Alpha-Guard radon survey in soil–gas and dwellings of some uranium-rich areas of Himachal Pradesh, India

It is well established that some selected areas of Himachal Pradesh, situated in the environs of western Himalaya are quite rich in uranium-bearing minerals[1,2]. The results of survey of levels of concentration of uranium and radon in western Himalaya were communicated earlier, using emanometry and track-etch techniques[3–5]. This study pertains to Alpha-Guard radon survey in some selected areas of Himachal Pradesh known for uranium mineralization.

Alpha-Guard (PQ 2000 PRO model, Genitron Instruments, Germany) is a pulse-ionization-based counter which can record alpha counts from the decay of radon and its daughters in soil–gas and indoor air of dwellings. It is a highly sensitive, rugged and portable device with a wide dynamic range from 2 to 2×10^6 Bq/l. It can be operated in diffusion and flow modes, and the radon activity is recorded at 1 min to 24 h intervals. It is a direct-reading multisensor device; fully automatic, and calibrated using international standards. Its radon data can be corrected for meteorological fluctuations of temperature, pressure and relative humidity.

Alpha-Guard radon survey in soil–gas was carried out during May 1997 in the districts of Una, and Hamirpur (HP), and during September 1997 in the districts of Palampur and Kullu up to the tourist resort of Manali. A vast area extending over 300 km^2 was covered starting from Siwalik foothills near Punjab–Himachal border up to Rohtang pass in the higher Himalayas. But our main concern was to survey uranium-rich areas along the Beas and Parbati rivers. Another survey was undertaken during August 1997 for radon concentration measurement in the indoor air of dwellings in villages located in the vicinity of uranium-rich zones delineated by the soil–gas survey in the districts of Una and Hamirpur.

The results of radon survey in soil–gas are summarized in Table 1. Radon data pertaining to sites with a threshold value of 10,000 Bq/m^3 or more are reported. The highest radon concentration in soil–gas was recorded at Bangana, Bradha, Dharmaur, Palampur, Ramera, Samurkalan and Samurkhurd. The sites at Dharmaur, Ramera and Samurkhurd were abandoned after exploitation by Atomic Minerals Division of DAE. While the Alpha-Guard radon values for Samurkalan, using emanometry, were comparable to the radon concentration measured in the soil–gas; the radon values for Kasol and Ramera were found to be respectively 170 times and 15 times lower than the values reported earlier[3].

The results of radon survey in indoor air of dwellings of some selected villages of HP, in the districts Una and Hamirpur are summarized in Table 2. The highest radon values recorded were in the indoor air of Ramera dwellings. Since almost all the houses use similar building material for construction, i.e. burnt bricks and cement plaster with mud-plastered floors, the variation in radon concentration depends upon the number of windows, i.e. the ventilation provided in the living room. It has been observed that the radon values show large diurnal and seasonal fluctuation. During winter season when all the doors and windows are closed, the radon value can rise by a factor of 3. While in house E of Ramera village the day-time radon value was 297 ± 60 Bq/m^3, the average value during the winter night of 8 January 1998 was found to be 899 ± 43 Bq/m^3.

Alpha-Guard radon values for dwellings of Ramera village showed a variation

Table 1. Alpha-Guard radon survey in the soil–gas of areas known for U-mineralization (using 10 min flow mode)

Sl no.	Village	Radon value (Bq/m^3)	Temperature (°C)	Pressure (mbar)	Rel. humidity (%)
1.	Samurkalan	45600 ± 1720	32	962	78
2.	Samurkhurd	75400 ± 2620	30	958	85
3.	Bangana	73400 ± 2560	30	943	86
4.	Ramera	57200 ± 1970	24	907	89
5.	Jaan	13300 ± 695	29	875	54
6.	Bradha	73900 ± 2550	18	838	84
7.	Kasol	19500 ± 950	29	845	46
8.	Takrer	19400 ± 1060	19	838	85
9.	Dharmaur	57700 ± 2050	17	834	91
10.	Palampur	67300 ± 2300	32	876	60

Table 2. Radon concentration in indoor air of dwellings of some villages of Himachal Pradesh (using 1 h diffusion mode)

Sl no.	Village	House no.	Radon value (Bq/m^3)	Temperature (°C)	Pressure (mbar)	Rel. humidity (%)
1.	Ramera	A	159 ± 83	28	922	77
		B	232 ± 77	29	922	76
		C	118 ± 62	29	922	75
		D	222 ± 71	29	921	76
		E	297 ± 60	15	927	69
2.	Asthota	A	40 ± 52	22	939	49
		B	214 ± 54	20	939	55
		C	132 ± 40	20	939	55
		D	100 ± 38	17	939	60
3.	Galot	A	114 ± 43	30	929	74
		B	276 ± 59	29	930	76
		C	153 ± 56	23	929	85
		D	150 ± 12	26	932	90
4.	Kheri	A	114 ± 55	25	900	81
		B	70 ± 39	25	920	80

from 118 ± 62 Bq/m^3 to 297 ± 60 Bq/m^3. Radon concentration in the indoor air of Ramera village varied between 1032 ± 78 Bq/m^3 and 2414 ± 217 Bq/m^3, using track-etch technique[4]. The average value reported[6] for the village during the rainy season (July–September 1988) was 1532 Bq/m^3. It is therefore obvious that track-etch technique-recorded radon values are a magnitude higher than the Alpha-Guard radon values observed in our survey. Hence, the efficacy of track-etch survey being conducted in India under a BRNS coordinated project of DAE is questionable.

In village Asthota, the lowest radon value (40 ± 52 Bq/m^3) was recorded in house A, which is almost adjacent to other houses in the village. The apparent difference was perhaps due to the cement concrete flooring. This shows that radon entry from the soil–gas to indoor air of dwelling can be drastically reduced by the use of 'pucca' flooring and good ventilation.

Exposure to radon and its progeny is considered to be a health hazard for general public. International Commission on Radiological Protection (ICRP) in its report[7] has calculated the risk factors owing to radon exposure, and proposed action level for intervention in dwellings when the radon concentration level is beyond the permissible limit of 600 Bq/m^3. However, Alpha-Guard radon survey shows that there is no real cause for excessive radon scare and concern for its mitigation in the area under study.

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Occurrence of *Veryhachium* and its implication on the age of the Vaishnodevi Limestone, Jammu

The Lesser Himalayan carbonate sequence, the Vaishnodevi Limestone, is extensively developed in the Jammu region and extends for over 100 km from Purl in Punch to Muttal in Udhampur district. A Lower to Middle Riphean age has been attributed to it on the basis of stromatlitic assemblages[1]. Galena occurring in the topmost orthoquartzite horizon of the limestone sequence has been dated as 967 Ma by Pb-isotopic method[2]. An Upper Riphean–Vendian age was attributed to the shales occurring near Muttal, on the basis of microbiota[3]. A diversified chert biota discovered from near Bidda in the Riasi Inlier contains distinctive mat-building crustose, coccoid chroococacean cyanobacteria along with filamentous oscillatorian and nostocalean filaments[4].

In a restudy of the Bidda chert material *Veryhachium* a distinctive Phenerozoic acritarch has been recorded. The geological map of the fossil locality, the stratigraphic column showing the sample position and the associated fossil assemblage are detailed by Venkatachala and Ashok Kumar[4]. The genus *Veryhachium* was designated by Deunff[5] for a taxon, earlier named *Hystrichosphaeridium trisulcum*[6] from the Upper Ordovician of Crozon (Veryhach), in France. The genus is recorded mostly from Ordovician–Devonian sediments. Sargeant and Stancliffe[7] in a monographic study have listed all the known records of the genus. They have listed 28 records from Ordovician, 15 from Silurian, 14 from Devonian, 1 from Carboniferous, 4 from Triassic, 1 from Cretaceous and 3 from Tertiary sediments.

There are three known records from sediments older than Cambrian. The first is by Hofmann[8] from the Gunflint Formation of Ontario. Moore *et al.*[9] consider this fossil record as unrelated to *Veryhachium*. The second record is from the Lower Proterozoic of China[10]. This too seems to be a doubtful record. Further, these records of *Veryhachium* have not been considered by Sargeant and Stancliffe[7]. The third is from the Chert Phosphorite member of the Tal Formation at the Precambrian–Cambrian boundary[11] in the Korgai Syncline, Lesser Himalaya. The single specimen recorded has a distinct triangular body measuring ± 135 µm across and equally long spines radiating from the three angles (one of the angular spines is not preserved). This seems to be an authentic record. It could be possible that the *Veryhachium* containing phosphatic cherts in the Korgai Syncline belongs to Cambrian. In comparison, the occurrence of this fossil in the Bidda chert may extend the age of the Vaishno-devi Limestone to Cambrian. Extended studies are needed to confirm this conclusion.

Group: Acritarcha Evitt, 1963

Subgroup: Palynomorphitae Downie, Evitt and Sargeant, 1963

Genus: *Veryhachium* Deunff, 1954, emend. Sargeant and Stancliffe, 1994

Type species: *V. trisulcum* Deunff, 1954 ex Downie 1959

Occurrence: Upper Ordovician, France
Veryhachium vaishnavii sp. nov. (Figures 1 and 2)

Holotype: Figure 1, Slide. AR-2; Vaishnodevi Limestone, near Bidda, Jammu.