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A Fission Track Technique Used for Biogeochemical Prospecting in Northern India

N.P. SINGH, MANWINDER SINGH, SURINDER SINGH and H.S. VIRK
Department of Physics, Guru Nanak Dev University, Amritsar-143005, India

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ABSTRACT

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A fission track technique was employed to determine the uranium (U) content of plant species collected from different locations of the middle and outer Himalayas. The regional threshold for U content was 5.5 μg/g for plants of this area. *Berberis brachybotrys* and *Adhatoda vesica* were suitable for biogeochemical prospecting. The identification of anomalies in an area of U mineralization, confirmed that the biogeochemical technique could be successfully used in the exploration for uranium.

INTRODUCTION

Plants were successfully used in the search for uranium in Colorado Plateau as early as the 1950s by Cannon (1952). More recently, encouraging results obtained by various authors (Barakso, 1979; Walker, 1979; Dunn, 1981) in different geological environments in Canada and the U.S.A. have stimulated interest in biogeochemical prospecting for uranium. The present work reports investigations on biogeochemical prospecting for uranium in the Punjab, Himachal Pradesh and Uttar Pradesh regions of the outer and middle Himalayas, using the fission track (Virk and Kaur, 1979; Virk et al., 1981) method for analysis.

SAMPLE COLLECTION AND GEOLOGY OF THE AREA

The samples were collected from different locations of middle and outer Himalayas in May and October of 1982 and 1983 and the sample locations are as shown in Fig. 1. The most common plants, leaves and twigs of common trees and low bushes, were collected from three different radioactive locations (i.e. Shat, Maldeota and Paritibba) and three barren areas (i.e. Nainadevi, Jogin-

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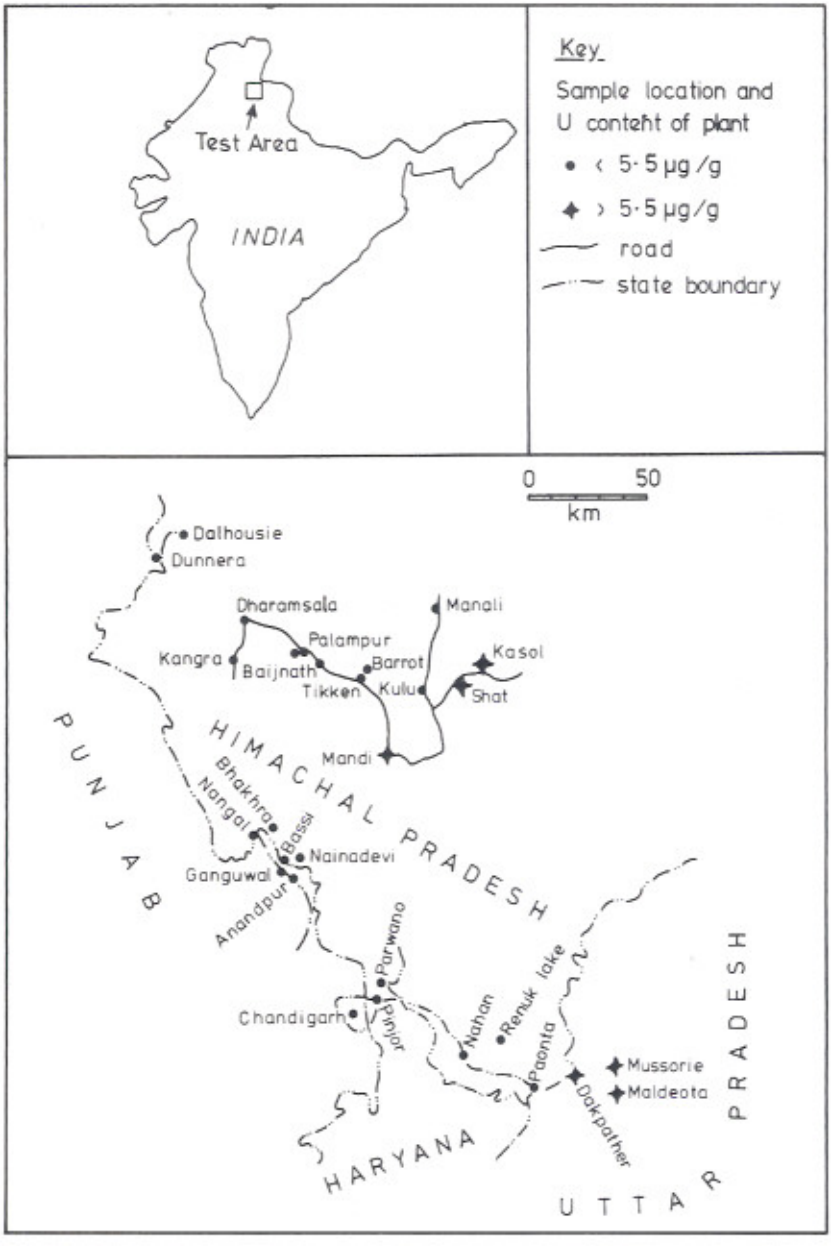

Fig. 1. Map showing sample locations (adopted from Survey of India).

der Nagar and Nahan). At all other sampling sites only *Adhatoda vesica* and *Berberis brachybotrys* species were sampled taking at least three specimens at each location.

Phosphorite and chert are the prominent rock formations in the Dehradun. In the Kulu, the rocks are quartzite, schist and gneiss. Rocks in the Siwalik area comprise mainly massive, soft and grey micaceous sandstones and clays.

EXPERIMENTAL TECHNIQUE

The experimental procedure for U estimation in plant samples is given elsewhere (Virk and Kaur, 1979; Virk et al., 1981). Plant samples were dried in an oven at 150°C and then charred at 500°C for 2 h in a muffle furnace. This residue was then pulverized. Fifty mg of the plant ash was thoroughly mixed with 100 mg of methyl cellulose and the mixture was pressed into pellets, 1.3 cm diameter and 0.1 cm thickness, using a hand pressing machine. Lexan discs of the same diameter were pressed against both sides of each pellet. The pellets were then packed in an aluminium capsule along with the standard, and were irradiated with a thermal neutron dose of 10^{15}n/cm^2 s in the thermal column of a CIRUS reactor at Bhabha Atomic Research Centre, Bombay.

After irradiation, the lexan discs were removed and etched in 6.25 *M* NaOH at 70°C for 25 minutes. The tracks recorded in the lexan discs were counted using a binocular microscope at a magnification of 600×. The U content in plant ash is determined using the formula:

$$U_x = U_s\ (T_x/T_s)(I_s/I_x)(R_s/R_x)$$

where the subscripts x and s are for unknown and standard respectively; U, the uranium content; T, the fission track density; I, the isotopic abundance ratio of U^{235} to U^{238} and R, the range of fission fragments in mg/cm^2 (Fleischer et al., 1975). The correction factor (R_s/R_x) is taken to be unity. Similarly (I_s/I_x) is taken to be unity on the assumption that the isotopic ratio is the same in the unknowns and standards.

The detection limit for U determination by the fission track method is reported to be 0.05 μg/g (Fleischer et al., 1975). The precision of the method is found to be 5–10%.

RESULTS AND DISCUSSION

The background concentration of U in plant ash was found to be 1.9 μg/g (mean of U content values for 74 plant samples collected from three different locations in non-mineralized areas). From the background value (1.9 μg/g) and standard deviation ($\sigma = 1.8$), we have assessed the regional threshold level of U at 5.5 μg/g (mean + 2 σ).

Taking the threshold at 5.5 μg/g, the contrast (ratio of actual to threshold values) was calculated for selection of optimum species and to differentiate the anomalies. Data for the U content and contrast for 19 common plant species collected from three different mineralized areas are reported in Table 1. It is evident that *Berberis brachybotrys* and *Adhatoda vesica* (Fig. 2) have a higher

TABLE 1

Comparison of U concentration and contrast in different plant species

Plant species	Family	U content (μg/g)	Contrast
Shat*			
Pinus sp.	Pinaceae	9.5	1.7
Prinsepia utilis	Rosaceae	12.0	2.2
Cedrus deodara	Pinaceae	15.0	2.7
Capsium sp.	Solanaceae	19.0	3.5
Solidago sp.	Asteraceae	23.0	4.2
Athyrium sp.	Solanaceae	26.0	4.7
Adhatoda vesica	Acanthaceae	32.0	5.8
Berberis brachybotrys	Berberidaceae	72.0	13.0
Maldeota*			
Rumex hestatus	Polygonaceae	6.3	1.1
Quercus incina	Fagaceae	6.7	1.2
Ricinus communis	Euphorbiaceae	6.7	1.2
Woodfordia fruticas	Lythraceae	7.1	1.3
Pinus sp.	Pinaceae	7.2	1.3
Hibiscus cancellatus	Malvaceae	7.4	1.3
Adhatoda vesica	Acanthaceae	12.0	2.2
Berberis brachybotrys	Berberidaceae	21.0	3.8
Paritibba*			
Cassia occidentalis	Caesalpiniacea	1.6	0.3
Cassia obtusifolia	Caesalpiniacea	4.9	0.9
Carissa caranbus	Apocyanceae	7.9	1.4
Siegesbackia orientalis	Apocyanceae	9.3	1.7
Ageratum conyzoides	Asteraceae	12.0	2.2
Adhatoda vesica	Acanthaceae	20.0	3.6
Berberis brachybotrys	Berberidaceae	41.0	7.5

Threshold background = 5.5 μg/g. Number of samples analyzed of each specimen = 3. *Sampling location.

contrast and therefore a higher uptake of uranium compared to other species. These two plant species are low bushes and common at all sampling sites in the area investigated. It was found that in both these plant species the U content decreased in the sequence leaves, branches, stems (Table 2). Thus the leaves and branches of these species can preferably be used as sampling media in a biogeochemical prospecting survey.

Uranium anomalies were identified in plant samples collected from Paritibba, Maldeota and Dakpather in the Dehradun-Mussoorie area of Uttar Pradesh, Shat and Kasol in the Kulu area and in the Mandi area of Himachal Pradesh (Table 3). The presence of U mineralization in the Dehradun-Mus-

Fig. 2. *Berberis brachybotrys* (a) and *Adhatoda vesica* (b).

soorie and Kulu areas (Saraswat et al., 1970; Udas and Mahadevan, 1974; Narayandas et al., 1979) confirms the biogeochemical anomalies of Paritibba, Maldeota, Dakpather, Shat and Kasol identified in these areas. These results indicate the potential of the biogeochemical technique for U prospection in the area.

TABLE 2

U concentrations of different organs of *Berberis brachybotrys* and *Adhatoda vesica*

Plant species		Sample location			
		Kasol		Shat	
		N	$\bar{x}$ (μg/g)	*N*	$\bar{x}$ (μg/g)
Berberis brachybotrys	L	3	33±4.3	4	65±4.8
	B	3	28±1.5	4	60±6.0
	S	3	12±2.5	4	31±5.1
Adhatoda vesica	L	4	14±1.2	4	32±4.0
	B	4	13±1.0	4	20±2.2
	S	4	12±2.1	4	13±3.6

L = leaves; B = branches; S = stem.

TABLE 3

Anomalous U concentrations in the leaves of plant species from several locations

Sample location	Plant species			
	Berberis brachybotrys		*Adhatoda vesica*	
	N	$\bar{x}$ (μg/g)	*N*	$\bar{x}$ (μg/g)
Shat[1]	4	65 ± 4.8	3	32 ± 4.0
Kasol[1]	4	33 ± 4.3	4	14 ± 1.2
Maldeota[2]	3	21 ± 4.5	3	12 ± 3.8
Paritibba[2]	3	41 ± 4.9	3	20 ± 5.4
Dakpather[2]	3	40 ± 4.3	-	n.a.
Mandi	3	29 ± 5.0	-	n.a.

n.a. – not available.
[1]Mineralization reported by Narayandas et al. (1979).
[2]Mineralization reported by Saraswat et al. (1970).

The present study also highlights the anomalous U content of 29 μg/g in *Berberis brachybotrys* species collected from the Mandi area, indicating the need for further investigations for U mineralization in this area.

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