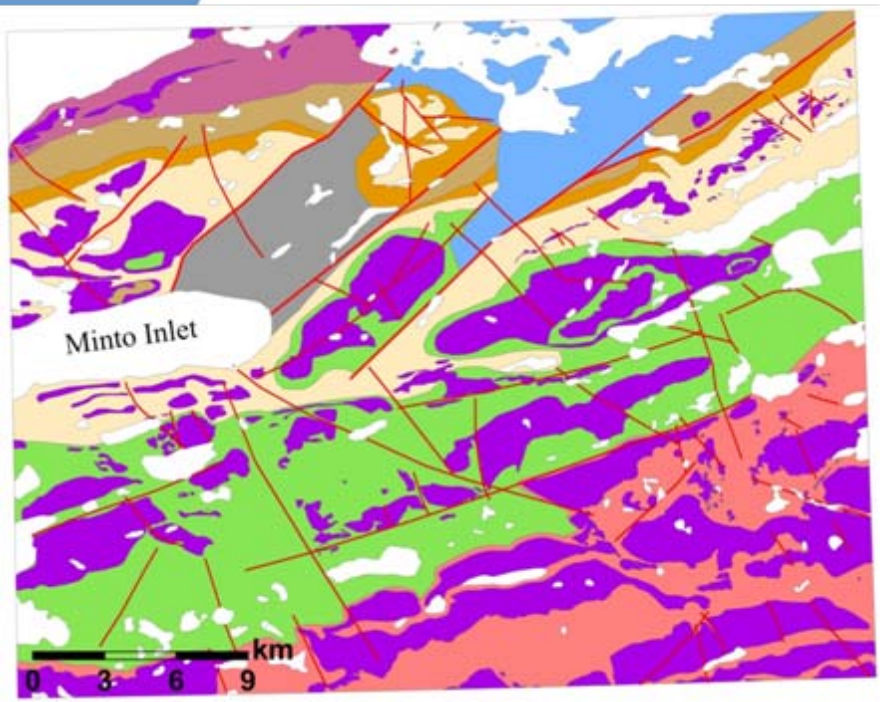


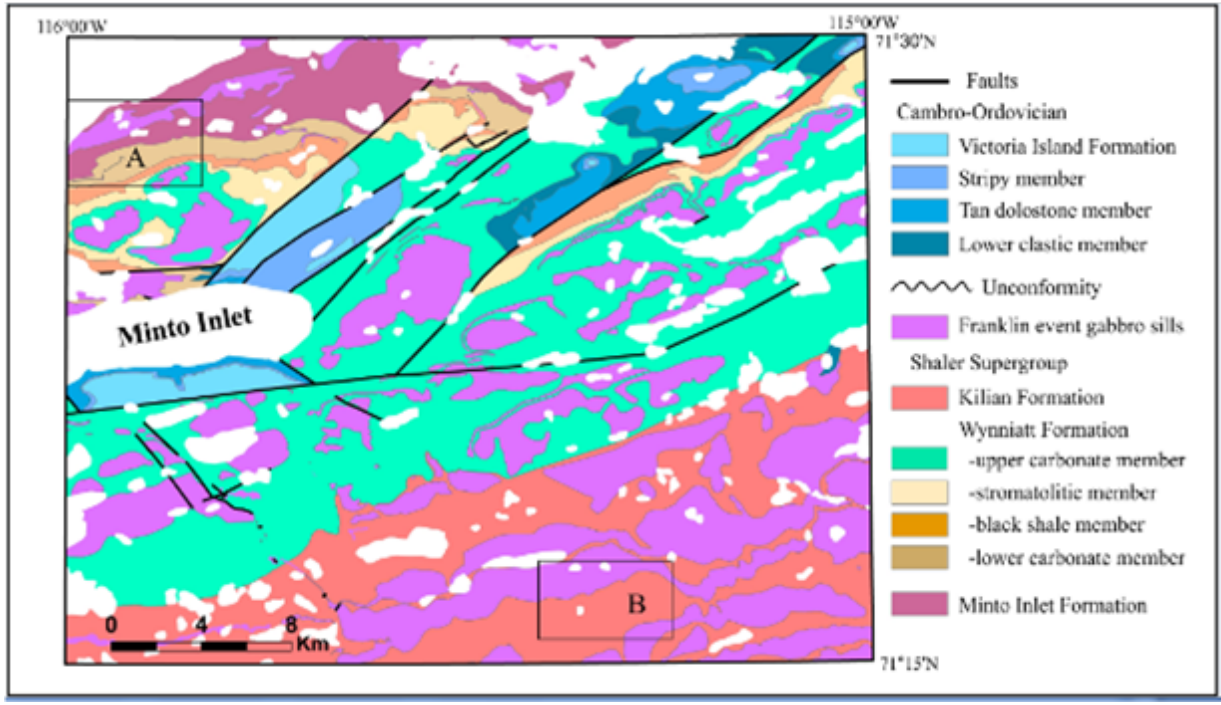


Existing 1:500,000 geological map (Thorsteinsson and Tozer, 1962; Hulbert et al. 2005),

Geological map generated using GeoEye images

Comparing Methods

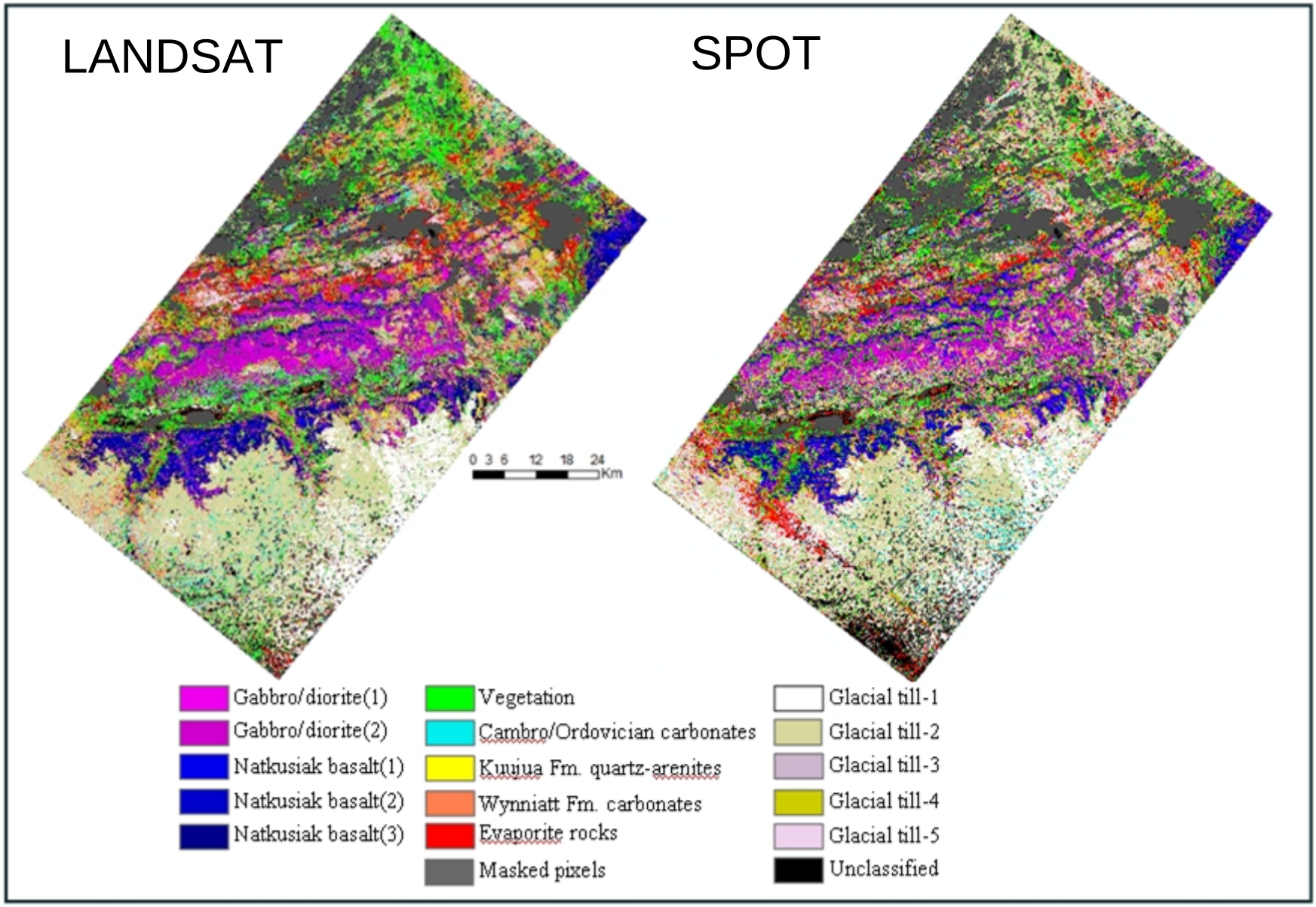


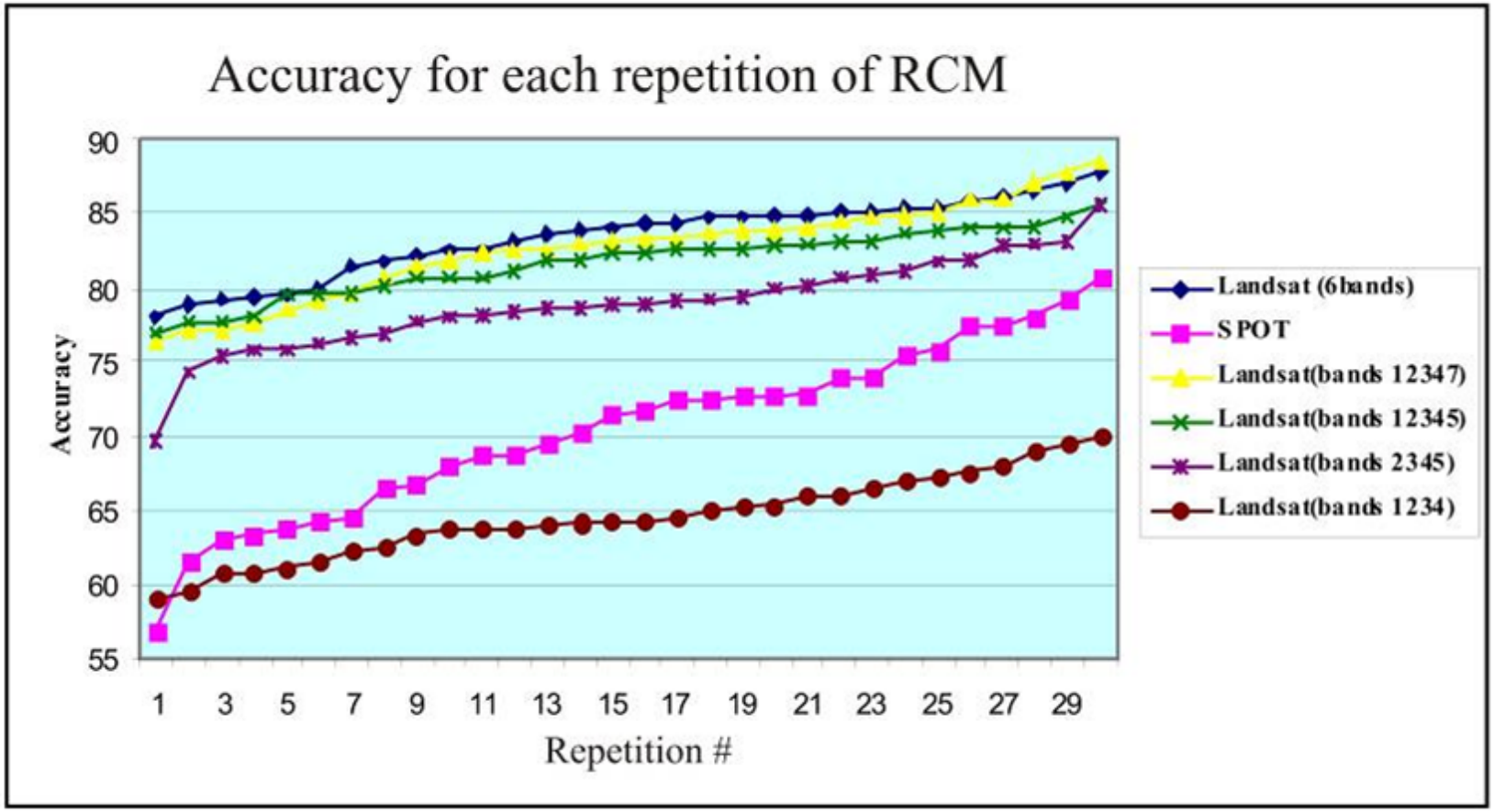


Geological map generated using GeoEye imagery

Geological map generated from field observations

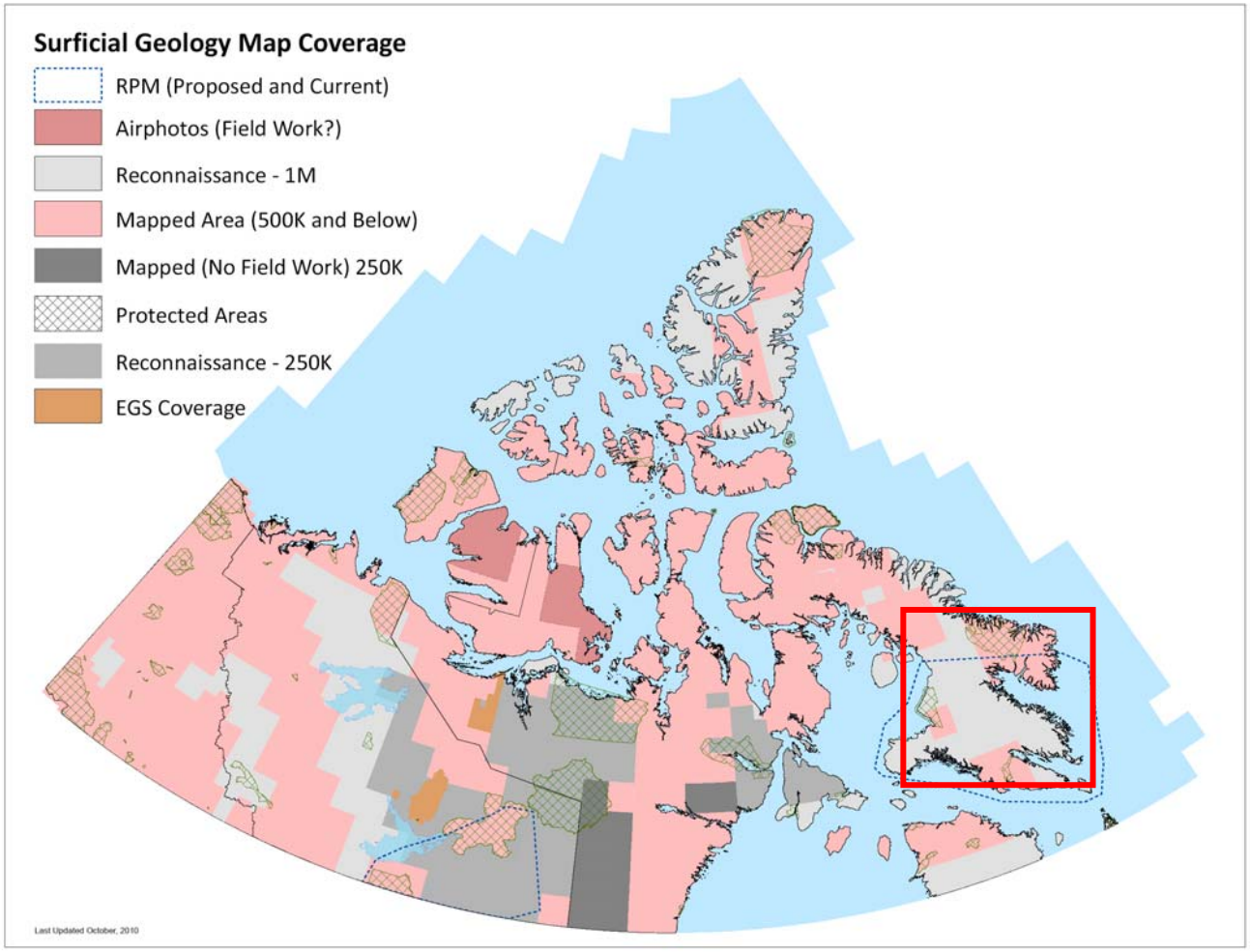
…also using supervised classification



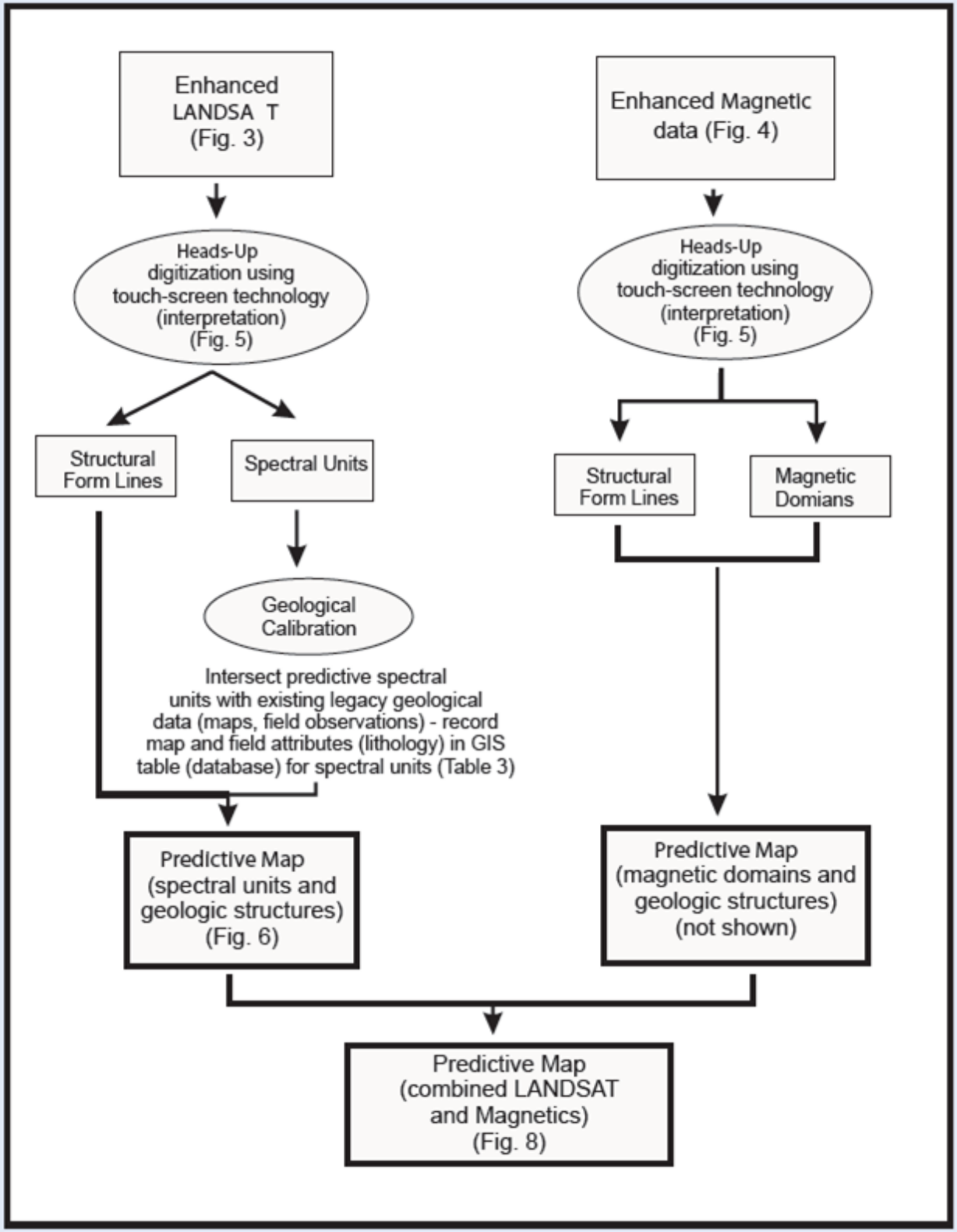


LANDSAT is still important as a mapping tool!

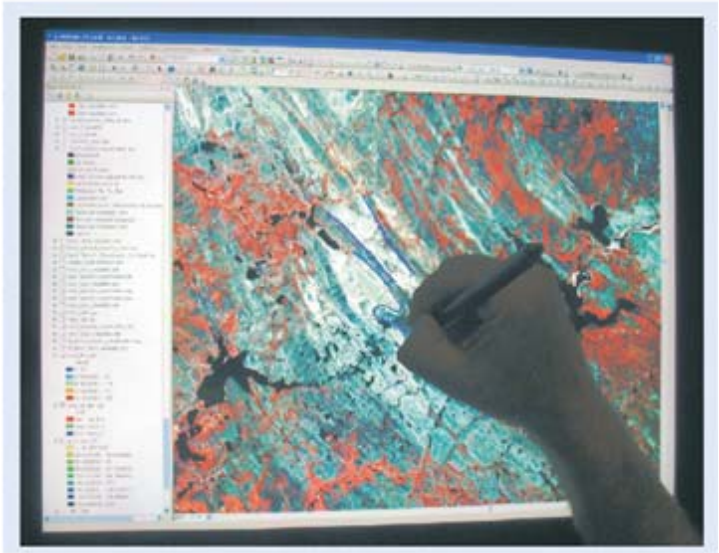
"WHITE SPACE MAPPING"



Hall Peninsula
Central Baffin Island

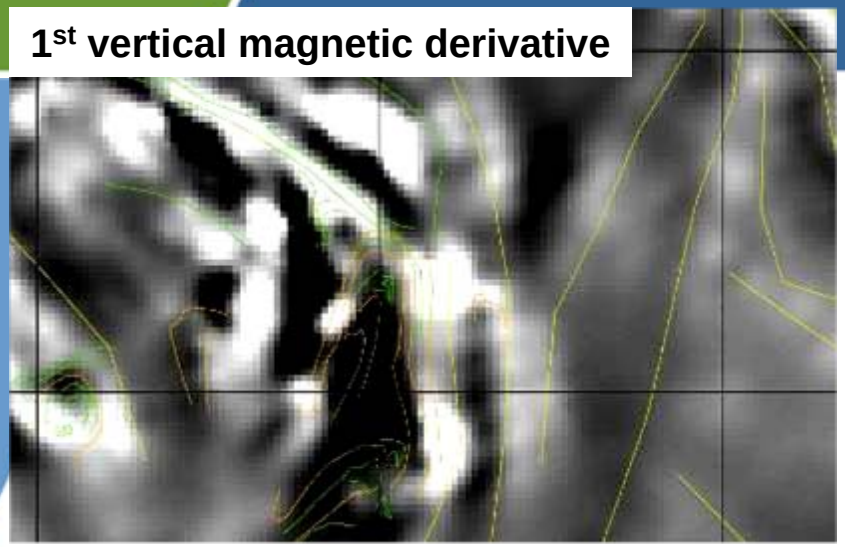


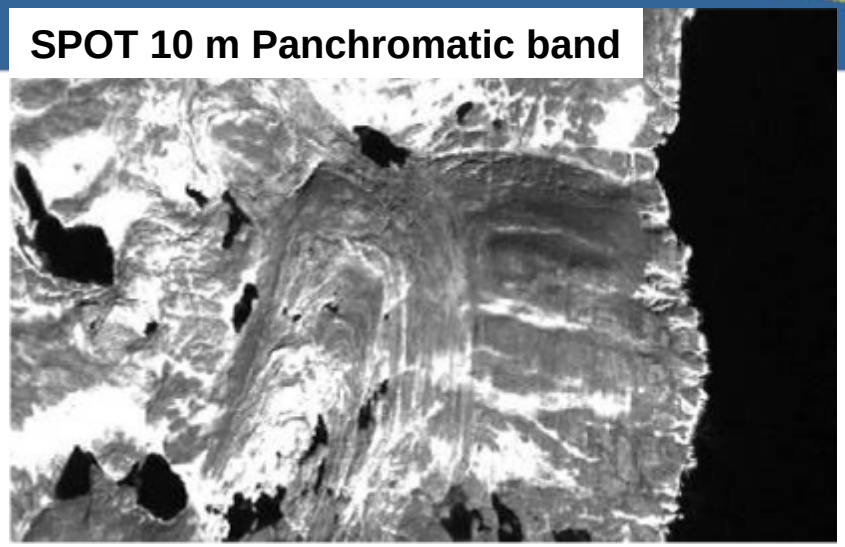
Methodology for Visual Interpretation

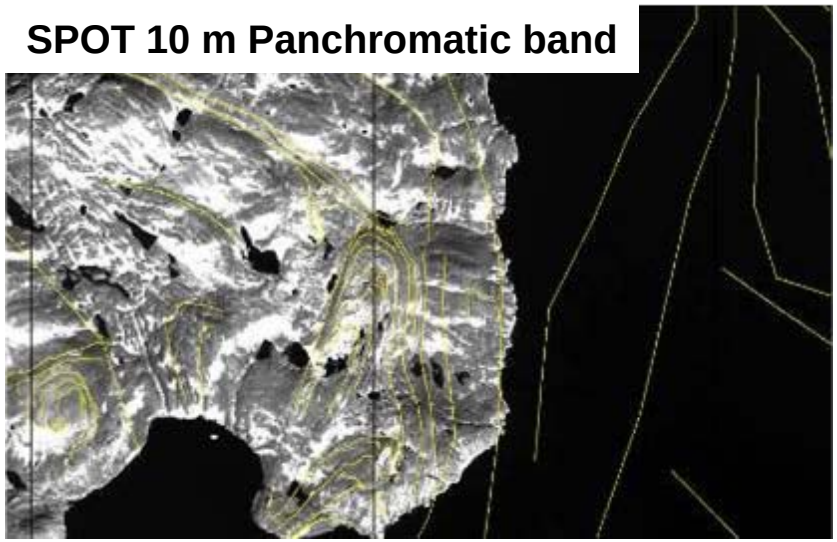


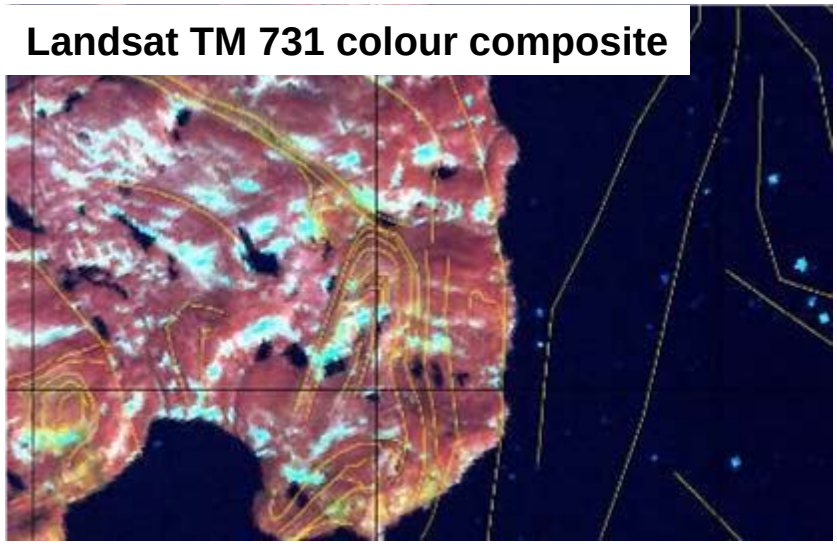
Canada

Why Multiple Sensors

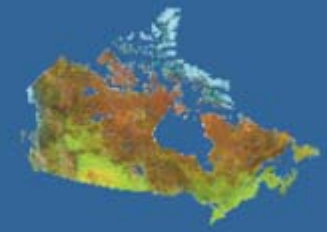




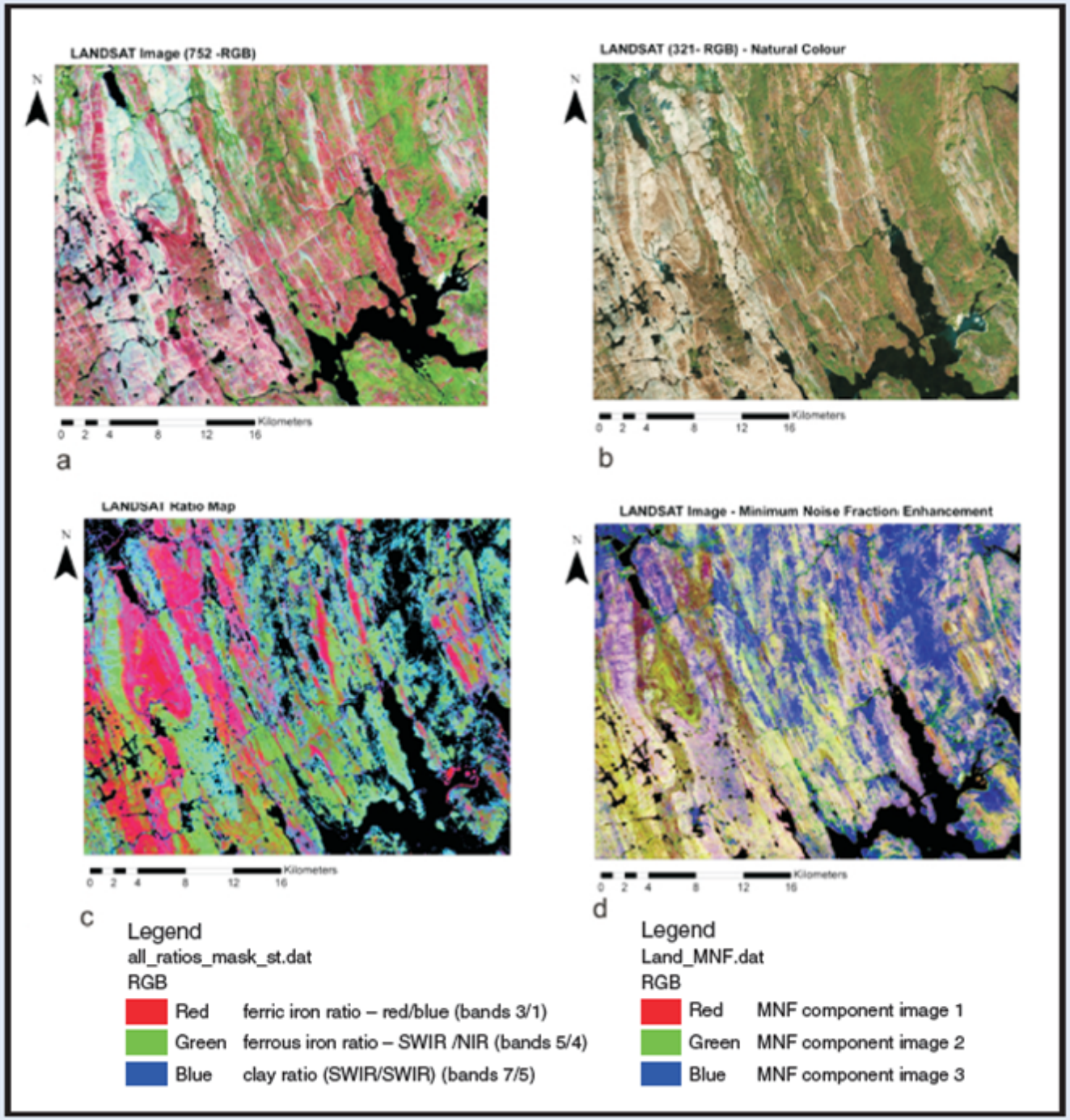


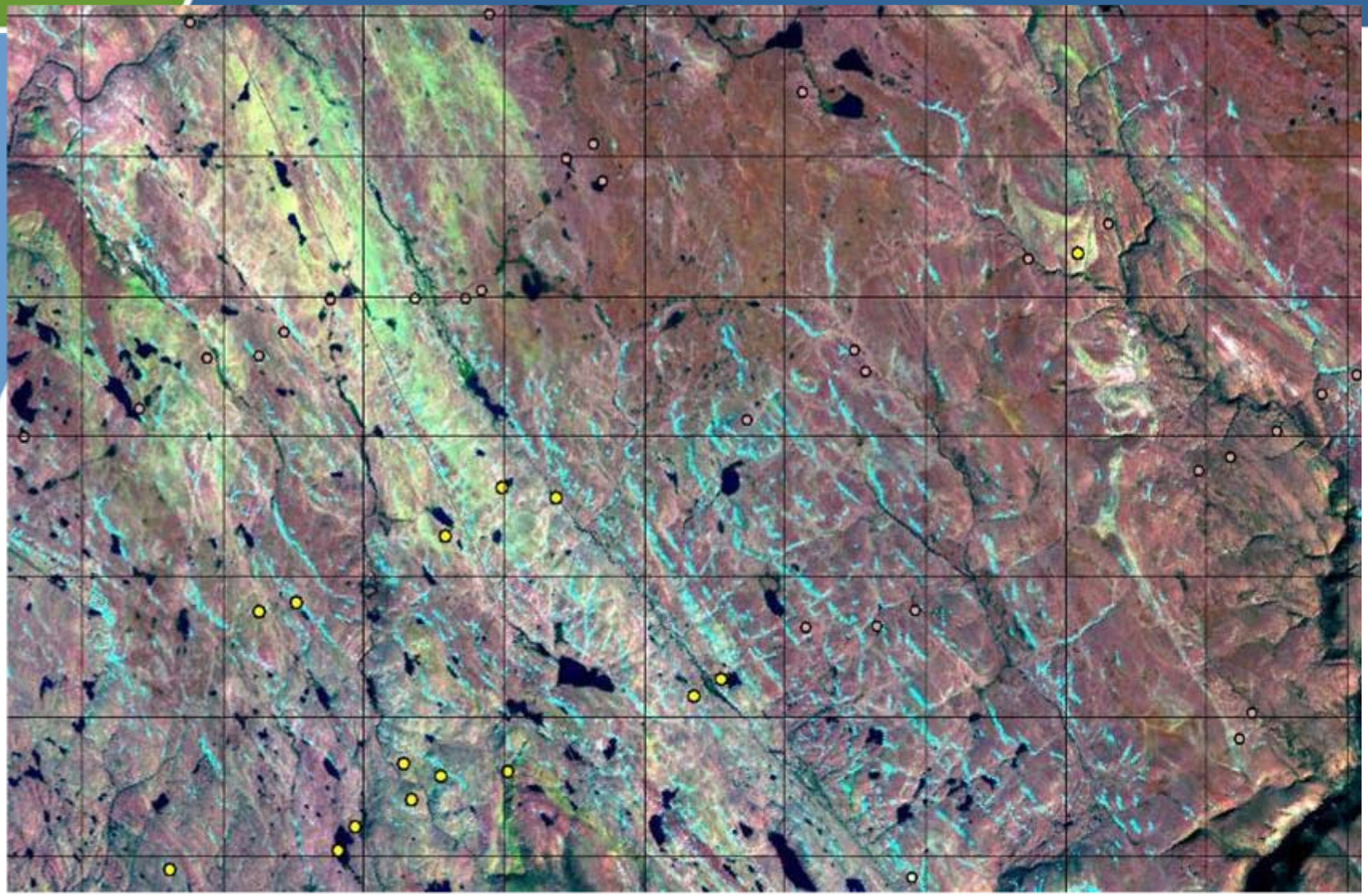


Form-foliation mapping Hall Peninsula (East)



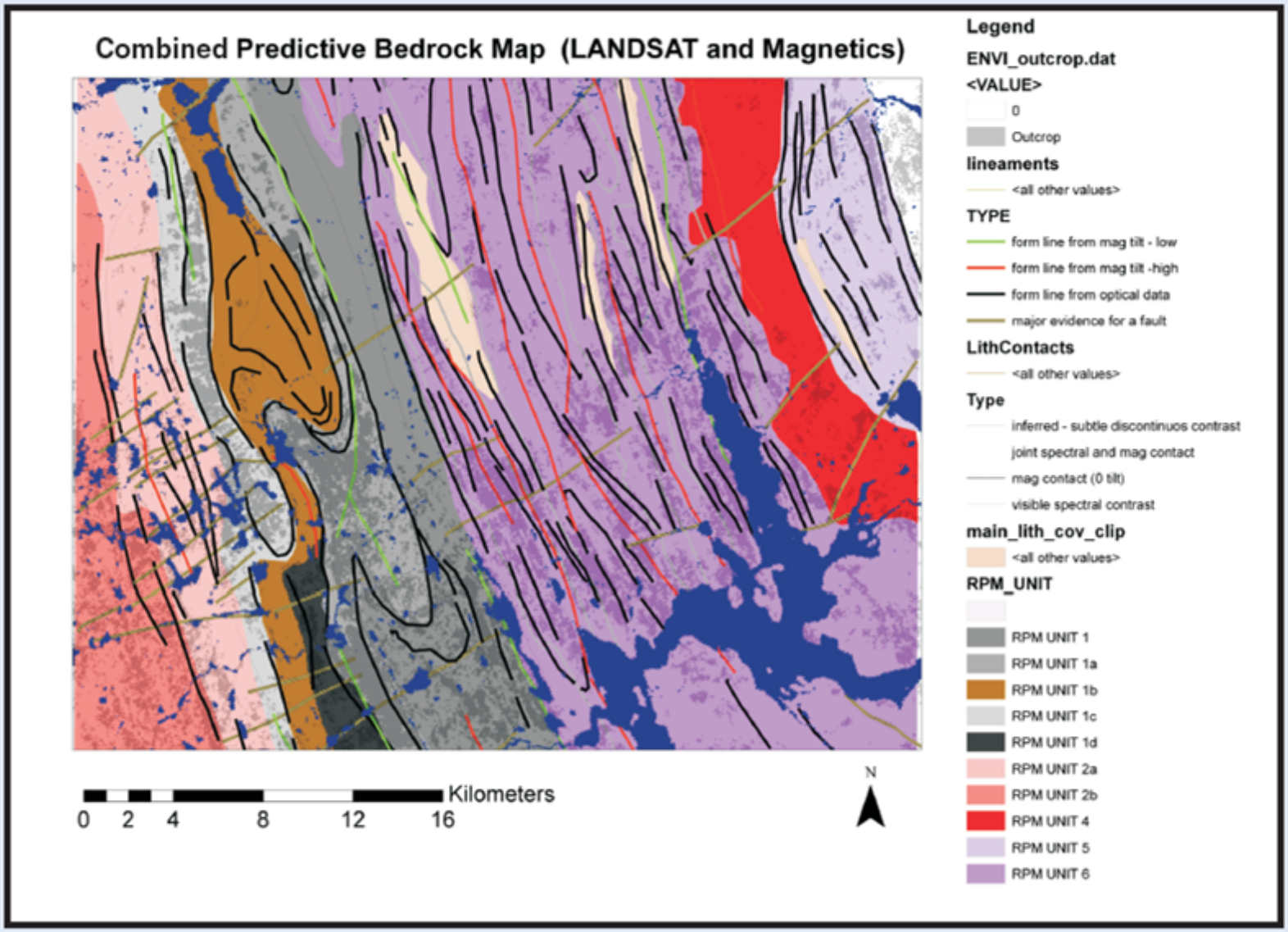
LANDSAT Enhancements





5 km

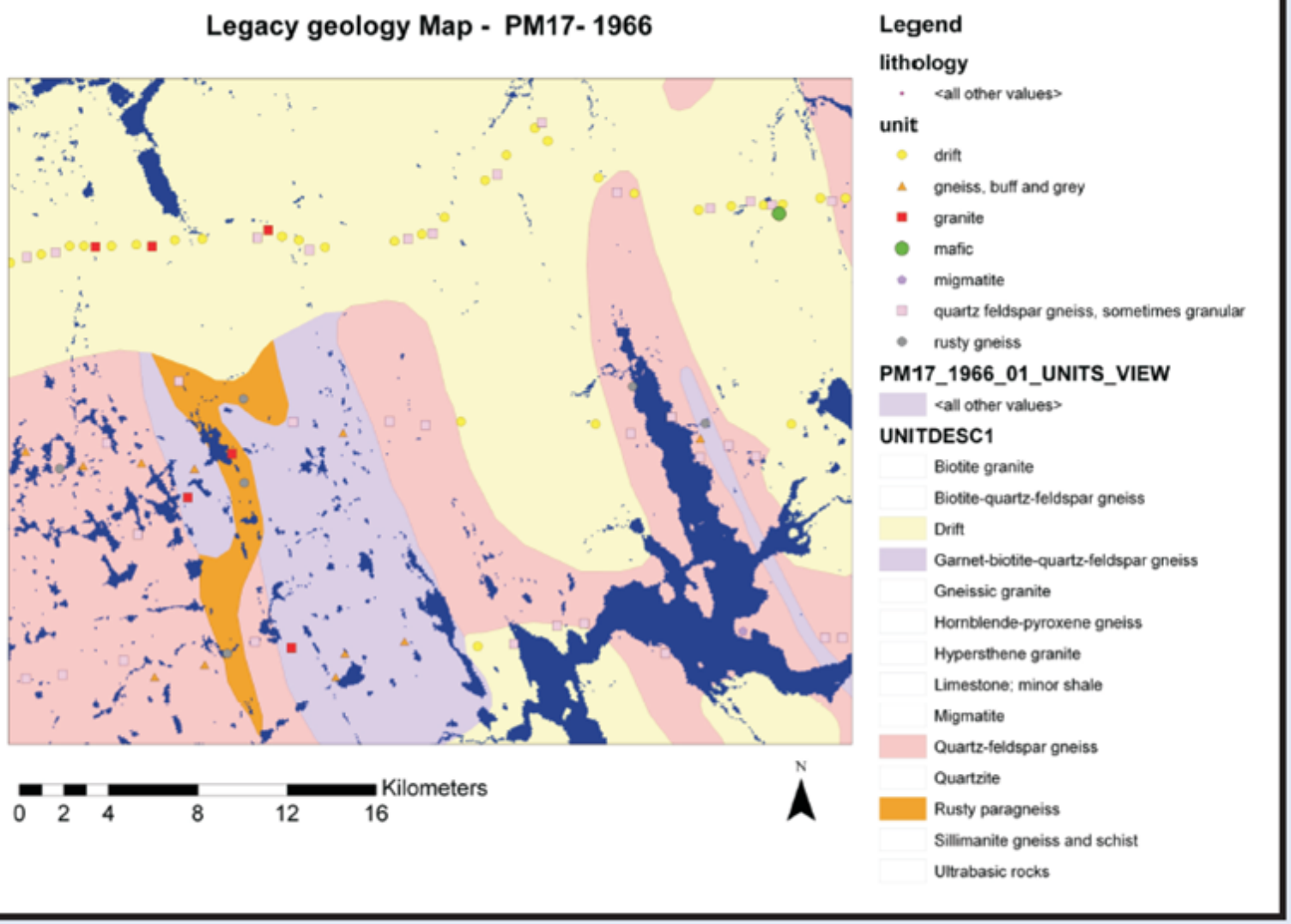
Resulting predictive map



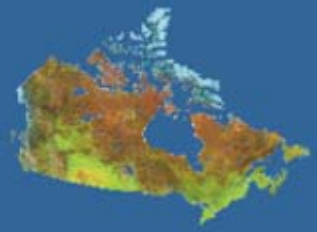
SPECTRAL UNIT	MAPUNIT 1 (International Polar Map – IPY-not shown) (Harrison et al., 2011)	DESCRIPTION	FIELD UNIT (Fig 9)	MAPUNIT 2 (Fig. 9)	RPMUNIT
RPM5	orthogneiss	monzogranite-tonalite	gneiss (mafic enclaves)	drift	Orthogneiss – monzogranite-tonalite
RPM4	Igneous intrusive	monzogranite-tonalite orthogneiss	quartz feldspar gneiss	drift	Intrusive - orthogneiss
RPM6	Intrusive	charnockite – monzogranite to syenogranite	quartz feldspar gneiss	quartz-feldspar gneiss	Intrusive - charnokite
RPM1	Sedimentary	psammite - semipelite	gneiss - buff, grey	garnet biotite quartz feldspar gneiss	Meta-sediment 1- psammite-semipelite
RPM1a	Sedimentary	psammite - garnet-biotite-quartz-feldspar	granite, rusty gneiss, gneiss	rusty paragneiss	Meta-sediment 2 - psammite
RPM1b	Sedimentary	psammite, semipelite	rusty gneiss, gneiss, granite	rusty paragneiss - gneiss	Meta-sediment 3 - psammite – semipelite - (rusty – high Fe content)
RPM1c	Sedimentary	psammite garnet-biotite-quartz-feldspar	gneiss (buff)-granite	garnet-biotite -quartz-feldspar Gneiss + rusty paragneiss	Meta-sediment 4 - psammite (less rusty)
RPM1d	Sedimentary	psammite - semipelite	quartz feldspar gneiss	quartz-feldspar gneiss	Meta-sediment 5 -psammite-semipelite
RPM2a	Intrusive	monzogranite-tonalite orthogneiss	quartz feldspar gneiss – buff gneiss	quartz feldspar gneiss	Gneiss 1 – quartz feldspar
RPM2b	Intrusive	monzogranite-tonalite orthogneiss	quartz feldspar gneiss	quartz feldspar gneiss	Gneiss 2 – quartz feldspar (slightly different colour than RPM2a)

Integration (overlaying) legacy data with RPM units to add a lithological name (when and where possible)

…compared to existing (legacy map)



SUMMARY



- RPM is an efficient (time, economic) way of expanding our mapping coverage of Canada's North
- A shift in paradigm for producing maps as well as field validation
  - Belief that it works – cultural shift for some!
  - Recognize limitations – these are predictions but what map isn't?
  - Training and mentoring!
- **GEMS to map 60% of Canada's North! = ECONOMIC DEVELOPMENT and SOVEREIGNTY!!**