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Biogeochemical Orientation Survey for Surficial Uranium Deposits, Laguna Sirven, Santa Cruz, Argentina

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DESCRIPTION

In Argentina, mineral ores are abundant but few studies of the chemical analysis of native vegetation growing in such areas have been reported. Uranium related activities begun in the 1950s. The Laguna Sirven project, located in Santa Cruz, Argentina has been identified by remote sensing to contain potential deposits of uranium.

A study in Nov. 2014 resulted in the collection of soils and plant species, along with radiometric field data, from sites associated with a possible U-deposit.

This study hopes to provide an insight into the potential of using remote sensing for mineral exploration of uranium and other mineral using possible indicator plant species (based on specific components –roots or leaves) and soil profiles.

METHODS AND RESULTS

Based on remote sensing data a sampling site was selected at Laguna Sirven, Santa Cruz, Argentina. Radar data obtained from the Endeavour Space Shuttle Radar Topography Mission (SRTM) provided a coarse digital elevation model. Various mineral index maps were generated based mostly on SWIR band data. These maps agree with the geology described for this area as a possible uranium deposit. This was used to confirm the sampling site investigated in this study.

The region is extremely arid and the plant life of this region is comprised of low level scrub-like species varying in population numbers over the sampling site.

Sampling site was selected based on the satellite information. After an initial inspection using the Radiation Solutions RS-230 BGO Super-SPEC handheld gamma ray spectrometer, surface soil (top 5 cm) and soil profiles (to a depth of approx. 90 cm) were collected. Approximately 500 g of soil were placed into labelled plastic bags and sealed.

At the locations with the highest radiometric levels there was a scarcity of plants, with only the presence of small shrubs and low level surface grasses and moss-type species. Plant samples were selected where possible to represent the sampling site. Soil material was carefully removed from the roots and all of the plant sample(s) placed in separate paper bags, sealed and labelled.

All samples were stored in a large plastic storage bin for transport back to the accommodation at Las Heras. Plant samples were dried (>20 ℃) before packing in large plastic sealed bags for transport to the UK.

After transportation of all the samples to the University of Surrey, it was deemed necessary to evaluate the analytical procedures, including sample preparation and instrumental analysis for uranium and other trace elements (Th, As, V, Fe, etc), which have been found to be present in acidic volcanic rocks [1], by inductively coupled plasma mass spectrometry (ICP-MS).

The techniques most suitable for routine analysis are laser-ablation ICP-MS or traditional solution nebulisation ICP-MS [3]. Furthermore, ICP-MS has the further advantage of determining the isotopic composition and ratio of the sample (234U, 235U, 236U and 238U) [2]. In this research traditional solution nebulisation ICP-MS was used with a collision cell due to the need to determine other trace elements besides uranium and thorium in the samples. This is because it may be possible to obtain further mineralisation information be evaluating the composition of the sample, for other elements 'associated'with uranium, namely, Fe, Mn, V, As, Se, Zr, rare earths, etc.) [4] [5].

The preferred digestion method is dry ashing using a subsequent acid dissolution of the 'ash'with aqua regia for plants and aqua regia/hydrofluoric acid for soils before elemental analysis. Therefore, all uranium analyses were undertaken using aqua regia digestion of media due to the possible stability of uranyl (V) chloride species [6]. Furthermore, multi-element analysis by ICP-MS uses a set of standards from 1 to 750 μg/l. In order to enhance the accuracy for selected elements, especially U and Th which are found at low levels in digested plant and soil samples (0.05 to 30 μg/l), it was found to be necessary to use an appropriate linear dynamic range of standards. This provided good quality control (QC) calibration data for certified reference material (CRM) analysis with good levels of accuracy (agreement between calculated mean values and the certified reference values) and precision levels of < 10% relative standard deviation.

The uranium values for plant samples in this study, based on the radiometric field measurements can be divided into 'background or low mineralised'areas and 'mineralised'. Therefore, the 'background or low mineralised' uranium levels ranged over 0.01 to 0.47 mg/kg (dry weight), with a median of 0.05 mg/kg (d.w.). Similarly, the 'mineralised'values cover 0.01 to 2.05 mg/kg (d.w.) with a median of 0.32 mg/kg (d.w.). These values are in agreement with the limited number of reliable values available in the literature. Several studies have also reported the uranium concentrations in plants and plant components (roots, stems, leaves) as a function of different soil levels [7].

Uranium levels in plant parts clearly confirm the findings of Singh et al. (2005) with the highest uranium levels in roots > stems˜leaves > flowers. The plant component levels do not show any accumulation of uranium as the values are typical of those reported by others as control sites after growth in soil with moderate levels (< 20 mg/kg) [7] [8].

Several studies have reported uranium levels for soils. Kabata-Pendias & Pendias (2000) provided a review of uranium levels in soils for various countries which ranged from 0.79 to 11 mg/kg (dry weight). The data for 'background or low mineralised'areas are in good agreement with the natural uranium levels in soils reported, ranging over 0.81 to 1.34 mg/kg (dry weight), with a median of 1.09 mg/kg (d.w.). Similarly, the 'mineralised' values cover 1.21 to 741.87 mg/kg (d.w.) with a median of 6.91 mg/kg (d.w.).

Interestingly, it also reported thorium levels for soils ranging from 3.4 to 10.5 mg/kg (dry weight). Therefore, the data for 'mineralised'areas are in general agreement with these typical thorium values for soils. Similarly, these sites have interesting levels of arsenic and vanadium which are for 'mineralised'areas above the range of normal values reported for soils; arsenic <1 to 95 mg/kg (dry weight) with a typical mean of 2.2 mg/kg As (d.w.); and vanadium <7 to 300 mg/kg V (d.w.) with a typical average of 90 mg/kg V (d.w.) [1]

DISCUSSION AND CONCLUSION

A Pearson correlation analysis of the plant data confirmed the existence of statistically significant correlations between uranium and arsenic (tcal = 7.11 > tcrit = 2.68, p < 0.01) or uranium and vanadium (tcal = 5.97 > tcrit = 2.68, p < 0.01). The same pattern was observed for As and V but not for Th and Fe. The data is in good agreement with published uranium values for soils by Kabata-Pendias & Pendias (2000) and Gavrilescu et al. (2000). Based on the multi-element values it is possible to evaluate what is the possible mineralisation of these sites, namely, carnotite.

Radiometric data collected during the field trip is in good agreement with the uranium values for plants and soils at Laguna Sirven. This confirms that the use of gamma radiation measurements for U, Th and K in the field are of use for identifying sampling sites for subsequent U/Th analysis. Moreover, this will aid in the identification of specific plant species for biogeochemical prospecting

In summary, this data is in good agreement with the limited published values by Bowen (1979), Dilabio et al. (1980), Kaur et al. (1988), Vargas et al. (1997), Singh et al. (2005) and Favas et al. (2014). Remarkably, the highest uranium levels were found in plant roots, with the U, As and V results confirming that the site around Laguna Sirven is of interest for future uranium and associated elemental research.

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Country or International Organization

Argentina

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