GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7454

Remote Predictive Map, Eastern Hall Peninsula, Baffin Island, Canada

E. Schetselaar, J.R. Harris, and D. Lemkow

2013

Natural Resources Canada
Ressources naturelles Canada

Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7454

Remote Predictive Map, Eastern Hall Peninsula, Baffin Island, Canada

E. Schetselaar, J.R. Harris, and D. Lemkow

2013

doi:10.4095/292802

Recommended citation
Schetselaar, E., Harris, J.R., and Lemkow, D., 2013. Remote Predictive Map, Eastern Hall Peninsula, Baffin Island, Canada; Geological Survey of Canada Open File 7454, p. 8. doi:10.4095/292802

ABSTRACT

The Hall Peninsula predictive bedrock map was produced for the Remote Predictive Mapping (RPM) project, part of the Geo-mapping for energy and minerals (GEMS) program; accompanying this map is a legend and various supporting figures. Three magnetic domains have been recognized corresponding to distinct Archean and Paleoproterozoic assemblages of tonalitic gneissic, metaplutonic and supracrustal rocks. These domains have been subdivided into RPM sub-units based on the interpretation of enhanced magnetic, remotely sensed (LANDSAT and SPOT4) and digital topographic data (DEM). Legacy data have been used to geologically calibrate the various RPM units. The RPM legend includes a description of the remotely sensed and geophysical characteristics as well as rock names based on the legacy field data and notes. Geological structures (faults, form lines) have also been included, compiled from legacy maps as well as interpretation of the various geoscience datasets. The complete geoscience dataset used to create this map will be released in a future Open File.

INTRODUCTION

The objective of remote predictive mapping is to upgrade the geoscience knowledge-base in sparsely mapped areas of Canada's North, re-assess regional tectonic synthesis, and support field mapping projects. The Geological Survey of Canada (GSC) has conducted many RPM studies in order to address this geoscience “gap”, initially within Natural Resources Canada’s Earth Science Sector, Northern Resources Development Program (2003–2007), and now as an integral component of the Geo-mapping for energy and minerals (GEMS) program. Some examples include Schultz Lake, NTS 66-A, (Grunsky et al., 2006); Boothia mainland area, Nunavut (Schetselaar and Ryan, 2009); western Minto Inlier, Victoria Island, N.W.T (Behnia et al, 2012); and Hearne Lake, N.W.T. (Stevens et al., 2013); as well as 10 comprehensive studies of Baffin, Boothia mainland, and Belcher Islands, Nunavut, and Snowbird Lake and the northern Cordillera, N.W.T. (Brown, et al., 2008; Harris and St-Onge, 2008; Harris et al., 2008a–e; Morris et al., 2008; and Wickert et al., 2008).

This Open File contains a stand-alone predictive geological map of the Hall Peninsula, Baffin Island, as well as notes and figures and images describing the RPM process, suitable for printing on a 8.5 by 14” format paper; it will be referred to as Figure 1a–f. The geoscience data used to produce this map will be published in a future Open File.

REMOTE PREDICTIVE MAPPING (RPM)

The remote predictive mapping method simply involves deriving geological information from any available geoscience data. In many cases, the data have been acquired remotely. These data may include remote sensing devices that measure a variety of properties of the Earth’s surface and subsurface. The properties may include magnetic total field (from which magnetic susceptibility can be derived) measured by a magnetometer, radio-active element emission measured by a gamma-ray spectrometer, density variations measured by a gravimeter, visible and infrared spectral reflectance measured by various optical and infrared sensors, emitted heat measured by a thermal radiometer, microwave backscatter by radar, and terrain height measured by an altimeter or extracted from airphotos. These parameters can be useful alone or in combination for producing a remote predictive geological map (Figure 1) or a series of predictive maps. Field data, if available, can be incorporated into the RPM process to aid, verify, and geologically calibrate the interpretations made from the geoscience data.

The method of information extraction may involve photo-geological interpretation of enhanced and/or fused images derived from the various data types or computer-assisted techniques that are useful for the identification of spectral and spatial patterns in the data. The output is most commonly a map or a series of maps showing predicted lithological units (bedrock, surficial, tectonic; Fig 1a), various geological structures (faults, lineaments, contacts, fold axes glacial flow indicators, etc.), bedrock outcrop, and suggested field traverses as well as areas in which to focus field mapping.

OPEN FILE 7454: REMOTE PREDICTIVE BEDROCK MAP, EASTERN HALL PENINSULA, BAFFIN ISLAND, CANADA

E. Schetselaar, J.R. Harris and D. Lemkow

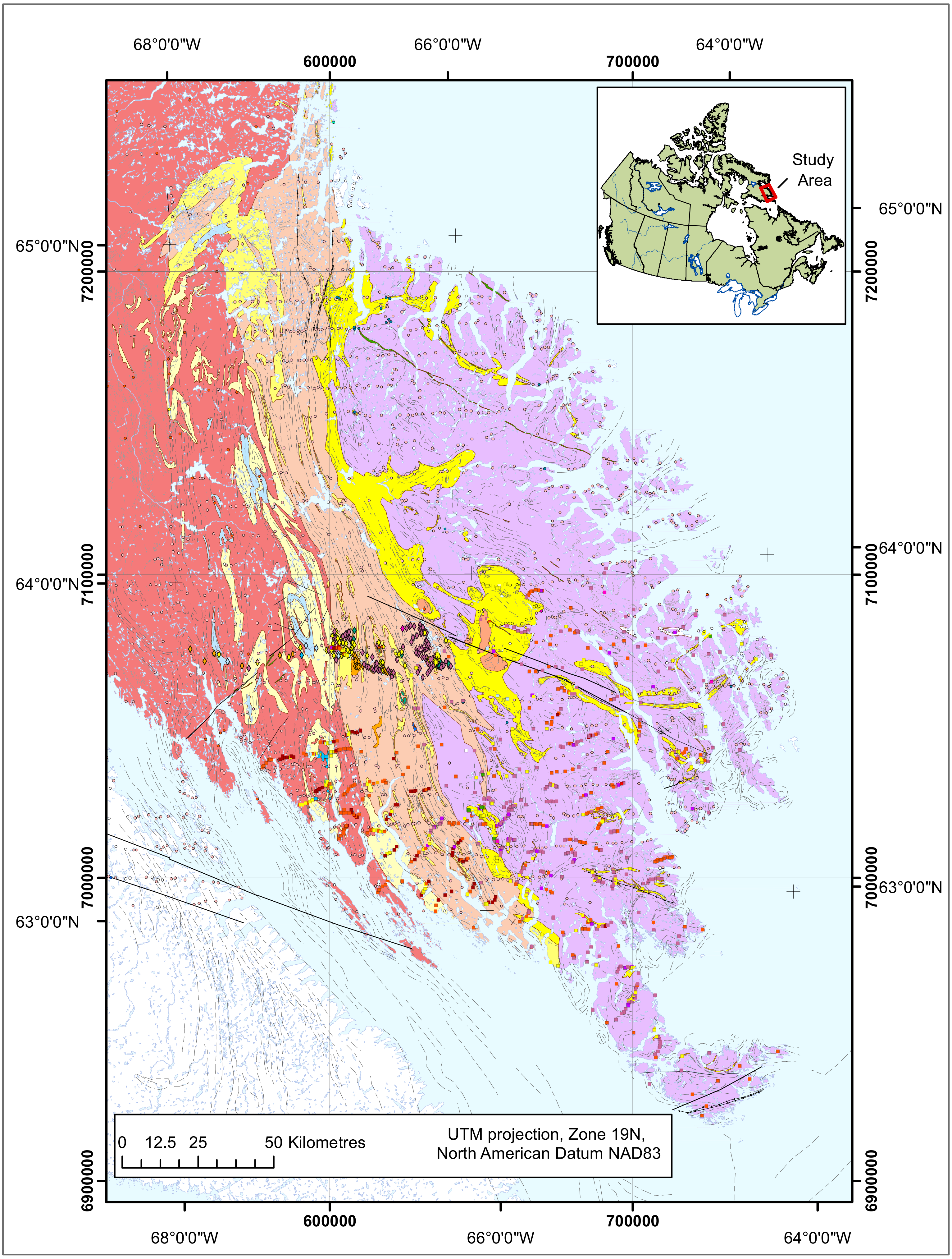


Figure 1a. Remote predictive map bedrock units interpreted from: (1) magnetic residual total field, 1st vertical gradient grids, (2) LANDSAT and SPOT multispectral image data, and (3) bedrock lithology field observations

RPM-DYKE: regionally extensive straight linear magnetic anomalies; occasional straight lineaments on SPOT Panchromatic image band

Magnetic domain 3: Archean tonalite gneiss basement - supracrustal cover

RPM-MD3-U4: magnetic lows; green to cyan tone on LANDSAT TM731 colour composite; weak FeO absorption feature in TM1-TM3 visible range of EM spectrum; migmatitic gneiss with screens of metasedimentary rocks

RPM-MD3-U3: elliptical magnetic lows and highs; dark pink to red tone on TM731 LANDSAT colour composite; elliptical and circular image patterns; granitoid plutons

RPM-MD3-U2: linear to curvilinear magnetic lows; green to cyan tone on TM731 LANDSAT colour composite, FeO absorption feature in TM1-TM3 visible range of EM spectrum; metasedimentary rocks (psammite, pelite, quartzite) migmatite, leucogranite

RPM-MD3-U1: curvilinear to circular magnetic highs; dark to light pink tone on LANDSAT TM731 colour composite, curvilinear image patterns; tonalite gneiss, metagabbro, ultramafic rocks, granite, granite gneiss, metasedimentary rocks

Magnetic domain 2: High-grade Paleoproterozoic mobile belt

RPM-MD2-U6: curvilinear magnetic highs (-400 to -100 nT); dark to light pink tone coarse knobby image texture on LANDSAT TM731 colour composite; monzogranite

RPM-MD2-U5: featureless magnetic lows (-800 to -500 nT); bright pink to white image tone on LANDSAT TM731 colour composite; leucogranite, migmatite, enclaves of metasedimentary rocks

RPM-MD2-U4: featureless magnetic lows (-800 to -700 nT); bright white tone on LANDSAT TM731 colour composite; marble

RPM-MD2-U3: curvilinear magnetic lows (-800 to -700 nT); dark green to cyan tone on LANDSAT TM731 colour composite; weak FeO absorption feature in TM1-TM3 visible range of EM spectrum; amphibolite

RPM-MD2-U2: broad linear magnetic lows (<-800 to -600 nT) with local curvilinear magnetic highs (-400 to -100 nT); light green to cyan tone on LANDSAT TM731 colour composite; FeO absorption feature due to weathering; metasedimentary rocks (psammite, semi-pelite, pelite, quartzite, paragneiss)

RPM-MD2-U1: prominent linear magnetic highs (-300 - 1300 nT); dark red to pink tone on LANDSAT TM731 colour composite; tonalite gneiss, granite, gabbro

Magnetic domain 1: Cumberland batholith, Paleoproterozoic

RPM-MD1-U4: featureless magnetic lows (-800 to -600 nT); light green to cyan tone on LANDSAT TM colour composite; garnet-bearing monzogranite, leucogranite, migmatite, enclaves of metasedimentary rocks

RPM-MD1-U3: curvilinear magnetic lows (-700 to -650 nT); bright white tone on LANDSAT TM731 colour composite; marble

RPM-MD1-U2: broad linear magnetic lows (-800 to -600 nT) with local linear to curvilinear magnetic highs (-400 to -100 nT); light green to cyan tone on LANDSAT TM731 colour composite due to FeO weathering; metasedimentary rocks (psammite, pelite, semi-pelite, quartzite) minor migmatite and leucogranite

RPM-MD1-U1: low magnetic background (-800 to -600 nT) with isolated linear to curvilinear magnetic anomalies (-400 to -100 nT); dark purple, red and green image tone on LANDSAT TM731 colour composite; monzogranite with enclaves of felsic gneiss and metasedimentary rocks

(Legend continued)

Legacy and recent bedrock lithologic observations

Blackadar, 1967
- limestone
- diabase dyke
- syenite
- granite (undifferentiated)
- migmatite diatextite
- quartzite
- marble
- amphibolite
- paragneiss, psammite, pelite
- granulite
- pyroxenite
- undifferentiated quartzo-feldspathic gneiss

Scott, 1999
- monzogranite (opx)
- white monzogranite (gt)
- marble
- amphibolite
- metasedimentary rocks
- tonalite (gt +/- opx)
- ultramafic rocks

opx - orthopyroxene
gt - garnet

Nunavut Geoscience Office, unpublished field data, 2012
- quartz monzonite
- alkali-feldspar quartz syenite; quartz syenite
- granitoid (undifferentiated)
- migmatite; diatexite
- serpentinite
- metaquartzite
- marble
- amphibolite
- paragneiss, psammite, semi-pelite, pelite, meta-ironstone
- peridotite
- gabbro, diorite, monzodiorite, quartz diorite
- charnockite
- tonalite

RPM structural interpretation
- Dyke inferred from magnetic residual total field and first vertical gradient data
- Fault inferred from LANDSAT Thematic Mapper colour composite image (bands 7,3,1)
- Fault inferred from first vertical gradient magnetic data
- Fault inferred from SPOT Panchromatic image band
- Foliation form lines inferred from first vertical gradient magnetic data
- Foliation form lines inferred from SPOT Panchromaic image band
- Ductile shear zone inferred from LANDSAT Thematic Mapper colour composite image (bands 7,3,1)
- Ductile shear zones inferred from first vertical gradient magnetic data

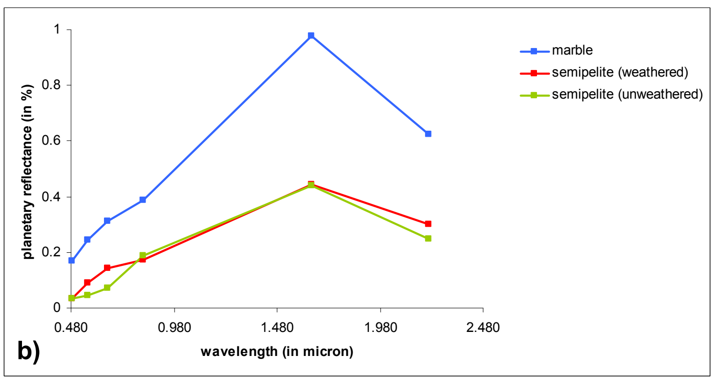


Figure 1b. LANDSAT 7 Thematic Mapper image spectra sampled at field stations illustrating spectral contrast between marble, weathered and unweathered semi-pelite. Note steep negative slope in the mid-infrared range (1.5 - 2.3 microns; TM bands 5 & 7) suggesting that spectral absorption features of metacarbonate rocks can be detected.

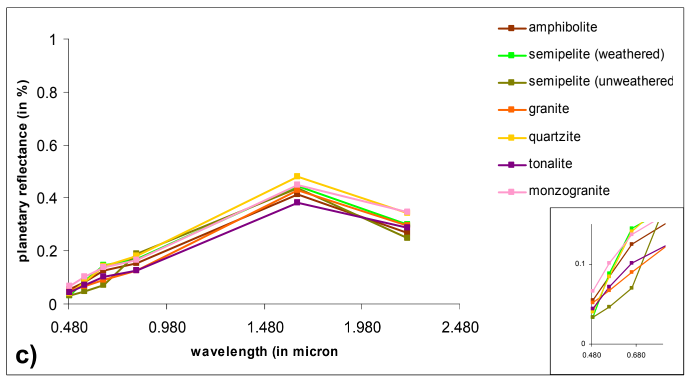


Figure 1c. LANDSAT7 Thematic Mapper image spectra sampled at field stations illustrating spectral contrast between supracrustal and igneous metamorphic rock units. Inset shows steep slopes in spectra in the visible range of the EM spectrum of weathered metasedimentary rocks due to Fe-oxide weathering relative to spectral slopes of unweathered metasedimentary and meta-igneous rock units

Remote Predictive Mapping (RPM) Methodology

The procedure employed to compile the remote predictive bedrock map of the eastern Hall Peninsula follows the methodology described in Harris (2008), Schetselaar et al. (2007) and Schetselaar and Woldai, (2008). This knowledge-driven image interpretation methodology includes four steps:

1. Assembling remotely sensed data, geological field observations and legacy geological maps in a geodatabase

2. Establishing systematic relationships between image signatures and bedrock units and structures by overlaying thematic queries of geological field observations on multiple layers of enhanced magnetic and satellite image data

3. Screen-digitizing RPM units and structures by visual image interpretation using GIS functions. This interpretative GIS mapping is driven by combining geological image interpretation skills with the knowledge gained in step 2

4. Establishing a RPM legend by integrating and validating the relationships between image signatures and geological field observations

The objective of remote predictive mapping is to upgrade the geoscience knowledge-base in sparsely mapped areas of Canada's North, re-assess regional tectonic synthesis and support field mapping projects.

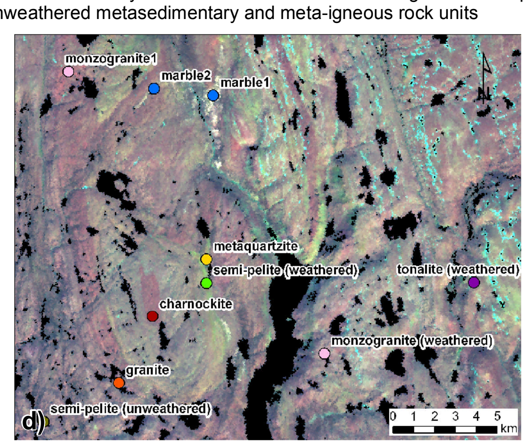
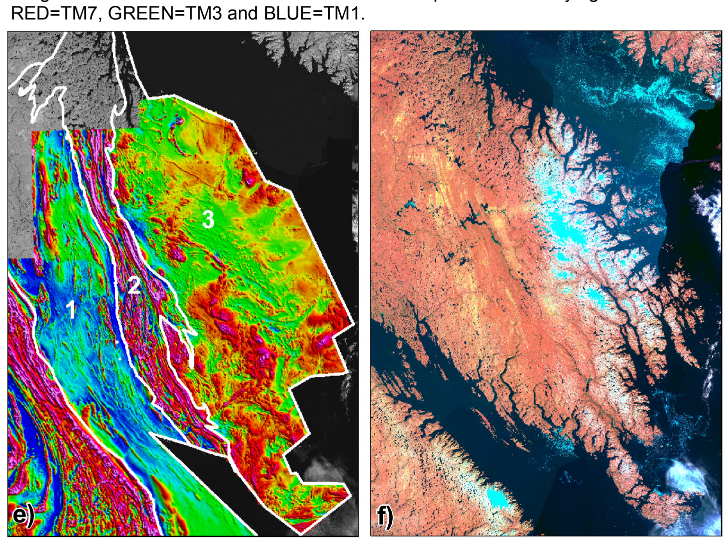


Figure 1d. Field stations with rock type observations for which LANDSAT TM image spectra were extracted. Image back-ground shows LANDSAT TM colour composite image with a band combination that is considered optimal for identifying bedrock units. RED=TM7, GREEN=TM3 and BLUE=TM1.



Residual total field magnetic grid (Fig. 1e) with overlay of magnetic domains. 1 = Cumberland batholith domain, 2 = high-grade mobile belt domain, 3 = Archean gneiss - supracrustal domain; LANDSAT7 TM colour composite mosaic (Fig.1f). RED= TM7, GREEN=TM3 and BLUE=TM1.

References

Blackadar, R.G., 1967. Geological reconaissance southern Baffin Island, district of Franklin. Geological Survey of Canada, Paper 66-47 and unpublished data.

Harris J. R. (ed). 2008. Remote predictive mapping: an aid for northern mapping, GSC Open File 5643; 306 pages 1 DVD

Schetselaar, E.M., Harris, J.R., Lynds, T. and de Kemp, E.A., 2007. Remote Predictive Mapping (RPM): a strategy for geological mapping of Canada's North. Geoscience Canada v. 34, p. 93-111.

Schetselaar, E.M., Tiainen, M. and Woldai, T. 2008. Integrated geological interpretation of remotely sensed data to support geological mapping in Mozambique in Pekkala, Y, Letho, T and Makitie, H. (eds.) Geological Survey of Finland, special paper 48, p. 35-63.

Scott, D.J., 1999. U-Pb geochronology of the eastern Hall Peninsula, southern Baffin Island, Canada: a northern link between the Archean of West Greenland and the Paleoproterozoic Torngat Orogen of northern Labrador. Precambrian Research 93, p. 5-26.

These predictive maps can comprise a series of layers within a Geographical Information System (GIS) and be integrated with field mapping to assist in constructing a 'traditional' geological map. In some cases, depending on the method(s) used to generate the map, a measure of uncertainty (or confidence) in the interpretation is also included. The predictive map or series of maps are by no means 'end products' but are intended to help assist, guide, and plan field-mapping studies, as well as assist in the production of the 'final geological map'. In cases where no existing geological information (or very minimal) exists, RPM maps serve as a first-order source for basic geological information and provide basic regional geological information with which to base future mapping or exploration programs. In areas where basic geological information exists, these maps may show areas where the predicted geology agrees and/or disagrees with the existing information. Both of these scenarios are important, as areas of agreement confirm what has been mapped traditionally and areas of disagreement point to areas that may require further field mapping and study. These maps can also be used in conjunction with field observations to build a geological map interactively (i.e. 'on the fly') while in the field.

These predictive maps can also be useful for planning a field campaign by providing information on areas where more detailed mapping is required, areas of bedrock outcrop and/or wetlands, and areas where detailed traverses could be undertaken. The RPM method differs from current methods for mapping the north, which traditionally relied on a homogeneous grid of traverses spaced 1 to 5 km apart over the area of interest regardless of the complexity of geology and supplemented with the interpretation of airphotos. The advantage of predictive maps is that they can show areas that are geologically homogeneous as well as those that are heterogeneous, allowing more field emphasis to be placed on the complex terrain. In addition, the signatures that have been extracted from various geoscience data sets, over an area that has been verified (mapped), can be used to help predict areas with similar geology where mapping is not possible.

The RPM philosophy is nothing new! It follows the traditional 'light-table' approach which involves overlaying geoscience data, potentially of varying scales and quality, on transparent paper on a light table except we now rely on GIS to store, manipulate and analyze the data. The RPM process involves compiling all available data from existing sources, studying the relationships between the data, and selecting the target areas for mapping and/or exploration from the integrated data. The difference is that more high-resolution digital (spectral and spatial) data and processing tools (GIS, image analysis, etc.) are now available to facilitate the compilation, integration, and analysis process.

METHOD

The procedure employed to compile the remote predictive bedrock map of the eastern Hall Peninsula follows the methodology described in Harris (2008), Schetselaar et al. (2007), and Schetselaar et al. (2008).

To summarize, this knowledge-driven image interpretation methodology includes four steps:

1. Assembling all the available geoscience data including remotely sensed data, geological field observations and legacy geological maps in a geodatabase. If data is in an analogue format it must be digitized, scanned or put into a digital database format (Fig. 1d, e show examples of LANDSAT and airborne magnetic data used in this study). Attribution of the geodatabase (i.e. recording all the geological parameters to be captured -*see* RPM legends associated with Fig. 1a - predictive geology map) can occur at this stage so that in the screen-digitization process the interpretations (units, structures) can be attributed 'on the fly'.

2. Establishing systematic relationships between image signatures and bedrock units and structures by overlaying thematic queries of geological field observations on multiple layers of enhanced magnetic and satellite image data. (Fig. 1b–d)

3. Screen-digitizing ('heads-up digitization') of RPM units and structures by visual image interpretation of enhanced magnetic data, satellite data (in this study, LANDSAT and SPOT 4) and digital topographic data using GIS functionality (Fig. 1a, e). This interpretative GIS mapping is driven by combining geological image interpretation skills with the knowledge gained in step 2

4. Establishing a RPM legend by integrating and validating the relationships between image signatures and geological field observations established in steps 2 and 3 (Fig. 1b, c, e) producing the final map (Fig. 1a).

SUMMARY

The objective of remote predictive mapping is to upgrade the geoscience knowledge-base in sparsely mapped areas of Canada's North, re-assess regional tectonic synthesis, and support field mapping projects.

The predictive map presented in this Open File (Fig. 1a and associated legends) includes interpretative RPM units and geologic structures. The RPM legend contains characteristics derived from the various geoscience data sets as well as geologic rock types derived from the legacy field observations that have also been overlaid on the predictive map.

REFERENCES

Behnia, P., Harris, J.R., Rainbird, R.H., Williamson, M.C., and Sheshpari, M., 2012. Remote predictive mapping of bedrock geology using image classification of Landsat and SPOT data, western Minto Inlier, Victoria Island, Northwest Territories, Canada; International Journal of Remote Sensing v. 33, p. 6876–6903. doi:10.1080/01431161.2012.693219

Blackadar, R.G., 1967. Geological reconnaissance southern Baffin Island, District of Franklin; Geological Survey of Canada, Paper 66-47 and unpublished data.

Brown, O., Harris, J.R., and Utting, D., 2008. Case study 6; Surficial mapping of northern Baffin Island using LANDSAT and topographic data, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 225–232; 1 DVD.

Grunsky, E., Harris, J.R., McMartin, I., 2006. Predictive mapping of surficial materials, Schultz Lake area (NTS 66-A), Nunavut, Canada; Geological Survey of Canada, Open File 5153, 49 pages; 1 DVD. doi:10.4095/221968

Harris J.R. (ed.), 2008. Remote predictive mapping: an aid for northern mapping, Geological Survey of Canada, Open File 5643, 306 pages, 1 DVD.

Harris, J.R. and St-Onge, M.R., 2008. Case study 3; The advantages of high-resolution spectral and spatial hyperspectral data for lithological mapping: an example from southeast Baffin Island, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 183–189, 1 DVD.

Harris, J.R., Martel, E., Currie, M., Pierce, K., Pilkington, M., and Keating, P., 2008a. Case study 1; Snowbird Lake, Northwest Territories *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 161–171, 1 DVD.

Harris, J.R., Schetselaar, E.M., de Kemp, E., and St-Onge, M.R., 2008b. Case study 2; LANDSAT, magnetic and topographic data for regional lithological mapping, southeast Baffin Island, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 173–12, 1 DVD.

Harris, J.R., Sanborn-Barrie, M., St-Onge, M.R., Pilkington, M., Lynds, T., and McGregor, R., 2008c. Case study 4; The application of remotely sensed data for structural mapping, southwest Baffin Island, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 191–202, 1 DVD.

Harris, J.R., Ford, K., Charbonneau, B., and Buckle, J., 2008d. Case study 5; Application of gamma-ray spectrometer data for lithological mapping in a Cordilleran environment, Sekwi region, Northwest Territories, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 203–223, 1 DVD.

Harris, J.R., Grunsky, E., and McMartin, I., 2008e. Case study 7; Classification of remotely sensed imagery for surficial geological mapping in Canada's North, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 233–244, 1 DVD.

Morris, W.A., Ugalde, H., Slavinski, H., and Markham, K., 2008. Case study 8; Geological mapping derived from topography, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 245–259, 1 DVD.

Schetselaar, E.M. and Ryan, J.J., 2008. Case study 9; A remote predictive mapping case study of the Boothia mainland area, Nunavut, Canada, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 261–281, 1 DVD.

Schetselaar, E.M. and Ryan, J.J., 2009. Remote predictive mapping of the Boothia mainland area, Nunavut, Canada: an iterative approach using Landsat ETM, aeromagnetic, and geological field data; Canadian Journal of Remote Sensing, v. 35, suppl. S1, 2009; p. S72–S94.

Schetselaar, E.M., Harris, J.R., Lynds, T., and de Kemp, E.A., 2007. Remote Predictive Mapping (RPM): a strategy for geological mapping of Canada's North; Geoscience Canada v. 34, p. 93–111.

Schetselaar, E.M., Tiainen, M., and Woldai, T., 2008. Integrated geological interpretation of remotely sensed data to support geological mapping in Mozambique *in* GTK Consortium geological surveys in Mozambique 2002–2007, (ed.) Y, Pekkala, T. Letho, and H. Makitie; Geological Survey of Finland, special paper 48, p. 35–63.

Scott, D.J., 1999. U-Pb geochronology of the eastern Hall Peninsula, southern Baffin Island, Canada: a northern link between the Archean of West Greenland and the Paleoproterozoic Torngat Orogen of northern Labrador; Precambrian Research v. 93, p. 5–26.

Wickert, L.M., Budketwitsch, P., and Morris,W.A., 2008. Case study 10; Lithological mapping using ASTER, Belcher Islands, Nunavut, *in* Remote predictive mapping: an aid for northern mapping; (ed.) J.R. Harris, Geological Survey of Canada, Open File 5643, p. 293–296, 1 DVD.