ASTER IMAGERY

INFORMATION AND PRICE LIST

INTRODUCTION

This document is intended as a general introduction to data from the ASTER sensor and gives prices for the supply of data and products derived from the data. The reader is encouraged to go to either the EROS or NASDAQ sites for more information -

http://imsweb.aster.ersdac.or.jp/ims/html/MainMenu/MainMenu.html
http://edcdaac.usgs.gov/dataproducts.html

In an effort to keep the size of this document as small as possible, example imagery has been kept to a minimum. Separate PDF documents with example datasets have been prepared and are freely available from GEOIMAGE.

Aster Imagery with examples over Chuquicamata, Chile 406Kb
Spectral Unmixing of Aster Data, Escondida, Chile. 1.2Mb
Example of DEM Generation from Aster, Carajas area, Brazil. 756Kb

ASTER (Advanced Spaceborne Thermal Emission and Reflectance Radiometer) is an imaging instrument on board Terra - the first Earth Observing System (EOS) satellite. Terra was launched on December 18, 1999 from the Vandenberg Air Force Base in California and flies in a sun-synchronous polar orbit, crossing the equator in the morning at 10:30. ASTER is one of the five state-of-the-art instrument sensor systems on-board Terra with a unique combination of wide spectral coverage and high spatial resolution in the visible near-infrared through shortwave infrared to the thermal infrared regions. It was built by a consortium of Japanese government, industry, and research groups. ASTER data is expected to contribute to a wide array of global change-related application areas including vegetation and ecosystem dynamics, hazard monitoring, geology and soils, land surface climatology, hydrology, and land cover change.

ASTER consists of three different subsystems; the Visible and Near Infrared (VNIR) , the Shortwave Infrared (SWIR) and the Thermal Infrared (TIR). The VNIR subsystem consists of two independent telescope assemblies. One is vertical looking and has three detector arrays collecting data in the visible green, visible red and near Infrared wavelenghts, while a backward looking telescope has one detector array in the same spectral band as the near infrared of the vertical array. These infrared arrays (3N and 3B) generate an along-track stereo image pair with a base-to-height ratio of 0.6 and an intersection angle of 27.7 degrees and can be

An example of Spectral processing from our publicity sheet - Spectral Unmixing of Aster Data, Escondida, Chile by Mr Mike Hornibrook.

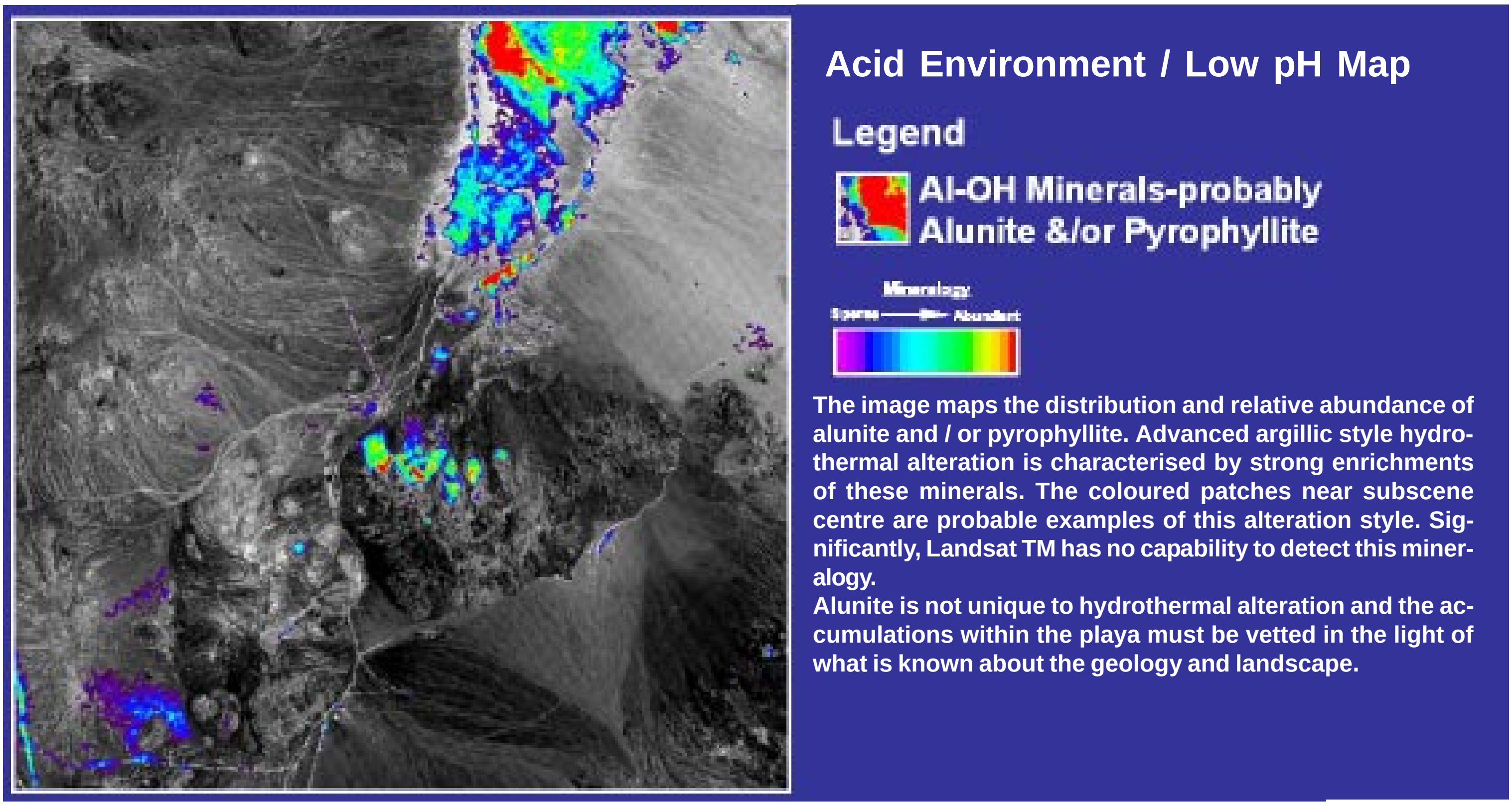
PRICING OF ASTER DATA AND PRODUCTS

Price per scene**	AUST PRICES	WORLD PRICE
Searches (see 3. below)	N/C	N/C
Supply of Level 1A or Level 1B HDF File	A$275	US$130
Supply of Level 1B HDF and image files. VNIR and SWIR are supplied as one 9-channel 15 m resolution file. TIR is supplied separately as one 5-channel 45 m resolution file.	A$360/ A$220/(7)	US$155/ US$100/(7)
Supply of Level 1B system geocoded ER Mapper format 9-channel VNIR and SWIR 15 m resolution and 5-channel TIR 45 m resolution files. Includes orthorectification using the USGS GTOPO30 DEM using PCI.	A$660/ A$460(7)	US$310/ US$210(7)
Production of a 15 m resolution DEM from Level 1A data. Includes supply of 3-channel orthorectified 15 m VNIR data.	A$1375/ $1320(7)	US$650/ US$600(7)
Supply of Level 1B orthorectified ER Mapper format 9-channel VNIR and SWIR 15 m resolution and 5-channel TIR 45 m resolution files. Includes supply of a 9-channel log residual 15 m resolution file (see 5. below)	A$440/ A$330(7)	US$210/ US$160(7)
Supply of Level 1A system geocoded data. 3-channel VNIR(15m) , 6-channel SWIR(15m) and 5-channel TIR (45 m). Includes radiometric correction to remove striping, rectification using internal gcps to get band registration in each module. Note misregistration between modules is of the order of a few pixels.	A$660/ A$495(7)	US$310/ US$240(7)

NOTES:

1. World prices exclude GST.
2. All prices exclude delivery from Geoimage to client.
3. Searches that are likely to take more than one hour will be charged at a suitable fee after discussion with the client.
4. Discounts are offered on bulk purchases and processing.
5. Available only after production of the 15 m DEM using the Level 1A data
6. Image files in either ERMapper, PCI or ERDAS formats.
7. Client supplied HDF file

GEOIMAGE is offering spectral processing of ASTER data using the services of Mr Mike Hornibrook of Spectral Geology Pty Ltd. Although it is difficult to give a firm pricing on these services, they will be based on US$500/A$1100 per day and a first pass spectral evaluation of a full scene Aster dataset would be expected to take one day and would include the processed data and a written report.



ASTER Sensor Systems

Sub-system	Band No.	Spectral Range (μm)	Spatial Resolution	bits
VNIR	1 2 3N 3B	0.52 – 0.60 0.63 – 0.69 0.78 – 0.86 0.78 – 0.86	15m	8bits
SWIR	4 5 6 7 8 9	1.600 – 1.700 2.145 – 2.185 2.185 – 2.225 2.235 – 2.285 2.295 – 2.365 2.360 – 2.430	30m	8bits
TIR	10 11 12 13 14	8.125 – 8.475 8.475 – 8.825 8.925 – 9.275 10.25 – 10.95 10.95 – 11.65	90m	12bits

~~used to generate digital elevation models.~~

ADVANTAGES/DISADVANTAGES OF ASTER IMAGERY

1.The VNIR data at 15m resolution is currently the best resolution multispectral data available commercially from satellite with the exception of the 4metre resolution IKONOS data. Comparison of the 10m resolution SPOT Panchromatic band shows that it has much better resolution than the ASTER data while a comparison with the Panchromatic 15m band on the LANDSAT7 ETM+ shows that the ASTER data is better both spectrally and spatially.

2.The SWIR data consists of 6 bands designated bands 4 to 9. Band 4 has a similar wavelength to LANDSAT band 5 and is located where most cover types have maximum reflectivity. Bands 5 to 9 cover an area of the Shortwave Infrared where many -OH bearing minerals and carbonate minerals have absorption features. Bands 5 to 8 approximately cover the wavelength limits of LANDSAT band 7. Minerals which may be of interest to exploration geologists and which will produce absorption features in this region are -

- Alunite / pyrophyllite; significant for mineral exploration (LANDSAT TM has no capability) and mine site rehabilitation / environmental studies. Defines low pH / acid environments ie advanced argillic style alteration.
- Kaolin group; significant for mineral exploration. Useful in defining argillic style alteration and mapping regolith deposits.
- Illite-muscovite-smectite; common minerals in the surficial environment and useful for geological mapping. Components of phyllic and argillic style alteration.
- Mg-OH / carbonate; significant in that LANDSAT TM is incapable of detecting these minerals directly. Major components of geological units and ore systems.

The Aster VNIR and SWIR data therefore promises enhanced discrimination of mineral assemblages relative to existing LANDSAT Thematic Mapper data.

3. ASTER TIR data is the only available multispectral thermal imaging data available apart from airborne systems and although it only has a resolution of 90m should be useful for defining surface silicification.

4. The along-track 3N and 3B stereo images allow the calculation of digital elevation models and although the base/height ratio is not as large as for the SPOT satellite data, this is compensated for by the fact that only one date imagery is required. (Spot is a side looking sensor and thus two dates of imagery in opposing directions are required for stereo viewing).

5. ASTER VNIR/SWIR/TIR scenes are 60km square and can be collected at angles up to 8 degrees to the vertical (VNIR data can be collected at up to +/- 24deg but the SWIR is limited to 8deg). If large area mosaics are required, the LANDSAT TM with its 180km square km coverage will provide better geometrical accuracy and much less work. What it comes down to is the spectral/ spatial accuracy verses the time and costs involved.

6. ASTER is currently free and can either be downloaded or ordered on CDROM or tape. Although this is an advantage, the time taken to do searches and process the data must be taken into account when comparing it with the much easier to order and process LANDSAT7 ETM+. It is my understanding that the Japanese charge for the data and it is only a matter of time before the US do also.

7. LANDSAT 7 data appears to be collected on a routine basis over most of the land surface. The collection routine for ASTER is not known and there appears to be areas where there is good coverage and areas where there is none. This coupled with the fact that only 10% of ASTER scenes have been processed to Level 1B scenes makes it difficult to predict if data will be available for any area with searching.

ASTER LEVELS

The main ASTER processing levels are -

ASTER Level 1A Data Set - Reconstructed, Unprocessed Instrument Data

The ASTER Level 1A product contains reconstructed, unprocessed instrument digital data derived from the telemetry streams of the 3 telescopes and their respective ground resolutions: Visible Near Infrared (VNIR), 15 m, Shortwave Infrared (SWIR), 30 m, and Thermal Infrared (TIR), 90 m. These depacketized, demultiplexed, and realigned instrument image data have their geometric correction coefficients and radiometric calibration coefficients calculated and appended but not applied. It also includes corrections for the SWIR parallax, and intra- and inter-telescope registration information.

This level of data is required to generate accurate digital elevation models but is no use spectrally because the bands are not registered.

ASTER Level 1B Data Set - Registered Radiance at Sensor

The ASTER Level 1B product contains radiometrically calibrated and geometrically co-registered data for all the channels acquired previously through the telemetry streams of the 3 different telescopes in Level 1A. This product is created by applying the radiometric calibration and geometric correction coefficients to the Level-1A data. Both intra-telescope and inter-telescope registration correction for all the bands has been accomplished relative to the reference band of each sub-system. The Level 1B radiance product offers the same number of bands at the same resolution as the Level 1A product. Level 1B data provide the input for generating higher Level 2 geophysical products.

Only approximately 10% of the data collected as Level 1A has been processed to Level 1B. GEOIMAGE is currently investigating producing Level 1B products from Level 1A.

ASTER Level 2 Surface Reflectance Product (VNIR)(AST_07)

The ASTER Level 2 Surface Reflectance Product is an on-demand product that contains atmospherically corrected Visible and Near Infrared data. It is generated using the 3 VNIR bands between 0.52 and 0.86 μm from an ASTER L1B image. Atmospheric correction involves deriving a relationship between the surface radiance/reflectance and the top of the atmosphere (TOA) radiance from information on the scattering and absorbing characteristics of the atmosphere. A digital elevation model provides the slope and elevation information for the accurate modeling of surface reflectance. Further details of the methodology are obtainable from-

http://edcdaac.usgs.gov/aster/asterdataprod.html

ASTER Level 2 Surface Reflectance Product (SWIR) (AST_07)

The ASTER Level 2 Surface Reflectance Product is an on-demand product that contains atmospherically corrected short-wave infrared data. It is generated using the 6 SWIR bands between 1.60 and 2.43 μm from an ASTER L1B image. The methodology is similar to that for the VNIR.

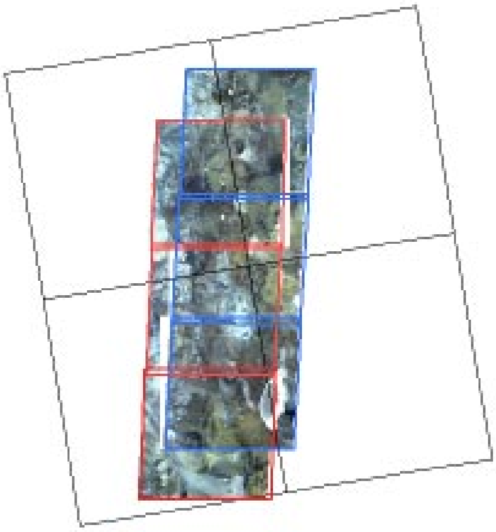
Log Residuals

Log Residuals is a technique introduced by the CSIRO for processing of LANDSAT TM and airborne scanner data in the 1980s. The transform removes the solar irradiance, atmospheric transmittance, instrument gain and topographic/albedo effects from image data to produce a pseudo reflectance image. This is achieved by first calculating the spectral and spatial geometric means from the data. Geometric means are calculated using logarithms of the data values and are used because the transmittance and other effects are considered multiplicative. The spectral mean is the mean of all bands for each pixel and removes topographic effects while the spatial mean is the mean of all pixels for each band and accounts for the solar irradiance, atmospheric transmittance and instrument gain. Each image data value is then divided first by the spectral and then by the spatial mean. (M. Hussey PhD Thesis). Tests that we have carried out show that the log residuals are a good substitute for the Reflectance data.

SEARCHES FOR ASTER DATA

Searches for ASTER data can be carried out on either the ERSDAC or EOS sites and enable the user to define the particular level of data required, a geographical window of interest, restrictions on the cloud cover, etc. The search engines are not particularly user friendly and the searches are very time consuming if the quick look images are required. A note of caution for first time users. The corner co-ordinates of the Level1B data are for the processed data and include the blank fill added to the edges to correct for earth-offset. To get accurate corner co-ordinates requires a Level 1A search however this will return more scenes than are available as Level1B.

GEOIMAGE is prepared to carry out searches for clients who order the data through us. As long as the area is not particularly large, the search will include a Mapinfo coverage map, a text listing of the available scenes, and JPEG thumbnails of the scenes. Note: It is possible to restrict the search by percentage cloud cover and this will be done where there are numerous scenes. The text listing however will not include cloud cover as this is not readily available except by examining the complete details of each dataset individually. Where a search is likely to take several hours, some charge will have to be made



Example of an ASTER search over the Escondida area in Northern Chile and displayed in Mapinfo. The results included vector surrounds of the scenes, jpegs of the six good scenes identified on a one degree grid. The total size of the files was approximately 50kb and was easily emailed to the client.

however this will be discussed with the client before hand.

DEM GENERATION FROM LEVEL 1A ASTER DATA

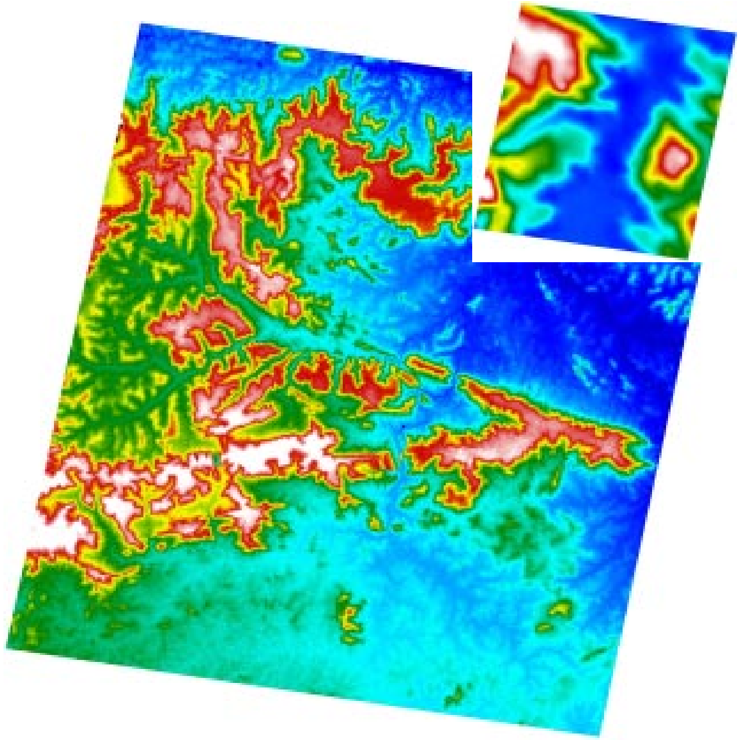
GEOIMAGE routinely produces Digital Elevation Models from ASTER Level 1A scenes using **PCI Orthoengine.**

Accuracy of the DEM will be highly dependent on the source of the ground control points used. Ideally it takes approximately 6 to 8 surveyed points spread evenly over the image, with a good range of z values, that can be identified accurately on the image. Such points are usually provided by the client either marked on a copy of the ASTER imagery or clearly marked on air photos.

Topographic maps are not usually accurate enough for X Y control unless they are available at large scales such as 25K and have detailed contour information. As a fall back it is possible to use in Australia, the 100K AUSLIG topographic series for X Y control and the 9 sec AUSLIG DEM as the Z control however the results will not be ideal. In such circumstances, it would be better to use LANDSAT 15m Pan which has been orthorectified as the X Y control and the 20m contours of the 100K AUSLIG topographic maps as the Z control. As the ground control points are easily identified on the TM Pan imagery, they can be moved so that they fall exactly on the contours thus assuring very accurate Z control.

We have had the same success in several areas of the world where local topographic maps in conjunction with the GTOPO30 DEM have been used to orthorectify LANDSAT7 ETM+ Pan data and then the Z control has been points on 50m or 100m contours on the topographic maps.

Some land cover types do not have sufficient texture to enable the image correlation necessary to generate the image offset and thus digital elevation values. Such cover classes include water bodies, salt lakes, homogeneous grass or bare soil areas, snow, etc. PCI can generate a score channel which gives a value from 0 (correlation failed) to 100 (good correlation) for each point in the generated DEM. This can be used either by Geoimage or the end client to edit and "fix" the areas of low correlation. PCI will routinely triangulate values within areas that are undefined if such areas are not edited out.
There will also be instances where the software correlates points that are obviously incorrect – these will need to be edited out if an accurate DEM is



Rainbow pseudocoloured 15m DEM produced from Aster, Carajas Area, Brazil. The area has a altitude range of 350m to 900m. The small inset image is the GTOPO30 data for the same area. Note the dissected lateritic surface that is the host to the iron deposits in this area.

DEM GENERATION FROM LEVEL 1B ASTER DATA

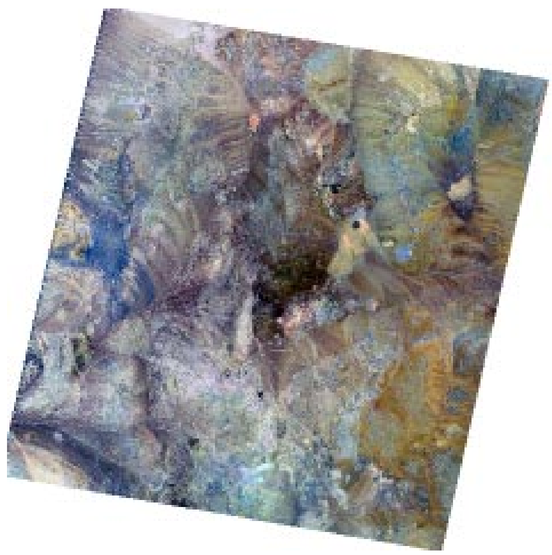
It is possible to generate DEMs from ASTER 1B data however because the data is two dimensionally resampled in the transition from Levels 1A to 1B the result would not be expected to be as accurate. We have carried out test of this using the same ground control points on the same 1A and 1B scene and although the resulting DEM images look very similar, the errors both in the ground control points used and in the topographic contours that have been used as control are much higher for the 1B scene.

It is also possible to generate Relative Digital Elevation Models from ASTER Level 1B scenes using **PCI Orthoengine.** Such processing should only be considered if there is no topographic control and the client is only interested in defining topographic features such as plateaus, drainage information, etc.

GEOCODING of ASTER 1B

The geolocational accuracy of the level 1B data appears to be very variable with mislocation up to a few kilometres. If the ephemeris data is used to rotate the data, the tracking of the satellite appears to be accurate however the location along the track is quite variable. GEOIMAGE offers a service to locate the data as accurately as possible using the best available maps (client supplied maps are welcome). Because the data can be collected off the vertical, the most accurate geocoding however involves the calculation of the DEM using 1A data and then the orthorectification of the 1B data using this DEM .

This ASTER image was collected on 26-Nov-2000 and the Zaldivar Mine / Escondida North prospect is in the central bottom of the image. The data was orthorectified using a DEM generated from 1A data with GCPs from an orthorectified LANDSAT 7 Pan scene. This presentation is a band 123 in BGR Log residual Image.



SPECTRAL PROCESSING OF ASTER DATA

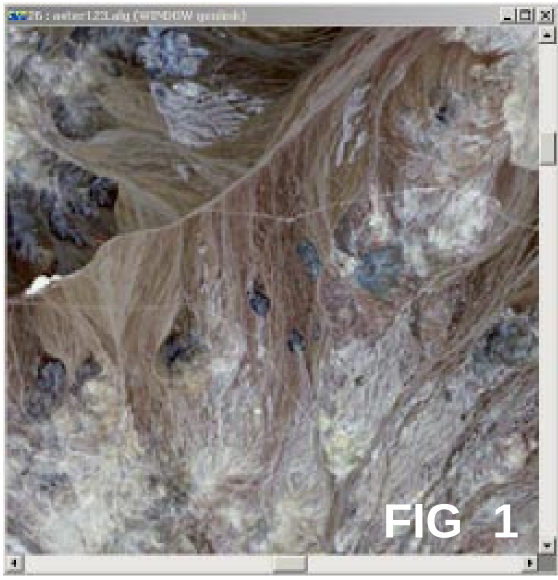
In a separate sheet, GEOIMAGE reports the findings of Mr Mike Hornibrook on the results of a Spectral Unmixing exercise in the Escondida region of Chile. In this report, we detail some of the simple processing that can be carried out on ASTER data using ERMapper. These examples have been prepared using a 9 channel VNIR and SWIR 15m dataset from the Escondida region in northern Chile from which we have also calculated a 9 channel Log Residual dataset.

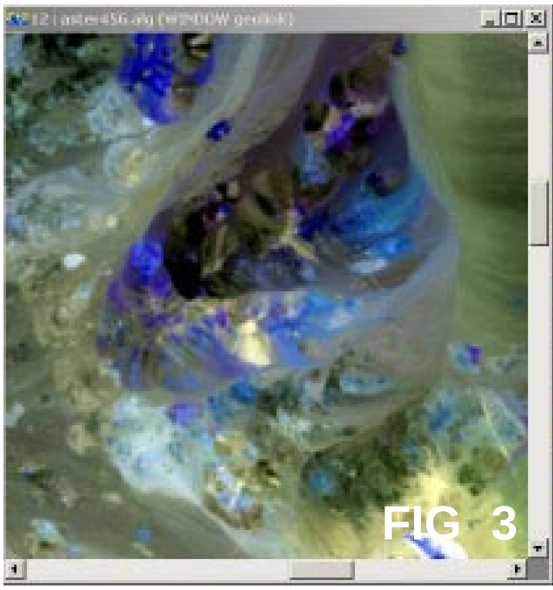
Figure 1 shows a band 123 in BGR colour composite over a 5km by 5km area and Figure 2 shows the same area in Log Residuals. Note the increase in spectral information in the Log Residual image.

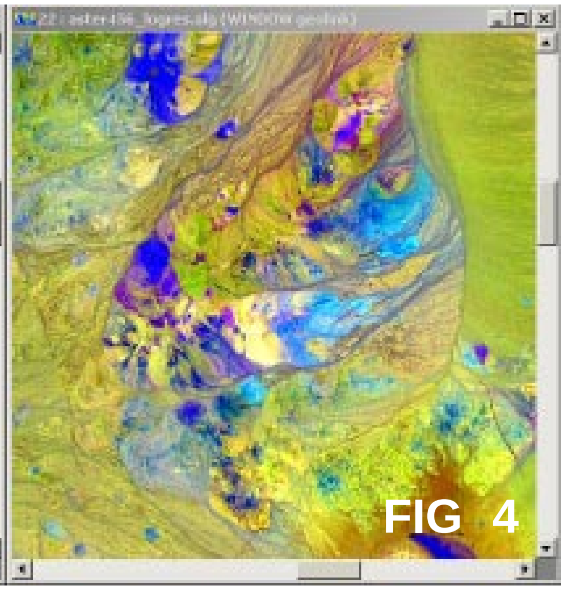
Similarly in Figures 3 and 4 we compare SWIR Bands 456 in BGR as raw data and as Log Residuals. The difference here is more spectacular and the image appears to have been sharpened by incorporating the 15m VNIR data in the Log Residual processing. These images cover approximately 10km by 10km.

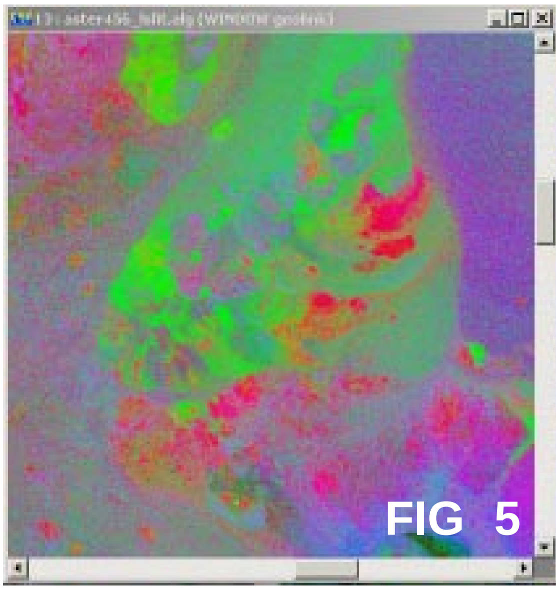
The LSFIT technique is one of the best techniques to predict clays by the absorption in Band 7 of LANDSAT TM. The LSFIT technique developed by the Australian CSIRO is a linear regression technique that compares the predicted band 7 with the actual band 7 to identify areas of anomalously high absorption and hence infer the presence of clays. The same technique can be used with ASTER data to predict absorption in particular bands. In Figure 5, Lsfit Residuals of Bands 4 5 6 have been displayed in BGR. Thus areas of red show absorption in band 6 and green show absorption in band 5. Note the Lsfit technique is used on the raw Level 1B data.

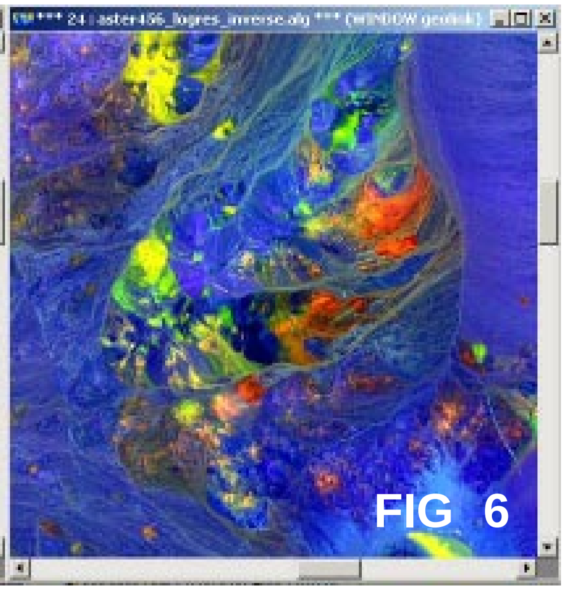
The Log Residual channels are pseudo reflectance data and can be changed to absorption by inverting them. In Figure 6, the bands 456 in BGR are inverted simply by using a formula “1/i1” in each channel. Thus the red areas represent areas that are absorbing in band 6, green colours are areas absorbing in band 5 and yellows represent areas that are absorbing in both channels.











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