MapPlace.ca Image Analysis Toolbox, British Columbia – Phase 2

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INTRODUCTION

Phase 1 of this project established the framework of the Image Analysis Toolbox (IAT) that has now been operational for one year. In Phase 2, the IAT was completed with the addition of more analysis tools, imagery and imagery types. Near-complete coverage of the province with Landsat 7 (ETM+) imagery is now available. One new ASTER image was purchased and 45 new ASTER images located along the boarder with the United States were obtained and loaded into the system. All the existing and new ASTER images were orthorectified to improve their spatial accuracy. One HYPERION hyperspectral image was purchased and added to the site requiring a new style of map presentation. Two new analysis tools were added to the IAT. A variety of program modifications were made to increase the efficiency of the site's operation and provide full access to all the ASTER bands for any given analysis.

The established IAT framework has proven robust during the past year of operation and capable of incorporating new imagery and analysis tools. The IAT is now an integral part of the Exploration Assistant component of the MapPlace.

IMAGE ANALYSIS TOOLBOX TOOLS

Two new tools, the Tasseled Cap Transformation and the Spectral Angle Mapper (SAM) were added to the IAT (Fig. 1). Program enhancements were also made to the existing IAT programs to increase their efficiency and capability.

ASTER Program Enhancement

ASTER imagery contains 14 image bands, three bands from the visual near infra-red region (VNIR), six from the shortwave infrared region (SWIR) and five from the thermal infrared region (TIR) of the electromagnetic spectrum (Kilby *et al.* 2004). Each of these three groups of bands has a different pixel resolution. The VNIR bands have 15 m sample spacing; the SWIR bands have 30 m spacing and the TIR 90 m spacing. IAT tools provided in Phase 1 were only capable of operating on any one of these groupings at one time. In Phase 2, all tools that could access more than one image band were adjusted to resample any ASTER band on-the-fly so that any combination of bands could be utilized by any of the tools. Now when bands from more than one spectral group are used in an analysis they are all resampled to a 15 m resolution. If all the bands are from the SWIR or from the TIR groups then the resolution will be the original sample size of 30 and 60 m, respectively.

Figure 1. Analysis tools control panel.

Tasseled Cap Transformation

The Tassled Cap Transformation is a traditional Landsat analysis technique used to compress spectral data into a few bands to reveal key forest attributes. It was originally developed for use with the early Landsat

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Thematic Mapper data in the early 1980s. It has more recently been modified to utilize Landsat 7 Enhanced Thematic Mapper Plus (ETM+) data. (Huang *et al.* 2002). The Tasseled Cap Transform uses a predetermined 6X6 transformation matrix to convert the Landsat 7 (ETM+) bands (1, 2, 3, 4, 5 and 7) into six new bands. This transformation was determined for at-satellite reflectance but the imagery in the IAT is in radiance values. As a result, the result will be less discriminating than if reflectance values were available but it is nonetheless a valueable method. The IAT Tasseled Cap tool displays the first three of these bands which together usually explain about 97% of the variance in the image. These three bands are referred to as the 'Brightness', 'Greenness' and 'Wetness' bands and are displayed as the red, green and blue bands of the resultant RGB analysis image, respectively. Figure 2 displays the control panel for this tool. The tool only works on Landsat images, when transformation matrices for the other image types become available the tool could be expanded to work on them as well. Most of the parameters required to operate this tool are preset. All the user is required to do is select the size of the analysis area by filling in the 'Analysis Area Pixel Width' entry box. Then the user clicks on the 'Digitize Centre of Interest' button and moves to the reference image and clicks on the point that will form the centre of the analysis image. The resultant image will highlight bare ground as red, wetness as blue and vegetation as shades of green and yellow (Fig. 3). The analysis highlights many image features that are not apparent in a natural colour image. Note the difference between wet and dry material in the tailings. Also the relative amount of vegetation in logging cut blocks can be visualized. This tool is excellent for highlighting outcrops and identifying differences in vegetation that could be the result of the underlying geology.
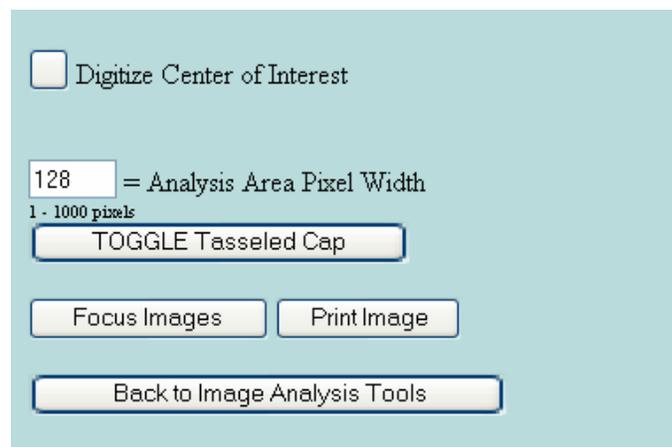
Figure 2. The Tasseled Cap Transformation control panel.
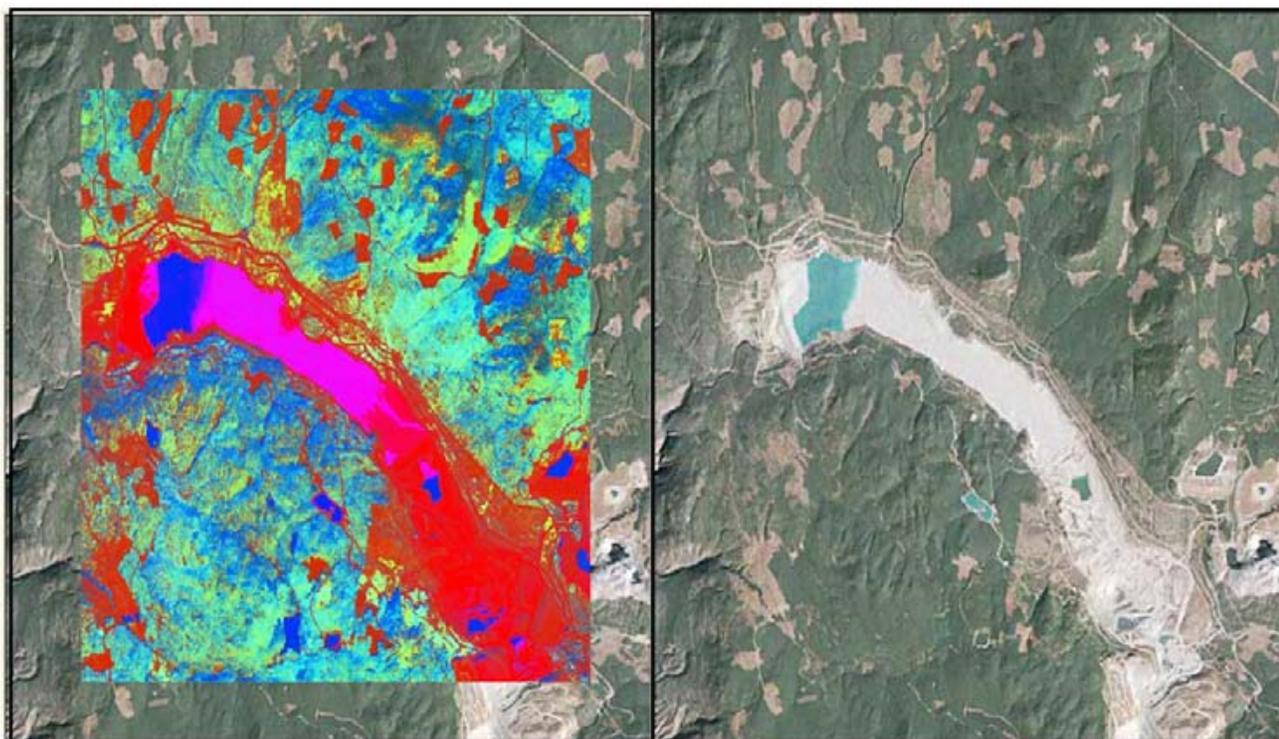
Figure 3. Results of the Tasseled Cap Transformation analysis over the Highland Valley operation.

Spectral Angle Mapper

The spectral angle mapper (SAM) generates an analysis image where each pixel contains the vector angle between a reference spectrum and the spectrum at each pixel location. In the IAT, the reference spectrum is selected by the user from a pixel on the reference image. The spectral angle may be calculated for any

number of contiguous image bands. This tool requires significant computation effort so the fewer bands and smaller analysis area that are used the quicker the result will be returned. Analysis based on large numbers of image bands could require several minutes to calculate. The best results are often obtained by selecting only the band range that is relevant to the target feature one is attempting to map. To use the SAM tool the user first selects the range of contiguous image bands that will form the spectrum by selecting the maximum and minimum bands of the range. Then a reference or target spectrum is selected by clicking on the 'Digitize Target Pixel' button and then digitzing a pixel on the reference image that contains the desired reference spectrum. The user may also select a colour scheme for the resultant analysis image from the 'Colour Map' selection box. The size of the analysis area may be selected by modifying the value in the 'Analysis Area Pixel Width' entry field. Then the user selects the area to be mapped with the SAM tool by clicking on the 'Digitize Centre of Interest' button and digitizing a location on the reference image. Different areas of the image may be mapped with the same reference spectrum simply by clicking on the 'Digitize Centre of Interest' button in the control panel and then selecting a new position on the reference image. This tool is useful when the user knows what exists at one position and wants to map all the areas with a similar spectral response. The spectrum for a single pixel is the result of the integration of all the individual spectrum received by the measuring instrument from the pixel area. Therefore pixels which contain only a partial amount of the target substance will still have a smaller spectral angle with the reference spectrum than pixels with none of the target substance so in this way some characteristics can be mapped at the sub pixel level.
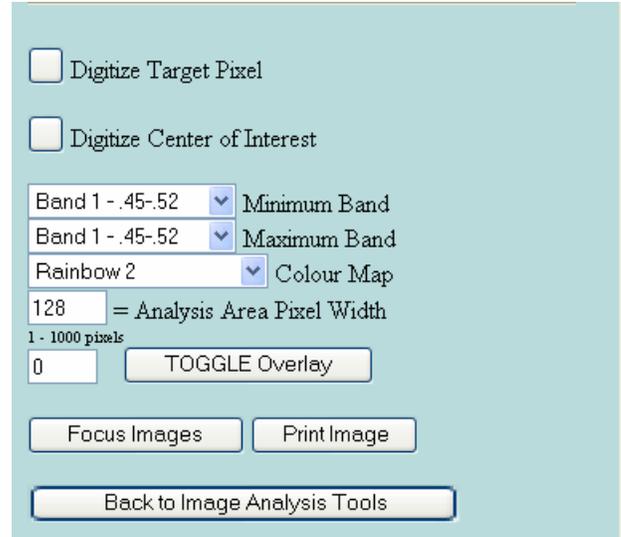
Figure 4. Spectral Angle Mapper control panel.
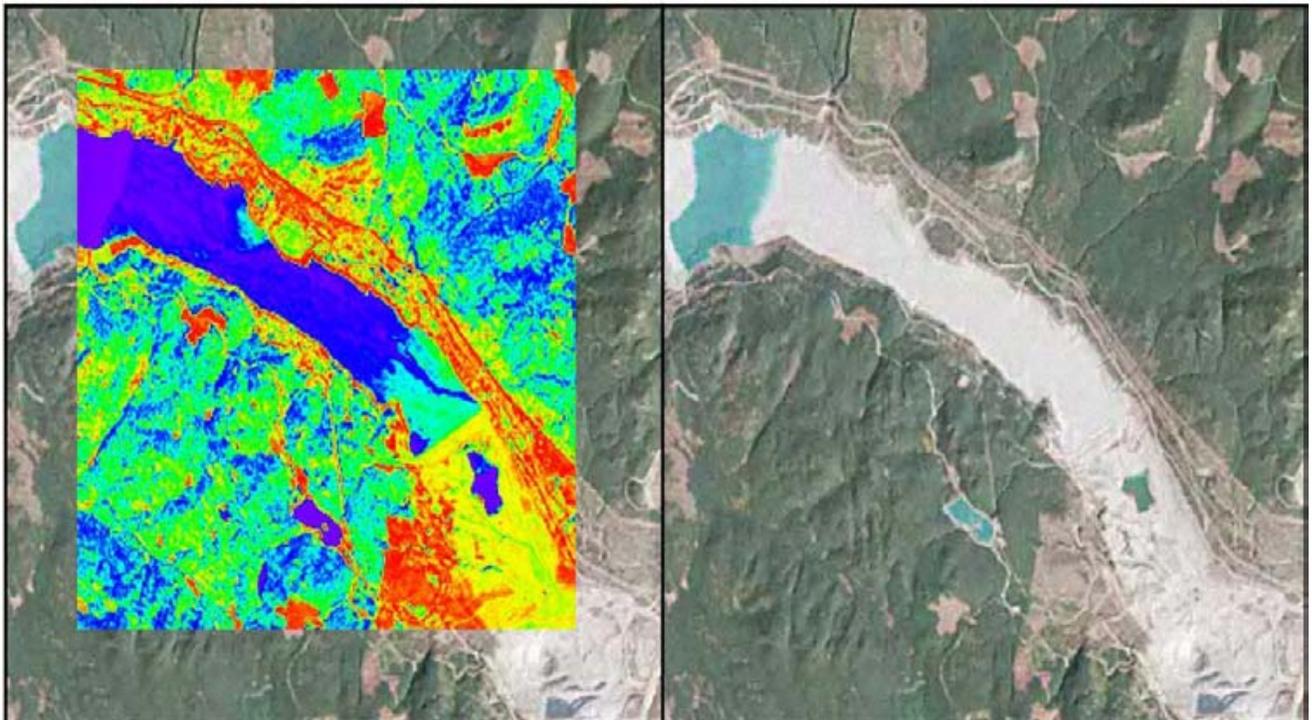
Figure 5. Results of a SAM analysis. The red colours have the smallest spectral angle with the reference spectrum that was obtained from the logging cut block in the upper centre of the image. The reference spectrum represented a mix of vegetation and soil.

IMAGE ANALYSIS TOOLBOX IMAGES

Landsat 7 (ETM+)

During Phase 2, 48 additional Landsat images were obtained and added to the system for a total of 68 images providing near complete coverage of the province (Fig. 6). The source and description of the Landsat 7 (ETM+) imagery is described in Kilby *et al.* (2004).
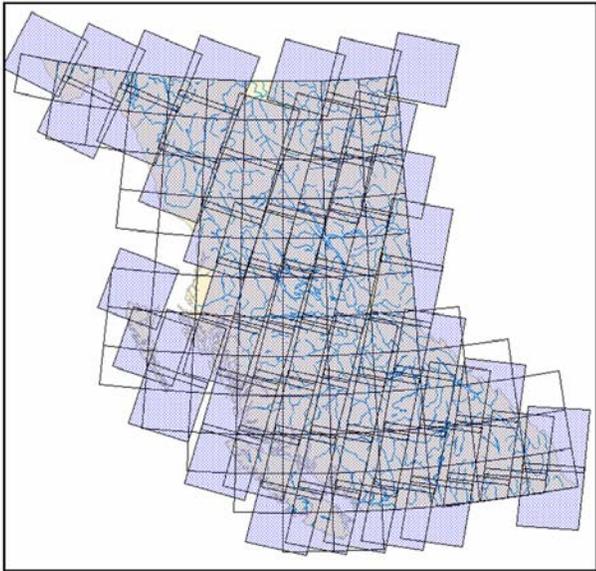
Figure 6. Distribution of Landsat 7 (ETM+) imagery.
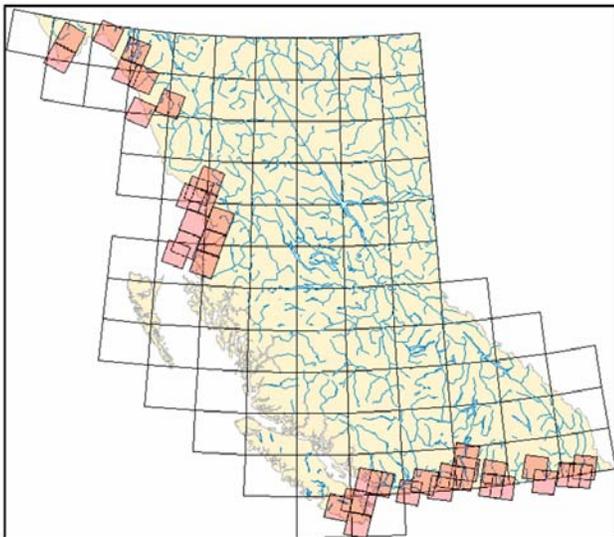
Figure 7. Distribution of ASTER imagery.

ASTER

During Phase 2, 46 new ASTER images were added to the system for a total of 51 images (Fig. 7). The images are primarily along the BC-US boarder as these images could be obtained at no cost. One image from the Okanagan Lake region was purchased. For a complete description of the imagery source and band characteristics see Kilby *et al.* (2004). All the ASTER images were orthorectified during this phase of the project to improve their spatial accuracy. The ASTER sensor can have cross track look angles of up to 8° which can cause a significant amount of image distortion. The orthorectification process removed this distortion and compensated for the topographic relief in the image area.

HYPERION

One HYPERION image was purchased and added to the system during Phase 2. HYPERION images have 242 bands that cover the VNIR, SWIR and TIR range of the electromagnetic spectrum, 355.57 to 2577.18 nm in approximately 10 nm increments (Fig. 8). The image purchased covers an area of 7 km wide by 88 km long in the Cariboo region. Part of the Equity Silver operation is captured in the northern part of the image (Fig. 9). The image was ordered through the United States Geological Survey website at http://eo1.usgs.gov/index.php and purchased from the EROS Data Center in Sioux Falls, South Dakota. Due to the very large size of the image and to reduce storage and processing requirements, a new map configuration was developed to hold the image during analysis. The map is oriented relative to the satellite orbit path rather than true north (Fig. 10). All of the usual map functions and information are available in the normal manner. The only caution is that the map is not in a UTM projection so the coordinate readout should be set to display latitudes and longitudes if accurate positions are to be determined from the map display.
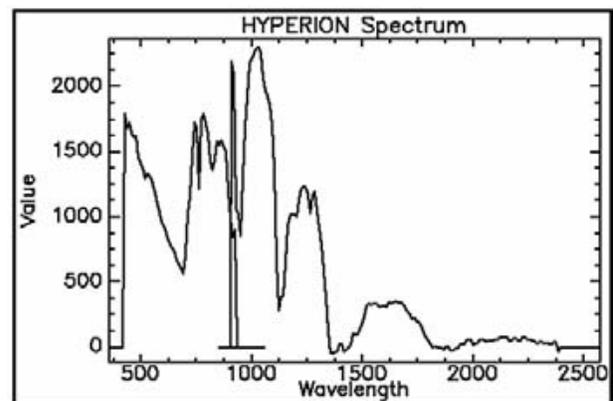
Figure 8. HYPERION spectrum from a conifer treed slope.
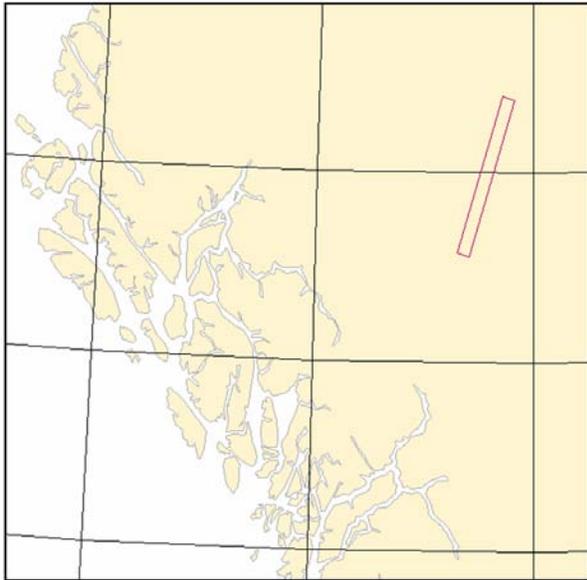
Figure 9. Location of the HYPERION image. Note orientation of the image.

Figure 10. HYPERION image in analysis map that is oriented parallel to the satellite orbit.

AVIRIS

The same single AVIRIS image is available for investigation as was available from the Phase 1 portion of the project. The image is from the Canal Flats area in southeastern British Columbia (Fig. 11). A complete
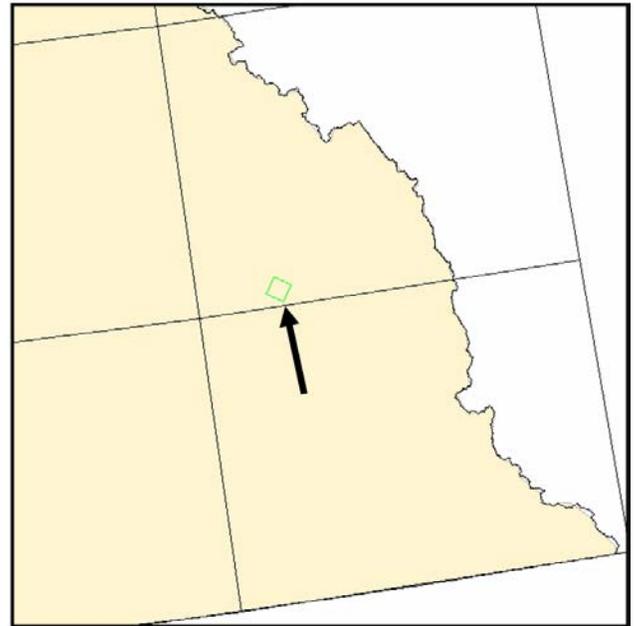
Figure 11. Location of the AVIRIS image.

description of the image is provided in Kilby *et al.* (2004).

ACKNOWLEDGMENTS

REFERENCES

Huang, C., Wylie, B., Homer, C., Yang, L. and Zylstra, G. (2002): Derivation of a Tasseled cap transformation based on Landsat 7 at-satellite reflectance; *International Journal of Remote Sensing*, Volume 23, no 8, pages 1741-1748.

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