RADARSAT-2 Polarimetric SAR Imagery: An Aid for Assessing the Uranium Potential of the Paleoproterozoic Thelon Basin, Nunavut

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Summary

This Remote Predictive Mapping (RPM) project is focused on selected areas prospective for uranium in the Amer Belt located in northeastern part of the Thelon Basin, Nunavut. The Amer Belt is structurally and lithologically complex, with relatively good basement exposure and bedrock outcrop, facilitating the use of various remote sensing techniques for bedrock and surficial mapping. The objective is to improve on surficial and basement structural-lithological maps of the study area by using RADARSAT-2 C-band polarimetric SAR images, together with geological, geophysical, digital elevation model (DEM), and optical remotely sensed (SPOT and aerial photographs) data. This paper briefly describes initial results of RADARSAT-2 imagery for mapping glacial landforms, lineaments, and lithological units.

Introduction

This remote sensing study is linked with geophysical (Tschirhart et al., this session) and geological components (e.g. Scott et al., and Pehrsson et al., this session) of the Northeastern Thelon Compilation for the Northern Uranium for Canada and Remote Predictive Mapping projects of Geomapping for Energy and Minerals (GEM) Program, NRCan. Our study is part of a project combining RADARSAT-2 polarimetric SAR images having HH, VV, VH, and HV polarizations, digital elevation models (DEM), SPOT imagery, and geophysical data (in collaboration with McMaster University) for improving and updating the existing geological framework in part of the Amer Belt located in the northeast Thelon Basin and surrounding basement terrain. The Amer Group has been a target of uranium exploration and is a favorable basement host for unconformity-associated deposits beneath the Thelon Basin. The Canadian RADARSAT-2 satellite (launched in Dec. 2007) has a C-band Earth observation Synthetic Aperture Radar (SAR) sensor, with an advanced capability of acquiring data in selective polarization and ultra-fine imaging modes (Ali et al., 2004). This paper presents preliminary results of the application of RADARSAT-2 polarimetric SAR images for mapping surficial geology, lineaments, and bedrock lithology at selected test sites in the Amer belt (Fig. 1).

Geological Setting of the Study Area

The Paleoproterozoic metasedimentary rocks of Amer Group unconformably overlie the Archean Woodburn Group greenstone belt, metagabbro intrusions, and granitoid gneiss, and form a west-southwest-trending, southwest-plunging synclinorium. The Amer Group has been affected by a minimum of three deformational events resulting in upper greenschist to lower amphibolite facies in the northeast, and subgreenschist facies in the southwest of the belt. The Amer Group is best exposed in the northern part of the study area where it plunges unconformably toward the southwest beneath the northeastern Aberdeen sub-basin portion of Thelon Basin. Outliers are also exposed in basement horsts dissecting the Thelon Basin and the Amer Group is speculated to continue south-southwesterly beneath the main Thelon Basin before re-emerging at its south end. The Amer Group comprises subgreenschist facies

metamorphosed conglomerate, quartz-arenite, feldspathic sandstone, mudstone, dolostone, and mafic volcanic rocks, all of which have been intruded by a variety of mafic and syenite dykes, and granitoid plutons of two ages: the ca. 1.85-1.8 Ga Hudson Suite, and the ca. 1.75-1.7 Ga Nueltin Suite (see Scott et al., this session)

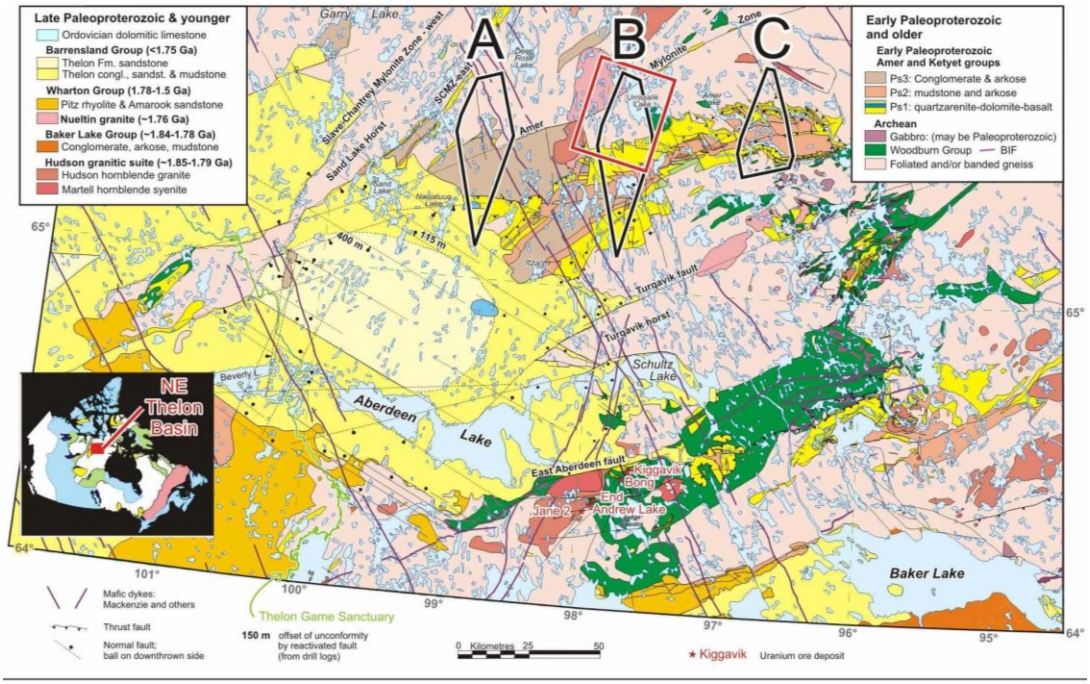

Figure 1: Geology of the northeast Thelon Basin region (From Pehrsson et al., this session). RADARSAT-2 polarimetric images were acquired at “A”, “B”, and “C” sites. Red rectangle shows the location of the image considered in this paper.

The Amer Group is overlain uncomformably in the study area by small patches of Wharton Group, and in turn by a broad area of Thelon Formation. The Wharton Group (~1.78-1.5 Ga) comprises the Amarook sandstone and overlying Pitz Formation (~1754 Ma) rhyolite. The Thelon Formation is the oldest unit of the Barrensland Group, and consists of undeformed pale red sandstone, conglomerate, deep red siltstone, and mudstone (Gall et al., 1992).

Methods

Seventy-one RADARSAT-2 polarimetric SAR images were acquired over three geologically important regions (Fig. 1) during August and September 2009. The images are single-look complex (SLC) image products with a resolution of 5.2×7.6 m (range×azimuth), and a swath width of 25×25 km. The results presented here are related to a single scene covering parts of the structurally complex Amer belt (Area B on Fig.1). The scene was acquired on the 13th of August 2009 at 13:09 hours with a descending orbit (facing west) and 32.95°incidence angle. It was processed using the *PCI Geomatica SAR Polarimetric Workstation*. First, the image was filtered by a Lee polarimetric filter with a 7×7 kernel to remove speckle (Lee et al., 1999). Next, total power and Freeman-Durden incoherent target decomposition (Freeman and Durden, 1998) images were calculated from the polarimetirc dataset. The target decomposition image provides information on surface scattering mechanisms (volume, smooth, and double bounce). The resulting images were orthorectified using a 1:50,000 DEM prepared at McMaster University.

Results

The total power image is useful for mapping glacial landforms and lineaments in the southern part of the studied scene (Fig. 2). Several lineaments were identified in total power image that are not present on the regional 1:250,000 geology map of the area (Tella, 1994). It also clearly

shows glacial ice flow indicators, such as crag and tails, and drumlins. The major ice flow direction (NNW) can be identified by the trend of large valley-like structures between the round-topped till features, which possibly represent tail structures extending from quartzite crags. The southwest corner of the image shows glacial groves-like features indicating WNW ice flow. Possible lithological contacts can also be delineated on this image.

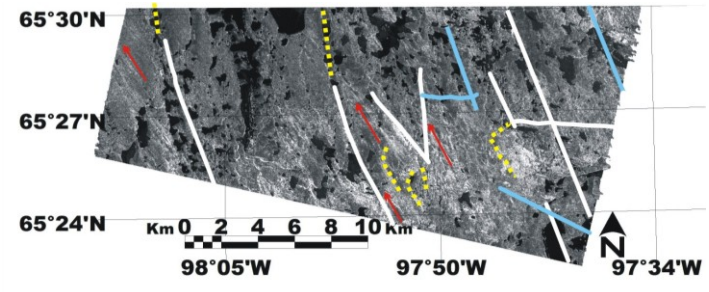

Figure 2: Total power RADARSAT-2 image of the southern part of the studied scene (blue rectangle of Figure 3). (Yellow lines: previously unmapped lineaments; White lines: identified faults in the 1:250,000 map by Tella (1994); Blue lines: faults mapped in Tella (1994), not distinguished on the image; Red lines: glacier flow direction (WNW) determined by crag and trail and drumlins, well correlated with the interpretation by Thomas (1981).

Initial comparison of the Freeman-Durden incoherent target decomposition image (Fig 3) with the surficial geology (Thomas, 1981) and bedrock geology (Tella, 1994) maps reveal that areas comprising quartz monzonite (Pqm) and foliated granite (Apg) are mostly covered by sandy till and till with silt and gravelly sand. These areas appear as green in Figure 3 due to a high volume scattering. In places, the quartz monzonite is possibly covered by till veneer (< 1 m), which is expressed in a light red pattern due to a high surface scattering because of smoother surfaces. The Freeman-Durden image helps identifying quartz monzonite (Pqm) and foliated granite (Apg), but not the augen gneisses (APqmd), (muscovite schist) Pas and banded gneiss (Am) due to the overlying till (silt and gravelly sand) coverage. More research on remote predictive mapping of the various rock units is needed using a combination of processed SAR imagery, detailed ground geological data and maps, optical remotely sensed imagery (Landsat, SPOT 5), and geophysical data in coordination with other parts of the Thelon Compilation Project (e.g., Tschirhart et al., this session).

Conclusions and Future Work

Initial results show that RADARSAT-2 polarimetric imagery provides useful information on glacial landforms, lineaments, and can also separate lithological units based on surface roughness properties. This analysis represents the first step in the evaluation of RADARSAT 2 polarimetric data for geological mapping, by comparison and integration with other geoscience datasets including field data, aerial photographs, Landsat, and SPOT imagery as well as regional geophysical data. The ultimate goal is to systematically relate surface and bedrock features evident in SAR imagery with surface expressions of subsurface uranium deposits and to understand the links between the two. This will help to understand the nature of uranium deposits within the Thelon basin and help draw analogies with those processes occurring in the larger and better understood Athabasca Basin. Further research will focus on the analysis of the full polarimetric signatures as well as supervised and unsupervised classification of the polarimetric data and evaluation of these products with respect to their usefulness for mapping surficial materials, landforms, structure and lithology.

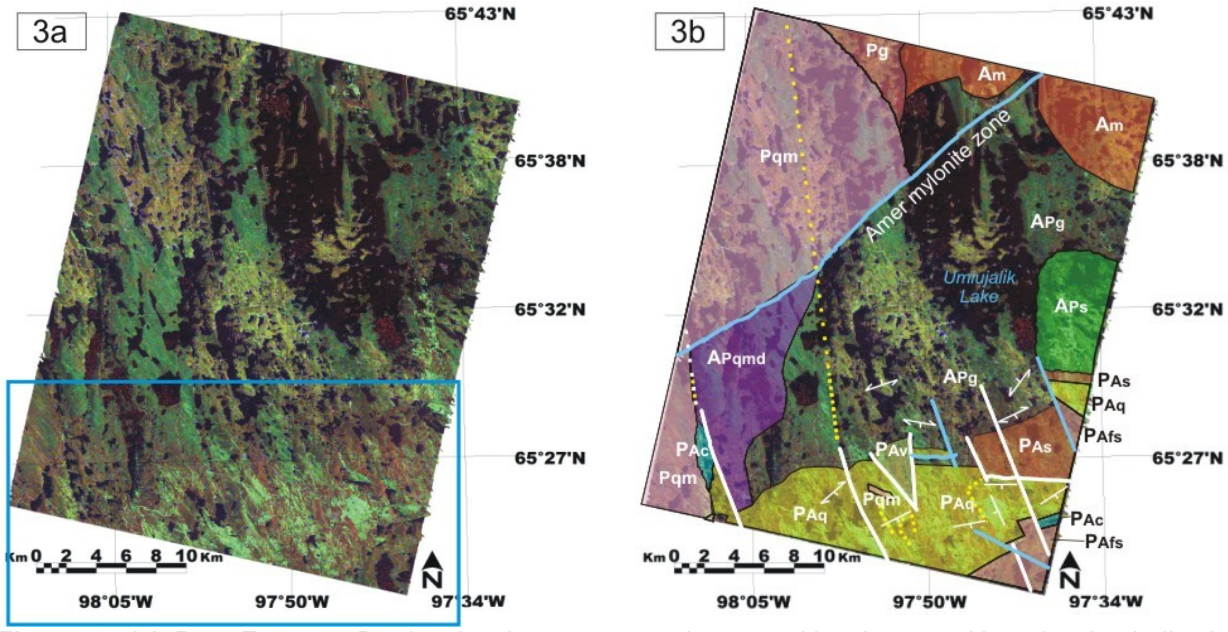

Figure 3: (a) Raw Freeman-Durden incoherent target decomposition image with red color indicating surface scattering; green color indicating volume scattering and blue color indicating double-bounce scattering. **(b)** Bedrock geology (Tella,1994) of the studied scene overprinted on the Freeman-Durden image (rock units: Am: varieties of banded gniess; APqmd: augen gneiss, APg: foliated granite; APs: biotite schist; APv: metavolcanics; Pas: muscovite schist; PAq: orthoquartzite; PAc: carbonates; PAfs: feldspathic sandstone; Pg: porphyritic granite; Pqm: quartz monzonite).

Acknowledgements

This is part of a M.Sc. study by the first author at the University of New Brunswick, supported by the Northern Uranium for Canada and Remote Predictive Mapping projects under the Geomapping for Energy and Minerals (GEM) Program, including logistical and travel support, and a Bursary via the Research Affiliate Program (RAP). Deborah Lemkow and Beth Hillary of the GSC, and the Canadian Space Agency provided extensive RADARSAT-2 data, also Victoria Tschirhart, McMaster University for providing DEM of 66 H and 66 G UTM grids.

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