

GEOSAT-AR: TECHNOLOGY TRANSFER PROGRAM OF ASTER DATA, IMAGE PROCESSING AND APPLICATIONS

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Commission VI, Working Group VI/3

KEY WORDS: ASTER, Technology Transfer, GEOSAT-AR, Geology, Training, Remote Sensing

ABSTRACT:

The remote sensing technology has started a new age for the geological resources exploration and research since ASTER data is available. In this framework cooperation agreement between the Japan International Cooperation Agency and SEGEMAR was signed: the GEOSAT-AR Project. It is the Advanced Spaceborne Thermal Emission and Reflection Radiometer -ASTER- technology transfer project which main goal is to have trained staff in order to generate and analyze new products and procedures for mineral exploration and environmental monitoring. In this paper, the development of the project during its four years duration and its main goals are summarized. The technological cooperation includes the introduction to ASTER data, data processing, SWIR and TIR analysis, products generation as alteration mineral mapping from SWIR data, lithologic mapping using TIR data and DEM from 3N-3B data as well as integration of remote sensing analysis and field survey for geological maps. GEOSAT-AR staff also will generate many intermediate products grouped into: 1) Satellite Data Set (color composition image, rocks distribution map, lineament map, vegetation, soil index map, land use index map, regional mosaic map), 2) Ground Data Set (spectral library, ground truth data and GCP Library). Six study sites were selected in order to acquire, learn, process and interpretate ASTER data, for the geological applications.

1. INTRODUCTION

As the remote sensing technology has developed rapidly, the Geological and Mining Survey of Argentina, SEGEMAR applied it using different satellite data for nearly 30 years. SEGEMAR is responsible of the National Program of Geological and Thematic Map of the country at different scales. Basic and systematical geological cartography at 1:250000 scale is being performed as well as 1:100000 scale was started in selected areas of high mining potential. Therefore to produce more detailed geological information it was necessary using modern technologies.

In the frame of a long time cooperation with the Japan Government and knowing the ASTER data capabilities, Argentina agreed to conduct a project under Japanese International Cooperation Agency –JICA- coordination. JICA experts and SEGEMAR authorities analyzed the requirement, conditions, investments, schedule, short and long term plans and management of the project. The agreement was signed on December 21, 2000.

2. OBJECTIVES

GEOSAT-AR Project started in March 2001 as an advanced satellite data technology transfer program for geological applications. The project will be developed during four years, up to March 2005. The agreed activities are detailed by year and periodically discussed, so if necessary some changes could be included.

The main objective of GEOSAT-AR Project is the technical capacitation in the characteristics and geological application of advanced remote sensing data. The first goal is the utilization of last generation satellite data such as Advanced Spaceborne Thermal Emission and Reflection Radiometer-ASTER, in order to produce geological maps and thematic maps for mineral

exploration. The second goal is the utilization of advanced satellite data, such as ASTER and / or PALSAR in environmental or hazardous areas study.

3. INTERNATIONAL COOPERATION

In order to carry out the GEOSAT-AR Project, JICA is responsible for the participation of 4 long-term experts and 6 to 8 short-term experts by year, technological training of counterpart, and provision of equipment.

On the other side, SEGEMAR is responsible for office facilities, participation of counterpart staff, equipment maintenance, and local costs.

3.1 Japanese Cooperation

The arrival of the four long-term experts, in March 2001, marked the beginning of the project. They are: Chief Advisor, Eng. Katsumi Yokokawa from MMAJ; Coordinator Mr. Koji Yamaguchi from JICA; Digital image Processing Expert, Eng. Manabu Kaku from MRC; and Geological Remote Sensing Expert, Eng. Itoshi Kohno from MITSUI.

In the first year, eight short-term experts were dispatched in specific fields of technology transfer for the project. During the second year, seven experts have been appointed to teach and train the GEOSAT-AR working group.

Also, seven geologists were trained in Japan, in optical and SAR remote sensing, ASTER data applications, ASTER TIR data processing and volcanoes monitoring.

The technology transfer cooperation also includes the equipment and other materials provision which is divided into three categories: the data processing system to implement

GEOSAT-AR laboratory, the field survey equipment and ASTER data.

3.2 Argentine counterpart

For the successful implementation of the project, the Argentine counterpart provides building and office facilities, the full time and part time counterparts and the administrative personnel. Four geologists from the Remote Sensing&GIS Division work full time in the GEOSAT-Project (Inés Di Tommaso, Silvia Castro Godoy, Cintia Marquetti and Diego Azcurra), as well as eight part time geologists and technicians. Also thirty geologists from Regional Geology, Geological and Mining Resources and Environmental Geology Divisions are involved.

The Argentine side supplies the equipment, instruments, vehicles and any other materials necessary for the implementation of the project other than those provided by the Government of Japan through JICA.

Regarding local costs, SEGEMAR is responsible by expenses for shipping of satellite data, field allowance and transportation for ground truth, sample analysis, organization of workshops and seminars and others local costs.

4. TRAINING PROGRAM AND ACTIVITIES

The training program started with focused courses on introduction on remote sensing and geographic information system, management of different image processing software, and UNIX introduction conducted by SEGEMAR professionals. Also radiometer management as well as GPS System management training courses were provided.

Japanese experts transfer knowledge and technology to the GEOSAT-AR work team regarding ASTER data in order to generate products to be utilized in geological and metallogenic maps at 1:100.000 scale as well as more detailed hazards and environmental impact studies. The training is on advanced satellite data, processing, analysis and interpretation, ground recognition and spectral measurements of different lithologies to generate products that are useful for mining exploration and environment monitoring.

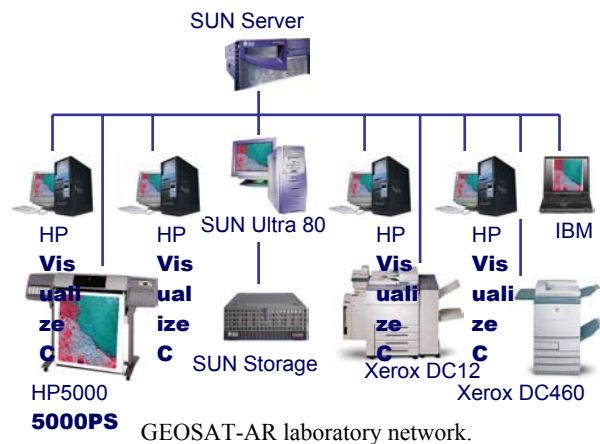
The RS&GIS staff is responsible for the processing, analysis and interpretation of data and must generate products such as: color image compositions (VNIR, SWIR, TIR), rock/mineral distribution map (from SWIR, TIR data), digital elevation model (DEM), lineaments map, vegetation index map, soil index map, land use classification map, multi-temporal map, and others. The field work includes measurements and survey in order to generate: the spectral library, ground observations and the GPS data library.

The geologists from SEGEMAR will be also trained to interpret these products in order to apply them in the geological and thematic mapping as well as in the environmental and hazards monitoring.

4.1 GEOSAT-AR Laboratory

In the beginning of 2001, the equipment was procured and the infrastructure prepared to implement the GEOSAT-AR Laboratory. From March to July the image processing hardware was installed. There is a network with SUN server, workstation and network storage (220 Gb), five HP workstation and four IBM notebooks. Also, there were installed XEROX network

B/W and color printers, HP5000 plotter and desktop accessories.



The installed software in the PC workstations are ENVI, ERDAS Imaging and ARC View. The Unix workstation supports ASTER DEM, ASTER Ortho Photo, ASTER Atmospheric Correction (TIR), ASTER Temperature/Emissivity Separation and ASTER Rock and Mineral Classification. Also, during 2002, it will be installed ASTER Atmospheric Correction (VNIR, SWIR). All the ASTER software is developed and provided by Japan.

For field work, the equipment was acquired and tested. The GER radiometer measures the visible, near and short wave infrared reflection, and the F-TIR microradiometer measures the thermal infrared emissivity from minerals and rocks. Also, GPS precision equipment was provided to geolocate samples and ground control points.



Radiometers GER (VNIR,SWIR) and Micro-FTIR.

4.2 2001-2002 GEOSAT-AR Training Program

The flow chart of the capacitation program was developed in different steps and ways. The GEOSAT-AR staff has daily consults and training with the long term experts and focused courses regarding ASTER data, applications, hardware and software management. They also are trained on specific topics in Japan.

Also, short time experts taught different topics to the same group. They are from ASTER Science Team, researchers, teachers and software developers from the main Japan universities and companies. So far ten experts had participated in the training program through courses or installing software and training the working group to use them. The main activities were the following:

ASTER Introduction and Application. Dr. Yasushi Yamaguchi from Nagoya University pointed out the ASTER Program characteristics, management structure and objectives, as well as ASTER data acquisition, geological utilization of

ASTER data and other applications.

ASTER Sensor: Level 1 Products. Dr. Hiroyuki Fujisada from Science University of Tokyo, was the sensor developer, in the course carried out ASTER system configuration, radiometric and geometric performance. Also he pointed out the processed ASTER Level 1 and DEM performance.



Dr. Y. Yamaguchi and Eng. H. Hyodo training courses.

Management of ASTER DEM software. Mr. Seiichi Hara, System Engineer from Central Computer Services Co. developed the program in Unix environment to generate the digital elevation model from ASTER 3N and 3B data. He installed it and introduced the geologist to use the program.

ASTER Data Management System – GMDMS. Eng. Hiroshi Hyodo from Mitsubishi Materials Natural Resources Corp. developed the system on ARC View environment. He installed it and trained the staff to manage the GMDMS.

ASTER Level 3A Processor. Eng. Ryo Nakajima, from Central Computer Services Co. introduced the ASTER ortho-processor concepts and management.

GCP Library System. Eng. Ryo Nakajima also installed the Unix ground control point library system and trained the GEOSAT-AR working group to input and query data.

Introduction to TIR: measurement of Thermal Infrared Spectral Response. Dr. Yoshiki Ninomiya from the Japan Geological Survey of AIST (Advanced Industrial Science and Technology) trained on thermal emissivity spectrum characteristics and on the management of FTIR micro-radiometer to measure TIR response from rocks and minerals.

ASTER SWIR Cross Talk Correction. Dr. Akira Iwasaki from the National Institute of Advanced Industrial Science and Technology spoke about the Cross Talk phenomena. He installed the correction algorithm and trained in its management as well as Level 1A SWIR data analysis.

Status of Next Generation Sensors. Dr. Hiroji Tsu from ERSDAC and Leader of the ASTER Science Team presented an up dating of the ASTER Project and next steps in short and middle time on new generation sensors development after ASTER.

ASTER TIR Atmospheric Correction. Dr. Hideyuki Tonooka from Ibaraki University developed an algorithm for atmospheric correction of thermal infrared ASTER Data, levels 1A, 1B and 3A. He installed the algorithm, showed the problems and how to correct the TIR atmospheric phenomena.

ASTER Rock and Mineral Classification. Eng. Hidehisa Watanabe from Mitsui Mineral Development Engineering Co. developed the algorithm to obtain rock and mineral map distribution from ASTER data. He installed the program and explained its operation and analysis results. During 2002 and next years of the GEOSAT-AR Program, other

experts will participate on diverse topics and fields like: SAR data application, environmental analysis, hazardous area analysis and hyperspectral data application.

4.3 Workshops and Seminars

Each study area where ASTER data is applied has a team responsible for the geological map. The GEOSAT staff and experts transfer the acquired knowledge and the results from the first processed ASTER data to the project geologists through workshops.

There were held four workshops, two in Salta city and two in Buenos Aires, involving more than fifteen SEGEMAR professionals. It were presented the capabilities, performance and problems of different products. The GEOSAT-AR group asked the requirements and necessity of products to study each region. Other workshops are scheduled to discuss the final interpretation and results.

During 2002, four to six workshops will be held, some of them in Comodoro Rivadavia, San Juan and Cordoba cities.

Two ASTER-GEOSAT Seminars were held, each one with one hundred participants from many organizations in Argentina, users of remote sensing data. The III° ASTER-GEOSAT Seminar will be held in October 24-25, 2002. As in the others, the Japanese experts will participate, as well as the GEOSAT-AR team and other researchers using ASTER data.



I° ASTER-GEOSAT Seminar on October 2nd. 2001

4.4 ASTER Course

The first course on ASTER data performance, processing, products and applications, will be held in next November. GEOSAT-AR staff will be responsible to train up to 12 participants in the course.

5. GEOSAT-AR STUDY AREAS

In the first two years of the project, ASTER data is applied to generate four geological maps, and two metallogenic maps. Six regions were chosen because of their mining potential interest and the need for more detailed geological data. These regions correspond to the sheet maps at 1:100.000 scale N°: 2366-22 Mina Aguilar, Jujuy Province; 2766-19 Farallón Negro and 2766-27 Andalgalá, Catamarca Province; 2969-17 & 23 Sierra de Famatina, La Rioja Province and 4169-17 & 18 Los Menucos, Río Negro Province; also, the 1:250.000 scale sheet N° 2969 III Maliman, in San Juan Province.

In Jujuy Province the target is to assess the PbAgZn mining potential of the ordoevic sedimentary units in the area between -23° to $-23^{\circ} 20'$ and $-65^{\circ} 30'$ to -66° .

Both areas in Catamarca Province belong to Farallón Negro Mining District, where the objective is the geological mapping and to identify alteration zones associated with minerals and

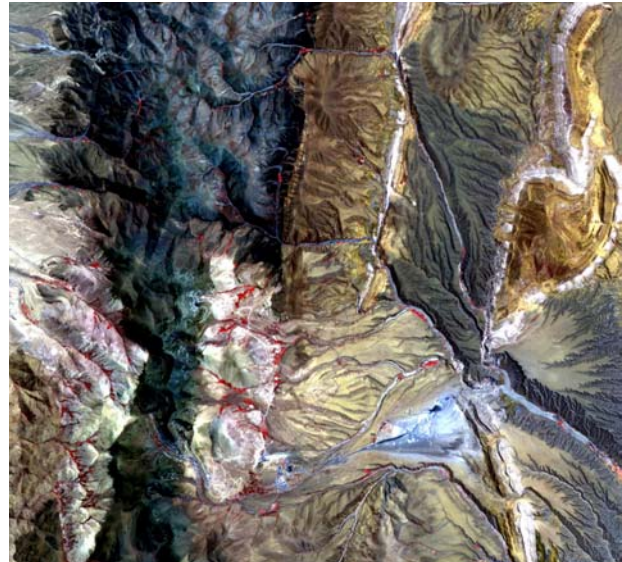
potential host rocks to compare with a comprehensive knowledge of porphyry copper deposits.

La Rioja study region involves polymetallic type –CuAu- and porphyry type –CuMo- mineralisations and the potential acid drainage flows through urban and agricultural areas, so an environmental geologic survey will be done by SEGEMAR between –28° 40' to –29° 20' latitude and –67° 30' to –68° longitude.

In Los Menucos region, Rio Negro Province, Triassic volcanic complex rocks are intruded by Permian to Miocene porphyry monzonite and breccias, with hydrothermal alteration associated with gold mineralisation. The study area is between –40° 40' to –41° and –67° 30' to –68°.

To generate metallogenic map of Maliman region in San Juan Province, is necessary to determine the distribution of hydrothermal alteration zones, which are different kinds of silicification affecting breccias, argillic and propylitic alteration (latitude from –29° to –30° and longitude from –69° to the Argentine-Chilean border).

Data from the six chosen regions was processed, but not all the interest areas are covered by ASTER data yet. In three of these regions field work was done, as well as spectral measurements was done in situ and in the laboratory to obtain VNIR-SWIR and TIR response from rocks and minerals, for the SEGEMAR spectral library. In the other three regions, Los Menucos, Sierra de Famatina and Maliman, the field recognition will be done from October to December 2002.



Sierra de Aguilar VNIR ASTER image, Jujuy Province.

At the same time, it was requested ASTER data of other regions for different SEGEMAR projects as La Picasa in Santa Fe Province, Telsen in Chubut Province, binational corridor (between Argentina and Chile) at latitude of Mendoza (Argentina) and Santiago (Chile), and others.

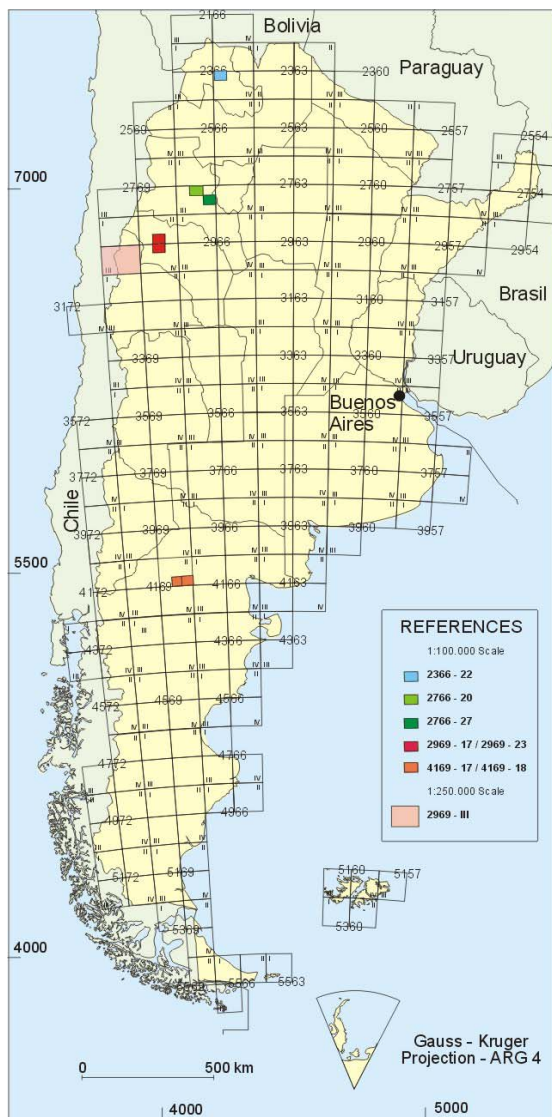
6. CONCLUSIONS AND GEOSAT-AR GOAL

At the end of the GESOAT-AR Project, March 2005, it is expected to have reach the following tasks:

- Training in advanced satellite data as well as managing specific software, GPS, radiometers GER and Micro-TIR.
- Generation of products for different study areas: color composition images, thematic maps, soil index maps, vegetation maps, digital elevation model, GPS library, Spectral library and others.
- Applying ASTER data in 12 areas to generate geological maps at 1:100.000 scale and 4 metallogenic maps at 1:250.000 and 1:100.000 scales.
- Eight ASTER-GEOSAT Seminars, more than 20 workshops and 4 ASTER Courses for technological transfer.

ACKNOWLEDGEMENTS

The author express thanks to SEGEMAR and JICA to allow publishing this paper, also extend the acknowledgements to ERSDAC for the provision of remote sensing data. I am grateful to ISPRS Technical Commission VI for accept this paper.



ASTER study areas location