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Remote Sensing Identification of Uranium Exploration Targets - Laguna Sirven Project, Santa Cruz, Argentina

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1. Introduction

The Laguna Sirven uranium-vanadium deposit belongs to the surficial geological type. The presence of uranium minerals, mainly carnotite, has been detected between 0.5 to 3 m depths, within the calcrete level which serves as cement to a polimictic matrix.

Uranium target areas were identified by means of the processing and interpretation of multispectral satellite imagery and SRTM data. LandSat 7 ETM+ and ASTER generated products indicated mainly two types of non-pedogenic mineral patterns related to the precipitation of uranium and vanadium minerals, showing two different depositional pathways, one related to carbonate minerals and another to sulfate minerals.

The present contribution briefly describes the methodology and results of the application of remote sensing techniques for the identification of uranium exploration targets in this type of geological model.

Laguna Sirven corresponds to a sedimentary deposit formed by rich uranium precipitations at the water table interface, creating calcretes of a large extent and typically tabular form. In most of these deposits, uranium comes from the weathering of volcanic rocks, which could be secondary uranium deposits. Uranium solubility is closely linked to oxidation potential, whereby under oxidizing conditions uranium is found as U6+ cation, highly soluble and therefore very mobile. However, in a reducing environment, the U6+ ion is converted into the insoluble form U4+. Thus, the uranium in solution flows through permeable strata until it meets reducing conditions and precipitates, such as the sediments of the Deseado River [1]. As previously studied, soils are important fixing materials due to the content of clay minerals, organic matter, iron hydroxides, manganese or aluminum hydroxides [2].

1. Methodology & Results

The rationale behind the application of this technology in the identification of uranium exploration is that the migration of minerals to the subsurface can generate local anomalous areas, which are characterized by reduction conditions that facilitate the development of a variety of chemical and mineralogical changes that can be detected through remote sensing techniques. Possible alterations include bleaching, the development of iron and clay minerals, the formation of carbonates and geo-botanical anomalies, among others.

Thus, the analysis of the presence and abundance of such minerals and soil chemical anomalies combined with a comprehensive study of the structural geology and geomorphology of the area facilitates the identification of uranium mineralized potential target areas.

The remote sensing study comprised different phases. Prospective areas are identified after the careful selection of imagery data during the acquisition phase and the later effective preparation, processing and interpretation of such spectral data.

First, LandSat-7 ETM+ and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) multispectral imagery and SRTM data was acquired, with the following spatial and spectral resolutions:

LandSat 7 ETM+:
Spatial Resolution: 15, 30, 60 meters.
Spectral Resolution: Seven (7) bands, ranging from 0.45 to 12.50 nm, (Visible, Near Infrared, Short Wave IR and Thermal IR).
ASTER:
Spatial Resolution: 15, 30, 90 meters.
Spectral Resolution: Fourteen (14) bands, ranging from 0.50 to 11.40 nm, (Visible, Near Infrared, Short Wave IR and Thermal IR).
SRTM:
Spatial Resolution: 90 meters.
Frequency: 5.3- 9.3 GHz

Atmospheric, radiometric and geometric corrections were applied to this data in a preliminary processing stage. Upon such corrections, imagery was georeferenced according to the POSGAR 1994, Faja 2 System. In this stage, ASTER´s thermal IR data was converted to superficial emissivity values by means of the normalization values taken from global maps with surface properties generated by various international research programs.

Later data processing included spectral enhancements through the application of a series of digital filters and the application of band ratioing and statistical analysis procedures, such as principal components. Band ratioing is a very fast and effective method to obtain information about the Earth's surface components from LandSat ETM+ and ASTER multispectral imagery. These ratios are simple mathematical relationships between values of two specific selected bands. The principal component analysis or rotation is a mathematical process originally designed to evaluate the spectral correlation between bands. By means of this process, the highly correlated data present in LandSat-7 ETM+ or ASTER bands is comprised into fewer bands using statistical algorithms. In the resulting set, the bands are non-correlated, and its reduced dimensionality allows the extraction of more information from it.

A suite of abundance mineral maps was created through the combination of several ratios that enhanced the presence of Al-OH and Mg-OH associated with clays and other hydroxyl minerals as well as other ratios that showed the presence of carbonates and iron oxide and hydroxide rich sediments. These mineral indexes have the advantage of normalizing spectral data, reducing the effect on the ground variations and the illumination differences [3].

The interpretation stage showed that both the Gypsum and the Carbonate Indexes proved to be the most useful tools within the generated products in the identification of uranium targets in the project.

The analysis of such mineral indexes indicated that the NW sector of the project is characterized by a suite of carbonate minerals while the SE section showed a large abundance of sulfate minerals. It is understood that this difference in exploration indicators was essentially due to the difference of the chemistry of the fluids from which mineralization was formed. Both high non-pedogenic carbonate and sulfate areas have a wide superficial extension and correlate with the known uranium anomalies found in the Laguna Sirven plateau. Such preliminary model was validated by means of ground gamma-ray spectrometry and soil geochemistry surveys recently performed [1].

1. Conclusions

Two prospective uranium exploration targets were identified within the project after the careful selection of remote sensing data during the acquisition phase and the later preparation, processing and interpretation of such spectral data.

The analysis of the presence and abundance of sulfate and carbonate related minerals indicated by both the Gypsum and the Carbonate Indexes proved to be a very useful tool to identify uranium targets in this calcrete-type deposit.

1. References

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