Serie Correlación Geológica - 33 (1 - 2): 7 - 14
Tucumán, 2017 - ISSN 1514-4186 - ISSN on-line 1666-9479

Search of mineralized sectors of Jaimanita stone deposits by implementing the spectral library of Cuban rocks

Yenibey PEREZ CARRASCO[1]

Resumen: *BUSQUEDA DE SECTORES MINERALIZADOS DE PIEDRA DE JAIMANITA MEDIANTE LA IMPLEMENTACION DE LA BIBLIOTECA ESPECTRAL DE ROCAS CUBANAS*. En la actualidad el yacimiento de piedra de Jaimanita confronta dificultades con los parámetros de calidad de los recursos evaluados. A raíz de esta problemática se dió la tarea de localizar zonas o sectores mineralizados con similares propiedades. Para viabilizar los trabajos pretéritos se utilizó como base la firma espectral de esta roca localizada en la biblioteca espectral de rocas cubanas. Como herramienta de trabajo se empleó el software ENVI y las imágenes satelitales ASTER (Advance Spaceborne Thermal Emission and Reflection Radiometer) de Cuba Occidental. El procesamiento de las imágenes consistió primeramente en llevar el dato ASTER VNIR y SWIR a Reflectancia, para esta operación se empleó el método FLAASH. Posteriormente se realizaron clasificaciones con el método Spectral Angle Mapper (SAM) a fin de obtener respuestas utilizando el espectro PIMA-ASTER de la roca Jaimanita tomado de la librería. Como resultado final de esta técnica se detecta que existen zonas representativas en diversas áreas de la franja Norte Occidental de Cuba, logrando minimizar en tiempo los trabajos de reconocimiento regional.

Abstract: At present time Jaimanita stone deposits facing problems with the high-quality parameters of the evaluated resources. Facing this problem, the objective was to find mineralized zones or sectors with similar properties like previous. To find a way to deal with the previous works it was used the spectral firm of this rock as a basic point, located in the spectral library of Cuban rocks. The ENVI software and the satellite images ASTER used as a working tool (Advance Space borne Thermal Emission and Reflection Radiometer) of Western Cuba. The processing of images firstly consists in carrying the piece of information ASTER VNIR and SWIR to Reflectance using FLAASH methodology. Later, classifications with the method Spectral Angle Mapper (SAM) carried in order to obtain answers using the PIMA ASTER spectrum of the Jaimanita rock taken from the library. Because of this technique the existence of representative zones in various areas of the North Western stripe of Cuba were detected minimizing the amount of time doing the works of regional recognition.

Palabras clave: Jaimanita. Biblioteca espectral. Imágenes ASTER. Procesamiento. Sectores mineralizados.

Key words: Jaimanita. Spectral library. ASTER images. Processing. Mineralized sectors.

[1] Oficina Nacional de Recursos Minerales (ONRM). Calzada esq. a 4, Vedado. Plaza de la Revolución. La Habana. Cuba
e-mail: yenibey@onrm.minem.cu
e-mail: yenibey.perez@nauta.cu

Introduction

At present, the only concessional deposit of Jaimanita in Cuba is located in the municipality of Caimito, in Artemisa province, West of Havana, and its central coordinates are between the 82035´16.56" length West and 23002´ 30.42" North latitude (figure 1)(González, 1999). It is composed of two sectors (North and Sur) separated by the road Havana Mariel. In the region, there are Cretaceous to Quaternary outcrops, but we will focus on the Quaternary, specifically on the Jaimanita formation. It is the youngest formation of all calcareous formations, coinciding with the Terrace of Seboruco, deposited and developed along the northern seashore, representing an important Pleistocene marine transgression.

Organogenic coral and shell limestone form the Jaimanita formation (Borrell, 1991); however, in the Southern zone they identified as compact sandstone. The limestone outcrops forming typical dogtooth reefs. The vegetation in the zone is monotonous varying in height because the zone is used to cattle rising. In the northernmost part, the vegetation presents coastal characteristics product of the proximity of the sea and the karst morphology. In both cases the upper vegetable soil does not exceeds 0.50 m in thickness. The color of limestone is generally white to beige white. Main thickness ranges from 0.7 to 6.75 m (Álvarez, 2013).

This deposit is almost exhausted and that is why other areas have to be discovered with similar characteristics by means of ASTER images. As study case we took an area on the Northeast of Havana province and Northwest of Matanzas province between the 810 37´32.58" as West and the 230 6´49.48" North (figure 2).

In this zone, there are three rock formations, Jaimanita, Vedado and Güines, from Neogene to Quaternary respectively. They are form by reef limestone showing a well-developed karst in the surface as well as hypogenic.

The objective of this work is the search of the Jaimanita rock by its spectrum PIMA ASTER located in the spectral library of Cuban rocks. This raw material is considered as ornamental rock used for coating walls having simple compression strength and oscillating between 50 – 336 kg/cm^2. The average absorption is more than 10 %, abrasiveness oscillates between 0.64 – 0.70 g cm^2 and bending strength goes from 26 to 115 kg/cm^2. Construction enterprises highly demand this rock for buildings, hotels and for maintenance and restoration of emblematic structures in Havana, Cuba (Álvarez, 2013).

Not until 2011, Cuba could begin to work with a spectral library of Cuban rocks. It was

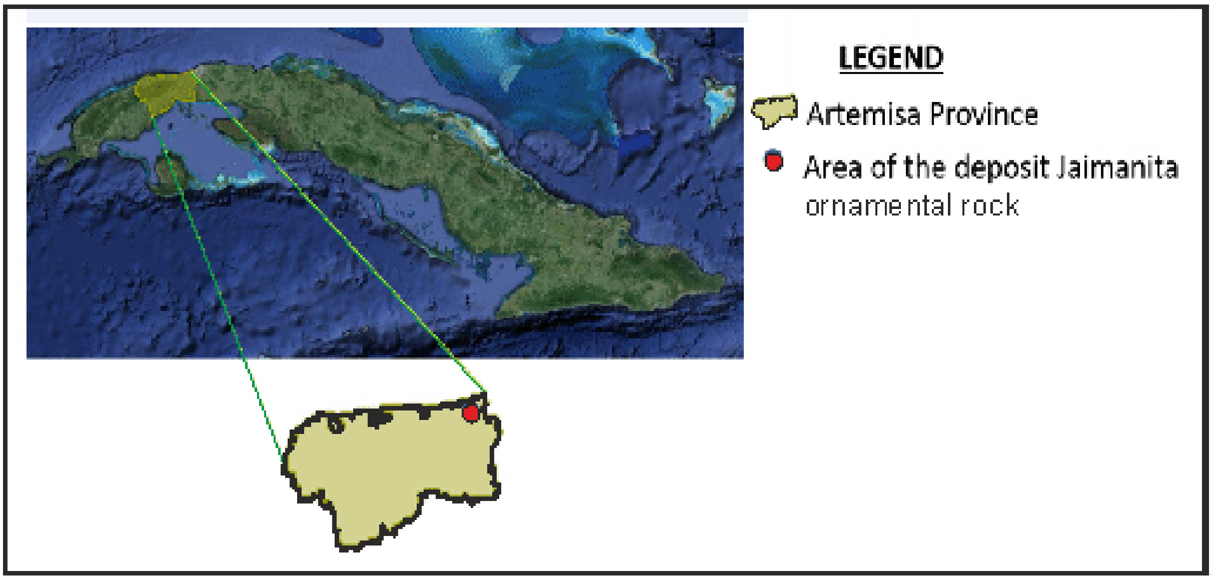

Figure 1. Geographical location of the deposit of Jaimanita ornamental rock. / **Figura 1.** *Ubicación geográfica del yacimiento de roca ornamental Jaimanita.*

possible thanks to the implementing of the project of international cooperation FOAR, named "Image Processing satellite ASTER for geological and mining purposes", and taught-during from 2011 to 2013. Part of the work true in Cuba was possible by taking 46-sample and ending in the Argentinian Geological Service measuring the rocks with the spectrum radiometer PIMA. The spectrum library includes rocks like limestone, serpentine, shale, marble, gypsum, ophiolite, granitic rocks, etc.

Materials and methods

As tools and implements the spectral signature of the Jaimanita located in the spectrum library of Cuban rocks was used together with the ENVI Tutorials, Version 3.4 (2000) software and the satellite image ASTER from the eastern part of Havana and the western part of Matanzas. Classifications were performed with the Spectral Angle Mapper Method (SAM) in order to obtain answers using the PIMA ASTER spectrum of the Jaimanita rock included in the 46 samples being in the Spectrum Library of Cuban Rocks (figure 3). Obtained thanks to the use of the spectrum radio meter PIMA (Portable Mineral Infrared Analyzer) of the Argentinian Geological and Mining Service (SEGEMAR) during the work in the project of international cooperation named FOAR Image Processing satellite ASTER aimed towards geological and mining purposes between 2011 and 2013.

As primary base the ASTER 1 - B image was used (Coefficient of radiometric calibration and of geometric correction), between the East Havana and West of Matanzas. Processing was carried on by means of the ENVI software and the ASTER data of the given scene were passed through reflectance; however, we first worked with the data of the SWIR subsystem in radiance in order to apply the spectral index of calcite because it has the absorption in the band 6 (Ninomiya, 2004).

The method used to generate the data of reflectance was the module FLAASH (Fast Live – of – Sight Atmospheric Analysis of Spectral Hypercubes) of the ENVI. This method forms part of the module for atmospheric corrections of the ENVI program for multi and hyper-spectral images that which takes data from the visible, infrared regions and close in -

Figure 2. Gray Scale VNIR Banda 1. Area where the searching processes for the Jaimanita rock will be work. / **Figura 2.** *Gray Scale VNIR Banda 1. Área de cobertura donde se realizarán los procesamientos en búsqueda de la roca Jaimanita.*

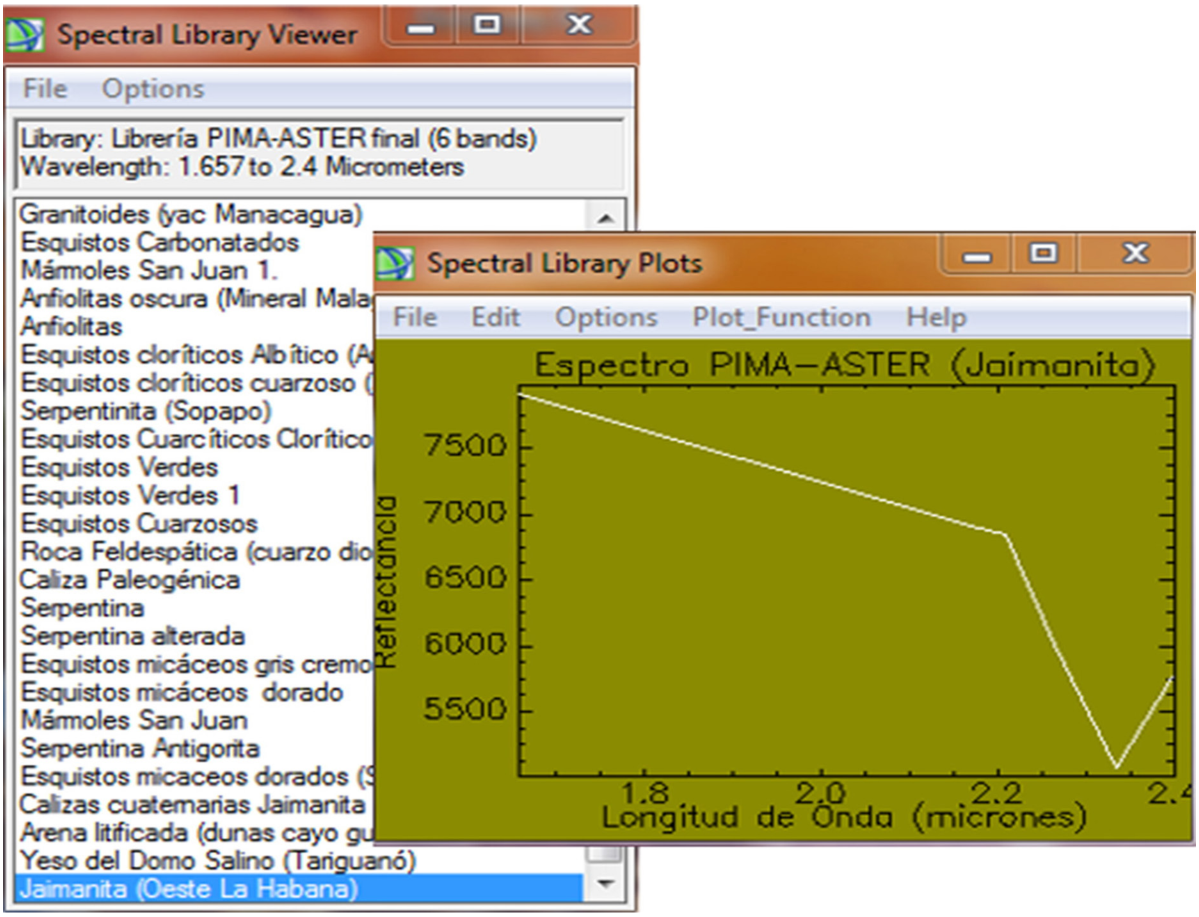

Figure 3. Sample of Cuban rocks Spectral Library where the Specter PIMA ASTER of the Jaimanita rock west of Havana appears as a highlight. / **Figura 3.** *Muestra de la Biblioteca Espectral de Rocas Cubanas donde se resalta el Espectro PIMA-ASTER de la roca de Jaimanita procedente del Oeste de La Habana.*

frared shortwave up to 2.5 micrometer (figure 4).

We also apply different combinations like RGB: 682, 689, 459 and 468; Quotients of bands NDVI: (3 - 2)/(3 + 2), the quotient of vegetation RVI: 3/2 and the band 3; Applying bands 2 and 3 respectively in order to attenuate the vegetation (Ninomiya, 2004); the quotient of Gray Scale 4/6 band and the index of calcite from subsystem Swir. The classification with the method Spectral Angle Mapper (SAM) was also usedin order to obtain answers using the spectrum PIMA ASTER of Jaimanita rock.

All combinations done had interference due to three factors of introduction of errors; theywere: The dense existing vegetation, the weathering effect upon the rock and that most of the outcrops were no it thicker than 15 meters. In spite of these limiting tropical conditions in our country, some areas with potentialities for future extraction of Jaimanita rock were detected.

Results

As a more relevant result it can be said that combination of RGB: NVDI RVI Banda 3 enhanced the areas discovered together with other zones whose vegetation was very dense being evident its attenuation (figure 5). When the index of calcite was also applied the response was evident in areas with less vegetation (figure 6).

These procedures correspond mainly to Jaimanita Formation and Vedado Formation (figure 7) showing the enhancement in the whole seashore of Havana and Matanzas, coinciding with the Jaimanita Formation (IGP. 2011).

The result of the spectral classification of

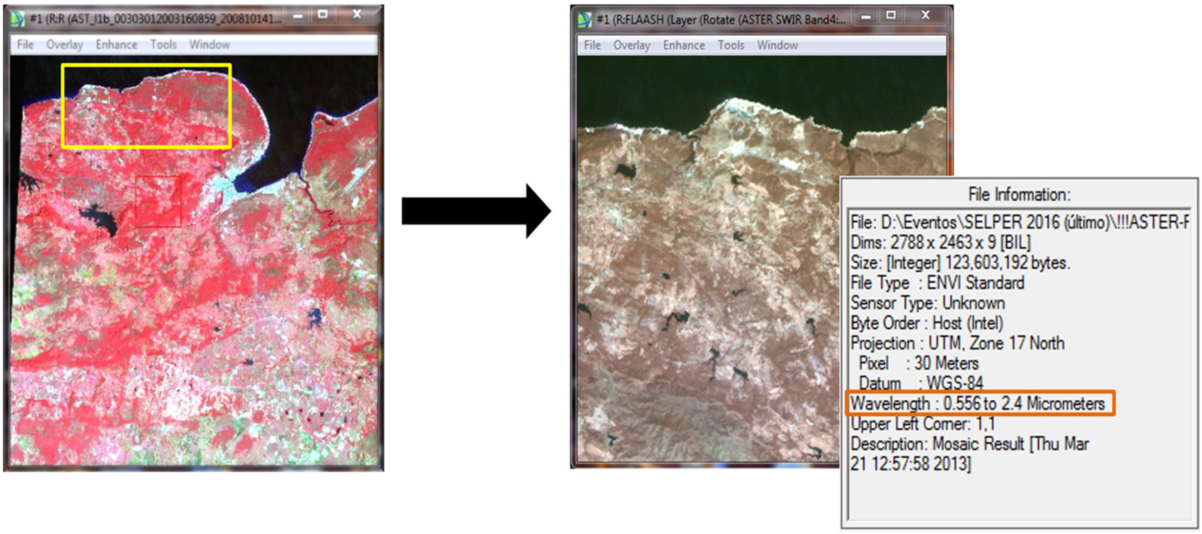

Figure 4. RGB: 321 East of Havana and West of Matanzas. The image ASTER 1 B passed to Reflectance applying the FLAASH module. In the extreme right of the figure is evident that the wavelength oscillates between 0.556 and 2.4 microns. / **Figura 4.** *RGB: 321 Este de La Habana y Oeste de Matanzas. Se representa la imagen ASTER 1-B pasada a Reflectancia aplicando el módulo FLAASH. En la tabla del extremo derecho se evidencia que la longitud de onda oscila entre 0.556 a 2.4 micrones.*

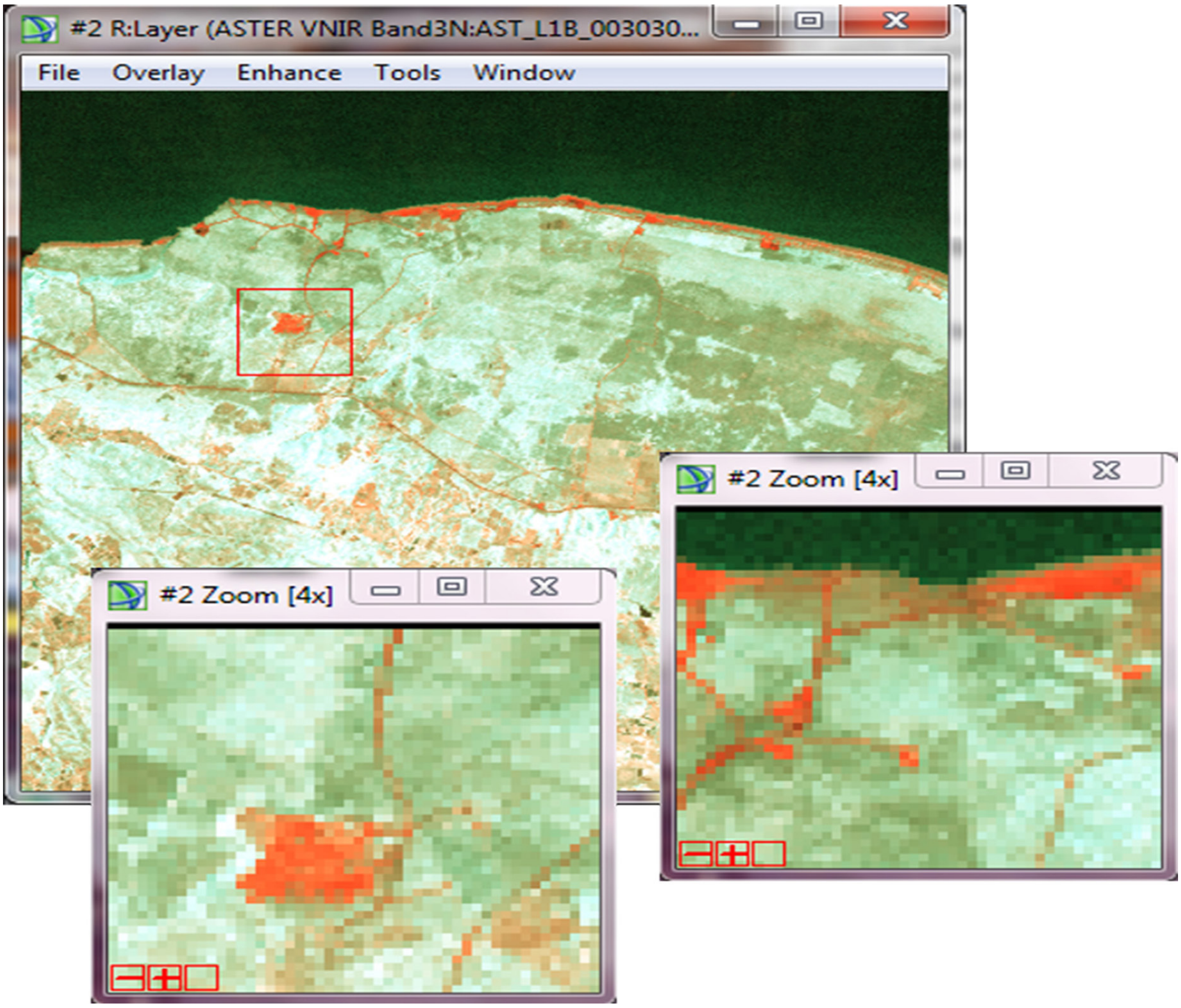

Figure 5. In the image a RGB: NDVI RVI Banda 3 was carried on; enhancing the discovered areas and decreasing the vegetation in very dense zones./ **Figura 5.** *En la imagen se realizó un RGB: NDVI RVI Banda 3; realzando las áreas descubiertas y disminuyendo la vegetación en zonas muy densas.*

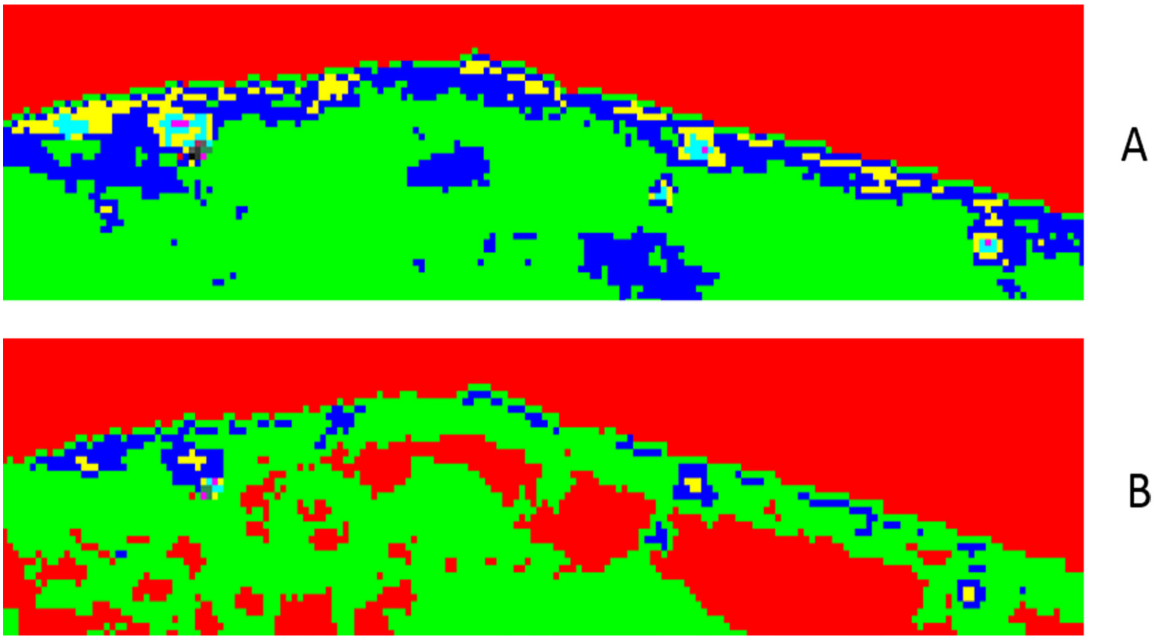

Figure 6. In images A and B the calcite index was applied, giving Image A due to the absorption of the band 6. / **Figura 6.** *En las imágenes A y B se aplicó el índice de calcita, dando mayor respuesta la imagen A debido a la absorción de la banda 6.*

the spectrum PIMA ASTER IGP. (2011) of Jaimanita rock in the image RGB 468 East of Havana and West of Matanzas was positive (figure 8), although the best answers obtained were in the zones not covered by vegetation. That is mainly due to the use of the curve pattern of minerals measured in the laboratory. That is why the obtained data of the rock in the surface is mainly a mixture of minerals, together with the existence of three main factors such as dense vegetation, weathering of the rocks and the outcrops not exceeding 15 meters in thickness.

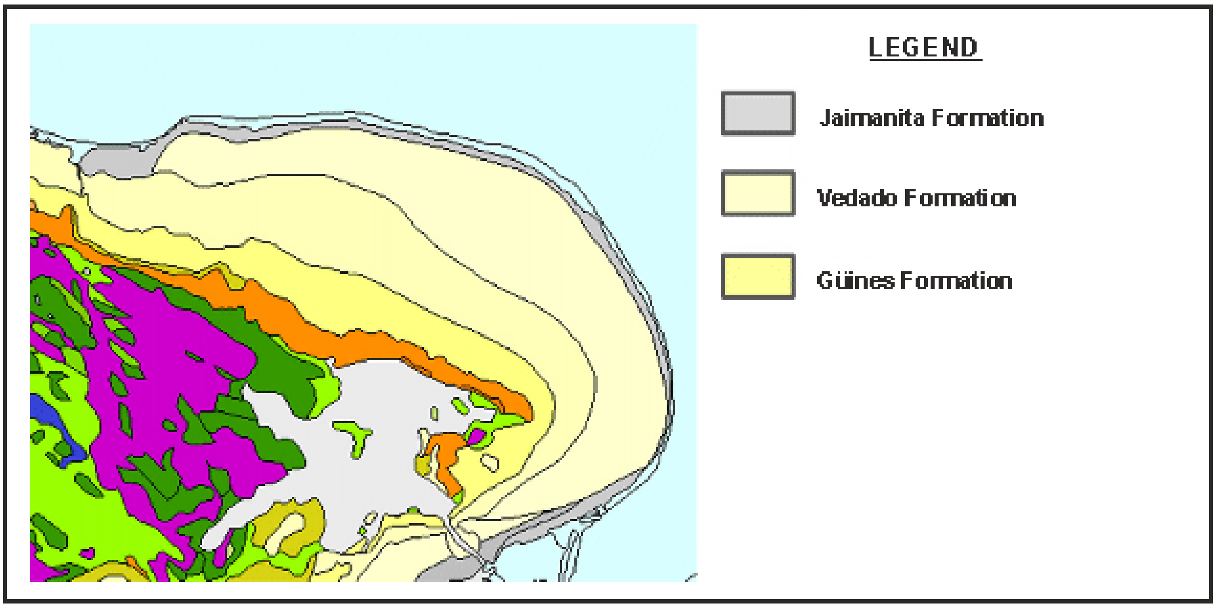

Figure 7. In this figure, the zone is in the northwestern part of Matanzas Bay corresponding to the geologic map of Cuba where the result of the processing of the figures corroborates 5 and 6 showing Jaimanita and Vedado formations in the whole Havana – Matanzas seashore. / **Figura 7.** *En esta figura se muestra la zona Norte – Noreste de la bahía de la provincia de Matanzas correspondida en el mapa geológico de Cuba donde se corrobora el resultado del procesamiento de las figuras 5 y 6, la cual muestra la formación Jaimanita y Vedado en todo el litoral de las costas de La Habana – Matanzas.*

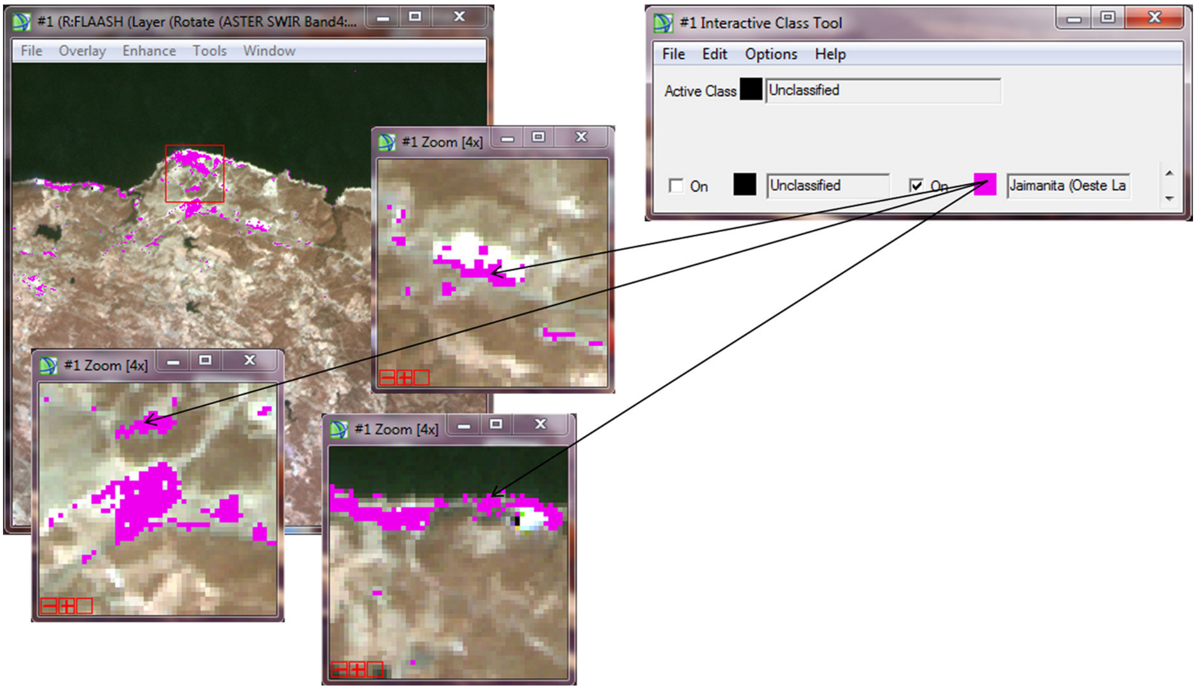

Figure 8. Evidence of response on Jaimanita rock using the Spectral Angle Mapper (SAM). / **Figure 8.** *Evidencia de respuesta de la roca Jaimanita a través del empleo del método Spectral Angle Mapper (SAM).*

Conclusions

1- In spite of these limitations due to the tropical conditions in Cuba, some areas with potentialities for future extractions of rock of Jaimanita was found, and this work is aimed toward this purpose.

2- The quotient of band used attenuates the vegetation and enhances zones totally or partially discovered.

3- The index of calcite of the Swir subsystem identifies mineral disturbance in the study area.

4- The classification of the image using the method of the spectral angle (SAM) with thespectrum obtained from the Jaimanita rock from the spectral library of Cuban rocks responds in areas where vegetation is poor or do not exist.

5- The main errors during the processing of the image are due to the dense existing vegetation, the weathering of the rock and that the outcrops do not exceed 15 meters in thickness.

6- The processing of ASTER images is a useful tool to find possible mineralization from the computer desk.

Acknowledgements

The result of this work was thanks to the participation of a group of experts and specialists belonging to the Argentinian Geological and Mining Service (SEGEMAR) and the Geological Service of Cuba who made possible the basis of our work. Without their help, it would not be possible to reach the results discussed in this report.

References

Álvarez, L.R. 2013. Recálculo de recursos piedra de revestimiento yacimiento Jaimanita sector Sur, inédito, pp. 3-6.

Borrell, R. 1991. Informe de Exploración dentro de los límites del coto minero del yacimiento Jaimanita Habana, inédito, pp. 11-19.

González, D.M, 1999. Informe sobre la prospección y exploración en el yacimiento de Piedra para revestimiento Jaimanita Municipio Bauta, Provincia

Habana, inédito, pp. 20, 8-9.
Instituto de Geología y Paleontología (IGP) 2011. Mapa Geológico de Cuba a escala 1:100.000.
ENVI Tutorials, Version 3.4 2000. *The Environment for visualizing images*, September, 2000 Edition, 590 pp.
Ninomiya, Y. 2004. Lithologic mapping with multispectral ASTER TIR and SWIR date, Geological Survey of Japan, AIST, Proceedings of SPIE, Vol. 5234, pp. 180 – 190.

Recibido: 07 de Noviembre del 2016
Aceptado: 07 de Abril del 2017