



Ministry of Energy & Mines
 Energy & Minerals Division
 Geological Survey Branch

**ASSESSMENT REPORT
 TITLE PAGE AND SUMMARY**

Title of Report: Rexspar Project Area Assessment Work Report, Spectral Analysis Study of the Clearwater-Birch Island Claims by RM Resource Management Ltd, January 2006

Authors: A W Randall **Signatures:** (See Statements of Qualification)
D J McLelland

Notice of Work: N/A

Statement of Work Payment Numbers: (See Work Filing Confirmation Statement following)

Property Name: Rexspar

Claim Names: N/A

Commodities Sought: Uranium

Location: Kamloops Mining Division
 NTS 082M/12 UTM Zone 11 (NAD 83)
 Northing: 5716300 Easting: 298200

Owners: Aldershot Resources Ltd
 600 – 666 Burrard Street
 Vancouver, BC, V6C 2X8

Operators: As Above

Property Geology Keywords: Eagle Bay Assemblage, trachyte, volcanogenic uranium

References:

- ARIS Reports** -05502, 06252, 07503, 07647, 06161, 06773, 01912, 01737;
- Minfile Reports** - 082M021, 082M022, 082M023, 082M043, 082M031, 082M007, 082M158, 082M042, 082M034

Type of Work:

Geochemical (Other): Spectral Analysis Study (Work done on all claims)

Total Cost:.....\$8,193.89

Mineral Claim Exploration and Development Work/Expiry Date Change

Confirmation

Recorder: ALFRED WALTER
 RANDALL (122235)
 Recorded: 2006/JAN/09
 D/E Date: 2006/JAN/09

Submitter: ALFRED WALTER
 RANDALL (122235)
 Effective: 2006/JAN/09

Event Number: 4062735

Work Start Date: 2005/SEP/01
 Work Stop Date: 2006/JAN/06

Total Value of Work: \$ 8193.89
 Mine Permit No:

Work Type: Technical Work
 Technical Items: Geochemical

Summary of the work value:

Tenure #	Claim Name/Property	Issue Date	Good To Date	New Good To Date	# of Days Forward	Area in Ha	Work Value Due	Submission Fee
501853		2005/JAN/12	2006/JAN/12	2008/JAN/12	730	502.38	\$ 4019.06	\$ 401.91
502043		2005/JAN/12	2006/JAN/12	2007/JAN/12	365	301.32	\$ 1205.28	\$ 120.53
502157		2005/JAN/12	2006/JAN/12	2008/JAN/12	730	361.59	\$ 2892.68	\$ 289.27

Total required work value: \$ 8117.02

PAC name: Aldershot Resources Ltd
 Debited PAC amount: \$ 0.00
 Credited PAC amount: \$ 76.87

Total Submission Fees: \$ 811.70

Total Paid: \$ 811.70

The event was successfully saved

**REXSPAR AREA PROJECT
ASSESSMENT WORK REPORT**

Spectral Analysis Study of the Clearwater-Birch Island Claims

Kamloops Mining Division
NTS 082M/12
UTM Zone 11 (NAD 83)
Northing: 5716300
Easting: 298200

For

Aldershot Resources Ltd
600 – 666 Burrard Street
Vancouver, BC
V6C 2X8

By

R M Resource Management Ltd

January 2006

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EXECUTIVE SUMMARY

RM Resource Management Ltd was asked by Aldershot Resources Ltd to carry out a Spectral Analysis program on it a number of its mineral claim holdings in British Columbia which had been staked for their Uranium potential. Geologically this area is widely underlain by Eagle Bay Volcanic, Metavolcanic and Metasedimentary rocks. Uranium mineralization in this area is described as of Volcanogenic origin. This report outlines work done on the Clearwater-Birch Island (Rexspar) area claims. Work was initiated in September 2005 and completed in January 2006.

The program involved acquisition of satellite spectral data available from NASA, reconfiguring this data into a workable format, geo-referencing to Trim map bases and extensive and rigorous classification of the data in search of indicators that might lead to the discovery of uranium mineralization. Although Spectral Analysis is still in its infancy, this work program was not intended to be a research project but rather to apply recently developed technology, methodologies and the latest computer software available for spectral analysis as a tool for mineral exploration.

The Clearwater-Rexspar area claim blocks cover or in the vicinity of several known uranium deposits including one significant deposit that may be held by underlying crown grants. Clarification of ownership of these crown grants needs to be investigated further. In the meantime the claims, that are the subject of this report, are valid tenure and consequently may/must be explored in order to maintain that tenure.

This spectral work program was highly labour and computer intensive. Literally thousands of files had to be created for each area. These files were subject to rigorous classification and analysis resulting in numerous spectral images for examination. Results of this work have however been inconclusive although all indications are that the spectral data was of good quality and analysis techniques were applied in a logical and meticulous fashion. A number of images are presented in this report to illustrate some of the results obtained. A review and comparison of these images with known geological data indicates there is no clear correlation. Neither were any obvious indications of uranium mineralization or its associated geological features discerned from the spectral imagery produced. It is therefore recommended that no additional Spectral Analysis work be undertaken at this time pending further review of the science.

RM Resource Management Ltd
January 2006

INTRODUCTION

In early January of 2005 three mineral claim tenures were staked over the Rexspar uranium deposit and associated showings. This prospective ground hosts several volcanogenic style Uranium prospects. The rising demand and price of Uranium on the world market was the incentive for these acquisitions. The claims were staked by Matthew Mason and subsequently optioned to Aldershot Resources Ltd who is funding this work program.

Aldershot Resources asked RM Resource Management Ltd to undertake an interdisciplinary technical exploration work program involving the use of Spectral Analysis to see if any uranium mineralization or other geologic features associated with the localization of uranium mineralization could be identified on the Aldershot properties. Spectral Analysis is a newly developed and still evolving exploration tool. Dave McLelland has gained valuable experience in the use of Spectral data as part of his GIS Masters degree program that he recently completed. Alf Randall has teamed up with McLelland to handle the management, geological and reporting aspects of this program. This work program has provided an opportunity to test out from a geological and prospective point of view whether Spectral Analysis combined with existing geological data could be applied as an easy to use tool for the mineral explorationist.

LOCATION AND ACCESS (See Figure 1 - Location Map)

The Rexspar uranium deposit is located 15 kilometers south-east of the Town of Clearwater near the community of Birch Island in central British Columbia. Access to the area is via Highway 5 which parallels the group to within 5 kilometers and then via about 30 kilometers of logging roads which cross the claims. The CN rail line passes within one half kilometer to the north of these claims.

PHYSIOGRAPHY

This prospect area is situated on the southwest side of the North Thompson River. Gentle slopes near the river rapidly change to steep slopes with deeply incised stream channels higher on the valley side. Elevations range from about 500 meters in the Thompson River valley to about 1500 meters in the highlands to the south.

The hill sides are sparsely to heavily covered by timber including pine, tamarack and poplar. Most of the claim area has been logged. Some areas have grown back in small second growth timber which obscures the ground from aerial view in some areas. Recent logging has opened a number of areas allowing greater visibility for spectral image analysis.

MINERAL CLAIM STATUS

Three blocks of claims encompasses 58 mineral claim cells including 1,165 hectares were staked over and surrounding the Rexspar crown granted claims. These claims were staked by Matthew Mason in January 2005 and subsequently optioned to Aldershot Resources Ltd. Aldershot has a 100% interest, subject to terms of the option agreement, in these claims.

The core Rexspar deposit showings appear to be held under Land Title tenures (indicated to by Crown Granted) by Conrex Steel Limited of Rexdale, Ontario. Crown Grant and Land Title tenures are not managed by BC Mineral Titles hence they do not identify nor guarantee what minerals or rights are held by these Titles. Crown Granted mineral claims do not show as Mineral Titles under the Mineral Titles management system. Mineral rights associated with Crown Granted titles are very convoluted and require extensive search by certified professionals to establish accurate ownership. Access to title information is difficult to obtain. The Aldershot mineral claims were staked over these titles because of this ambiguity. While clarification of title is researched, work can be carried out in the vicinity of the titles as this is obviously a favourable area for localization of uranium mineralization.

A list of claims follows and a claim map is shown in Figure2.

Tenure No.	Number of Cells	Area (Ha)	Anniversary Date
501853	25	502.382	12-Jan-06
502043	15	301.321	12-Jan-06
502157	18	361.585	12-Jan-06

PREVIOUS WORK (paraphrased from Minfile 82M021)

Mineralization was first recognized at this site in the early 1900's while exploring for base metals. Fluorite was also found. In 1949 uranium mineralization was discovered. During the period 1943 to 1976 a total of 368 exploration diamond drill holes were completed, primarily on the main Rexspar deposit. Three other uranium occurrences (F, G, H zones) along with the Fluorite zone were also discovered and explored

The presence of uranium mineralization became known in late 1949. Dr. F.R. Joubin studied and reported on the mineral occurrences during 1950 and 1951. Rexspar Uranium, later reorganized as Consolidated Rexspar Minerals and Chemicals Ltd., acquired the rights to mineral claims incorporating the uranium bearing zones and delineated three uranium deposits in the late 1950's. However, the deposits were not brought into production. Denison Mines Ltd. resampled and undertook an economic feasibility study in 1969. Exploration programs and geological reviews were conducted in 1969-1972, directed mainly at determining fluorite reserves. Additional diamond drilling of the uranium bearing zones was carried out in 1976 and the drill core was used in a metallurgical test program undertaken to establish process flowsheets.

In 1926 Smuggler Hill Development Company was formed to explore and develop silver and lead deposits (Smuggler, 082M023 and Foghorn, 082M029), which were originally staked in 1918 by A.G. McDonald. The results of this early exploration activity were reported by H.G. Nicol, 1926 and D.B. Starrett, 1930. A manganese occurrence was examined by W. Elliot and N.C. Stines in 1929 (Smuggler Manganese, 082M158). Further geological examinations of fluorite occurrences were reported on by D.B. Starrett, R.P.D. Graham and M.R. Wilson in the early 1940's (Spar, 082M007). The ground was relocated in 1942 by Ole Johnson and the B.C. Fluospar Syndicate developed

the fluorite deposit in 1943. The property was leased by A.E. Sjoquist and optioned in 1951 by Technical Mine Consultants who conducted an extensive exploration and development program for Rexspar Uranium and Metals Mining Co. Ltd.

The Fluorite deposit and the three uranium deposits have been outlined by fairly close spaced diamond drilling and by surface sampling. A total of 368 surface and underground holes have been drilled from 1943 to 1976, for a total of approximately 17,280 metres. Of these, 121 holes were on the "A" deposit, 81 on the "B" deposit, 125 on the "BD" deposit and most of the others on the fluorite deposit. Drifts, cross cuts and raises for a total of 664 metres were driven in the "A" and "BD" uranium zones. The property has been prospected several times over the years. Geological mapping, radiometric surveying, soil sampling and metallurgical testing have also been performed. Work conducted by Placer Development Ltd. during October, 1981, included ground magnetometer and VLF - EM surveys.

In 1987, Consolidated Rexspar changed its name to Conrex Corporation and sold the property in 1988 to Gold Ventures Limited. American Bullion Minerals Ltd. attempted to get a permit to do exploration on the main fluorite zone in the early 1990's.

GEOLOGY (See Figure 3 - Geology Map)

Regionally the area is underlain by northwest striking northeast dipping Eagle Bay Assemblage of rocks. The oldest rocks of this complex which underlie the area are the Upper Proterozoic to Lower Cambrian paragneiss metamorphic rocks including metavolcanics and interlayered metasediments. To the east and north-east of the claims are some Upper Proterozoic to Lower Cambrian sedimentary units composed of quartzites and quartz-arenites. The next units in the sequence include calc-alkaline volcanics which are overlain by andesitic volcanics. These volcanics are overlain by a mixture of marine sediments and volcanics of the Fennell Formation. Detailed geology of the area follows as described in Minfile 82M021 Capsule Geology.

The rocks hosting the Rexspar uranium deposits consist of a deformed and metamorphosed pile of alkali feldspar porphyry, porphyry breccia, lithic tuff and breccia of trachytic composition, with occasional pyritic schist of rhyolitic composition. Rocks of this "trachyte" unit are light grey in colour and stained rusty brown or yellow due to widespread pyrite. They may be massive, brecciated, or markedly schistose and lineated. Fractured and sheared crystals of potassium feldspar and albitic plagioclase, and rock chips of trachytic composition occur in a fine-grained groundmass of feldspar and sericite. The trachyte unit, which is 15 to 120 metres thick, is apparently a mixture of intrusive porphyry and its extrusive equivalent tuffs and tuff breccias. It is likely related to a volcanic centre or vent active during the Middle Devonian.

The above unit is structurally underlain by quartz-sericite schist, chlorite schist and dacitic and andesitic volcanic breccia, with interlayers of grey phyllite, slate, chert and sericitic quartzite.

The prominent schistosity, which is parallel to the compositional layering and was probably produced during the first phase deformation, is deformed by tight, recumbent, east trending second-phase folds. These structures are refolded by upright third-phase, northerly to northeasterly trending structures. Subsequent late kinks and prominent north trending tension fractures are commonly followed by post-tectonic felsic and mafic dykes of Cretaceous or later age. High-angle, northerly trending faults sharply control the distribution of the trachyte unit.

The geological setting and mineralogy suggest that the mineralized zones were formed by deuteric, volatile rich fluids during a late-stage in the formation of the trachyte unit. The considerable amount of thorium and widespread rare earths associated with the uranium support its origin as primary rather than secondary.

A potassium/argon age of 236 Ma +/- 8 Ma for fluorphlogopite from one of the mineralized zones is considered a minimum age and used cautiously because of some analytical problems. This Middle Triassic age suggests the mineralization is syngenetic with the host rocks, that is in no way related to the nearby Cretaceous Baldy batholith.

MINERALIZATION

Uranium and thorium mineralization occur exclusively in the trachyte unit and mainly in the dark-coloured, upper part of the unit, which shows extensive replacement by silver-grey fluorphlogopite and pyrite, with lesser fluorite and calcite. The replacement zones, a few centimetres to several metres in size, generally occur as coarse-grained segregations, which show conformable and crosscutting relationships and deformation similar to the surrounding rocks. The best grade material occurs in a series of discontinuous, conformable tabular masses or lenses, generally less than 20 metres thick and up to 140 metres long. A detailed description of the mineralization and deposit characteristics follows as from Minfile 82M021 Capsule Geology.

The principal radioactive minerals include uraninite, uranothorite, torbenite, metatorbenite, thorianite and uranium thorite. They occur as tiny discrete grains within fluorphlogopite flakes, and cause pleochloric haloes, or are scattered in the pyrite-fluorphlogopite matrix. Uranium and thorium also occur in monazite and niobium ilmenorutile. Rare earths, mainly cerium and lanthanum, occur in bastnaesite and monazite. Other minerals include celestite, galena, sphalerite, chalcopryrite, molybdenite, scheelite, siderite, dolomite, barite and quartz.

Three main tabular zones of radioactivity occur parallel to the surfaces of the alkali feldspar porphyry and have irregular terminations above and below. The BD or Black Diamond zone is a flat-dipping lens with a strike length of 140 metres, dip-slope length of 90 metres and an average thickness of 15 metres. A 1.8 metre sample across part of the zone assayed 0.09% uranium, 0.14% thorium oxide, 0.025% niobium and trace yttrium and lanthanum. The zone lies along the upper surface of the porphyry and the radioactivity appears to be mainly associated with uranothorite, associated with rutile. The A zone, 600 metres east-northeast of the BD zone, is a shallow dipping irregular lens averaging 15 metres thick which has been traced along strike for about 60 metres. It

pinches out at a slope depth of about 60 metres and appears to occur at a lower horizon in the porphyry mass. A 1.8 metre sample across the zone assayed 0.07% uranium, 0.06% thorium oxide, 0.015% niobium and trace yttrium, lanthanum and cerium. The principal radioactive mineral is uraninite associated with rutile. The B zone, 360 metres north-northeast of the BD zone, averages 8 metres wide, strikes about 60 metres and has a dip-slope length of about 75 metres. Ore reserves for the three zones outlined by polygons within the proposed pit limits as defined by a cutoff grade of 0.021 per cent uranium are 1,114,385 tonnes grading 0.066% uranium with an overall stripping ratio of 12:1. The ore zones also grade 5 to 10% fluorite.

Smaller zones occurring in relation to the BD zone include the F zone, 450 metres to the west, the H zone, 600 metres to the north-northeast, and the G zone (082M022), 1420 metres to the northeast. The Fluorite zone (082M007) lies about 550 metres northeast of the BD zone and contains no uranium reserves.

2005 TECHNICAL WORK PROGRAM - SPECTRAL ANALYSIS STUDY

Methodology

Remote sensing techniques and spatial data analysis through Geographic Information Systems (GIS) have been jointly applied in the mineral exploration context to identify mineral rich potential areas in a number of locations throughout the world including the detection of uranium deposits and associated radioactive materials. The Spectral Analysis work associated with this project is not intended to research and develop new spectral analysis methods or to develop new software. The aim is to utilize a combination of Spectral image data and sophisticated analysis software along with geological and other exploration data from the various project target areas as an exploration tool in search of uranium deposits or associated geological features which may result in the location of new uranium mineralization. Any other mineralized deposits that may be identified as a result of this work will also be given due attention if time allows.

A wide range of Image analysis techniques were applied to spectral data from this project area. A good deal of effort went into a type of Multivariate Classification and Regionalization (grouping of like, statistically significant data) defined as Supervised Classification (described earlier) which was carried out to try to establish spectral characteristics for various geological models related to the project area. These “test areas”, or “training areas” as they are described in the literature, provided an opportunity for signature development of characteristics relevant to the styles of mineralization and related geological features that are present on the subject claims. Other methods used to try to extract useful spectral maps were the hard classification operators (Principal Components Analysis, Fisher or Linear Discriminant Analysis, Maximum Likelihood, Minimum Distance Parallelepiped, Canonical Components Analysis, and Neural Network Texture Classification) and the soft classification operators (Bayesian Analysis, Dempster-Shafer Weighting, and Fuzzy Classification). These procedures although able to produce spectral images, the results often did not provide obvious or even subtle indications of a relation to underlying geology or mineralization.

The procedure which did produce data that was most frequently considered to be correlative to underlying geological features, although at times tenuous, was the technique

called Unsupervised Classification (described earlier). This procedure and related methodology is described in the following analytical steps.

Analytical Steps

1. Compilation - The first step included an extensive geological, mineralogical and mineral deposit research and compilation from historical sources in search of features which could be used as spectral targets. These features, which are identified and described in the geology and mineralization sections of this report, were digitized where possible into map overlays.
2. Base Maps - Acquisition of Trim Maps for each area to form base maps.
3. Spectral Data Acquisition - Selection and acquisition of spectral image Granules for each area. Images can be chosen from a variety of satellite passes over a wide range of time.
4. Data Quality Assessment - The images selected were then checked to ensure they adequately covered the subject areas and were of suitable quality. For example if there was too much cloud cover or if the images were of poor resolution they were rejected and replaced with new granules.
5. Geo-referencing - Spectral Images were then linked or geo-referenced to the UTM grid system by overlaying on Trim Map bases then a Digital Elevation Model (DEM) and a Digital Terrain Model (DTM) were derived.
6. Spectral Data Noise Correction - Unwanted responses (noise) from features such as water, vegetation, topography, shade, cloud cover etc were filtered or screened out as part of the image analysis process. At times this spectral noise may still be present in the images used and must be recognized as such when making interpretations.
7. Purified - Through an iterative process (5000 to 20000 iterations) data are projected repeatedly onto a random vector. Pixels that exceed an imposed threshold are collected as extreme and therefore representative of the data set.
8. n-Dimensional Visualization
9. Data Classification - This data is then subjected to a number of analytical techniques designed to isolate the target minerals and/or their pathfinders, associations or emmittances. Spectral libraries were selected for suitability and imported. Comparative analysis was performed against these spectral library signatures established for known minerals, rock types and expected alteration products of the various rock units. The comparative analysis was done using the following classification methods:
 - Spectral Angle Mapping (SAM)
 - Spectral Unmixing
 - Mixture Matched Filtering
10. Output - Spectral Classifications were then displayed for visual analysis as:
 - Greyscale Quantification Images - When displayed in grayscale for specific classifications, the system identifies relative abundances of specified end members (eg minerals or rocktypes). These concentrations normally show up in

white (light grey) when there is high co-relation and in dark grey to black if there is a low coefficient of co-relation (i.e. when none of the specific components are present).

- False color composite images can then be used to highlight specific minerals and mineral assemblages representing classifications or groups with vector data layers. Spectral comparison tests were then made using the one of the material suites listed below selected from the various spectral libraries.
 - a) Metamorphic Rock Types
 - b) Intrusive Rock Types
 - c) Minerals
 - d) Vegetation
 - e) Soils

However one must use some caution in accepting these classifications. Just because a given pixel is classified as a specific mineral doesn't make it so. Classifications are a measure of similarity and not necessarily definitive identifiers. Ground truthing is important to check and test the apparent results.

- RGB – Some of the data were also subject to RGB (Red-Green-Blue) analysis. This is a very simplified chromatic expression of spectral relationships. Pure colors in these images represent areas where the mineralogy is relatively pure. Mixed colors indicate spectral mixing, with the resultant colors indicating how much mixing is taking place and the relative contributions of each endmember.

11. Post Processing - Classified images require post-processing to evaluate classification accuracy and to generalize classes for export to image-maps and vector GIS. Greyscale, false colour and colour symbology responses were overlaid along with the base geological features gathered in Step 1 and were reviewed visually to see if any spectral anomalies, eg. bright or dark spots overlying these features could be identified or colour patterns reflecting underlying geology could be found. A selection of the resulting spectral signatures which most closely reflected real or apparent underlying geological features were then displayed as color coded maps.

Results

The primary objective of this exercise in the Clearwater-Rexspar area was to see if several known Uranium deposits or associated rocks located in the vicinity of these claims have a recognizable spectral signature. The Spectral Analysis was done on a portion of one spectral data granule. This is an area where there is only sparse satellite spectral coverage. The image used in this analysis covers the west claims and part of the east claim.

Several iterations of this process were done starting with the broader geological features, typically rock types including igneous and metamorphic suites and finally classifications were done for specific minerals. Matching results were identified, often including several duplicate responses. Duplicates were either displayed collectively or left out if no additional useful information was evident by their inclusion. The results of the classification procedure were viewed as spectral maps. The resultant maps have been

compared against known geology, mineralization, structure, topography and physiography to try to explain the patterns shown.

These classifications have generally been identified by the name of the “mineral” or “rock type” that shows the greatest proportion of positive co-relation or if not the greatest, is the identity which more reasonably fits the geological picture. These ID’s may however only reflect an apparent co-relation and should not be relied upon to infer any direct relationship. Spectral data management specialists always recommend using local experience and if possible ground truthing as a check on what is really being spectrally measured. Results of the spectral plot reviews are discussed in the figure descriptions following. A tabulation of the files used in preparation of the output is displayed in Appendix III.

Figure 5a - This suite included “Igneous Rocks” and produced 6 matching results 4 of which were unique. Rock types indicated by the spectral classification include Diabase, Andesite and Norite along with Lamprophyre, all close to or potentially reflective, spectrally, of the underlying volcanic rock package.

The two versions of “Diabase” have been displayed in this figure. In a very general way it appears that “#6 Diabase” mimics the Eagle Bay rocks while “#2 Mafic Diabase” reflects the Foghorn Mountain andesitic rocks.

Figures 5b – This was a Multi-Material classification. Curiously there were only 6 matches all of which were minerals, including: #1 & #9 Natrolite, #2 Magnesiochromite, #3 & #4 Pyrite, and #6 Cobaltite.

Chromite is a common constituent of igneous rocks and therefore the widespread distribution of Magnesiochromite in this image is likely a reflection of its content in the underlying volcanic rocks.

Cobaltite has similar chemical and spectral characteristics to pyrite and hence may be reflecting pyrite in this instance. It is typically encapsulated by the pyrite classes in this image. The greatest concentration is along the south edge of this spectral image and may be part of the zone of pyrite concentration noted below in the Figure 5c description.

Figures 5c – This is the same classification as in Fig 5b showing both pyrite classes separate from the other spectra. The #4 Pyrite distribution appears to be encapsulated within the #3 Pyrite. The pyrite spectral distribution is generally focused to the southwest of the uranium showings however there is an indication of northward trending zone of greater pyrite intensity (including both pyrites) extending into the area of the uranium mineralization.

Digital Elevation and Terrain models have been created and are included in the digital database provided with this submission but are not reproduced as part of this report as they do not add anything to the specific results displayed.

Conclusions

The rocks in the area are predominantly of igneous volcanic origin along with sparse sedimentary units. Uranium mineralization in the area is primarily of volcanogenic origin. A suite of igneous rocks and minerals and associated alteration products should produce the most likely and detectable spectral association. These rocks and associated minerals have shown up generally very low on the spectral reflectance ranking scale in comparison with less common and often more unusual or exotic rocks and minerals. This is thought to possibly be a result of masking of these primary minerals by other less abundant minerals which for some reason demonstrate stronger reflectance responses. The mineral or rocktype names presumed by the automatic comparison to spectral data library information are therefore not necessarily indicative of the actual rock or mineral association. Results of this preliminary examination are inconclusive. With the exception of the "Pyrite" distribution, there were few patterns that, either individually or collectively, clearly assist in the search for uranium mineralization on these claim blocks.

The spectral data is of good quality with minimal problems from atmospheric interference. Methodologies and software used for the screening and classification process are the best available. This therefore suggests that surface vegetative cover may be screening the spectral response of rock outcroppings to a greater extent than had been anticipated. This was evident in a number of plots where areas are being highlighted either positively or negatively by the spectral image created and are directly co-relatable to areas of trees or vegetation or cleared areas. It had been hoped that logged areas and road networks would be sufficient to allow some recognizable response. Specific mineral, rock type and alteration concentrations, related to the target minerals sought, may be too low or too discrete to provide a detectable response. The relief in some areas is significant and therefore perhaps may also have had a spectral screening effect. Quaternary sediments, including gravels and till cover are quite widespread over the area and, although generally thin on hillsides may also have contributed to the screening of the spectral response. Till has typically been derived from sources far from the locations examined and therefore is unlikely to have any spectral characteristics that might reflect underlying rocks or mineral deposits.

Other rock and mineral associations could have been examined in more detail however due to time constraints this Spectral Analysis has been primarily focused on uranium mineralization and its associated rock types. Some of the conclusions presented here must be regarded as tentative as there are many more in-depth tests that could have been applied if more time was available. Ground truthing could not be done as the area was snow covered by the time this data was available for review. The ground work has however been laid, including background research, in anticipation of further exploration in search of Uranium or other sources of mineralization on these properties. At this time it is recommended that further review of the spectral technique be done including some ground truthing before committing to additional spectral analysis studies. Wider satellite image coverage of the area should also be over the next year or so.

REFERENCES

Area Specific References

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<http://www.gisdevelopment.net/aars/acrs/1999/ps1/ps1225.shtml>

A total of 171 deposits have been studied by 66 persons for two years. In this study, we have summarized the elements of image interpretation and established six image-geology patterns, also reclassified into ten types. This research has verified the effect applying remote sensing image feature on study of geological ore-controlling environments and evolutions; and we have predicted 120 favorable areas.

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- j) **The US Geological Survey** has included in the seven tasks for its Remote Sensing (ASTER) Crustal Investigation and Characterization Team:

Task Six: Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Data for Mineral Resource Studies: Project sites investigated are related to uranium/molybdenum deposits <http://crustal.usgs.gov/projects/remote/#task6>

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FIGURES

Figure 1 – Location Map

Figure 2 – Claim Map

Figure 3 – Geology Map

Figures 4 – (Note – There are no Figures for this section)

Figures 5 – Rexaspar Project Area, Spectral Image Maps

5a –Igneous Association, “Diabase”

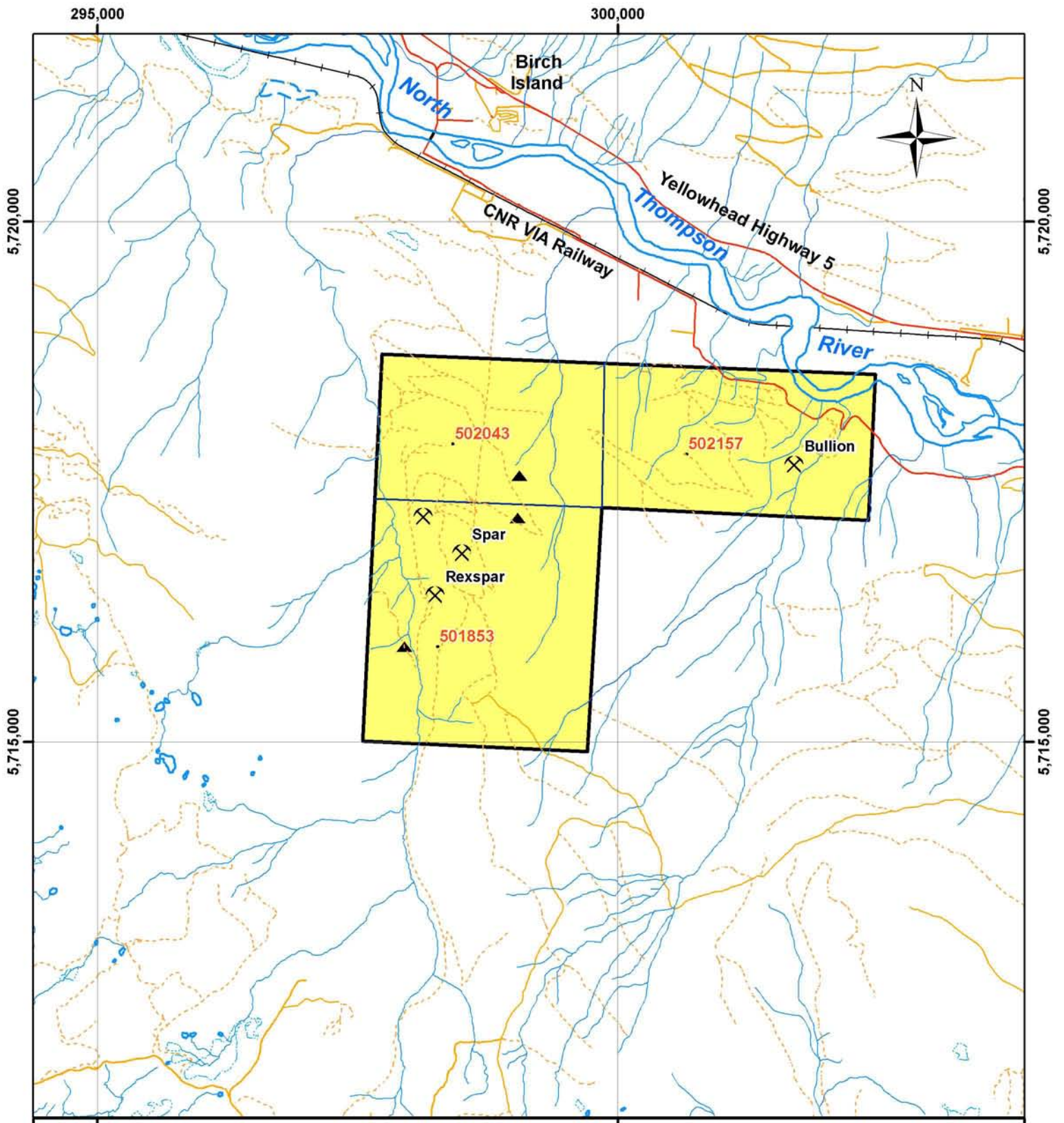
5b – Multi-Material Association, “Magnesiochromite-Pyrite-Cobaltite”

5c – Multi-Material Association, “Pyrite”



**Aldershot Resources Ltd
BC Uranium Project Areas
General Location Map**

Figure 1

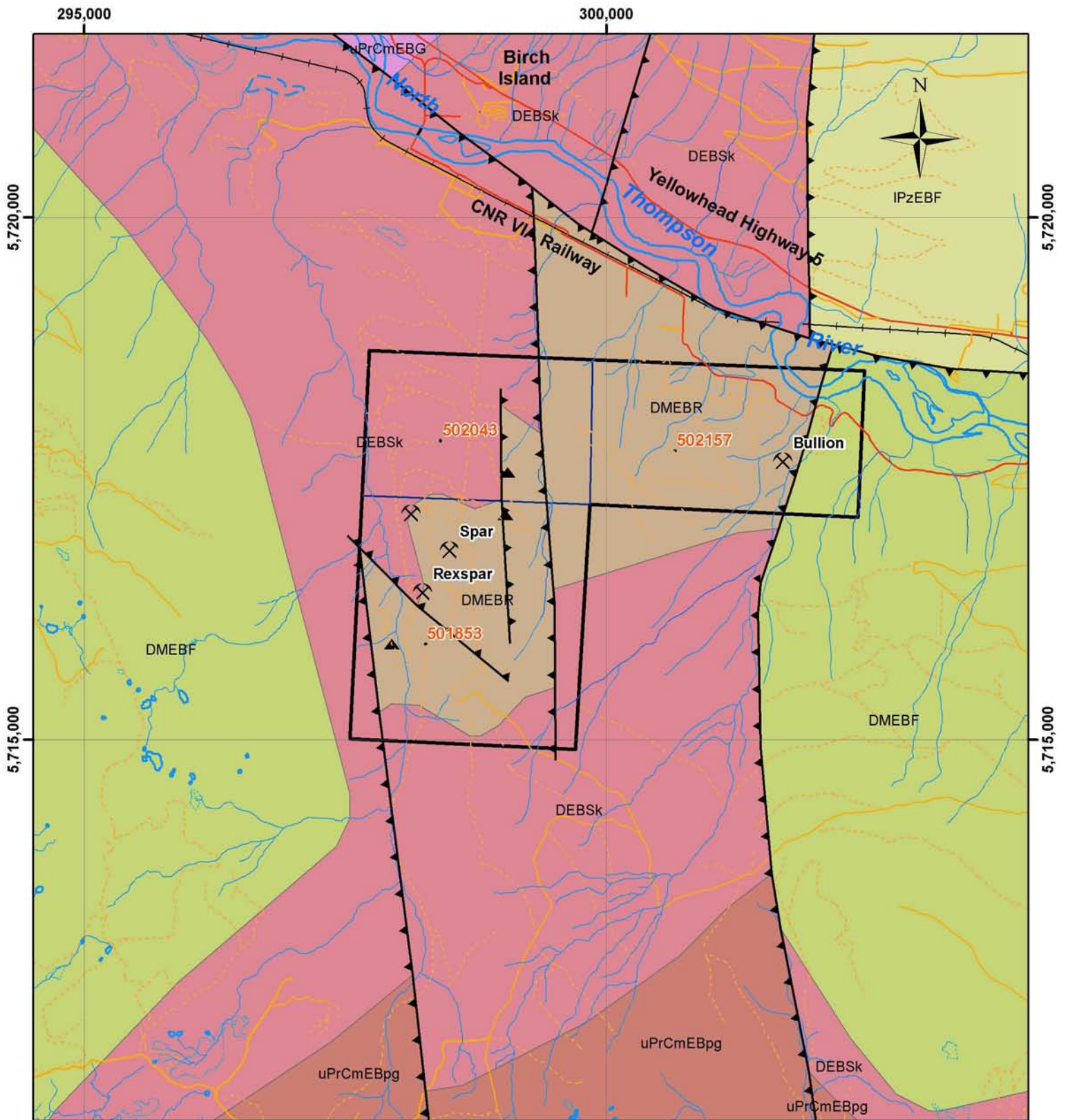


- Aldershot Claims
- Old Mine Working
- Uranium Showing
- Other Mineral Showing

ALDERSHOT RESOURCES LTD.

**Rexpar Area
Claims Location Map**

Mapping: <small>GLOBAL GEOMATICS LTD.</small>	Prepared By: RM Resource Management	Fig. 2
--------------------------------------------------	----------------------------------------	--------



Old Mine Working
 Uranium Showing
 Other Mineral Showing
 Fault Lines

Geology

- DEBSk - Paleozoic - Eagle Bay Assemblage - Skwaam Bay Unit calc-alkaline volcanic rocks
- DMEBF - Paleozoic - Eagle Bay Assemblage - Foghorn Mountain Unit andesitic volcanic rocks
- DMEBR - Paleozoic - Eagle Bay Assemblage - Rexspar Unit calc-alkaline volcanic rocks
- DPFL - Paleozoic - Fennell Assemblage - Lower Structural Division marine sedimentary and volcanic rocks
- Kqm - Mesozoic - Unnamed quartz monzonitic intrusive rocks
- MEBS - Paleozoic - Eagle Bay Assemblage - Slate Creek Unit mudstone, siltstone, shale fine clastic sedimentary rocks
- ICmEBJ - Paleozoic - Eagle Bay Assemblage - Johnson Lake Unit greenstone, greenschist metamorphic rocks
- ICmEBIm - Paleozoic - Eagle Bay Assemblage limestone, marble, calcareous sedimentary rocks
- IPzEBF - Paleozoic - Eagle Bay Assemblage - Forest Lake Unit greenstone, greenschist metamorphic rocks
- uPrCmEBG - Proterozoic to Paleozoic - Eagle Bay Assemblage - Graffunder Lakes Unit quartzite, quartz arenite sedimentary rocks
- uPrCmEBpg - Proterozoic to Paleozoic - Eagle Bay Assemblage paragneiss metamorphic rocks

1:50,000



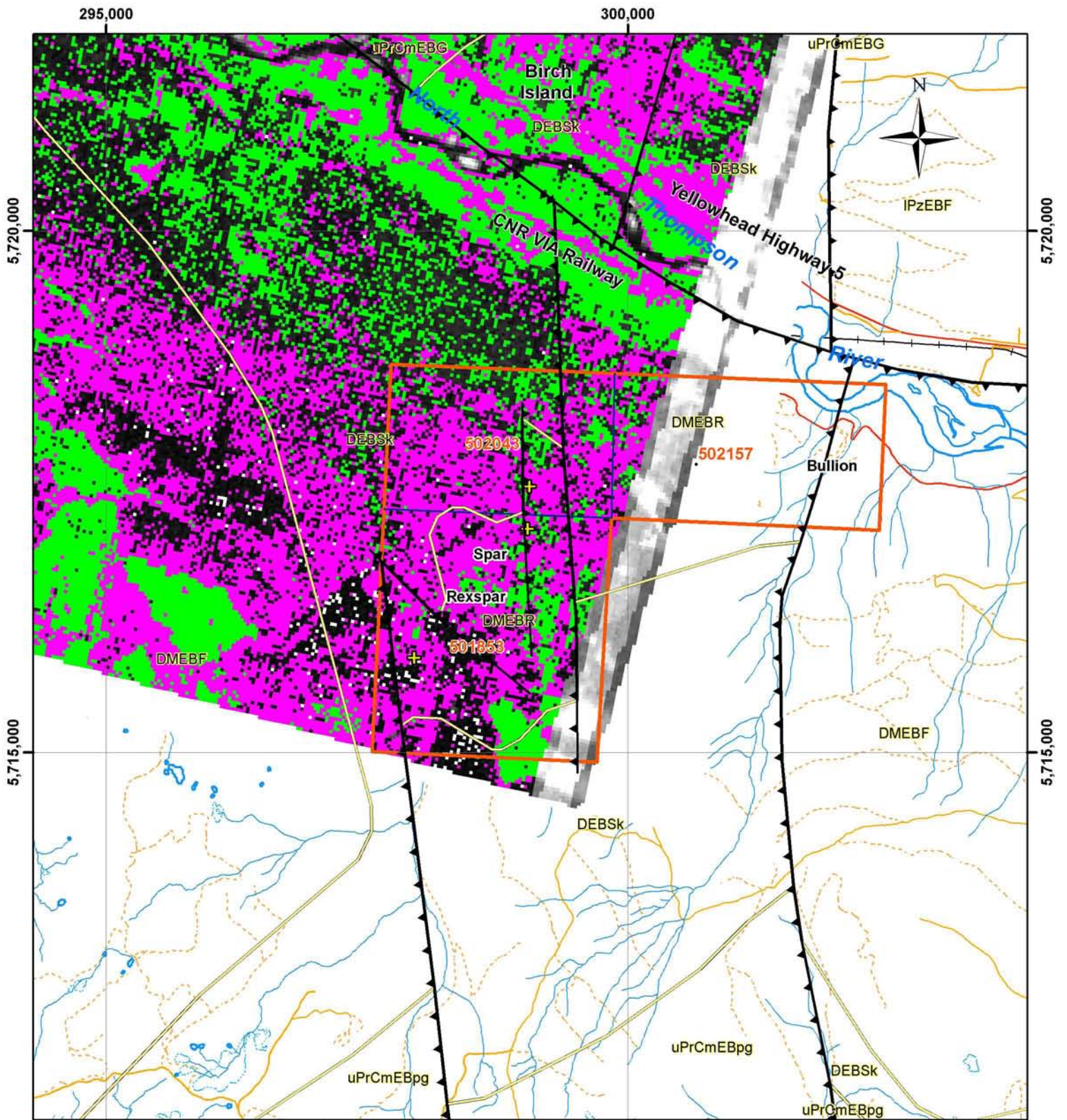
ALDRESHOT RESOURCES LTD.

**Rexpar Area
Geology Map**

Mapping:
GLOBAL GEOMATICS LTD.

Prepared By:
RM Resource
Management

Fig. 3



General Legend

- Aldershot Claims
- Geology Contacts *
- Uranium Showing
- Fault lines

Spectral Classification Legend

- "Igneous" Classes
- Mafic Diabase
 - Diabase



ALDRSHOT RESOURCES LTD.

**Rexpar Area
Spectral Image 15
"Diabase"**

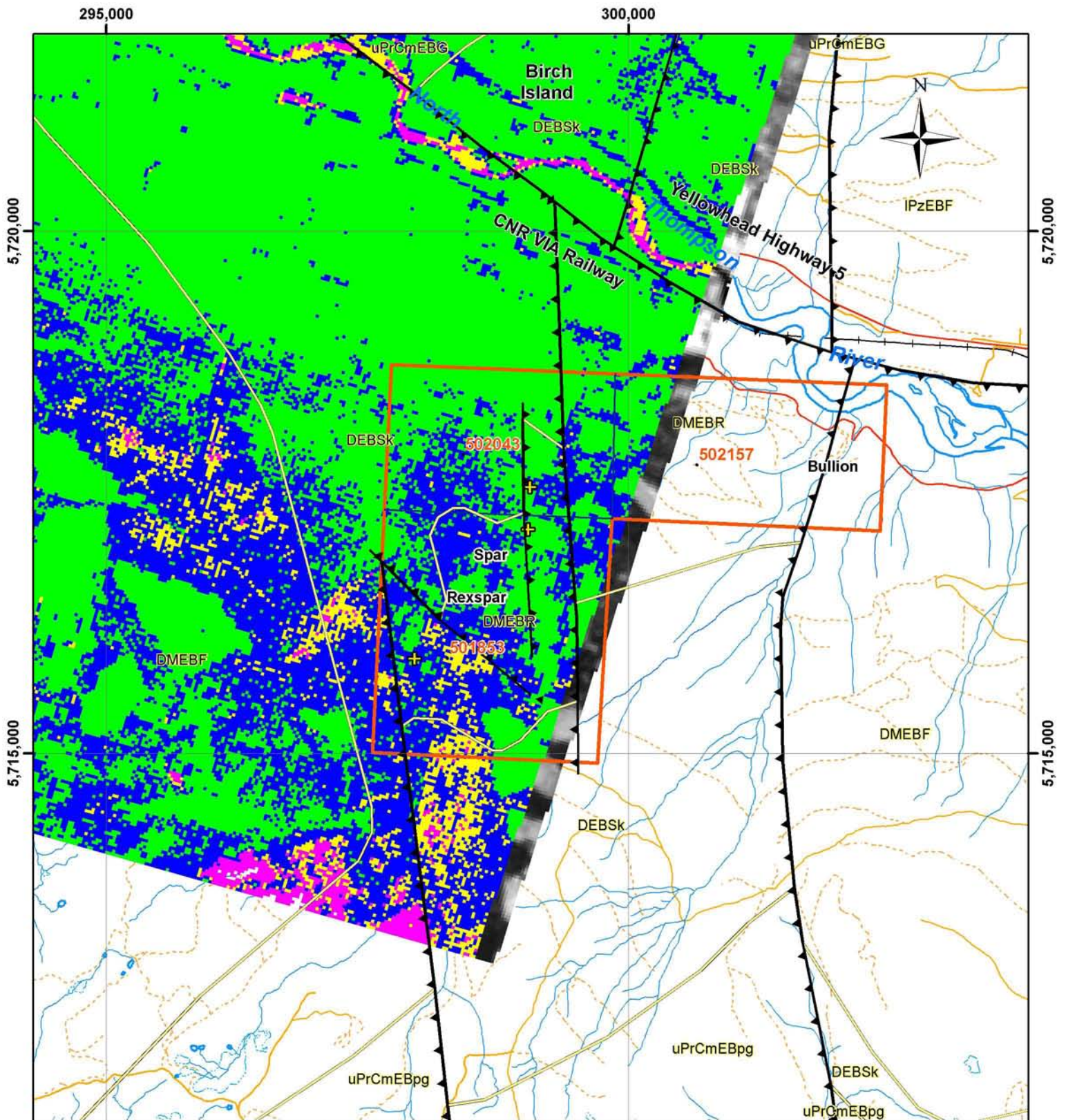
*Refer to Fig 3 for Unit Descriptions

Base Image digital file: 0624 b2-2 Prep 15

Mapping:
GLOBAL GEOMATICS LTD.

Prepared By:
RM Resource
Management

Fig. 5a



General Legend

- Aldershot Claims
- Geology Contacts *
- Uranium Showing
- Fault lines

Spectral Classification Legend

- Multi-Material Classes
- Magnesiochromite
 - Pyrite
 - Pyrite
 - Cobaltite



ALDRSHOT RESOURCES LTD.

**Rexpar Area
Spectral Image 20
"Magnesiochromite-Pyrite-Colbaltite"**

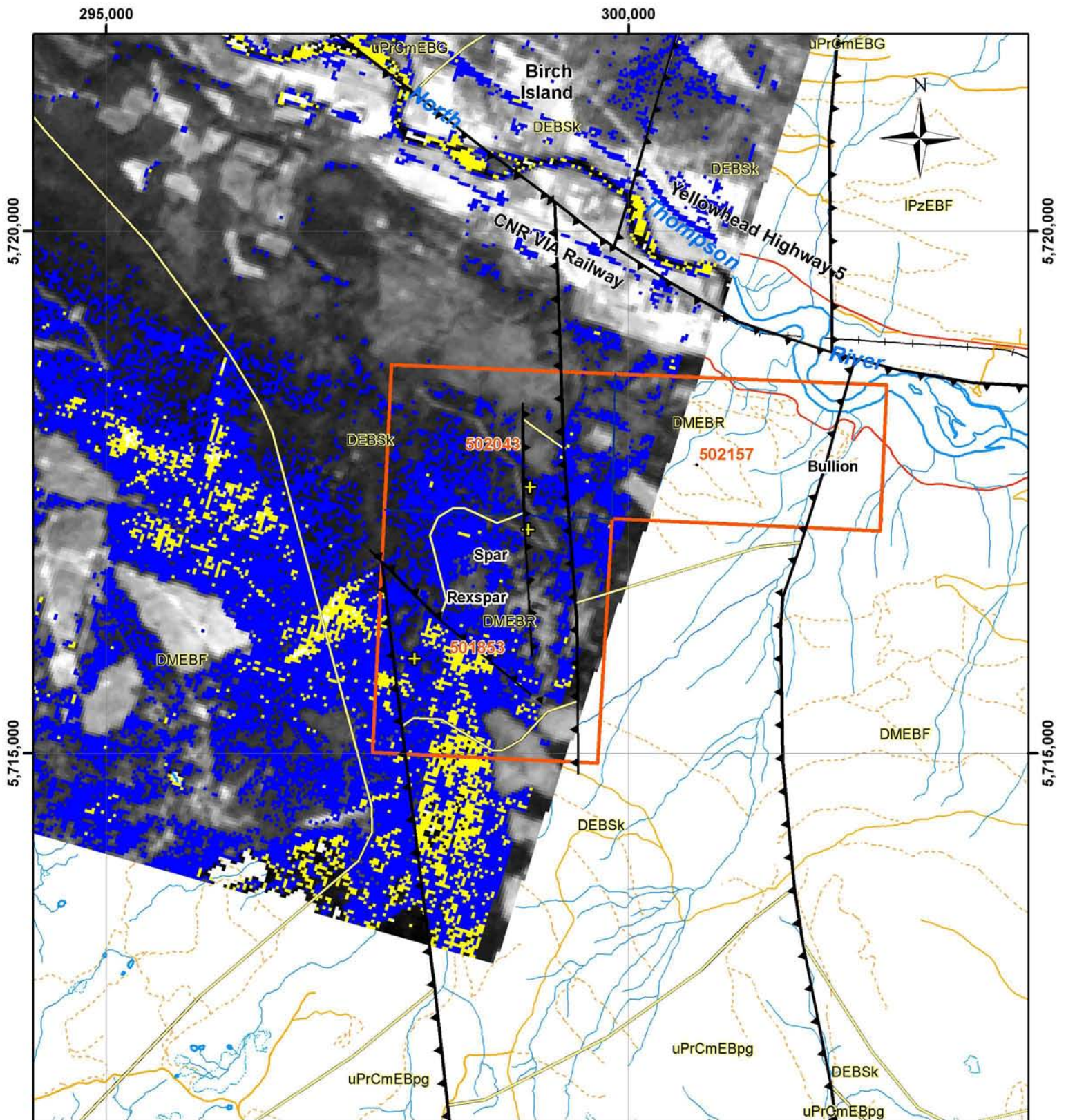
*Refer to Fig 3 for Unit Descriptions

Base Image digital file: 0624 band 2 base 4 Prep 20

Mapping:
GLOBAL GEOMATICS LTD.

Prepared By:
RM Resource
Management

Fig. 5b



General Legend

- Aldershot Claims
- Geology Contacts *
- + Uranium Showing
- Fault lines

Spectral Classification Legend
Multi-Material Classes

- Pyrite
- Pyrite



ALDERSHOT RESOURCES LTD.

**Rexpar Area
Spectral Image 21
"Pyrite"**

*Refer to Fig 3 for Unit Descriptions

Base Image digital file: 0624 band 2 base 4 Prep 21

Mapping:
GLOBAL GEOMATICS LTD.

Prepared By:
RM Resource
Management

Fig. 5c

APPENDIX I - Project Cost Report

- Total Assessment Work applicable costs for this project are:..... \$8,193.89

- Personnel and Work Periods are listed here while actual numbers of work days for each are shown on the following table. Work days associated with this project have been apportioned as part of a larger multi-property work program. Work was carried out intermittently on this project during the intervals shown below.
 - Project Manager – Alf Randall – Sept 1, 2005 – Jan 6, 2006
 - Manager Spectral Analysis – Dave McLelland – Sept 1, 2005 – Jan 6, 2006
 - Consulting Geologist – Marie Randall – Nov 9 & 10, 2005

- Costs such as Travel Communications and Field Equipment Rental have been apportioned from the overall Aldershot BC Uranium Project costs.

Aldershot Resources Ltd
BC Uranium Project
Assessment Work Cost Report
Project Area: Rexspar

Cost Categories		Project Costs				Total
		Units	Rate	No Units	By Item	
Technical Personnel						\$3,400.00
	Project Manager - A Randall	\$/Day (8 hr)	\$650	1.00	\$650.00	
	Spectral Analysis Manager - D. McLelland	\$/Day (8 hr)	\$550	5.00	\$2,750.00	
	Consulting Geologist	\$/Day (8 hr)	\$500			
	Other Consultants	\$/Day (8 hr)				
Travel						
	Lodging	Cost				
	Meals	Cost				
	Automobile	\$/Km	\$0.51			
	Ferry, Airfare etc					
Miscellaneous Costs						
	Materials and Supplies	Cost				
	Freight	Cost				
Communications						\$24.34
	Telephone	Project Cost	\$519.71	3%	\$15.59	
	Internet	Project Cost	\$291.53	3%	\$8.75	
Field Equipment Rental						
	4X4 Truck	\$/Day	\$200			
	ATV	\$/Day	\$100			
	Aircraft					
Technical Equipment Rental						\$600.00
	Computer 1- Spectral Analysis Mgr	\$/Hr	\$25	15	\$375.00	
	Computer 2 - Spectral Analysis Mgr	\$/Day	\$25			
	Portable Computer - Spectral Analysis Mgr	\$/Day	\$25			
	Computer 1- Project Mgr	\$/Day	\$25	3	\$75.00	
	Computer 2 - Project Mgr	\$/Day	\$25			
	Portable Computer - Project Mgr	\$/Day	\$25			
	Software Rental	\$/Day	\$25	6	\$150.00	
	GPS 1	\$/Day	\$20			
	GPS 2	\$/Day	\$20			
Sample Analyses						
	Rock Sample Preparation	\$/Sample				
	Soil/Silt Sample Preparation	\$/Sample				
	Rock Samples Analyses (incl prep)	\$/Sample	\$18.83			
	Soil Samples Analyses (incl prep)	\$/Sample	\$26.76			
	Stream Sediment Sample Analyses (incl prep)	\$/Sample	\$26.76			
Data Acquisition and Reformating						\$1,455.80
	Spectral Data Reformating	\$/Day (8 hr)	\$550	1	\$550.00	
	Spectral Data Granule Acquisition	\$/Granule	\$105.80	1	\$105.80	
	Trim Map Acquisition Costs	\$/Sheet	\$400.00	2	\$800.00	
Map & Report Preparation						\$2,713.75
	Report Preparation	\$/Day	\$650	2.00	\$1,300.00	
	Mapping Contractor	Cost	\$1,380.00	1	\$1,380.00	
	Printing & Copying	\$/Page	\$0.45	75	\$33.75	
Total Assessment Work Applicable Costs						\$8,193.89
Assessment Work Filing Fees						
	Assessment Filing Fees	\$/Hectare	\$0.40	1165.288	\$466.12	
Total Non Assessment Work Applicable Costs						\$466.12
Total Project Cost						\$8,660.00

APPENDIX II - Statements of Qualification

A W Randall – Project Manager

D McLelland – Manager Spectral Analysis

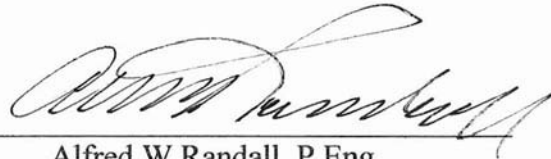
M R Randall – Consulting Geologist

Statement of Qualification

I, **Alfred W Randall, P.Eng.** do hereby certify that:

1. I am currently self-employed as a Consulting Geological Engineer by:
A. W. Randall Geological Engineering,
399 Dorset Road, Qualicum Beach,
British Columbia, Canada, V9K 1H5
2. I graduated with a BASc degree in Geological Engineering from the University of British Columbia in 1972.
3. I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia.
4. I have applied my skills as Geologist, and Geological/Mining Engineer for 32 years since graduating from university.
5. I am the Project Manager and am responsible for the preparation of this report. I visited the property during the period October 15-20, 2005.
6. This report was prepared on behalf of RM Resource Management Ltd who has been engaged by Aldershot Resources Ltd to complete a work program on these properties.
7. I have no material or financial interest in the subject properties or the companies owning them.
8. This report has been prepared in accordance with generally accepted geological and engineering practices. It is based upon the best information available at the time of preparation. I am not aware of any material fact or material change with respect to the subject matter of the report that is not reflected in the report and therefore the omission of which makes the report misleading.

Signed: _____



Alfred W Randall, P.Eng

Dated: January 3, 2006

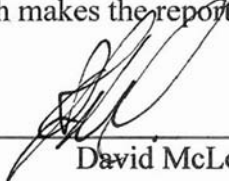
Qualicum Beach, British Columbia



Statement of Qualification

I, **David J. McLelland** do hereby certify that:

1. I am self employed as a Geospatial Analyst by:
McLelland Geospatial Science,
325 Dorset Road Qualicum Beach,
British Columbia, Canada V9K 1H5
2. I am a post graduate student of Geographic Science and have completed the post-graduate certificate in applied and theoretical GIS at Simon Fraser University, and completed the academic component of the MSc. program requirement. That this work is also in partial fulfillment and serves as base data for a thesis in Geospatial Science.
3. I have completed the B.C.I.T. /B.C.Y.C.M. Mineral Exploration program, and Completed the B.C.I.T./ B.C.Y.C.M. Advanced field School.
4. I am the Spectral Analysis Manager and I am responsible for the management of data and execution of analysis.
5. This report was prepared on behalf of RM Resource Management Ltd. who has been engaged by Aldershot resources Ltd. to complete an work program on these properties.
6. I have no material or financial interest in the subject properties or the companies that own them.
7. This report has been prepared in accordance with generally accepted Scientific Principles and is based upon the best information available at the time of preparation. I am not aware of any material fact or material change with respect to the subject matter of the report that is not reflected in the report and therefore the omission of which makes the report misleading.

Signed: 
David McLelland


Date: : January 3, 2006

Qualicum Beach, British Columbia

Statement of Qualification

I, Marie R Randall, do hereby certify that:

9. I am currently self-employed as a Consulting Geologist residing at
399 Dorset Road, Qualicum Beach,
British Columbia, Canada V9K 1H5
10. I graduated with a B.Sc. degree in Geology from Queens University in Kingston Ontario in 1975.
11. I have applied my skills as Geologist on and off for 25 years since graduating from university.
12. I assisted in the field work and report preparation associated with this project. I visited the property during the period October 16-20, 2005.
13. This report was prepared on behalf of R M Resource Management Ltd who has been engaged by Aldershot Resources Ltd to complete an work program on these properties.
14. I have no material or financial interest in the subject properties or the companies owning them.

Signed: 
Marie R Randall

Date: January 3, 2006

APPENDIX III - Spectral Image Digital Data Index

Rexspar Project Area

ASTER File No.	Prep No.	Fig No.	Base Image Composition	Spectral Library	Classification Group Displayed	No. of Matches	Unique Classes Identified
L1B.0624	15	5a	0624, band2 base4 (SWIR 1) Greyscale	USGS	Igneous Suite "Diabase"	6	4
L1B.0624	20	5b	0624 band2 base4 (SWIR 1) Greyscale	USGS JHU,IG CP, JPL	Multi-Material Suite "Magnesio-chromite+pyrite+Cobaltite"	6	4
L1B.0624	21	5c	0624 band2 base4 (SWIR 1) Greyscale	USGS	Multi-Material Suite "Pyrite "	6	4

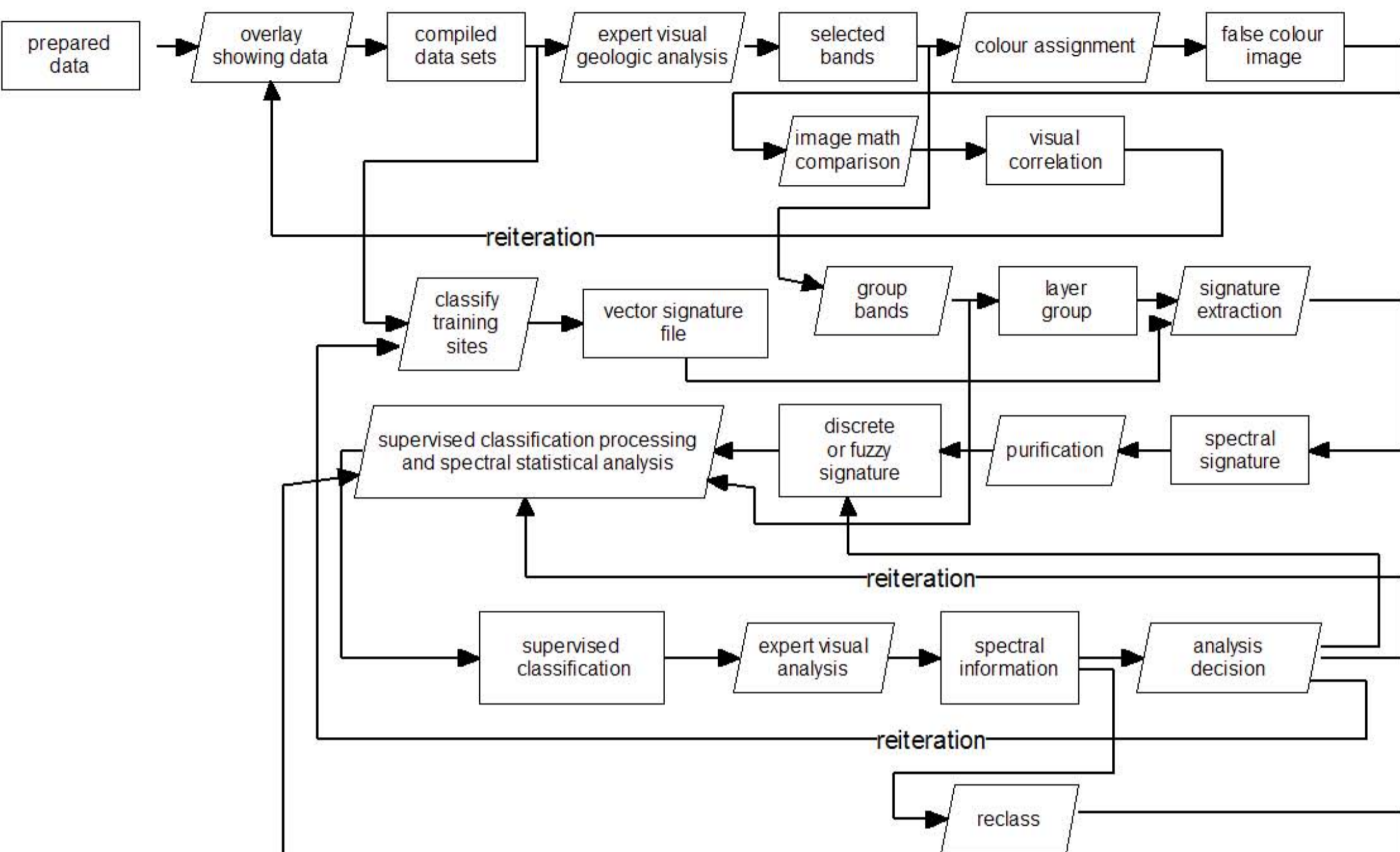
Definitions of Digital Terms Used:

- ASTER File No. = Digital file number of the original Satellite "granule" used for this spectral analysis
- Prep No. = Number assigned to preliminary output and associated description files.
- Figure No. = Number of output Figures in report.
- Base Image Composition = Spectral Information used in construction of the displayed data. Includes Spectral Band number, Band Width number, and other identifying information.
- Classification Group Displayed = Mineral, Rock or other specific material suites from Spectral Libraries used in this classification
- Multi Material – Refers to classifications using all spectral libraries and material suites collectively including all the above classes as well as Soils, Vegetation, Water, Snow etc
- USGS etc = Library(s) Used in classification comparisons
- No. Matches = Number of specific items identified in the classification process
- Unique Classes = Number of different items identified (ie non-duplicates)
- SWIR =Short Wave Infrared
- SAM Class Rule = Spectral Angle Mapping Classification uses the n-dimensional angle to match pixels to reference spectra. This algorithm determines the spectral similarity between two spectra by calculating the angle between the spectra, treating them as vectors in a space with dimensionality equal to the number of bands of a single Rule (Formula) in this case is a mean value
- Mean = Mean value derived from a scatter gram or a semi-variogram distribution of Spectral DN's
- n-D = n-dimensional

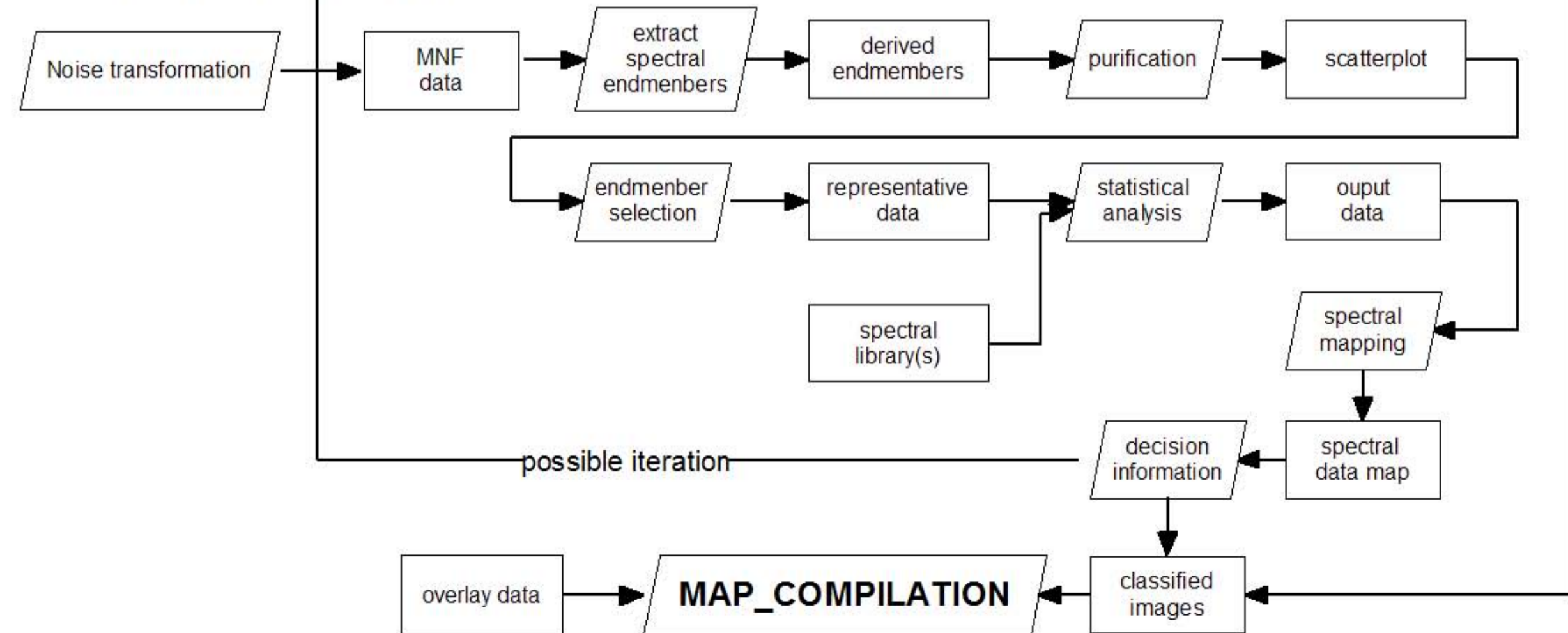
APPENDIX IV - Spectral Analysis Flow Chart

Spectral Analysis Data Management Flow Chart

SUPERVISED CLASSIFICATION



UNSUPERVISED CLASSIFICATION



APPENDIX V

SPECTRAL IMAGE ANALYSIS – TECHNICAL DISCUSSION

Remote Sensing Overview..... i

Spectral Image Noise Effects..... iii

Spectral Data Libraries..... iii

Spectral Analysis Data Extraction, Signature Determination, and
Spectral Matching Methods..... iv

Spectral Data Classification..... vi

Geological Applications of Spectral Analysis..... ix

Data Sources and Software..... xi

Data Presentation and Storage..... xii

Computer Hardware Requirements..... xiii

Conclusions..... xiii

APPENDIX VI

SPECTRAL IMAGE ANALYSIS - TECHNICAL DISCUSSION

(From Krause ^a, Micro Images ^b and NRCAN ^c)

Remote Sensing Overview

Remote Sensing is the science and art of acquiring information (spectral, spatial, and temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation. Without direct contact, some means of transferring information through space must be utilized. In remote sensing, information transfer is accomplished by use of electromagnetic radiation (EMR). EMR is a form of energy that reveals its presence by the observable effects it produces when it strikes the matter. Types of EMR response with respect to type of energy sources and with respect to wavelengths are as follows:

1. In respect to the type of Energy Resources:
 - Passive Remote Sensing: Makes use of sensors that detect the reflected or emitted electro-magnetic radiation from natural sources.
 - Active remote Sensing: Makes use of sensors that detect reflected responses from objects that are irradiated from artificially-generated energy sources, such as radar.
2. In respect to the wavelength, Remote Sensing is classified into three types:
 - Visible and Reflective Infrared
 - Thermal Infrared
 - Microwave

Spectroscopy is the study of light that is emitted by or reflected from materials and its variation in energy with wavelength. As applied to the field of optical remote sensing, spectroscopy deals with the spectrum of sunlight that is diffusely reflected (scattered) by materials at the earth's surface. Instruments called spectrometers (or spectroradiometers) are used to make ground-based or laboratory measurements of the light reflected from a test material. An optical dispersing element such as a grating or prism in the spectrometer splits this light into many narrow, adjacent wavelength bands and the energy in each band is measured by a separate detector. By using hundreds or even thousands of detectors, spectrometers can make spectral measurements of bands as narrow as 0.01 micrometers over a wide wavelength range, typically at least 0.4 to 2.4 micrometers (visible through middle infrared wavelength ranges).

Remote imagers are designed to focus and measure the light reflected from many adjacent areas on the earth's surface. In many digital imagers, sequential measurements of small areas are made in a consistent geometric pattern as the sensor platform moves and subsequent processing is required to assemble them into an image. Until recently, imagers were restricted to one or a few relatively broad wavelength bands by limitations of detector designs and the requirements of data storage, transmission, and processing. Recent advances in these areas have allowed the design of imagers that have spectral ranges and resolutions comparable to ground-based spectrometers.

In reflected-light spectroscopy the fundamental property that we want to obtain is *spectral reflectance*: the ratio of reflected energy to incident energy as a function of wavelength. Reflectance varies with wavelength for most materials because energy at certain wavelengths is scattered or absorbed to different degrees. These reflectance variations are displayed as spectral reflectance curves (plots of reflectance versus wavelength) for different materials. The overall shape of a spectral curve and the position and strength of absorption bands in many cases can be used to identify and discriminate different materials. For example, vegetation has higher reflectance in the near infrared range and lower reflectance of red light than soils. The configuration of spectral reflectance curves provides insight into the characteristics of an object and has a strong influence on the choice of wavelength region(s) in which remote sensing data are acquired for a particular application.

Multispectral remote sensors such as the Landsat Thematic Mapper produce images with a few relatively broad wavelength bands and consequently drastically under sample the information content available from a reflectance spectrum by making only a few measurements in spectral bands up to several hundred nanometers wide. Hyperspectral remote sensors, on the other hand, collect image data simultaneously in dozens or hundreds of narrow, adjacent spectral bands. These measurements make it possible to derive a continuous spectrum for each image cell. After adjustments for sensor, atmospheric, and terrain effects are applied, these image spectra can be compared with field or laboratory reflectance spectra in order to recognize and map surface materials such as particular types of vegetation or rock types or diagnostic minerals associated with ore deposits.

Imaging spectrometers or Hyperspectral Sensors collect unique data that are both a set of spatially contiguous spectra and a set of spectrally contiguous images. These data have been available since 1983 however they are just now achieving widespread use, primarily due to a number of complicating factors related to the maturity of the field. Issues that have slowed acceptance and use of Hyperspectral data include: lack of high quality data sets for most areas of interest, inadequate correction for sensor and atmospheric effects, availability and suitability of specific analysis software, and the relative paucity of well-trained scientists to analyze the data.

High-quality Hyperspectral data is now available from aircraft systems, as well as global coverage from satellite systems. Data is now readily available for most areas of the planet. Most modern image processing systems can handle the high number of spectral bands however new algorithms are under development which will dramatically improve speed and quality of output. Publicly available atmospheric correction software makes it possible to use these data without a priori knowledge and finally sophisticated analysis software allows even scientists new to Hyperspectral analysis to derive useful information from this data.

Hyperspectral images contain a wealth of data, but interpreting them requires an understanding of exactly what properties of ground materials we are trying to measure,

and how they relate to the measurements actually made by the Hyperspectral sensor.

Spectral Image Noise Effects

Atmospheric Effects - Even a relatively clear atmosphere interacts with incoming and reflected solar energy. For certain wavelengths these interactions reduce the amount of incoming energy reaching the ground and further reduce the amount of reflected energy reaching an airborne or satellite sensor. The transmittance of the atmosphere is reduced by absorption by certain gases and by scattering by gas molecules and particulates. These effects combine to produce the transmittance curve. The pronounced absorption features near 1.4 and 1.9 μm , caused by water vapor and carbon dioxide, reduce incident and reflected energy almost completely, so little useful information can be obtained from image bands in these regions. This curve does not however show the effect of light scattered upward by the atmosphere. This scattered light adds to the radiance measured by the sensor in the visible and near-infrared wavelengths, and is called *path radiance*. Atmospheric effects may also differ between areas in a single scene if atmospheric conditions are spatially variable or if there are significant ground elevation differences that vary the path length of radiation through the atmosphere. Many atmospheric correction algorithms are now available to handle this “noise effect” and the corrections are virtually invisible to the user as they are done before receipt of spectral data packages.

Sensor Effects & Data Noise - A sensor converts detected radiance in each wavelength channel to an electric signal which is scaled and quantized into discrete integer values that represent encoded radiance values. Variations between detectors within an array, as well as temporal changes in detectors, may require that raw measurements be scaled and/or offset to produce comparable values. Data noise management includes making periodic comparisons with original data to ensure integrity and completeness after manipulations and modifications.

Spectral Data Libraries

Several libraries of reflectance spectra of natural and man-made materials are available for public use. These libraries provide a source of reference spectra that can aid the interpretation of Hyperspectral and Multispectral images. Each library is composed of a series of sub-libraries that list spectral data for a variety of materials that has been produced by various techniques and sorted into equivalent groupings. Each library needs to be reviewed to determine which data matches characteristics of the material (minerals or rocks) that are being sought or expected in the target areas and which are comparable to the type of spectral response reproduced in the images being used. Some of the libraries used in this work program are listed below.

ASTER Spectral Library - This library has been made available by NASA as part of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imaging instrument program. It includes spectral compilations from NASA’s Jet Propulsion Laboratory (JPL), Johns Hopkins University (JHU), and the United States Geological Survey. The ASTER spectral library currently contains nearly 2000 spectra, including minerals, rocks, soils, man-made materials, water, and snow. Many of the spectra cover the entire wavelength region from 0.4 to 25 μm . You can search for spectra by category, view a spectral plot for any of the retrieved spectra, and download the data for individual spectra.

USGS Spectral Library - The United States Geological Survey Spectroscopy Lab in Denver, Colorado has compiled a library of over 800 reflectance spectra that covers the ultraviolet to near-infrared region of the electromagnetic spectrum over the wavelength range from 0.2 to 3.0 μm . Along with sample documentation, the library includes spectral responses of minerals, rocks, soils, physically constructed as well as mathematically computed mixtures, vegetation, microorganisms, and man-made materials. The samples and spectra collected were assembled for the purpose of using spectral features for the remote detection of these and similar materials.

Johns Hopkins University Spectral Index Database – This library contains additional spectral image data to that available in the libraries listed above.

ICGP (Institute for Chemistry and Dynamic of the Geosphere) spectral library.

Collectively these libraries include approximately 25 sub-libraries of spectral data which contain approximately 625,000 individual spectra for use in comparison with and classification of spectra derived from satellite images.

Spectral Analysis Data Extraction, Signature Determination and Spectral Matching Methods

Analysis of imaging spectrometer data allows extraction of a detailed spectrum for each picture element (pixel) of the image. High spectral resolution reflectance spectra collected by imaging spectrometers allow direct identification (and in some instances, abundance determinations) of individual materials based upon their reflectance characteristics including minerals, atmospheric constituent gases, vegetation, snow and ice, and dissolved and suspended constituents and water quality in lakes and other water bodies and the near-shore environment

The critical step in most imaging spectrometer data analysis strategies is to convert the data to reflectance so that individual spectra can be compared directly with laboratory or field data for identification. This requires that accurate wavelength calibration be performed. Laboratory measurements made before and after data acquisition usually provide the initial wavelength calibration. An additional check on the wavelength calibration can be made by comparing the positions of known atmospheric absorption features to their locations in the imaging spectrometer data. Atmospheric carbon dioxide absorption bands located at 2.005, and 2.055 μm are useful for wavelength-calibration of the data in the shortwave infrared. In the visible and near-infrared portion of the spectrum, narrow atmospheric water bands at 0.69, 0.72, and 0.76 μm can be used to calibrate wavelengths.

In order to directly compare Hyperspectral image spectra with reference reflectance spectra, the encoded radiance values in the image must be converted to reflectance. A comprehensive conversion must account for the solar source spectrum, lighting effects due to sun angle and topography, atmospheric transmission, and sensor gain. In mathematical terms, the ground reflectance spectrum is multiplied (on a wavelength per wavelength basis) by these effects to produce the measured radiance spectrum. Methods for detecting a target spectrum against a background of unknown spectra are often

referred to as matched filters, a term borrowed from radio signal processing. Various matched filtering algorithms have been developed, including orthogonal subspace projection and constrained energy minimization. All of these approaches perform a mathematical transformation of the image spectra to accentuate the contribution of the target spectrum while minimizing the background. In a geometric sense, matched filter methods find a projection of the n-dimensional spectral space that shows the full range of abundance of the target spectrum but hides the variability of the background. In most instances the spectra that contribute to the background are unknown, so most matched filters use statistical methods to estimate the composite background signature from the image itself. Some methods only work well when the target material is rare and does not contribute significantly to the background signature. A modified version of matched filtering uses derivatives of the spectra rather than the spectra themselves, which improves the matching of spectra with differing overall brightness.

Some Hyperspectral image applications do not require finding the fractional abundance of all endmember components in the scene. Instead the objective may be to detect the presence and abundance of a single target material. In this case a complete spectral unmixing is unnecessary. Each pixel can be treated as a potential mixture of the target spectral signature and a composite signature representing all other materials in the scene. Finding the abundance of the target component is then essentially a partial unmixing problem.

The shape of a reflectance spectrum can usually be broken down into two components: broad, smoothly changing regions that define the general shape of the spectrum and narrow, trough-like absorption features. This distinction leads to two different approaches to matching image spectra with reference spectra. Many pure materials, such as minerals, can be recognized by the position, strength (depth), and shape of their absorption features. One common matching strategy attempts to match only the absorption features in each candidate reference spectrum and ignores other parts of the spectrum. A unique set of wavelength regions is therefore examined for each reference candidate, determined by the locations of its absorption features. The local position and slope of the spectrum can affect the strength and shape of an absorption feature, so these parameters are usually determined relative to the continuum: the upper limit of the spectrum's general shape. The continuum is computed for each wavelength subset and removed by dividing the reflectance at each spectral channel by its corresponding continuum value. Absorption features can then be matched using a set of derived values (including depth and the width at half-depth), or by using the complete shape of the feature. These types of procedures have been organized into an expert system by researchers at the U.S. Geological Survey Spectroscopy Lab.

Many other materials, such as rocks and soils, may lack distinctive absorption features. These spectra must be characterized by the overall shape of their spectral curve. Matching procedures utilize full spectra (omitting noisy image bands severely affected by atmospheric absorption) or a uniform wavelength subset for all candidate materials. One approach to matching seeks the spectrum with the minimum difference in reflectance (band per band) from the image spectrum (quantified by the square root of the sum of the

squared errors). Another approach treats each spectrum as a vector in spectral space and finds the reference spectrum making the smallest angle with the observed image spectrum.

Linear unmixing is an alternative approach to simple spectral matching. Its underlying premise is that a scene includes a relatively small number of common materials with more or less constant spectral properties. Furthermore, much of the spectral variability in a scene can be attributed to spatial mixing, in varying proportions, of these common endmember components. If we can identify the endmember spectra, we can mathematically unmix each pixels spectrum to identify the relative abundance of each endmember material. The unmixing procedure models each image spectrum as the sum of the fractional abundances of the endmember spectra, with the further constraint that the fractions should sum to 1.0. The best-fitting set of fractions is found using the same spectral-matching procedure as described previously. A fraction image for each endmember distills the abundance information into a form that is readily interpreted and manipulated. An image showing the residual error for each pixel helps identify parts of the scene that are not adequately modeled by the selected set of endmembers.

The challenge in linear unmixing is to identify a set of spectral endmembers that correspond to actual physical components on the surface. Endmembers can be defined directly from the image using field information or an empirical selection technique. Alternatively, endmember reflectance spectra can be selected from a reference library, but this approach requires that the image has been accurately converted to reflectance.

Variations in lighting can be included directly in the mixing model by defining a shade endmember that can mix with the actual material spectra. A shade spectrum can be obtained directly from a deeply shadowed portion of the image. In the absence of deep shadows, the spectrum of a dark asphalt surface or a deep water body can approximate the shade spectrum.

Spectral Data Classification

Organizing spectral data into useful bits of information requires a sorting or “classification” system. There are two types of classification, Unsupervised and Supervised.

In an *Unsupervised Classification*, the objective is to group multiband spectral response patterns into clusters that are statistically separable. The pixels in an image are examined by the computer and grouped into spectral classes. This grouping is based solely on the numerical information in the data and the spectral classes are later matched by the analyst to information classes. In order to create an Unsupervised Classification the analyst typically determines the number of spectral classes to identify and a computer algorithm will find pixels with similar spectral properties and group them accordingly. Each of the spectral classes in an image are assigned a gray tone value ranging from black to white, with intermediate shades of gray. Programs, called clustering algorithms, are used to determine the statistical groupings in the data. Usually, the analyst specifies how the initial classification should proceed. In addition to specifying the desired number of

classes, the analyst may specify parameters to determine how close pixels' digital numbers (DN's – see definition below) must be to be considered in the same class. Once the clustering process has run, the analyst may want to combine or further break down some clusters. Thus, unlike its name suggests, an unsupervised classification often requires interaction with an analyst.

Supervised Classification is essentially the opposite of Unsupervised Classification in that the interpreter knows beforehand what classes are present and where each is in one or more locations within the scene. These are located on the image and then areas containing examples of the class are circumscribed making them Training Sites (see definition below). The determination of training sites is based on the analyst's knowledge of the geographical region and the surface cover types present in the image. Once the training sites have been established, the numerical information in the entire image's spectral bands are used to define the spectral "signature" of each class. Once the computer has determined the signatures for each class, it will compare every pixel to the signatures and label it as the class that it is mathematically closest to. Instead of clusters then, one has class groupings with appropriate discriminant functions that distinguish each (it is possible that more than one class will have similar spectral values but unlikely when more than 3 bands are used because different classes or materials seldom have similar responses over a wide range of wavelengths). All pixels in the image lying outside training sites are then compared with the class discriminants, with each being assigned to the class it is closest to. This makes a map of established classes with a few pixels usually remaining unknown.

Various classification or comparison methods are available to determine if a specific pixel qualifies as a class member including Parallelepiped, Maximum Likelihood, Minimum Distance, Mahalanobis Distance, Binary Encoding, and Spectral Angle Mapper are available to sort the data. In the analysis done for this project Maximum Likelihood, Spectral Angle Mapper (SAM), Spectral Unmixing and Mixture Matched Filtering were most commonly used techniques.

Maximum Likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless a probability threshold is selected, all pixels are classified. Each pixel is assigned to the class that has the highest probability (i.e., the "maximum likelihood").

The *Spectral Angle Mapper (SAM)* is a physically-based spectral classification that uses the n-dimensional angle to match pixels to reference spectra. The algorithm determines the spectral similarity between two spectra by calculating the angle between the spectra, treating them as vectors in a space with dimensionality equal to the number of bands. Small angles between the two spectrums indicate high similarity and high angles indicate low similarity. Spectral Angle Mapping (SAM) - This algorithm takes as input a number of "training classes" or reference spectra from ASCII files, ROIs (Regions of Interest), or spectral libraries. It calculates the angular distance between each spectrum in the image and the reference spectra or "endmembers" in n-dimensions (see definition below). The

result is a classification image showing the best SAM match at each pixel and a "rule" image for each endmember showing the actual angular distance in radians between each spectrum in the image and the reference spectrum. Darker pixels in the rule images represent smaller spectral angles, and thus spectra that are more similar to the reference spectrum. The rule images can be used for subsequent classifications using different thresholds to decide which pixels are included in the SAM classification image.

Spectral Unmixing weighs membership in classifications against imposed constraints. Geologic surfaces are rarely composed of a single uniform material, thus it is necessary to use mixture modeling to determine what materials cause a particular spectral "signature" in imaging spectrometer data. In order to determine the abundances, we must first determine what materials are mixing together to give us the spectral signature measured by the instrument. Selection of "endmembers" is the most difficult part of linear spectral unmixing. The ideal spectral library used for unmixing consists of endmembers that when linearly combined can form all other observed spectra. The endmember library defined using the n-dimensional visualization procedure is used in the unmixing process and abundance estimates were made for each mineral.

Mixture Matched Filtering creates and measures statistical covariance in pure pixel populations. It provides a rapid means of detecting specific minerals based on matches to specific library or image endmember spectra. This technique produces images similar to the unmixing as described above, but with significantly less computation. Matched filter results are presented as gray-scale images with values from 0 to 1.0, which provide a means of estimating relative degree of match to the reference spectrum (where 1.0 is a perfect match).

Supervised classification is much more accurate for mapping classes, but depends heavily on the cognition and skills of the image specialist. The strategy is simple: the specialist must recognize conventional classes (real and familiar) or meaningful (but somewhat artificial) classes in a scene from prior knowledge, such as, personal experience with the region, by experience with thematic maps, or by on-site visits. This familiarity allows the specialist to choose and set up discrete classes (thus supervising the selection) and then assign them category names. Thus, in a supervised classification, the analyst starts with information classes and uses these to define spectral classes. Each pixel in the image is then assigned to the class which it most closely resembles.

Training sites are areas representing each known land cover category that appear fairly homogeneous on the image (as determined by similarity in tone or color within shapes delineating the category). Specialists locate and circumscribe them with polygonal boundaries drawn on the image display. For each class thus outlined, mean values and variances of the DN's (See definition below) for each band used to classify them are calculated from all the pixels enclosed in the site. More than one polygon can be established for any class.

Digital Number (DN) or spectral vector is a value assigned to a pixel in a digital image. It is a mathematically calculated measure of light intensity or electromagnetic radiance

from the pixel. When DN's are plotted as a function of the band sequence (increasing with wavelength), the result is a *spectral signature* or spectral response curve for that class. In reality the spectral signature is for all of the materials within the site that interact with the incoming radiation.

n-Dimensional Visualization - Spectra can be thought of as points in an n-dimensional scatterplot, where n is the number of bands. The coordinates of the points in n-space consist of "n" values that are simply the spectral reflectance values in each band for a given pixel. The distribution of these points in n-space can be used to estimate the number of spectral endmembers and their pure spectral signatures, and provides an intuitive means to understand the spectral characteristics of materials. In two dimensions, if only two endmembers mix, then the mixed pixels will fall in a line in the histogram. The pure endmembers will fall at the two ends of the mixing line. If three endmembers mix, then the mixed pixels will fall inside a triangle, four inside a tetrahedron, and so on. Mixtures of endmembers "fill in" between the endmembers. All mixed spectra are "interior" to the pure endmembers, inside the simplex formed by the endmember vertices, because all the abundances are positive and sum to unity. This "convex set" of mixed pixels can be used to determine how many endmembers are present and to estimate their spectra.

Classification now proceeds by statistical processing in which every pixel is compared with the various signatures and assigned to the class whose signature comes closest. A few pixels in a scene do not match and remain unclassified, because these may belong to a class not recognized or defined. In fact at this level there is an overlap between Supervised and Unsupervised classifications. Spectra determined by Unsupervised classifications are now compared to selected spectra as determined by the analyst and thus become effectively Supervised.

Field work, if logistically possible, before and after computer-based classification of an image, is the key to selecting and then checking class locations. Thus it is the best insurance for achieving a quality product. But, if an on-site visit is not feasible, a skilled interpreter can develop a fairly reasonable classification based mainly on his/her abilities in recognizing obvious ground features in the scene.

Geological Application of Spectral Analysis

Classical geologic mapping and mineral exploration utilize physical characteristics of rocks and soils such as mineralogy, weathering characteristics, geochemical signatures, and landforms to determine the nature and distribution of geologic units and to determine exploration targets for metals and industrial minerals. Subtle mineralogical differences, often important for making distinctions between rock formations, or for defining barren ground versus potential economic ore, are often difficult to map in the field. Multi-band, multi-sensor Multi Spectral Imaging (MSI) has been available for some years. More recently Hyperspectral remote sensing, the measurement of the Earth's surface in up to hundreds of spectral images, has provided a unique means of remotely mapping mineralogy. A wide variety of Hyperspectral data are now available, along with operational methods for quantitatively analyzing the data and producing mineral maps.

The key to the search for minerals however is in the use of the Short Wave Infra Red (SWIR) part of the spectrum as minerals are best detected at these levels.

Remote-sensing displays, whether they are aerial photos or space-acquired images, show the surface distribution of the multiple formations usually present and, under appropriate conditions, the type(s) of rocks in the formations. Experienced geologists can recognize some rock types just by their appearance in the photo/image. They are now also beginning to identify geological features, rocks and minerals from their spectral signatures.

A common way of mapping formation distribution is to rely on training sites at locations within the photo/image. Geologists identify the rocks by consulting area maps or by visiting specific sites in the field. They then extrapolate the rocks' appearance photographically or by their spectral properties across the photo or image to locate the units in the areas beyond the site (in effect, the supervised classification approach).

In doing geologic mapping from imagery, we know that rock formations are not necessarily exposed everywhere. Instead they may be covered with soil or vegetation. In drawing a map, a geologist learns to extrapolate surface exposures underneath covered areas, making logical deductions as to which hidden units are likely to occur below the surface. In working with imagery alone, these deductions may prove difficult and are a source of potential error. Also, rock ages or rock types/composition are not directly determined from spectral data, so that identifying a particular characteristic requires some independent information such as knowledge of a region's rock types and their sequence, alteration features and distribution.

Spectral data derived from confused sources can also be handled using *Fuzzy Set* theory for mineral exploration. Some spectral data can be very clearly organized into groups based on their spectral properties. The boundary of each group is quite sharp because each training site is a region that contains a known material (e.g. basaltic rock). One of the main assumptions in the traditional classification methods is that the training sites represent pure samples of the classes they represent. But this is rarely the case with the geological materials. With fuzzy classification it is assumed that the boundaries are transitional.

A Fuzzy set is characterized by a fuzzy membership grade (also called a possibility) that ranges from 0.0 to 1.0, indicating a continuous increase from nonmembership to complete membership in the group. For example, if a pixel is covered by 60% altered and 40% by unaltered rocks, it would be considered to have a fuzzy membership grade of 0.60 in the class of altered and a membership grade of 0.40 in the unaltered class. Wang (1990) has developed a method of classification of remotely sensed data by using fuzzy logic. The same method is used to classify remote sensing and geophysical data sets. Geological information and data interpretations used in mineral exploration are inherently ambiguous. The quantitative precision of expressions like "relatively high", "high", "fair", "low", and "relatively low" or "fairly favorable" for the mineral occurrence, as well as grey areas between these expressions, is difficult to define. Fuzzy set theory provides a

mathematical framework to represent the linguistic and data ambiguities frequently encountered in mineral exploration, geological information analysis and interpretation. Idrisi has produced a software module called FUZCLASS, a so called soft classifier, to handle this type of interpretation.

Other Methods used in the spectral unmixing process included: Principle Component Analysis, Bayesian Analysis, Dempster-Shafer, Fisher and other Linear and Non-linear statistical classification and assignment operations.

Principal Components Analysis (PCA) is a statistically based procedure for transforming a set of correlated variables into a new set of uncorrelated variables. This transformation is a rotation of the original axes to new orientations that are orthogonal to each other and therefore there is no correlation between variables. PCA is a decorrelation procedure which reorganizes by statistical means the DN values from as many of the spectral bands as we choose to include in the analysis. In producing these values, we used all seven bands and requested that all seven components be generated (the number of components is fixed by the number of bands, because they must be equal). Color composites made from images representing individual components often show information not evident in other enhancement products

A variant of PCA is known as *Canonical Analysis (CA)*. Whereas PCA uses all pixels regardless of identity or class to derive the components, in CA one limits the pixels involved to those associated with pre-identified features/classes. This requires that those features can be recognized (by photo interpretation) in an image display (single band or color composite) in one to several areas within the scene. These pixels are "blocked out" as training sites. Their multiband values (within the site areas) are then processed in the manner of PCA. This selective approach is designed to optimize recognition and location of the same features elsewhere in the scene.

Data Sources and Software

The following is a list of material sources and software used for this project.

- ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System. ASTER is a cooperative effort between NASA, Japan's Ministry of Economy, Trade and Industry (METI) and Japan's Earth Remote Sensing Data Analysis Center.

ASTER has been designed to acquire land surface temperature, emissivity, reflectance, and elevation data. An ASTER scene covers an area of approximately 60 km by 60 km and data is acquired simultaneously at three resolutions. The images are georeferenced to the WGS84 datum and Universal Transverse Mercator (UTM) projection. A complete ASTER scene consists of 14 bands of data, with one additional band pointing backwards to create parallax. The three bands in the visible and near infrared (VNIR) part of the spectrum have a 15m resolution and an 8-bit unsigned integer data type. This file also features a second near infrared backward-scanning band labeled Band 3B. This is used to create a stereo view of the earth to

develop elevation information. The six bands in the short wave infra-red (SWIR) have a 30m resolution and also have an 8-bit unsigned integer data type. Finally there are five thermal bands (TIR) with a 90m resolution and have a 16-bit unsigned integer data type.

- ASTER Granules - The basic unit of Hyperspectral Satellite data coverage is defined as *Granules*. Each granule represents area on average about 60km x 60km. ASTER satellite data granules were acquired from NASA's ASTER facility for the various mineral claim areas.
- IDRISI GIS is a powerful raster-based GIS system produced by Clark Labs, an off-shoot of Clark University. The current version of Idrisi used for this project is Kilimanjaro 14, plus extensions.
- IDRISI Kilimanjaro - Image format conversion and spectral signature development was performed using Clarke University's "Kilimanjaro" Image Analyst software coupled with a spectral scan for indicator minerals and rock types. Resulting spectra are then compared by Principal Components Analysis to Spectral Library data.
- ENVI – "Environment for Visualizing Images" is image processing software produced by Research System (RSI). This software provides tools for traditional image processing tasks and is supported by import filter, classification, multi- and hyperspectral processing, data-transformation, registration, calibration, filtering, radar, topographic and mapping modules.
- Hyperspectral Data Libraries are used for matching spectral plots from exploratory data with known spectral responses from specific minerals, rocks and other features
 - NASA's Jet Propulsion Laboratory ASTER Index
 - USGS Spectral Library
 - Johns Hopkins University Spectral Index Database
- ATMOC is software supplied with the IDRISI package that is used to screen atmospheric and topologic noise.
- Clark Labs IDRISI Cartalinx - This is a database development and topological editing software package. These data are then typically exported to a GIS either as entire coverage or as a series of map layers.
- FUZCLASS - Supervised Fuzzy Classification procedure (described earlier) was performed using this soft classifier available in IDRISI image processing software.
- MYSQL – Microsoft ACCESS relational database management system.

Data Presentation and Storage

Spectral data map presentations in digital format are provided as a series of separate digital data base layers and overlays. A selection, or in some cases all, of the layers noted below may be included in the image displayed. Hard copy presentations and assessment report .PDF files will normally show combined layers on a single sheet for each

classification map presented in this report.

- Base map satellite photo coverage layer
- Base spectral image in greyscale
- Classified spectral image layer
- UTM grid layer
- DEM or DTM layer
- Geology and mineral showing information layers

Data transformations and digitization methods and data formats are disclosed together with analysis results in a metadata file for future use. This information has been provided separately as a set of CD's to accompany this assessment report submission.

Computer Hardware Requirements

The massive quantities of data that need to be analyzed require significant computing power. Two AMD Athelon 64 systems powered with dual core processors and with a 250 gig hard disks and 100 gig auxiliary external storage were required to handle the heavy duty processing and data storage requirements of this project.

Conclusion

Spectral Images may become representative of mineralization or host geology, in much the same way as these features may be detected using airborne geophysical techniques. These spectral representations form a statistical pattern that is distinct from the surroundings (or anomalous with respect to surroundings) and can therefore be considered to indicate the possible presence of a geological unit or mineralized body.

With the advent of space imagery, geoscientists now can now improve and extend the geologic exploration process in three important ways: 1) The advantage of large area or synoptic coverage allows them to examine in single scenes (or in mosaics) the geological portrayal of Earth on a regional basis 2) The ability to analyze Multispectral bands quantitatively in terms of numbers (DNs) permits them to apply special computer processing routines to discern and enhance certain compositional properties of Earth materials. 3) The capability of merging different types of remote sensing products (e.g., reflectance images with radar or with thermal imagery) or combining these with topographic elevation data and with other kinds of information bases (e.g., thematic maps; geophysical measurements and chemical sampling surveys) provides an opportunity to improve exploration success.

Most spectral studies to date have been focused on relatively barren and flat terrain with moderate to extensive rock exposures. However with the advent of radar spectral detection methods research has shown that spectral signatures of underlying host rocks and alteration types beneath a partial canopy of vegetation and even beneath partial surficial cover can also be detected in less than barren locations.