ERSDAC News

No.67

2001. 03

ASTER Collection of World Geology
– Escondida Mine, Chile –

ASTER VNIR image [April 23, 2000 / R, G, B = 3, 2, 1]

Description

The target of the cover-page composite (R,G,B = 3,2,1) is Escondida Mine (Northern Chile). It was captured by ASTER VNIR on April 23, 2000, successfully identifying open-pit mines and other mine equipment distinctly enough. A decorrelation stretch image for the same area is shown in Fig. 2 (R,G,B = 8,6,4). It corresponds to the alteration mapping of a variety of minerals that have relation to the mineralization.

The Escondida mine is a representative porphyrycopper-type deposit, yielding the largest volume of copper in the world. It started to be tapped in 1990 by mining companies in Australia including several Japanese companies. Some of copper ore are shipped to refineries in Japan as well. Around the area existed a great number of ore deposits, mainly, of gold, silver, and copper like the Zaldivar deposit and the El Salvador deposit. Additionally, the region, a representative arid land of the world, has scarce vegetation. Those facts make the region suitable for the development of alteration mineral mapping technique using remote sensing data. Actually, ERSDAC has so far worked for development of alteration mineral mapping technique and conducted researches on geological analysis, using JERS-1 and ASTER satellite data targeting there. Figure 3 indicates the target sites.

Fig. 2 ASTER SWIR Image（RGB=864）

Fig. 3 Target Area

Every image in Fig. 4 is a six-scene mosaic, respectively of VNIR (R,G,B = 3,2,1), SWIR (R,G,B = 5,6,7), and TIR (R,G,B = 14,12,10). Color tone of each image can successfully tell lithofacies and altered minerals and reflects north-south system geological features of the region.

Geological features of/around the region can be divided broadly, from west, into Cordillera de la Costa, Depresion Central, and Cordillera de las Andes, each stretching in the N-S direction. Respective features are described as follows.

Cordillera de la Costa in the west is composed of the Paleozoic, Triassic-Jurassic, and Lower Cretaceous systems for the most part. On the other hand, the most part of Cordillera Domeyko, which occupies the eastern part of the target region and is mainly composed of volcanic product, is made up of the Tertiary system, although the Paleozoic and Triassic-Jurassic systems constituting inlier with reverse fault are also seen in the western part and part of the central area.

It is the Domeyko fault system, traversing the near central area of the target region in the near N-S direction, that defines the region's geological feature as regional geological structure. The Atacama fault system is also seen in the western part of the target region.

(Hirose , Project Planning Division)

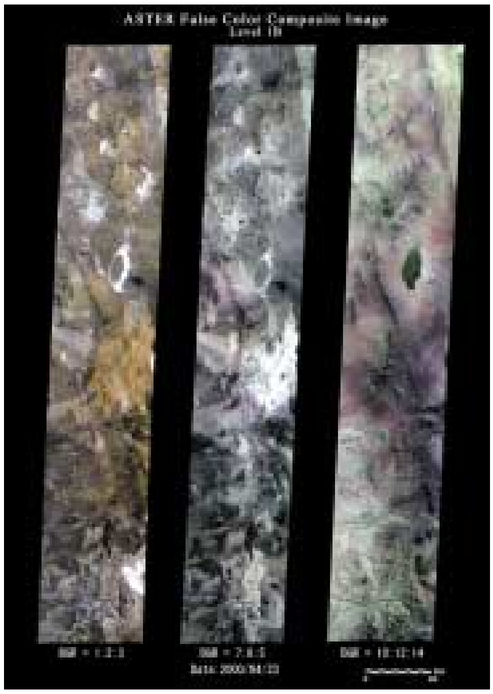


Fig. 4 ASTER Mosaic Images（VNIR, SWIR, TIR）

1. Present Status of Oil/Gas Exploration in Poland

Poland is a country having a population of about 40 million, some one third as large as that of Japan, and its area of approximately 320 thousand square kilometers, a Hokkaido-excluded equivalent of Japanese land area (about 380 thousand square kilometers). This country is, like Japan, also poor in oil resources, domestically producing it only about half the amount Japan does.

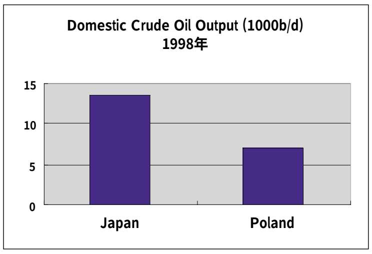
Visiting Geofizyka Torun Co. (Fig. 1-1), a Polish Oil and Gas Corporation (POGC)-affiliated physical survey company based in Torun City about 200km northwest of Warsaw, we investigated the present situation of oil/gas exploration as well as utilization trend of remote sensing data in Poland. Then ASTER and PALSAR were explained.

Fig. 1-1 Geofizyka Torun Co.

According to Geofizyka Torun Co., remote sensing data are now used by many physical survey companies of the world and already a tool which cannot be dispensed with. Geofizyka Torun further added that, other than for direct survey purposes, applications are also under consideration such as for pipeline construction.

Physical survey (Seismic) to find oil/gas resources is in many cases three-dimensional (a survey by surface arrangement of seismic signal receiving and transmission points) and pre-programming of measuring lines is its important element. Measuring lines are programmed to optimize reflective buses from the subsurface structure by combining oscillator/transmission point arrangements.

The present measuring-line program assumes any survey area surfaces as plane but, since there are obstacles such as rivers, bridges, private houses, marshes, and fences in fact, measuring lines programmed beforehand can rarely be used as is on the site. If picture data of the survey area are available, obstacles can be precluded before programmed and, if DEM (Digital Elevation Model) information is available, undulations can also be taken into consideration to program measuring lines. They also say that high expectation is placed on DEM data since such information available permits reflective buses to be calculated more precisely at the processing stage, thereby improving the accuracy of physical survey



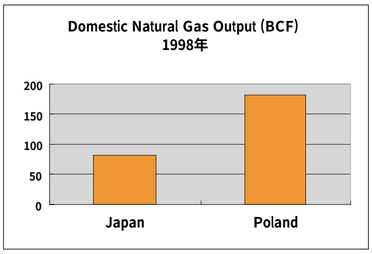


Fig.1- 2 Comparison of Oil/Natural Gas Output between Japan and Poland (1998)
Source: Oil Corporation (Japan), EIA (Poland)

In laying a pipeline, selection of its course is another hard task, which importantly requires topographical identification. DEM information can be quite effective if available from remote sensing data. Meanwhile, burying a pipeline raises a problem of pipeline corrosion, which must be prevented by some measure and, in areas where soil is less resistant against electricity, pipelines may be more easily corroded. It is, therefore, useful if dangerous areas can be known by remote sensing, they commented.

We mentioned ERSDAC activities such as by referring to the start of ERSDAC data delivery to general users and joint research programs. We also referred to actually implemented computer-based demonstrations of ASTER data search as well as studies started from 1999 to identify active layers in soil-freeze areas which may cause a problem with pipeline construction, seeming to attract their great attention.

(Kikuchi, Technical Department)

Fig. 1- 3 Demonstration of ASTER Data Search

2. Technology Trend of Remote Sensing 1

–1st Geological Hyperspectral Focus Group Adelaide 2001–

Australia, a big country rich in resources, early started its efforts to apply high-spectral resolution remote sensing technology to resources exploration. Trends of hyperspectral sensor utilization technology at various institutions within Australia as well as foreign countries are summarized from lectures given at the "1st Geological Hyperspectral Focus Group Adelaide 2001," a scientific lecture forum sponsored by the Primary Industries and Resources SA (hereinafter PIRSA) of the South Australia's state government as follows.

The "1st Geological Hyperspectral Focus Group Adelaide 2001" is a scientific lecture forum focusing on applications of hyperspectral remote sensing to geological and resources areas. With mineral mapping particularly for mineral resources exploration purposes as its main subject, it was attended by, not to speak of those engaged in researches at CSIRO (Commonwealth Scientific and Industrial Research Organization), AGSO (Australian Geological Servey Organization), and other research organizations/universities, a good many businessmen such as from sensor and software developer-manufacturers, survey contractors, prospecting houses, and mining companies.

The meeting was held in the state's capital Adelaide under the following schedule:

Feb. 19 : Pre-conference Workshop
Feb. 20 : Lecture/Presentation : Present Opportunities, etc.
Feb. 21 : Lecture/Presentation : Next Generation Integration, etc.
Feb. 22 : Post Conference Workshop

At the plenary session, 22 lectures including keynotes were given for well-defined various subjects including the present status of available hyperspectral sensors, geological mapping, next generation systems, data integration, and alteration mapping. By-field lecture contents are summarized as follows:

(1) Keynote Speech

Lectures were given by CSIRO's remote sensing group leader J. Huntington concerning the utility of hyperspectral remote sensing technology in the mining field under the title "Hyperspectral Sensing in the Mineral Industry - A Review of Opportunities" and by PIRSA's A. Mauger about a campaign to stimulate the HyMap(Fig. 2-1)-based exploration activity in the Musgraves region.

(2) Present status of available hyperspectral sensors

Four lectures were given about the present status of available hyperspectral sensors. They were concerning the utilization of HyMap outside Australia, mineral mapping based on the thermal-infrared hyperspectral data obtained from SEBASS, mineral mapping by an experimental hyperspectoral sensor OARS, and portable spectrometer-based ground mineral alteration mapping.

OARS is a line profiler (non-image sensor) developed for intended simultaneous data acquisition such as with airborne electromagnetic and airborne magnetic/radiometric surveys, observing a 0.489~2.515μ m-wavelength band with 186 channels. OARS most advantageously has two independent measuring systems; one for ground surface survey and the other for observing the ether. This permits on-board exclusion of atmospheric absorption/scattering effects, thereby enabling ground surface reflectance to be measured. OARS' ground surface resolution is some 10m (width) × 1m (flying direction) when flying 80m above ground.

Fig. 2 -1 HyMap System

(3) Geological mapping

Lectures about geological mapping numbered 5, namely, concerning geological /alteration mapping with OARS/TIPS-based visible to thermal infrared-range data, HyMap data processing method which takes BRDF effects into consideration, cases where hyperspectral remote sensing is applied to the exploration of mineral resources, mapping for soil contents of salt, and hyperspectral remote sensor-based mineral alteration mapping for open-pit gold mining surfaces.

(4) Next generation system

Two lectures, which were given for next generation systems, relate respectively to Hyperion Project and Australian domestic verification (Cal/Val) program and the South Australian state government's HyMap-based data acquisition project.

(5) Data integration

Concerning data integration, 3 lectures were given: Survey integrated with various airborne electromagnetic/magnetic/radiometric mineral surveys as well as hyperspectral remote sensing; Explanation of the South Australian state government's prospecting promotion project TEISA (South Australia's Targeted Exploration Initiative), and Introduction of a new-type hyperspectral sensor ARGUS. ARGUS is a new-type hyperspectral sensor under development at Fugro Co. and a line profiler covering visible-to-short wavelength- and thermal-infrared ranges.

(6) Alteration mapping

Lectures with regard to alteration mapping took up 4 topics, namely, HyMap-based alteration zone mapping of volcanogenic massive sulfide deposits, ASTER data-based geological/alteration mapping, alteration mapping to cover rarely rock-exposed areas, and reflectospectral morphological mineral mapping of white mica.

(7) Other

Lectures given other than the above included one concerning efforts to survey the state of pollution due to acid water from abandoned mines, which is reflected such as on jarosite distribution, using hyperspectral data, and apply survey results to environment control.

(Kazuya Okada, Sumitomo Metal Mining Co., Ltd.)

2. Technology Trend of Remote Sensing 2

—AVIRIS Workshop 2001—

February 27 through March 2, 2001, the 10th AVIRIS Earth Science and Application Workshop was held at NASA/IPL, U.S. and some 70 papers were read there.

First, AVIRIS Team of JPL reported improvements toward 2000 flight, the state of AVIRIS operation in 2000, in-flight calibration, and others. This was followed by presentations such as concerning various developments in analytical approach and applied study cases. Hyperion on board the EO-1 Satellite whose synchronous flight was tested by AVIRIS in Argentina was also mentioned, making us feel that the curtain of satellite hyperspectrum days is finally rising. The S/N ratio of Hyperion is similar to that at the time of early AVIRIS development. Their view was, therefore, that the expected level of results quality equal to applied studies using the present AVIRIS' S/N ratio would depend upon future validation results of Hyperion.

Presentations about applied study cases referred such as to utilization of Hawaiian data including image data once taken by AVARIS from the Hawaiian Islands in 2000 to target coral reef and other shallow water environment, coverage of areas of different vegetation from U.S. mainland's, and observation of presently active volcanoes such as Kilauera and Mauna Loa. Many also read mineral mapping and other geological/resources-related papers and some took up the problem of mineral resources development and surrounding environment. Others further made presentations from a methodological viewpoint about progressive applications of hyperspectrum technology to global warming-related carbon dioxide and other carbon cycle problems. In its connection, it was also reported that a proposed program could be promoted toward exclusive use of satellite hyperspectral sensors for solution of the carbon cycle problem. According to the report, such global environment-related problems were beginning to be taken up as considerably important items.

Ways of developing data analysis approaches are divided into one which determines the ground surface reflectance from the brightness of reflective spectra observed, namely, one concerning so-called Atmospheric Correction, and the other using the ground surface reflectance determined for mapping-purpose processing. Concerning Atmospheric Correction, HATCH (High-Accuracy Atmospheric Correction for Hyperspectral Data: Qu et al, 2000) under development as a successor of the atmospheric correction program called ATREM (Atmospheric Removal program: Gao et al, 1993) developed by Colorado University and now widely diffused was reported, occasionally in comparison with ATREM.

In its presentation regarding the development of mapping approaches, Geological Society of America referred to Tetracoder algorithm and its demonstration. Tetracorder is a mapping program where spectral absorption-zone waveforms are matched to those in a library to determine the presence of various minerals for highly precise classification while confirming whether or not there is any absorption pattern. Many researchers use ENVI (Environmental for Visualizing Image) of Research Systems Inc. (RSI), U.S. as a mapping approach. ENVI employs a mapping approach toward finding end-member pixels from the image or considering each pixel spectrum as a linear combination with the end-member given from outside to determine the percentage of each end-member presence.

(Kinya Okada, JGI, Inc.)

3. EOSIWG Meeting

A 3-day meeting of EOSIWG (Earth Observing System Investigators Working Group) was held Jan. 30 through Feb. 1, 2001 in Fort Lauderdale, Florida, U.S.A. EOSIWG meetings serve as an opportunity where researchers from various countries' aerospace-related organizations including NASA, U.S., each participating in the Geophysical Project whose task is to observe changes in the global environment, gather for reporting their development programs, research efforts, study results, and other topics relating to sensors carried by EOS satellites as well as for technology exchanges among them. Participants in the recent meeting numbered approximately 150. Level 1 WG Chief Examiner Hiroyuki Fujisada (Science University of Tokyo) and Thermal Emissivity Separation WG member Tsuneo Matsunaga (Tokyo Institute of Technology) attended it as researchers involved in ASTER, one of our foundation's projects, together with Science Team Leader Dr. A. Kahle as well as Project Manager Mr. Pniel from U.S.

The plenary session started with a lecture which Mr. G. Asrar of NASA/HQ gave, as the director general of EOS Project, concerning the present status of and future outlooks for space development with his remarks; "Geoscience is important from a national point of view and NASA intends to play an active role of leading any and every geophysical works." This lecture was followed by successive reporting on each of EOS Project satellites (including Terra, Aqua, and Aura) and on-board sensors (including ASTER, MODIS, and MISR) in terms of its present state as well as future expectation.

As for ASTER, Japanese and U.S. ASTER Science members each reported on verification results of equipment sensors as well as the algorithm to prepare standard products, and analytical results of ASTER data (including analytical volcanic SO2 concentration and geological mineral identification results). After that, 15 papers were read about study results of global environment changes. It seemed to our impression that ASTER-related reports to this meeting were rather highly reacted since IWG members listened so carefully and asked so many questions.

(Kato, Dept. of R&D)

Fig. 3 -1 Introduction of ASTER at EOSIWG

4. Symposium for ALOS Data Application User's and ERSDAC'S PALSAR Data Application Project

The Symposium for ALOS Data Application User's was held at Kogakuin University (Nishi-shinjuku, Tokyo) on 27 march 2001, cosponsored by NASDA and ERSDAC. The objectives were to further understanding from the industrial circles so that that may expand and keep the user community of ALOS data and to exchange information among the developer side and private companies.

NASDA's representatives in charge of the ALOS program opened the symposium by showing respective outlines of the program, the satellite system and sensor profiles. And they continued with reports on scientific researches on the program and application studies for the ALOS data and the service and mechanism of data distribution. Reports from RESTEC, ERSDAC, and Geographical Survey Institute came next. Each representative introduced their project to apply ALOS data. Then lastly private companies revealed their application plans.

Y. Shiokawa, representing ERSDAC, reported on their project with PALSAR in his presentation titled "ERSDAC's Plans for PALSAR Data Application", where the PALSAR data is planned for use in resource and environment fields. Their plans for ALOS observation and of data application technique development can be divided primarily based on the following categories of themes: (1) Resource exploration: basin mapping, (2) Geological environment: regional mapping, (3) Development of polarized data application technique, and (4) Urgent observation.

(1) Resource Exploration (Basin Mapping)
Purpose : Generate the database for resource exploration to promote new exploration projects.
Target Area : Primary basins of the world (See Fig. 4-1)
Mode of PALSAR : Off nadir − 45 °
To be observed − twice / year

(2) Geological Environment: Regional Mapping
Purpose : Mainly monitor geological hazards through joint researches and thereby promote monitoring of environmental changes caused by resource exploration and damage decreases of disasters.

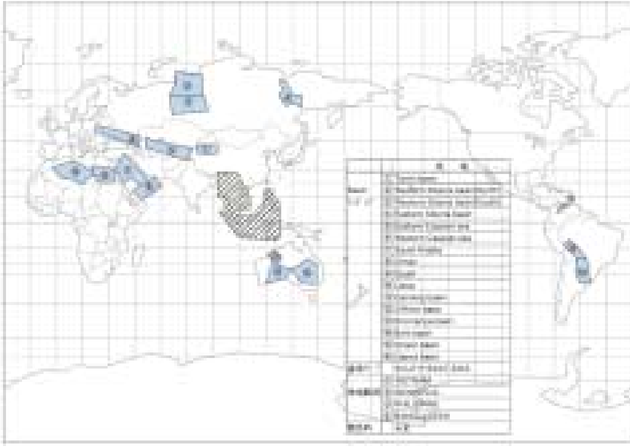


Fig. 4 -1 PALSAR Observation Plan

Target Area : East Asia
Mode of PALSAR : Normal mode
Change detection using Interferometry

(3) Development of polarized-data application technique
Purpose : Develop the polarized-data application technique, one of the main features of PALSAR and with great hopes for its practical use.
Target Area : Southeast Asia
Mode of PALSAR : Full Polarimetry

(4) Urgent observation
Purpose : Grasp information when a catastrophic event like volcanic eruption, earthquake, flooding, etc. strikes and convey it to institutions concerned.

Y. Shiokawa then presented an outline of PALSAR/GDS under development by ERSDAC and capped the symposium by reporting that development of the ALOS ground data system is right on track toward the launch of 2003.

(Shiokawa, Project Planning Division)

Fig. 4 - 2 PALSAR GDS Master Schedule

5. Introduction to ASTER Data Application

― Rock/Mineral Distribution Estimation using ASTER Data ―

The ASTER sensor is expected to achieve higher degree of accuracy in zonation of rocks and minerals than conventional satellite sensors. This will give a quick summary of the rock/mineral estimation using all channels spectral data of ASTER.

With general conventional estimation, a pixel of satellite data is divided into one category. Actually, however, a pixel of data is composed of plural elements in many cases, so it is difficult to handle it as it is. Even if it is the case of rock/mineral on the land surface of the earth that we cover, it is less probable that a pixel of data is made up of only one rock or mineral. This method is a method in which homology of spectral patterns between a target rock or mineral and each pixel in a given image is evaluated by combining fuzzy inference and pattern recognition. By this, it allows estimation of whether or not or how probable a rock or mineral exists in a pixel of data, that is to evaluate possibilities of existence on a rock-by-rock/mineral-by-mineral basis.

This method is composed of four blocks:

1. Selection of target pixels to be processed selection of pixel for processing,
2. Calculation of each indicator,
3. Fuzzy inference, and
4. Making nonfuzzy.

In the phase of Block 1, pixels are judged if they should be processed. (To put it concretely, pixels with totally different spectral patterns will be rejected.) In Block 2, input value for inference is derived. (Similarity in spectral patterns between rocks/minerals and those seen in pixels will be evaluated with a variety of indicators.) Then the fuzzy inference will actually be applied in Block 3, where overall homology of their spectral patterns is comprehensively evaluated with plural indicators. In Block4, digitalization of the inferential results is performed.

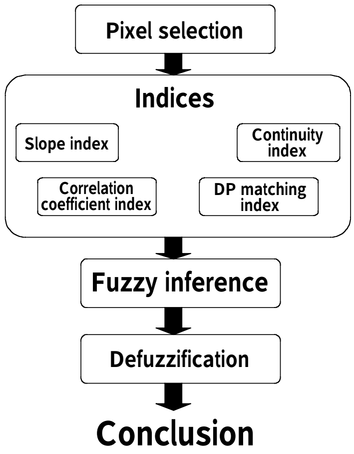


Fig. 5 -1 Flowchart of the processing

Figure 5-2 shows an example of inferential results of rock/mineral distribution by this method, derived from ASTER processed data of Mt. Fitton (Australia) and the nearby area. The results inferred for minerals agreed so well with the region's geological mapping as to eloquently express the effectiveness of the method. Distribution of rocks/minerals is generally complex like seen in Fig. 5-2. Therefore, it is impossible to perfectly discriminate and classify rocks/minerals with one method alone. It is more practical to judge by combining information from different sources. In the future, parameters for this method will be modified with actual data to attain higher precision for better results.

ASTER Images ― Mt. Fitton, Australia ―

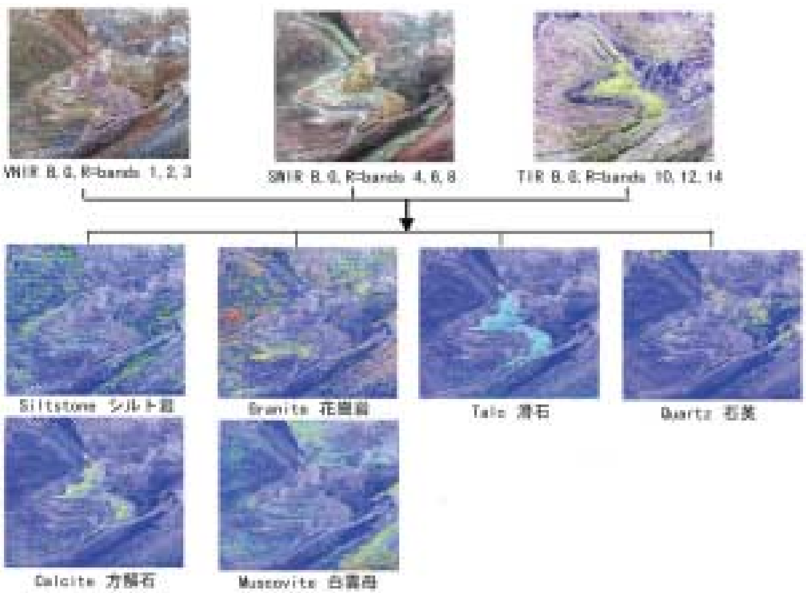


Fig. 5 - 2 Mineral distribution map

6. Activities

- Jan. 24 ● Participated in the exhibit at the 5th Society of Exploration Geophysicists (SEGJ) International Symposium
- Feb. 19 ● Mr.R.L.M.Viera of Ministerio de Relaciones Exteriores, Comercio Internacionaly Culto, trainee from International Institute for Mining Technology (MINETEC), and other five visited
- Feb. 23 ● 4th General Research Committee held
- Mar. 12 ● 32nd board of trustees meeting held
- Mar. 12 ● Dr. Huntington (CSIRO/Australia) visited
- Mar. 13 ● Representatives from Agency of Natural Resources and Energy of the Ministry of Economy, Trade and Industry (METI) visited
- Mar. 19 ● 3rd Technical Committee held
- Mar. 21 ● Dr. Al-dail (KACST/Saudi Arabia) visited
- Mar. 22 ● 45th Board of Directors Meeting held
- Mar. 27 ● Symposium for ALOS Data Appliction User's held (Cosponsored with NASA)

Fig. 6 Exhibition at SEGJ

7. Acquisition and Processing of ASTER Data – Status Quota

Data take and processing work have been running smoothly. The total number of scenes observed by ASTER up until the end of March 2001 amounted to about 180,000, and data of about 120,000 scenes amount were processed to Level 1. ASTER keeps acquiring about 600 scenes of data daily almost on a regular basis. Data of 500 - 600 scenes including what once processed are Level 1-processed and stored everyday, while 50 - 60 scenes level 1B-processed and stored.

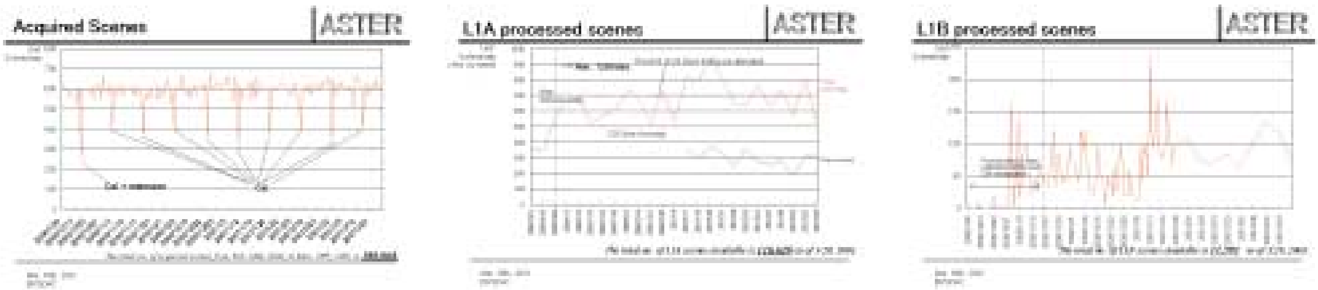


Fig. 7 ASTER Observation and Processing Status

–Personnel Shifts–

DATE	NAME	TO / CURRENT	FROM / PREVIOUS
Jan. 1	T. Kobayashi	Special Assistant to the Secretary General	NASDA
Jan. 1	M. Oyanagi	Dept. of R&D (Manager)	Nikko Exploration & Development Co., Ltd.
Feb. 1	Y. Mita	General Administration Dept. (Hired as regular staff member)	General Administration Dept.(Temporary staff)
Mar. 1	K. Omagari	Technical Department (Chief Researcher)	GEOSYS, INC.
Mar. 19	A. Maruyama	Retired	Special Assistant to the Secretary General
Mar. 31	Y. Shiokawa	Back to Sumitomo Metal Mining Co.,Ltd.	Project Planning Div. (Assistant to General Manager)
Mar. 31	M. Katoh	Back to Mitsubishi Materials Natural Resources Development Corp.(MRC)	Dept. of R&D (Deputy of General Manager)
Mar. 31	N. Oikawa	Back to Japan Petroleum Exploration Co.,Ltd. (JAPEX)	Dept. of R&D (Deputy of General Manager)
Mar. 31	R. Takamura	Back to Hitachi, Ltd.Technical Department	ASTER System Operation Div.(Chief Researcher)
Mar. 31	Y. Onoda	Back to Research Institute Of Systems Pianning,Inc.(ISP)Technical Department	PALSAR System Div.(Chief Researcher)

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By Earth Remote Sensing Data Analysis Center (ERSDAC)

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