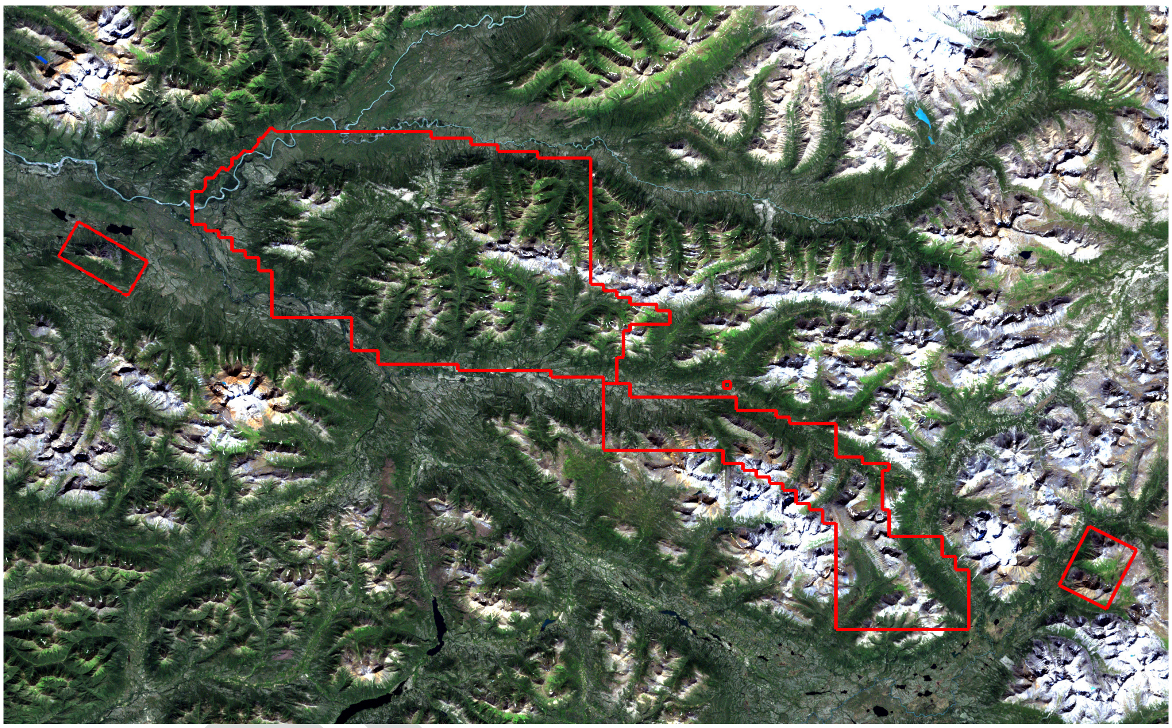
ASTER ANALYSIS
of the
ORO Claims, Yukon



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15 July 2011

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INTRODUCTION

Summary

Cal Data Ltd. was contracted by Linda Dandy for Colorado Resources Ltd. to acquire and analyze ASTER Multispectral imagery covering the ORO claim group in eastern Yukon. D. Dunlop provided the claim descriptions. A search for available ASTER and other imagery was performed. The claim area had very poor ASTER coverage with all imagery having issues with cloud cover or sensor problems. Good LandSat 7 (ETM+) imagery was available for the claim group. Initially the best available ASTER image was purchased. The preview image showed some problems with the image in the area of the claims but it was felt there could be some useful portions. Unfortunately when acquired virtually the whole region of the claims was useless. The LandSat image was processed and evaluated. LandSat only has reasonable spectral coverage in the VNIR portion of the spectrum with very limited capabilities in the SWIR (one band). Examination of the LandSat image showed several areas of potential interest. As a result of consultation with L. Dandy two additional ASTER images were acquired to add some additional spectral and spatial resolution in the areas of interest from the LandSat evaluation.

The LandSat image files were obtained through the NASA Land Processes Distribution Active Archive Center (LPDAAC) at no cost. The required ASTER imagery was identified through the LPDAAC website and then purchased from ERSDAC (Earth Remote Sensing Data Analysis Centre) in Japan at a cost of 9800¥ per image.

The claim area was fully exposed in the LandSat image but significantly cloud covered in the ASTER images. The two ASTER images that were used in the analysis had VNIR and TIR sensor data and one had SWIR data.

Image analysis included converting the imagery from digital number format (DN) to relative reflectance values through standard preprocessing techniques. The imagery was rectified to the UTM Zone 9 projection, WGS 84 datum.

A full range of products were constructed from the imagery. In the case of the LandSat image these included a pan-sharpened natural colour image, temperature map as well as the mineral maps generated during the analysis. In the case of the ASTER imagery the products included; near-natural colour imagery, DEMs, anaglyph images, temperature maps and mineral maps generated from the spectral analysis.

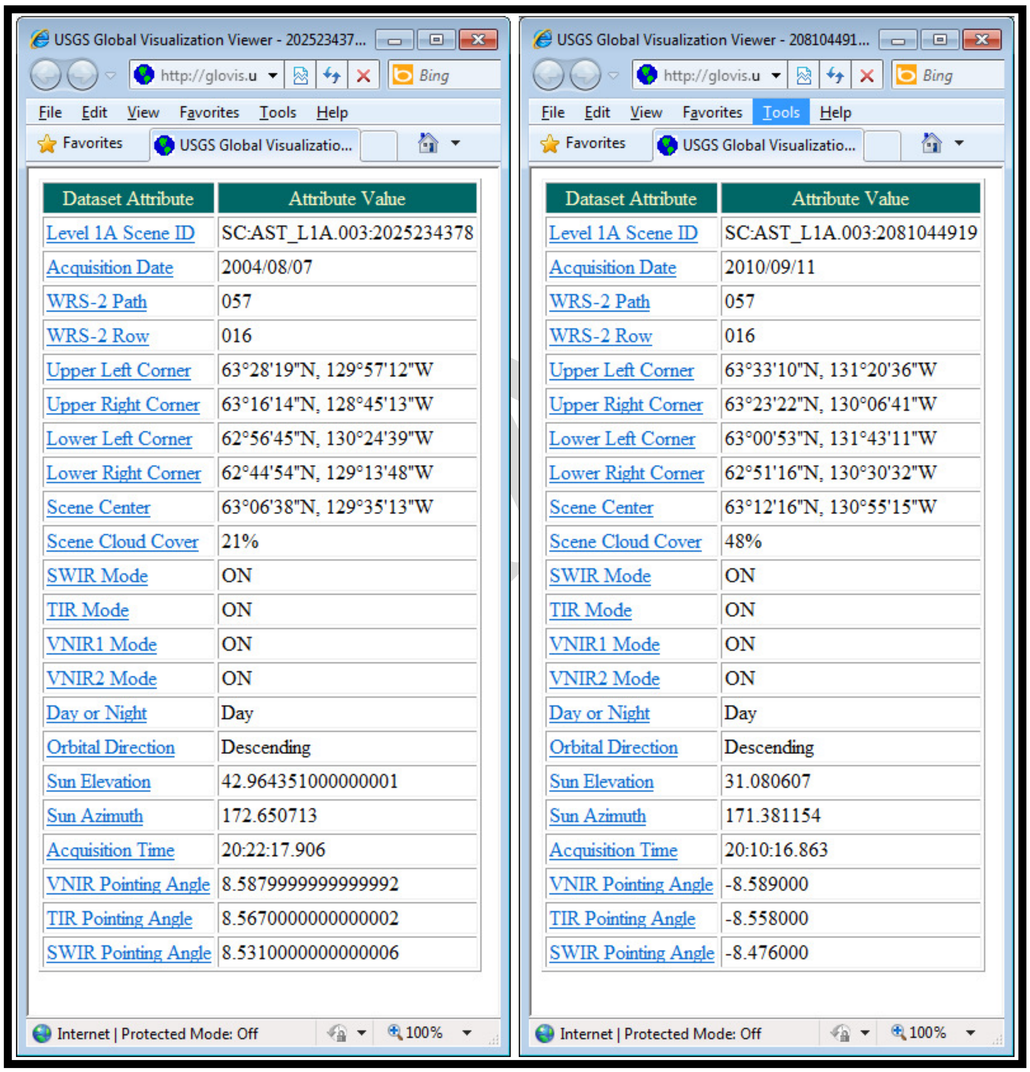
The spectral analysis was performed on the ORO claim area using hyperspectral and multispectral techniques on both the LandSat and ASTER imagery.

Any mineral or rock identification made based on ASTER or LandSat spectra must be considered an estimate as the spectral and spatial resolution of the sensors is not adequate to positively identify individual materials in most cases.

All original and useful intermediate image data as well as products are provided in digital format in the Appendix (DVD).

Area and Image

The ORO claims are located in eastern Yukon Territory centred on geographic coordinate 63° 14’ 17” N 130° 48’ 15” W. The three ASTER images were collected on August 15, 2006, August 8, 2004 and September 11, 2010. The August 15, 2006 image was not used as the area covering the claim group was not collected. The September 11, 2010 image covers most of the claim group except the eastern edge. The August 8, 2004 image covers the eastern portion of the claims. Both these images have VNIR and TIR coverage but only the August, 2004 image has SWIR coverage. The images (approx. 60 x 60 km) were obtained with Level 1A processing from ERSDAC. The image information for the two ASTER images used in the analysis are shown in Figure 1.



Dataset Attribute	Attribute Value
Level 1A Scene ID	SC:AST_L1A.003:2025234378
Acquisition Date	2004/08/07
WRS-2 Path	057
WRS-2 Row	016
Upper Left Corner	63°28'19"N, 129°57'12"W
Upper Right Corner	63°16'14"N, 128°45'13"W
Lower Left Corner	62°56'45"N, 130°24'39"W
Lower Right Corner	62°44'54"N, 129°13'48"W
Scene Center	63°06'38"N, 129°35'13"W
Scene Cloud Cover	21%
SWIR Mode	ON
TIR Mode	ON
VNIR1 Mode	ON
VNIR2 Mode	ON
Day or Night	Day
Orbital Direction	Descending
Sun Elevation	42.964351000000001
Sun Azimuth	172.650713
Acquisition Time	20:22:17.906
VNIR Pointing Angle	8.5879999999999992
TIR Pointing Angle	8.5670000000000002
SWIR Pointing Angle	8.5310000000000006

Dataset Attribute	Attribute Value
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Acquisition Date	2010/09/11
WRS-2 Path	057
WRS-2 Row	016
Upper Left Corner	63°33'10"N, 131°20'36"W
Upper Right Corner	63°23'22"N, 130°06'41"W
Lower Left Corner	63°00'53"N, 131°43'11"W
Lower Right Corner	62°51'16"N, 130°30'32"W
Scene Center	63°12'16"N, 130°55'15"W
Scene Cloud Cover	48%
SWIR Mode	ON
TIR Mode	ON
VNIR1 Mode	ON
VNIR2 Mode	ON
Day or Night	Day
Orbital Direction	Descending
Sun Elevation	31.080607
Sun Azimuth	171.381154
Acquisition Time	20:10:16.863
VNIR Pointing Angle	-8.589000
TIR Pointing Angle	-8.558000
SWIR Pointing Angle	-8.476000

Figure 1. ASTER image metadata for the two images.

The claim boundaries and coverage of the two ASTER images are shown in Figure 2 overlain on the natural colour LandSat ETM+ image used in the analysis.

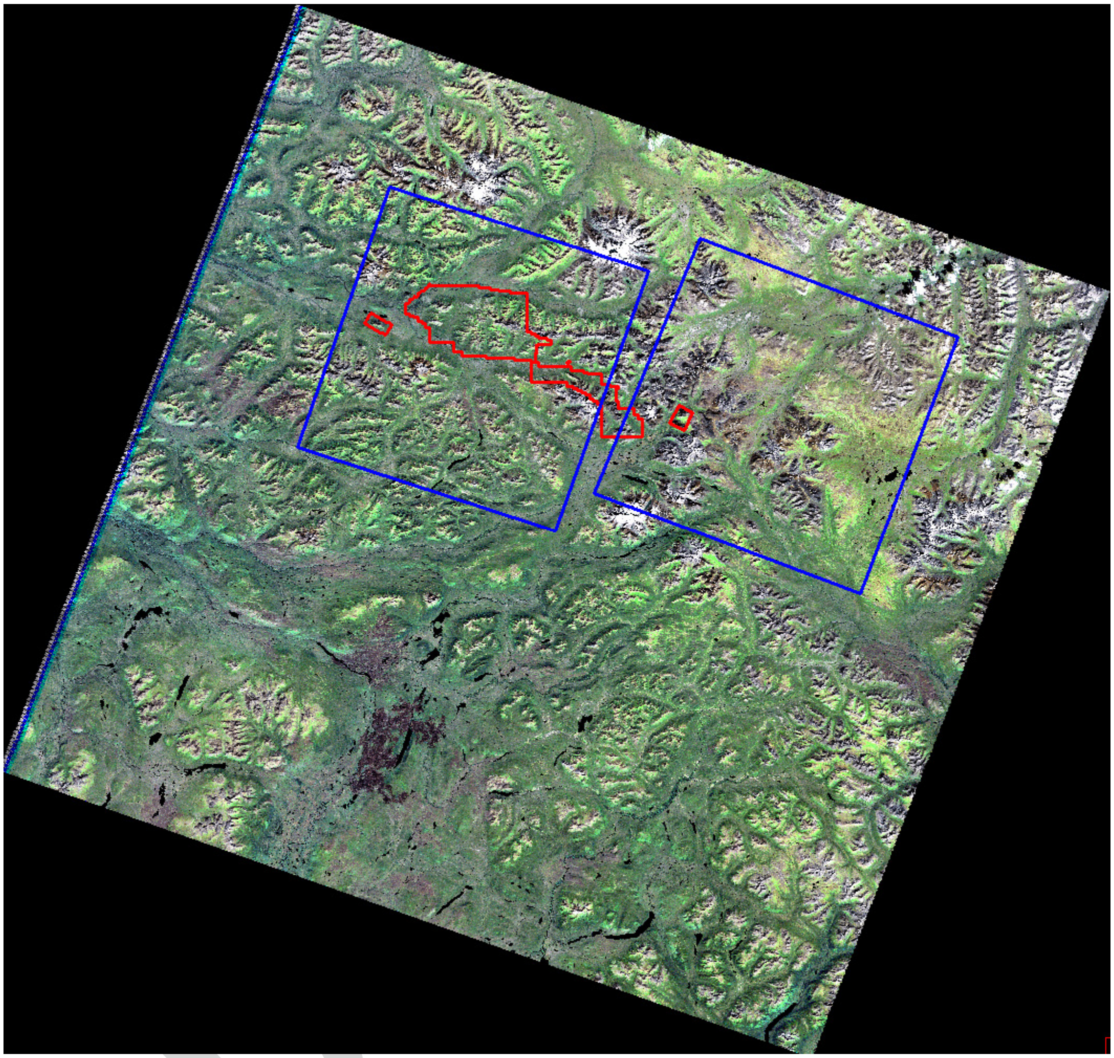

Figure 2. LandSat ETM+ image with claim boundaries shown in red and the outlines of the two ASTER images shown in blue.

IMAGE ANALYSIS

Pre-analysis Processing (preprocessing)

LandSat

Upon obtaining the raw LandSat image a number of preprocessing steps are required to transform the raw data values into relatively standard values. In this case the standard values are relative reflectance values. The imagery was obtained in a rectified form being projected in UTM Zone 9, WGS-84 datum. LandSat 7 ETM+ has 3 bands in the VNIR, 3 bands in the SWIR and 1 band in the TIR with two different gain values. These bands all have 30 metre pixel resolutions. In addition there is a 15 metre panchromatic band.

The 6 bands from the VNIR and SWIR were converted to at satellite relative reflectance using a built-in calibration routine within the ENVI image analysis software. This conversion is not as rigorous as the method used for ASTER but it has become a standard conversion and provides good results. The TIR band was processed with a similar routine that produced a temperature map in degrees Kelvin.

The original downloaded LandSat image data and the calibrated (at satellite reflectance and temperature) data in ENVI format are provided in the appendix.

ASTER

Upon obtaining the raw ASTER images a number of preprocessing steps are required to transform the raw data values into relatively standard values. In the case of this study these standard values are relative reflectance and emissivity. The relative reflectance spectrum of a mineral has the same shape as a true reflectance spectrum but the values are relative and not absolute. In most cases it is the shape of the spectra and the relative band values that are used in any analysis. The image pixels are also spatially adjusted to conform to the UTM map projection. Orthorectification is employed to compensate for the effects of topography in this spatial adjustment. Both ASTER images were projected to UTM Zone 9 on the WGS-84 datum.

Step 1- Orthorectification, gain and offset: The raw ASTER data is shipped in a format where the pixel values are simple DN (digital numbers). To convert these values to 'at sensor radiance' specific gains and offsets must be applied. The ASTERdtm program makes these corrections at the same time that it orthorectifies the VNIR, SWIR and TIR image bands. As part of the orthorectification process a relative digital terrain model (DTM) is generated from the ASTER data to provide the basis of the orthorectification. In addition anaglyph images were also create during this process. The result of this step is orthorectified 'at sensor radiance' data. The spatial accuracy of the orthorectification has not been evaluated but will be internally consistent and within 30 metres of true position. Often there is a slight displacement between the positions of the three sensor data.

Step 2- Atmospheric correction was performed using specialized software called ACORN5 that compensates for the effects of atmospheric gases on the amount of light energy that penetrates and is reflected by the atmosphere. The original ASTER data is in the form of 'at sensor radiance' which is a measure of the amount of light the satellite sensor receives from all sources. A significant amount of the light that the sensor sees is reflected from the atmosphere and never reached the ground surface. This light obviously provides no information about the ground features and should be removed. The atmosphere also absorbs or otherwise scatters some of the light reflected from the ground surface. This missing light at the sensor is calculated by knowing the incident light angle value and general atmospheric conditions. Water vapour has the largest effect on the ability of light to penetrate the atmosphere. The water vapour value was obtained from a MODIS product image taken on the same day from the same platform. The relative reflectance values obtained from this process provide a spectra shape similar to what would be obtained with a field spectrometer or in a laboratory setting. This processing is essential so that the various band measurements at a given pixel have standard relative values. Otherwise the standard ratios and band formula used to identify minerals or mineral groups would be of little value. Figure 3 contains a view of the input panel for this calculation and records the values utilized. The elevation used was the average elevation of good rock exposure within the claim block.

Step 3- The VNIR, SWIR and TIR bands were used during this study. These bands are collected by three different sensors on the satellite platform. The VNIR bands have 15 metre ground sample distances (GSD or Pixel) wide, the SWIR bands have 30 metres pixels and the TIR bands have 90 metres pixels. The individual sensor images are examined and their spatial positions are adjusted so that all the band images for a single ASTER image are co-aligned.

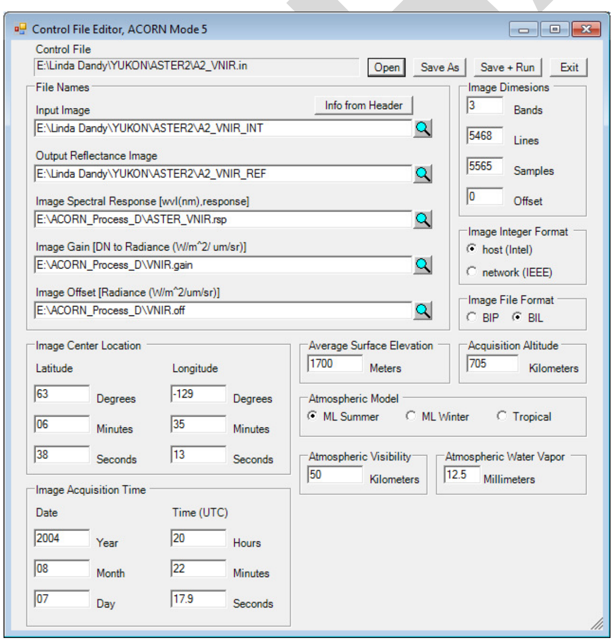

Figure 3. Input panel for the ACORN5 atmospheric correction process for the VNIR bands of the August 2004 image.

The original ASTER download files in HDF format along with the atmospherically corrected and orthorectified image files are available in ENVI *.BIL format in the appendix. Also included in the appendix is the digital elevation model in ENVI *.BIL format.

Analysis

LandSat 7 ETM+-

Natural Colour Image-

A natural colour image of the whole LandSat image was constructed using bands 3,2,1 as red, green and blue. This image has 30 metre pixel resolution and provides a high contrast image useful for visualizing the natural colours one would expect to see with the naked eye. The image is provided in the appendix as a geoTIFF

Pan Sharpened Image-

The natural colour image discussed above was pan sharpened using the Brovey (colour normalization) process to provide a colour image with 15 metre resolution. The pan sharpening dulls the colours somewhat but significantly enhances the detail that can be seen in the image. Figure 4 compares the natural colour and pan sharpened images.

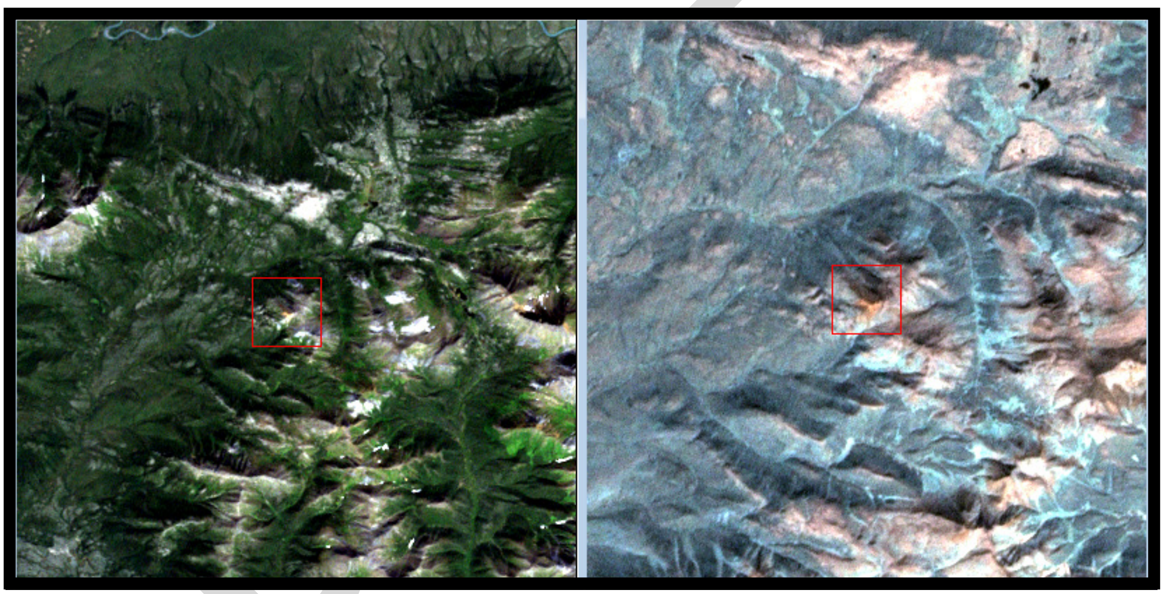

Figure 4. LandSat natural colour image on the left and the pan sharpened version of this image on the right. Small red box covers the ORO deposit site.

Tassel Cap-

Tassel Cap analysis is a traditional LandSat analysis based on principal component analysis. It has been used since the first LandSat launch in the 1970's. Preassigned weightings of the principal components are used to indicate brightness, greenness and wetness. These three components explain about 97% of the image variation. Three additional components are mapped to explain the remaining image variation. The first three components are mapped as red, green and blue in Figure 5. This image is useful to highlight the spectral variations within the image and could prove useful in picking up subtle features. Examination of the other components showed that the fifth component highlighted the ORO deposit area (Figure 5). The fifth component maps the area of the

ORO deposit as white and certain other rock exposures as black. Snow and ice are also mapped as white in this image. A mask based on the temperature image was used to remove the snow and ice (cool temperatures < 300º K) so that any white (high value) pixels remaining would be rocks with component scores similar to the ORO area.

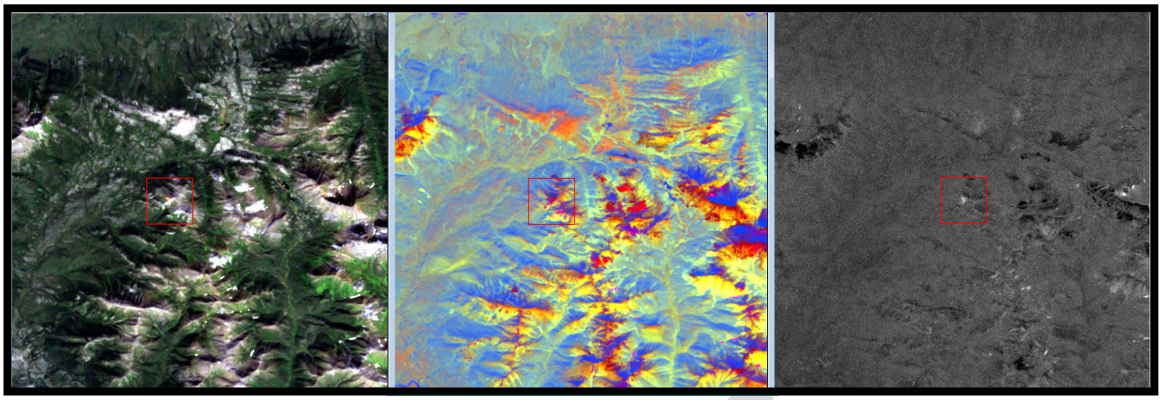

Figure 5. Comparison (from left to right) of the natural colour, Tassel Cap brightness-greenness-wetness and Tassel Cap fifth component. Red box is centred on the ORO deposit.

A masked and density sliced image was prepared indicating high scores on the 5th component. The distribution indicated by this image correlates well with tan to rusty weathering rocks. These rocks may be a specific rock type or indicate some level of alteration. The image '5thTC_Coloured.tif' is provided in the appendix. Figure 6 shows part of this image compared with the natural colour image. The highest values on this image should be investigated to determine what the spectral features indicating.

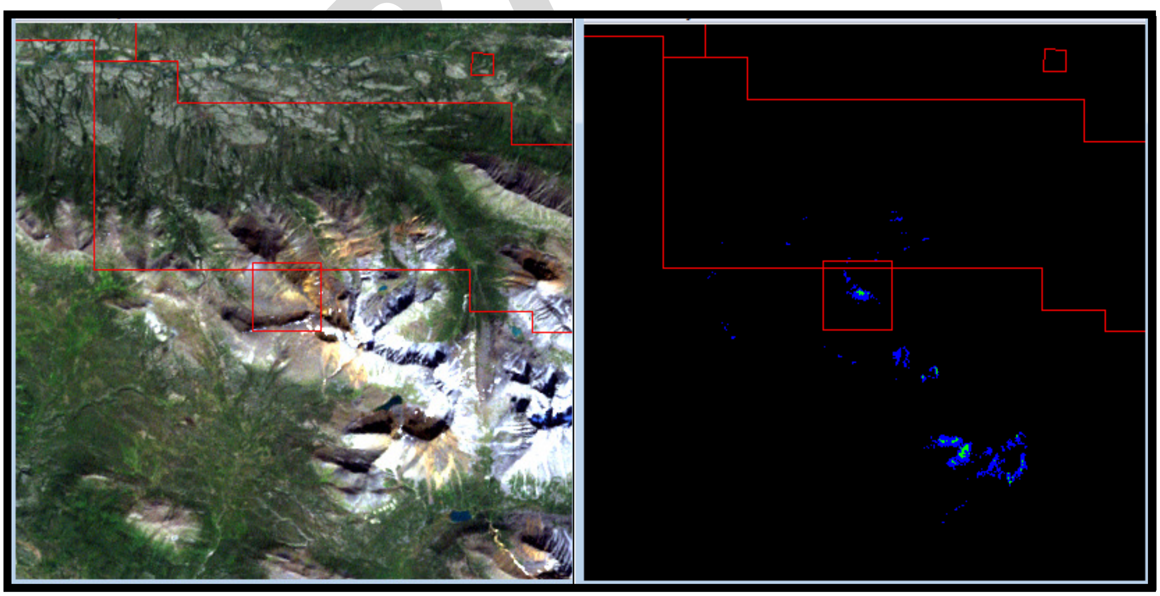

Figure 6. Natural colour image on left and colour mapped 5th Tassel Cap scores on rock. Property boundary for reference.

Spectral Angle Mapper-

Spectral Angle Mapping (SAM) was used to compare interesting spectra with other spectra within the image. A spectrum from the ORO deposit area and another spectrum from the area highlighted in Figure 6 were used. The results of the mapping highlight areas with similar spectra to the two sampled areas. The assumption being that there is something interesting where the sample spectra were collected. Four spectra were collected two from each area. Figure 7 shows the shape of the sampled spectra. The spectra names are the pixel locations from which they were collected. Also included in Figure 7 are a few typical spectra of minerals that roughly match the image spectra. LandSat does not have enough spectral bands to make absolute spectral matches but visual comparisons of the spectra can give some indication of the general types of minerals being investigated.

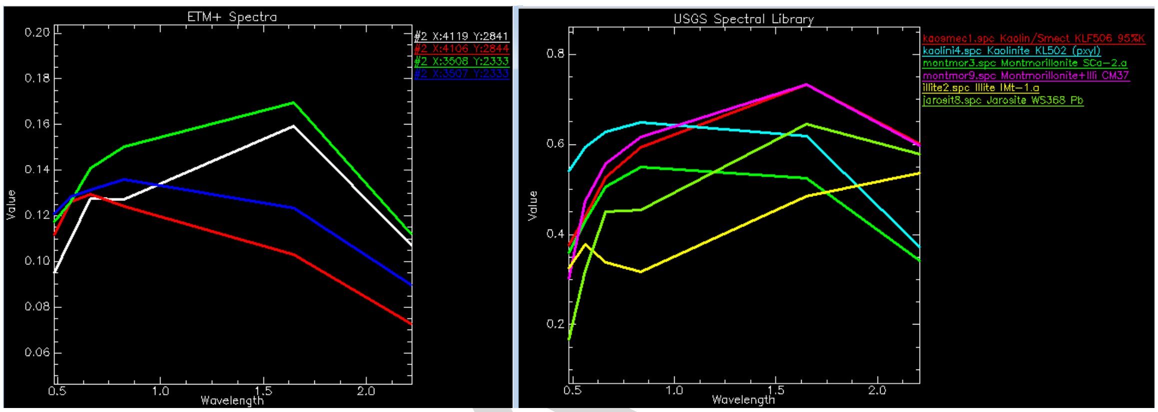

Figure 7. Image spectra on the left and USGS library spectra on the right.

The white image spectrum from 4119-2841 has a distinctive shape that is very similar to a jarosite library spectra. The blue and red image spectra appear similar to kaolinite while the green spectrum seems to match best with a kaolinite-smectite spectrum. The SAM maps for these four spectra were calculated and then coloured to map out the areas of the image that best fit each of the spectra. These "mineral maps" are provided in the appendix and displayed, partially, in Figure 8. When using these images only the red mapped pixels should be considered as areas to investigate the green and blue areas help highlight the more prospective red pixels. As expected the Red and Blue spectra have similar mappings. The Jarosite mapping is often associated with the other clay related spectra but in some areas is slightly offset spatially. For field investigation the Jarosite mappings should be investigated and the associated clay alterations. Some of the clay mappings are very likely related to sedimentary rocks rather than any mineral related alteration.

There are a number of locations with Jarosite mappings within or near the claim group. In addition several interesting clay areas are present that seem to be related to alteration of some sort. Figure 8b illustrates an area just outside the claim group showing the presents of all four SAM mappings and obvious colour anomaly in the natural colour imagery. A possible extension of this material into the claim group should be investigated.

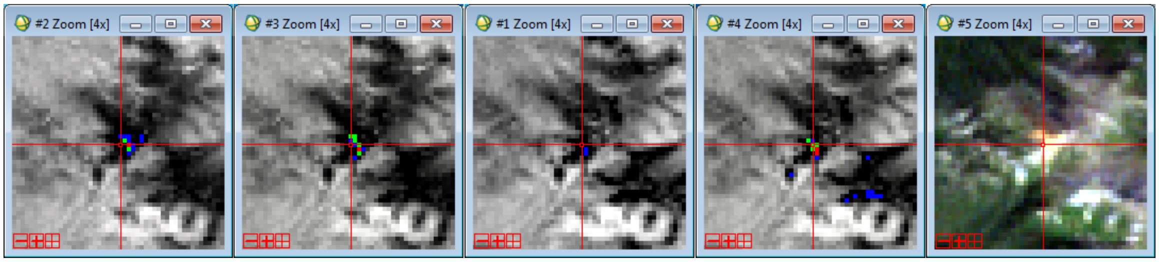

Figure 8a. Oro deposit area with (left to right) jarosite, green, red and blue SAM mappings at 401295E and7019985N. Natural colour image at right.

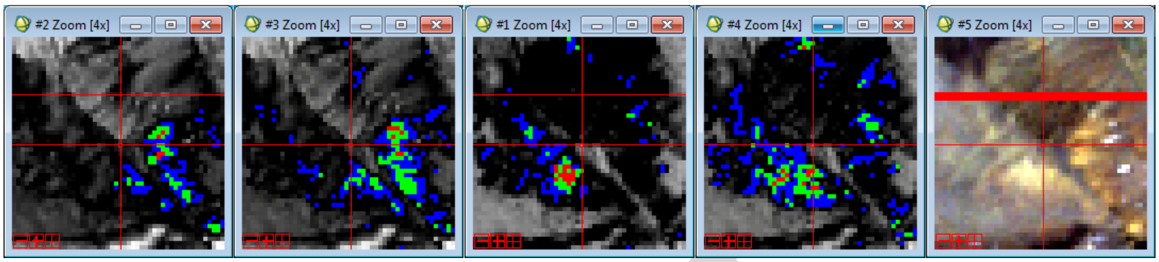

Figure 8b. Prospective area just outside claim group at 419415E and 7004800N. Order of displays is the same as in 8a.

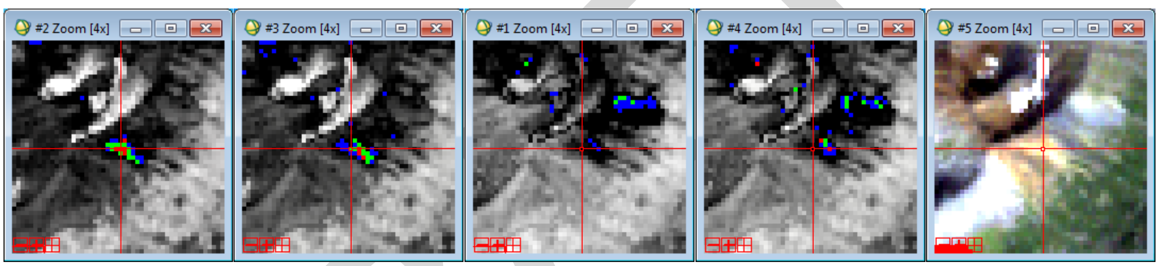

Figure 8c. A Jarosite mapping within the claim group at 429525E and 7002285N. Display order same as above.

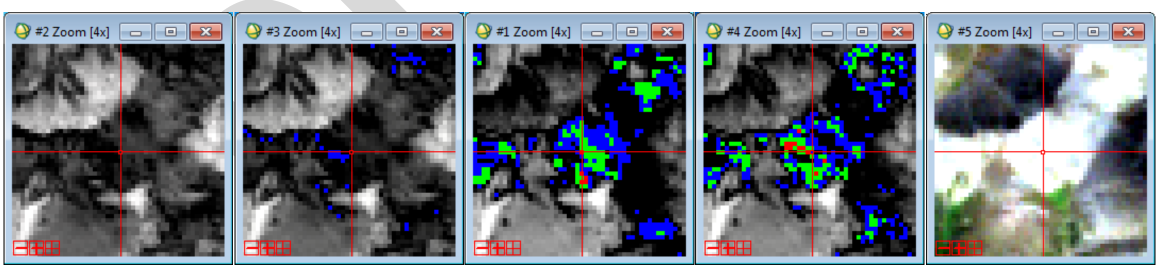

Figure 8d. A Kaolinite? rich area with no iron oxide colouration at 436095E and 6994455N. Display order same as above.

Figure 8c illustrates a nice zone of potential interest with the central portion of the claim block. There are several other similar but weaker mappings in this area.

Figure 8d illustrates a zone of strong mappings for the Red and Blue spectra (Kaolinite?) with no indication of iron related colouration.

Crosta Targeted Principal Component-

Crosta analysis is a common method of examining LandSat imagery with principal components (PCA). By using certain bands related to mineral types of interest principal components have been shown to be able to highlight areas of the imagery containing the targeted material. Two such analysis were performed on the LandSat image in this work; bands 1,3,4 and 5 for iron oxides and bands 1,4,5 and 7 for hydroxyl bearing minerals. The LandSat image was masked to remove all water, snow and vegetation prior to the analysis so these materials would have no influence on the process. In both cases strong negative values of the 4th principle component appeared to map the desired material best. Figure 9 illustrates several examples of these mappings. The resultant Crosta maps are provided as geoTIFFs in the appendix. In many cases the mapped areas from this analysis correspond to the areas identified with the SAM mappings. When viewing these maps comparison to the natural colour image should also be made to verify the highlighted pixels are representing rocks and not snow. In some cases, especially on the hydroxyl map snow has been mapped.

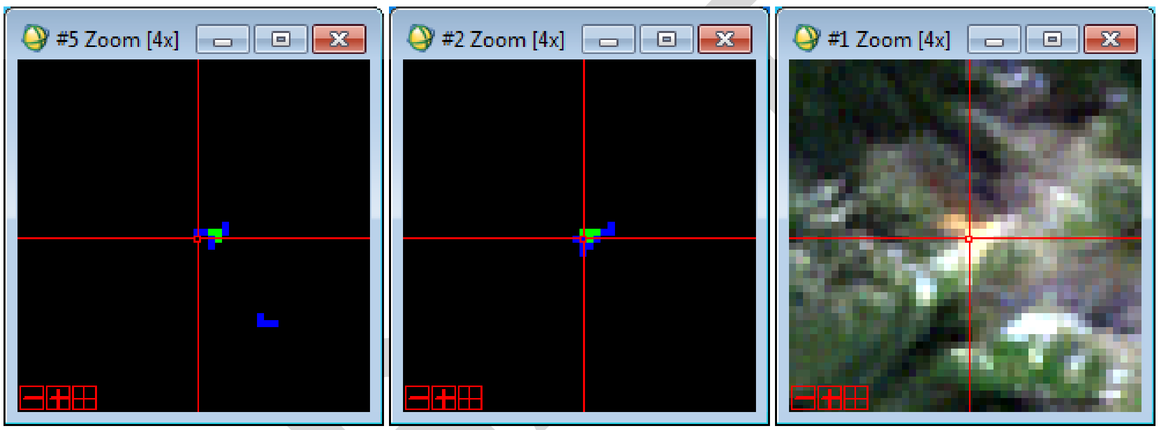

Figure 9a. CROSTA hydroxyl, CROSTA iron oxide and natural colour images of the ORO deposit area. Same location as Figure 8a.

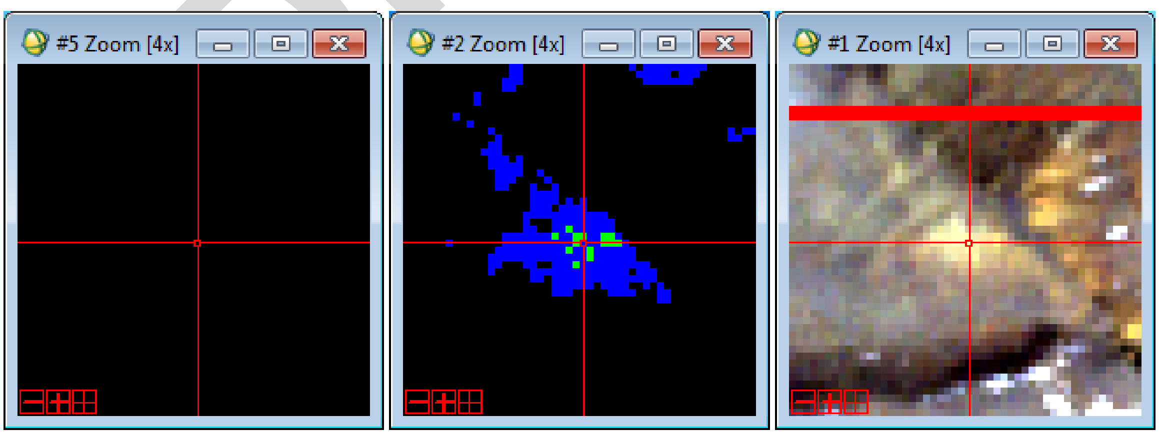

Figure 9b. CROSTA hydroxyl, CROSTA iron oxide and natural colour images of iron oxide colouration. Same location as Figure 8b.

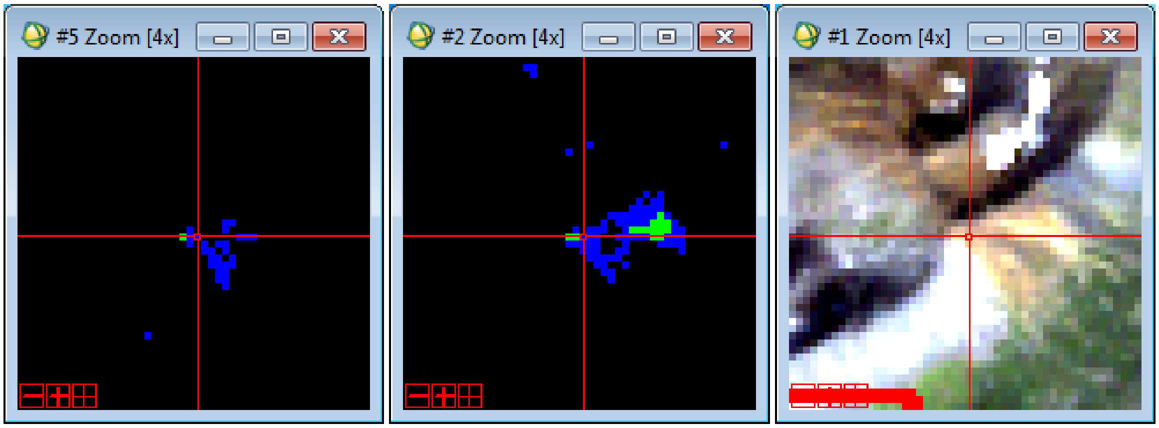

Figure 9c. CROSTA hydroxyl, CROSTA iron oxide and natural colour images of a site in the claim group. Same location as Figure 8c.

The combination of Crosta, Tassel Cap and SAM spectral maps can be used in combination to highlight areas with spectral characteristics that are significantly different from the surrounding rocks and thus disserve investigation. As mentioned before LandSat does not have the spectral resolution in the SWIR range to differentiate the hydroxyl bearing minerals to the extent possible with ASTER. However the LandSat analysis has identified several areas for further investigation. The fact that most of the spectral maps generated highlight the ORO deposit area provides some assurance of their validity.

ASTER were used to help better define some of the areas suggested through the LandSat analysis. The ASTER imagery had very poor coverage due to cloud cover but where sites of interest are exposed additional understanding of the material involved is possible.

ASTER

Natural Colour Image- The product generated from the orthorectified ASTER data is a near-natural colour image. ASTER does not sample the blue range of the electromagnetic spectrum so the resulting image is only an approximation to what one would see if viewing the natural scene. In this study the three VNIR bands were used to generate this view. These bands are combined in various combinations to produce the three colours red, blue and green. The result is a close approximation to a natural colour scene. The images have 15 metre pixels and are available in the appendix in geoTIFF format (A2_Natural.TIF and A3_Natural.TIF). Figure 10 displays these natural colour images. The images in the appendix are both projected in UTM Zone 9.

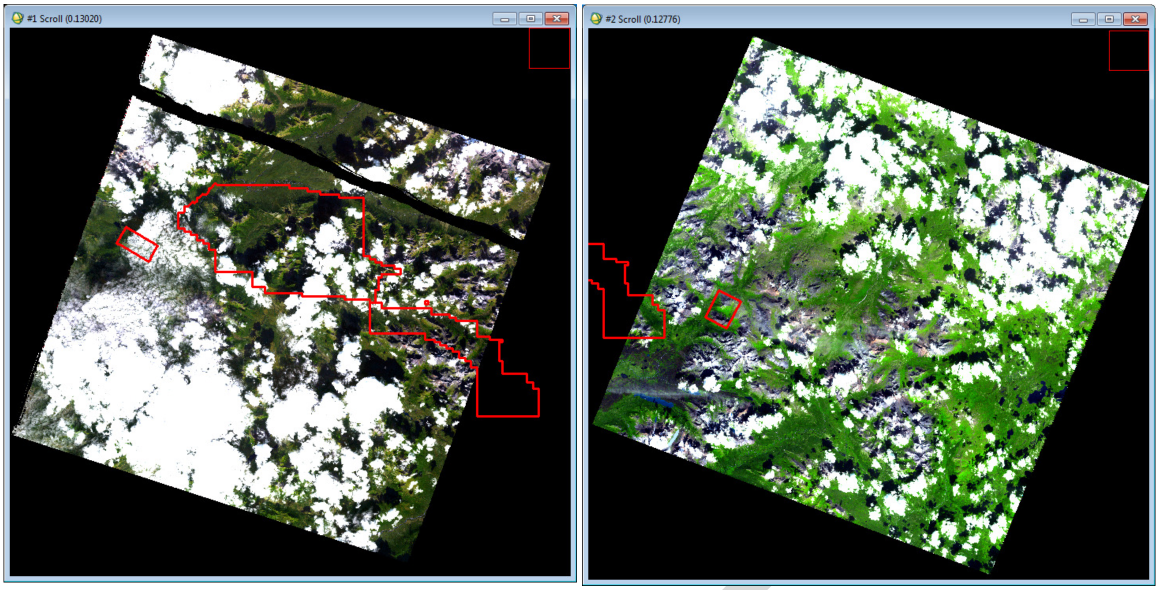

Figure 10. Natural colour images of the two ASTER images. A3 on the left and A2 on the right. ORO claim boundary show for reference purposes.

VNIR Analysis- Simple three band images using the VNIR bands with 15 metre resolution shows the distribution of rock exposure, vegetation and cloud cover. Figure 11 illustrates these images that are also included in the appendix as geoTIFF files.

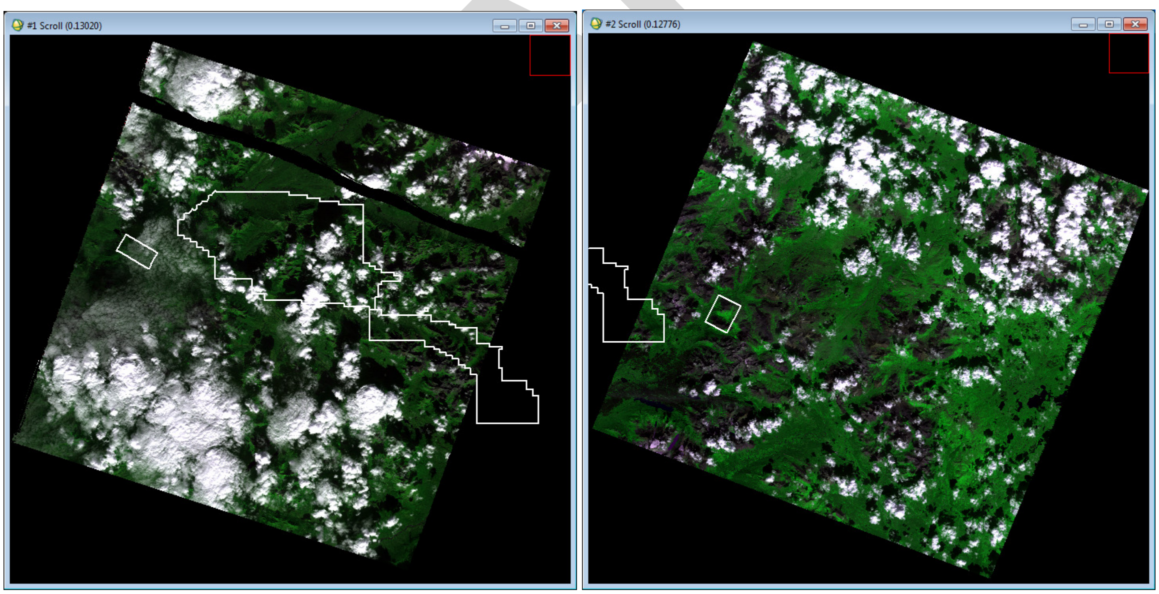

Figure 11. VNIR false colour images create by using bands 2,3,1 for red, green and blue.

The two ASTER image provide very poor coverage of the rock exposure within the property. ASTER has superior spectral properties relative to LandSat so it was used to compare the spectra obtained from both types of imagery in an attempt to verify the findings from the well exposed LandSat image. The three ASTER bands forming the

ASTER VNIR spectra were compared with the corresponding bands in LandSat at a number of locations where outcrops were exposed in both images. The areas of iron bearing minerals form very distinct colour anomalies in the LandSat image. Several of these areas were observable in both types of imagery. A prominent limonite exposure is illustrated in Figure 12. The LandSat image has 30 metre pixels and the ASTER image has 15 metre pixels in this figure. There is significant illumination difference in the two images. The LandSat image was collected in August 1999 and the ASTER was collected in September 2010. The sun angles were 43 and 31 for the LandSat and ASTER image respectively. This difference is apparent in the length of hill shadows and the difference in colouration. Figure 13. compares the spectra from the two images with library spectra for goethite. The spectra are taken from a south facing hillside to achieve the maximum possible sun angle.

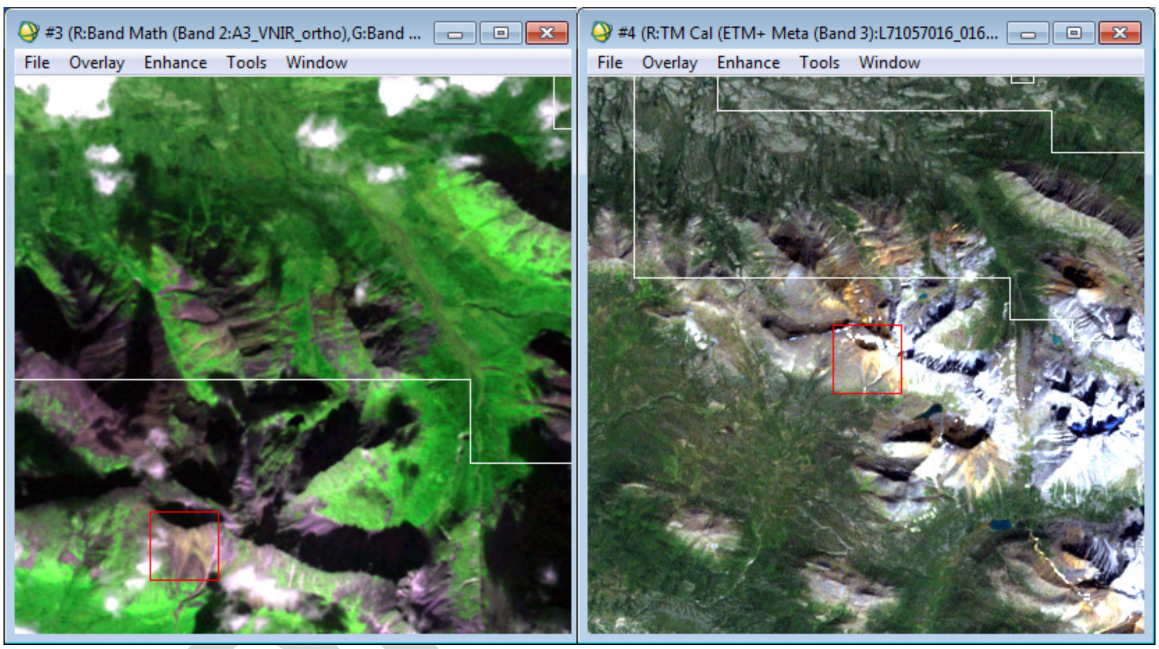

Figure 12. Limonite exposure illustrated in ASTER (left) and LandSat (right). The centre of the small red box is the comparison site.

The similarity between the spectra from the two images and their good match with the library spectra provides a good level of confidence that the LandSat interpretations for iron-bearing minerals is sound. The possible jarosite spectra is not apparent in the ASTER image but this is likely due to the shadows and low sun angle not providing enough illumination for the spectra to be full resolved in the ASTER image.

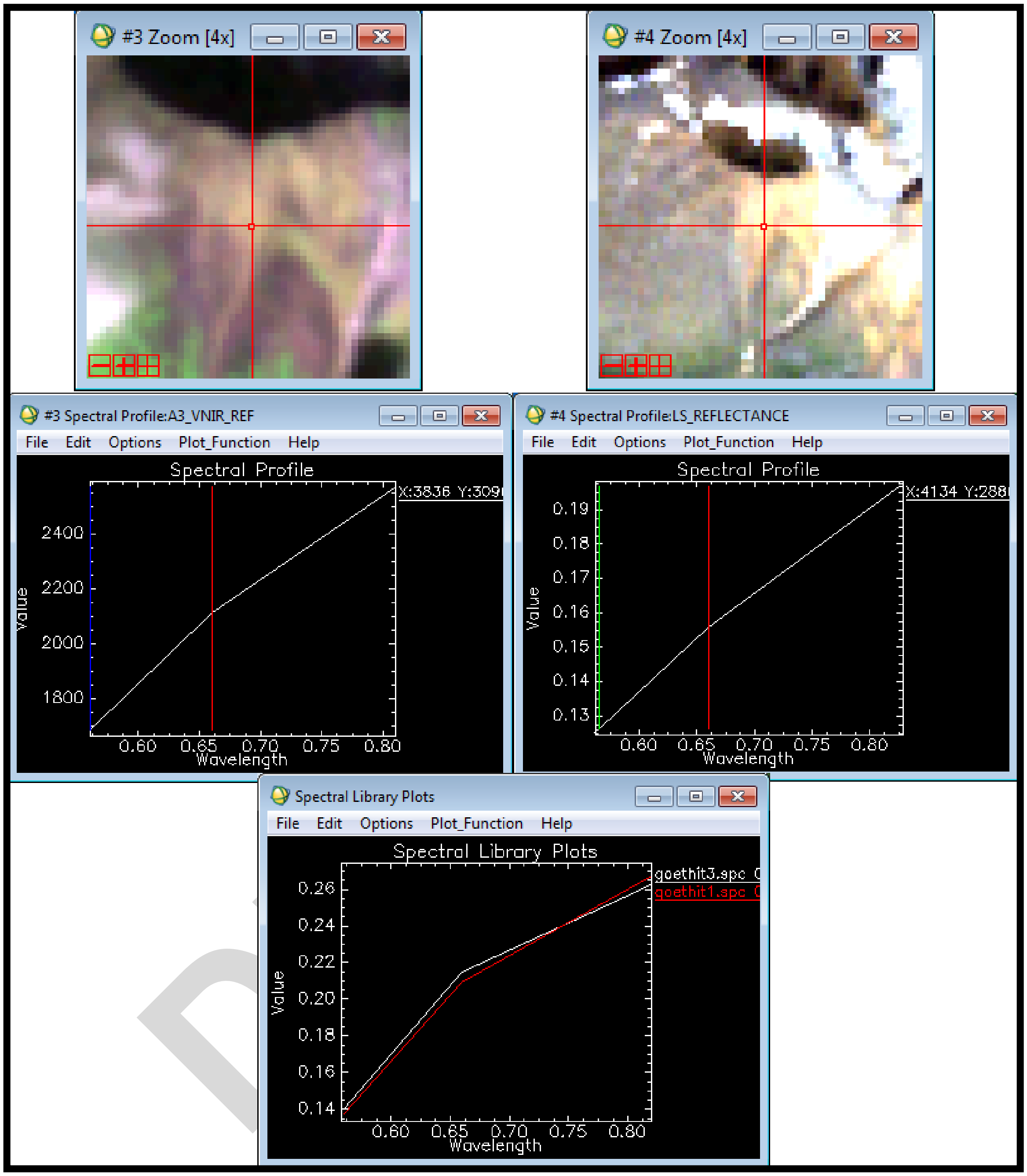

Figure 13. Spectra collection sites in ASTER (left) and LandSat (right) with the crosshairs indicating spectra collection site. Middle row are the two VNIR spectra from the ASTER and LandSat images with the bottom spectra for goethite being from the USGS library.

SWIR RGB Image- Only ASTER A2 had usable SWIR data. A simple 3-band image constructed with three of the six SWIR bands often provides a useful view of the variation that can be detected by ASTER in this region of the EMS. The colour variation in Figure 12 shows the distribution and variation in spectra available from the image. In this view vegetation is light and dark brown, non-vegetated areas are steely grey and clay rich areas are light grey to pink. The 30 metre resolution of the SWIR sensor limits the spatial detail that is possible and will tend to mask materials that have a small spatial surface expression.

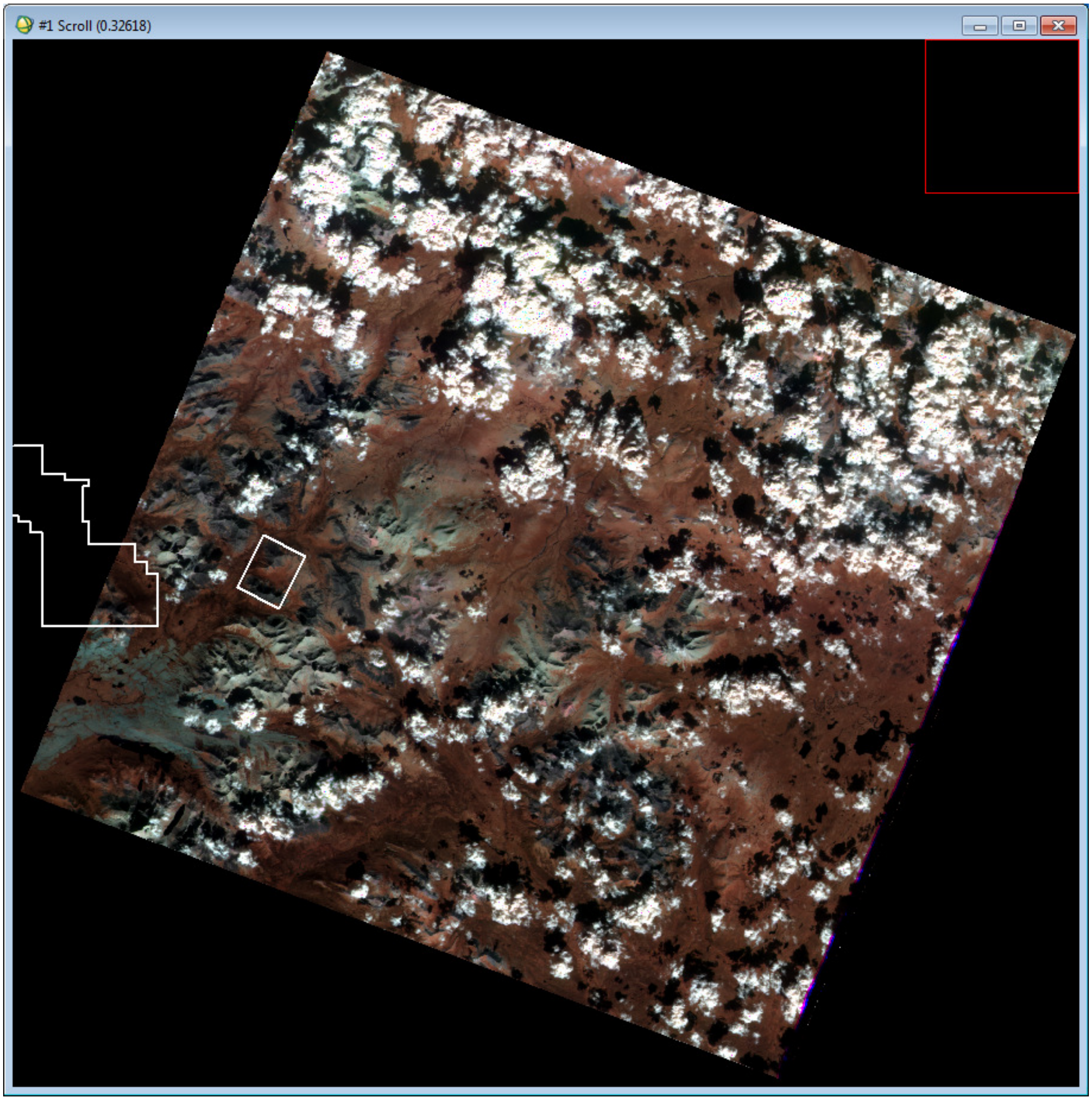

Figure 12. RGB image created from A2 ASTER bands 4, 6, 8 (SWIR bands). Claim boundary shown in white.

This ASTER image was used to verify that the clay (hydroxyl) mappings made with the LandSat image were reasonable. An area east of the claim group had a strong hydroxyl mapping in the LandSat and had a ASTER SWIR spectrum indicating kaolinite or a mixture of kaolinite and smectite. Figure 13 shows this test area.

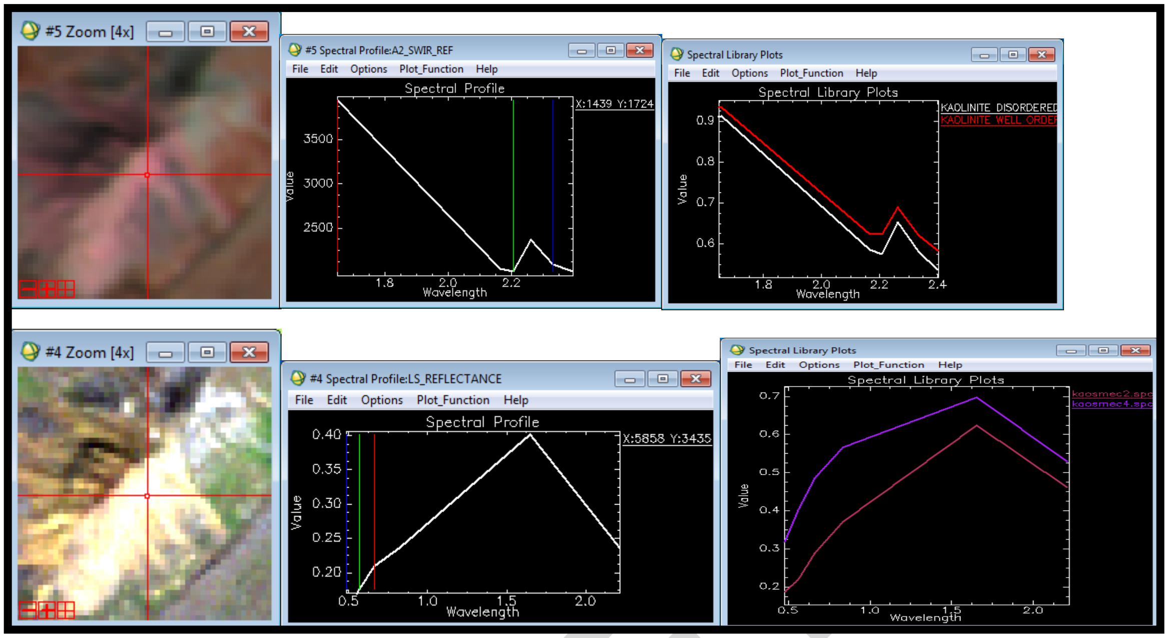

Figure 13. A comparison of hydroxyl rich area in LandSat and ASTER (SWIR). Left images show the sample site in ASTER(top) and LandSat (bottom). The middle spectral plot in the upper and lower row are the ASTER SWIR and LandSat image spectra respectively. The right images upper and lower row are spectral library plots for kaolinite (upper) and kaolinite-smectite (lower).

The comparison of clay rich areas in the LandSat image and the ASTER SWIR confirms that the LandSat mappings are reasonable for this material.

By comparing areas mapped as iron bearing and hydroxyl bearing in the LandSat image with the same locations in the ASTER image confirms that the LandSat mappings for these materials are reasonable. The LandSat mappings can then be used with a good level of confidence. Even though the ASTER data did not provide adequate coverage for the property it did confirm that the LandSat mineral mappings.

TIR Analysis - ASTER has five thermal infrared bands that measure the emissivity of the surface materials. The GSD (ground sample distance) or pixel size for the TIR sensor is 90 metres. This sample size is useful primarily for regional scale work but the TIR has the ability to identify most silicate materials better than the VNIR and SWIR sensors, such as quartz. Figure 14 illustrates the two ASTER TIR images based on bands 10, 11,12 as red, green and blue. The dark brown and black areas represent exposed rock and soil, the light blue is vegetation and the white and cream coloured areas are clouds and snow. The A2 image shows three smoke trails from fires. The smoke is very thin and not easily visible with the VNIR and SWIR bands but very obvious in the TIR.

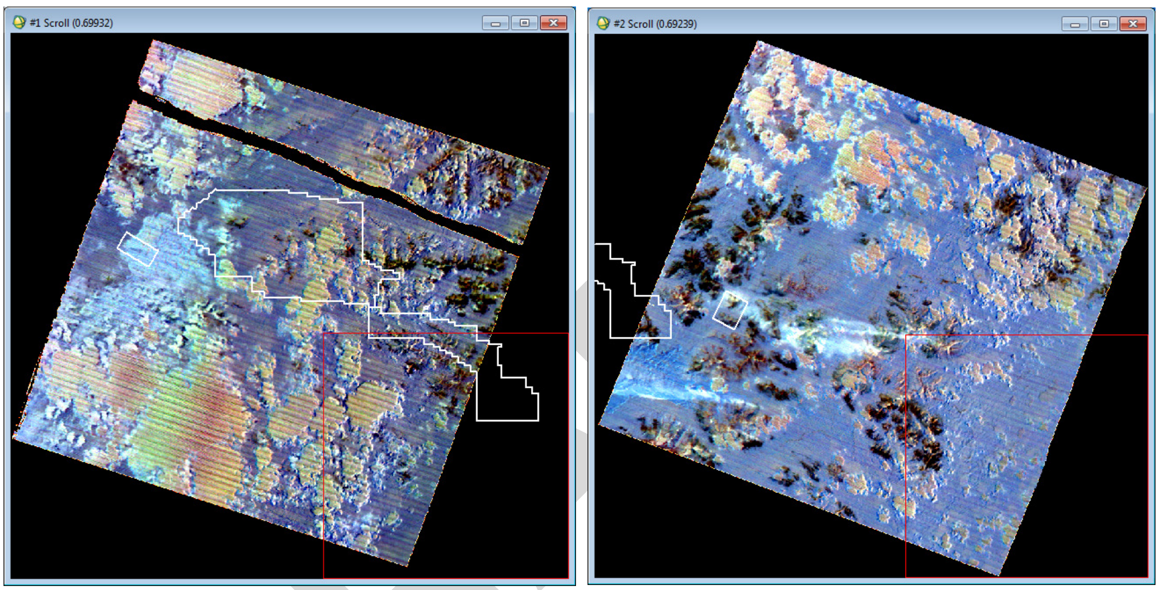

Figure 14. ASTER TIR RGB image using bands 10, 11, 12. A3 on the left and A2 on the right. ORO claims show in white.

Quartz SAM maps were constructed from the TIR images by using a quartz spectrum from the John Hopkins University Spectral Library (Figure 15).

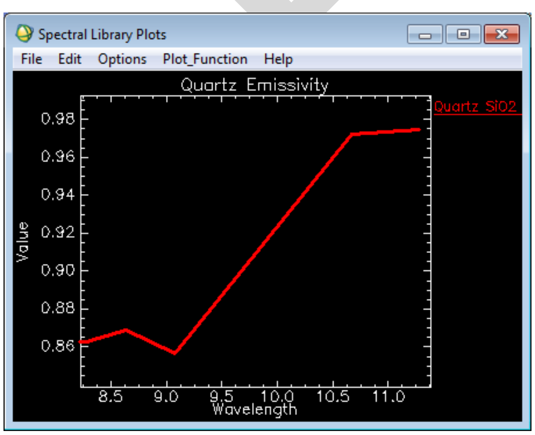

Figure 15. Emissivity spectrum of Quartz.

The SAM quartz mapping was strongly

influence by clouds which had a spectral features similar to that of quartz. A mask created from the TIR temperature data was applied to the Emissivity data to remove clouds. The mask also removed many areas of shadow from clouds and hills. The resultant mask was applied to the Quartz SAM maps which were then density sliced and coloured to highlight the pixels with the best spectral match to the Quartz library spectrum. Figure 16 shows examples of the maps over the ORO deposit site. The TIR related images have 90 metre pixels while the natural colour image has 15 metre pixels. The image spectrum under the crosshairs is shown in the figure also. This indicates that quartz or quartz rich material is present on the surface at the ORO site. If this is indeed the case then this mapping could prove useful in identifying similar sites elsewhere on the property. Caution must be used when looking at this mineral mapping as the mask was not perfect and there will be some false positives around cloud edges. Also the mask hid some shaded areas that will not show up in the mappings. TIR spectra are emissivity rather than reflectance and as such do not require illumination from the sun so spectrum from shaded areas are equally as valid as those from illuminated areas. In fact night time TIR mappings are often much better than daytime mappings. Therefore when utilizing the TIR data reference to the RGB TIR image, Natural colour image and the highlighted Quartz mapping image should made before accepting or rejecting an area as prospective for quartz mineralization. Coincident areas with iron-oxide and hydroxyl indications should be considered first.

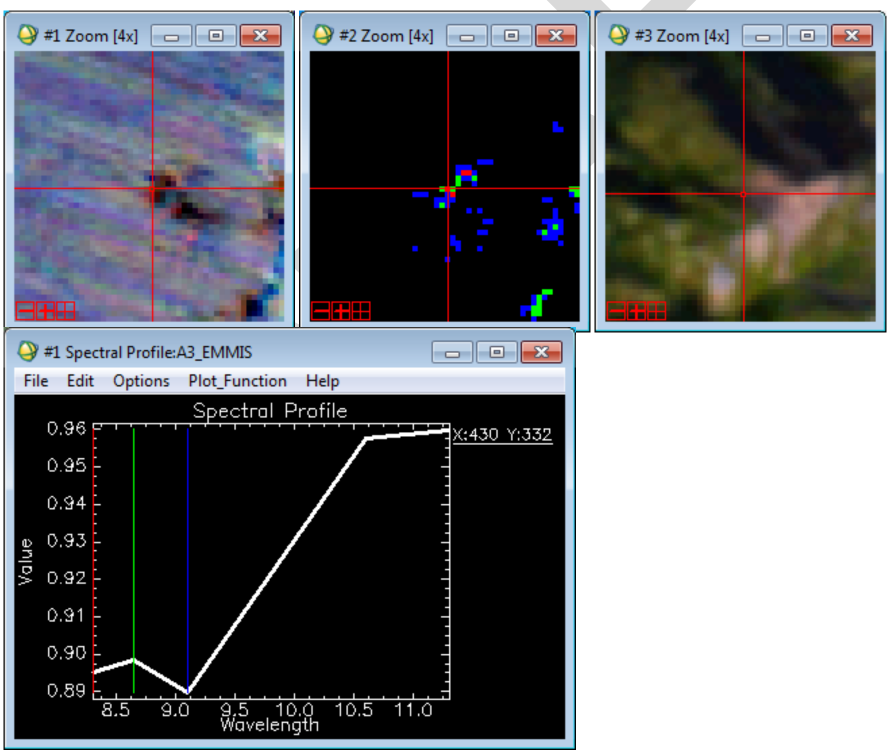

Figure 16. Quartz analysis images near the ORO deposit. Upper row left to right are the RGB Emissivity image, Highlighted SAM Quartz image and Natural colour image of the ORO site. The spectrum is from the ASTER image at the site of the crosshairs in the Emissivity images on the left.

The RGB Emissivity and Highlighted SAM Quartz images are provided as geoTIFF images in the Appendix.

CONCLUSIONS and RECOMENDATIONS

It is important to remember that any mineral identification made using ASTER or LandSat imagery is at best an estimate. Only through field verification should any reference to the existence of a mineral be taken as a given.

The analysis performed on the LandSat and two ASTER images covering the ORO claim group consisted of preprocessing phases where the imagery was corrected for a variety of sensor, atmospheric and geographic effects and an image analysis phase where spectral characteristics were identified and mapped.

Due to very poor ASTER coverage in the claim area a good LandSat image was obtained and analyzed. The ASTER images were used to examine the thermal infrared portion of the spectrum that can identify silicate minerals. Only one of the ASTER images had SWIR coverage which is used to map clay minerals commonly associated with hydrothermal alteration. Extensive cloud cover and low sun angle greatly reduced the value of the ASTER VNIR and SWIR data. The LandSat analysis generated a number of potential targets for further examination.

Standard LandSat analysis techniques were applied to the imagery with good results. Crosta Targeted Principal Component Analysis mapped hydroxyl and iron-oxide bearing minerals nicely. Spectral Angle Mapping using spectra from the ORO deposit and a potential jarosite occurrence highlighted a number of sites for field investigation. The 5th factor of a Tasseled Cap transformation also highlighted prospective areas. In most cases all the above analysis tended to identify the same areas. The fact that the known ORO site was positive in all these mappings suggests that other sites identified with these methods may be important. All the mineral mappings are provided in the appendix in geoTIFF format that can easily be loaded into a GIS. When selecting targets from the analysis reference should always be made to the corresponding natural colour imagery to assure that the prospective area is rock and not some combination of clouds, snow or vegetation that could have a spectral signature similar to the targeted rock.

When examining all the mineral map images one should only assume that the very best image matches (red pixels) represent the subject spectra. The images in this report are often too small to see all the important details. The digital report can be viewed at an expanded scale to improve the view and the full resolution images are contained in the appendix.

Silicification was mapped with the ASTER emissivity data. When using this mineral map it is especially important to assure that the highlighted pixels are representing good rock exposure as clouds and the thin edges of clouds can give a very similar thermal signature to quartz.

In addition to the mineral mappings a number of products were generated from the ASTER data. These included natural colour images, digital elevation models and temperature maps. All this information is provided in the appendix in geoTIFF format. Anaglyph images were also produced from the ASTER imagery to enable detailed stereo viewing of the scenes. Several pairs of paper anaglyph glasses are included in the product delivery.

APPENDIX: Analysis results and data files (on DVD)

1) **Raw Imagery (HDF):** Original ASTER and LandSat data as downloaded from LPDAAC and purchased from ERSDAC.
2) **Natural Colour (geoTIFF):** Natural Colour images of the two ASTER images and one LandSat image. A pan-sharpened version of the LandSat image is also included.
3) **Reflectance (ENVI BIL):** Reflectance and emissivity files for the two ASTER images and LandSat reflectance image.
4) **Digital Elevation Model (ENVI BIL):** Relative digital elevation models for the two ASTER images
5) **Anaglyph Images (PNG):** Anaglyph images created from the two ASTER images. Require cyan-red anaglyph glasses for viewing.
6) **Temperature (ENVI BIL):** One band TIR temperature data in ENVI format for the two ASTER images and one LandSat image.
7) **LandSat Maps (geoTIFF):** Predictive mineral maps based on LandSat analysis.
8) **ASTER Image Maps (geoTIFF):** Predictive mineral maps and false coloured images.