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Possibility of uranium deposits within the Warchha sandstone, Nilawahan Group (Lower Permian) of the Salt Range

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ABSTRACT: *On the basis of studies so far undertaken, the area from Warala in the east to Nurpur in the west has been selected for further exploration work. Phosphatic nodules are present through out this strike of 25 km. Chemical U_3O_8 within these phosphatic nodules varies from 430 to 1008 ppm with an over age of 719 ppm. Strong bleaching and uraniferous solution movements are present in Simbal, Chitti Dand and Matin areas. Color bandings and bleaching, due to uraniferous solution movements within the sandstone strata, indicate that some uranium deposit was formed in the vicinity of Moregangh and Matin area, which has been effaced due to block faulting resulted by the Salt Range Thrust. Therefore, areas of high radioactivity, bleaching, color bandings and relatively higher chemical value of U_3O_8 need attention for further exploration. Both within the sandstone as well as in the phosphatic nodules, such as Simbal, Karuli, Moregangh and Matin area*

INTRODUCTION

During the last three decades the geological work has been mainly concentrated on the fluvial Siwalik rocks of Pakistan, which has resulted in the discovery of uranium ore deposit at Baghal chur, Nangar Nai, Qubul Khel, Shanawah and Tonsa. Similarly the Permian rocks specially the Nilawahan Group of the Salt Range because of their continental origin are geologically favorable for the discovery of uranium recourses. As a result of extensive literature survey, it was observed that in the world excluding Russia & China, more than thirty uranium deposits occur in the sandstone, siltstone of Permo-Carboniferous rocks (Syed & Khan, 1991).

Permo-Carboniferous uranium deposits are confined to the following dominant sedimentary environments:

- Continental environment having dominantly high-energy fluvial system. The deposit form is mostly tabular with few roll front type.
- Marginal marine environment having lacustrine to brine lagoon system, with mostly tabular deposit form. The distribution of sandstone type uranium deposits in Permo-Carboniferous in relation to tectonic style of sedimentary basins is in platform and intracratonic basin.

The Permo-Carboniferous rocks of the Salt Range are divided into two parts. The lower part is predominantly of continental origin and called as Nilawahan Group. The upper part is entirely marine and known as Zaluch Group. The Nilawahan Group includes Tobra Formation, Dandot Formation, Warchha Sandstone and Sardhai Formation. The lithology of these formations comprises conglomerates, gritstone, sandstone and shale, sandstone with coal, carbonaceous matter and copper showings.

The average thickness of Nilawahan Group is more than 300 m and is exposed over a strike length of 150 kilometers from east to west in the Salt Range. All the

previous data on Permian sequence of the Salt Range comprising of reports (Syed et al., 1993-94; 1994-95 & 1995-96) established that all the surface anomalies within the Nilawahan Group of rocks encountered at different stratigraphic levels belongs to the Warchha Sandstone.

During the course of this work considerable radioactivity on the western margin of the Salt Range in the Warchha Sandstone was observed. Prospection work from Zaluch Nala to the Nilawahan Gorge in the Western Salt Range was conducted covering an area of 120 km^2.

The area between Zaluch Nala and Chidhru Nala has been radiometrically scanned. The traverses were made across and along the strike in order to thorough checking of outcrops of the Warchha Sandstone and to locate the radioactive anomalies. Geological cross sections were measured to study the variations in the lithofacies characters of rocks of the Nilawahan Group and the overlying Paleocene Unconformity. Sedimentological and structural studies have also been conducted along these sections. Small size shallow trenches were also excavated to check the subsurface behavior of radioactivity.

The detailed foot radiometric survey of the area led to the discovery of a number of radioactive anomalies in different levels of the Warchha Sandstone. The radioactivity at different spots ranges from 200 cps to 1800 cps on (SPP2-NF Scintillation Counter) with general background of 80 to 100cps. It has been observed that the radioactivity is generally associated with carbonaceous material at shale sandstone contact and at some localities it is associated indigenously with the well-cemented sandstone. In Buri Khel and further southeast, the radioactivity decreases and ranges from 200 to 300 cps. Radioactivity has also been encountered in the variegated rocks of the Datta Formation of Jurassic age. It ranges from 200 to 2000 cps with background of 100 cps.

Phosphate deposits have attracted the interest of economic geologists for a long time not only because of their phosphate content, but also because of their high uranium content. As the phosphatic nodules in the world are regarded by-product of uranium, from different deposits, therefore, these nodules attracted the attention of Geologists of AEMC, Lahore, to work further on them as potential source of uranium. The presence of phosphatic nodules in this sequence was a question mark for many years. The present work is an attempt to answer the following questions along with finding some uranium deposits.

- What is the genesis of phosphatic nodules regarding to hosting formation?
- What is its stratigraphic level?
- What is its relationship with space and time?
- Whether it has any relationship with overlying Paleocene Unconformity?
- Why it has restricted geographic occurrence?

PREVIOUS WORK

Phase I

During the year, 1990-91, a geological party comprising of Mr. Abdul Rashid and others was deputed to carryout uranium prospection in the Salt Range. The reasons for conducting uranium prospection in Salt Range, especially in the Nilawahan Group of Permo-Carboniferous age, were

1. The Permian rocks of Salt Range – on account of their continental origin, are geologically favorable for discovery of uranium resources.
2. In the world, excluding Russia and China, more than thirty uranium deposits occur in sandstone, siltstone of Permo-

Carboniferous rocks (Syed & Khan, 1991).

3. Permo-Carboniferous uranium deposits are confined in the continental environments, dominantly in high-energy fluvial system and marginal marine environments.

The geological party, after conducting extensive fieldwork in the Salt Range, recommended that the "Nilawahan Group" fulfill the general favorable criteria for hosting the uranium resources and also recommended to carryout further geological and radiometric investigations in the Nilawahan Group.

Phase II

During the field season of 1992-93, geological/radiometric surveys were carried out in Salt Range resulted in the discovery of several uranium, thorium anomalies in the eastern part of the Salt Range.

Phase III

Subsequent upon geological investigation in 1993-94 (geological mapping, section measurements, sampling, radiometric prospection) delineate more promising areas for hosting significant uranium resources in the Salt Range. To obtain subsurface geological information, four drill holes were planned, out of which only two holes penetrated the required depth.

The overall, geological, exploration and radiometric data collected, during the year 1991 to 1994, indicated several uranium favorable factors.

1. The chemical and mineralogical data of a number of samples collected from radioactive uranium anomalies associated with vitric flow, arkosic sandstone, arkosic arenite and mudstone.
2. From the four-drill holes, 179 samples were got analyzed chemically but only two holes represented sequential data (Hole No. SRC-1 and 4). Most of the information was of geological nature.
3. The geological and exploration work undertaken during the year 1993-94 have revealed that area of western part of Eastern Salt Range is more promising for hosting uranium deposit. This area exhibiting radioactivity of 400 to 1400 cps contains more than 100 to 498 ppm of U_3O_8 in mudstone.
4. These sediments show depletion of uranium for deposition within a suitable trap.
5. The authors of report (Shahid A. Syed et al., 1995) recommended detailed lithostructural mapping of western part of Eastern Salt Range, radiometric / spectrometric prospection, mapping of radioactive levels and geophysical investigations.

Phase IV

Geological and exploration work during the field season 1994-95 was carried out in the Eastern Salt Range in the light of recommendations made after field season 1993-94. The geological and exploration activities were concentrated in the western part of Choa-Saiden Shah and Karuli areas, which were considered more prospective for uranium deposition. Following deposition were conducted in the mentioned area.

1. Lithostructural mapping, radiometric/ spectrometric prospection, mapping of radioactive levels, lithofacies variation map, mapping of major unconformities and geophysical investigations were carried out (Faiq et al., 1994-95). Two areas were selected, i.e., Karuli and Chitti Dand for further exploration work following investigation on the basis of

work carried out in 1994-95 were recommended:

a. Exploration work is also required in the area to understand the control of uranium mineralization whether sedimentological or structural in nature.
b. Water-table monitoring hole is required to know the water table of the Warchha Sandstone.

Phase V

During the field season 1995-96, a geological party comprising of Mr. Faiq Mazhar, Dr. Aziz Ullah and Mr. Iftikhar Ali was deputed to conduct exploration work in the light of previous recommendations made after field season of 1994-95.

1. Two areas i.e., Karuli and Chitti Dand were selected for further detailed exploration work.

2. Geological mapping, geophysical survey and foot radiometric prospection was also carried out along with exploration work.

3. Chemical results received from the samples taken from Simbal, Karuli, Ghahi and Matin areas indicated high chemical U_3O_8 upto 1000 ppm. So these areas were selected for further exploration work.

In addition to above-mentioned exploration work a platform survey report No. 4 on "Uranium Potential Evaluation of lower Permian rocks (Eastern Salt Range)", complied by Naseem Ud Din et al., 1997, has also recommended further exploration work in the following areas: 1) Karuli Area, 2) Nila Area, 3) Matin Area, 4) Saloi Area and 5) Chitti Dand Area.

Phase VI

Significant work was undertaken (Azizullah et al., 2003) in connection with importance of the phosphatic nodules for acting as pathfinder for some uranium deposits in the Salt Range.

SEARCH OF PHOSPHATIC NODULES EASTERN SALT RANGE

The field party has collected samples as shown in Table 1 from the Salt Range. The location of the phosphatic nodules has been shown in Fig. 1.

Warala Village

Phosphatic nodules occur at the upper part (within shale) of the Warchha sandstone. These nodules are granule to pebble size, sharp edged, sub rounded with high density. They are pink speckled to grayish black in colour and found in chocolate colour shale depression above the last ridge forming Warchha Sandstone. There is only a single stratigraphic horizon of phosphate nodules bearing shale. The radioactivity ranges upto 500 cps with the background of 50 cps is observed.

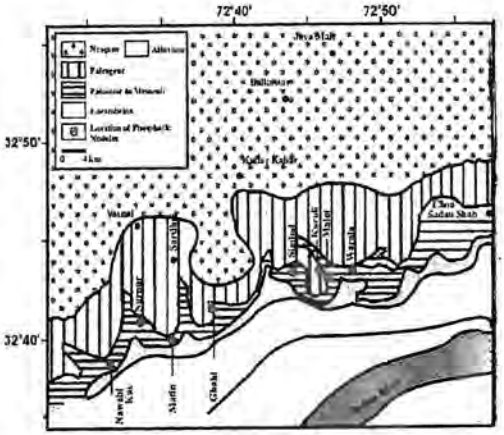

Fig. 1. Location map of Phosphatic Nodules in salt range

TABLE 1. DESCRIPTION OF SAMPLES COLLECTED FROM THE SALT RANGE AREA

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
1	WR-11/02	Simble Area (Salt Range)	879452 43 D/10	Black Concretion	(within the top shale of) Warchha Sandstone	Dark pinkish red to black color pebble sized radioactive concretions.	400/150
2	VFP-19/02	Pidh Area	080458 43 D/14	Carbonate layer	Dandot Formation	6 cm thick fibrous virtually of vitric flow. Yellowish grey in color. In the interbedded sandstone/ siltstone sequence below the 2nd sand body of Dandot Formation.	250/60
3	VFS-20/02	Saloi Area (Salt Range)	523190 43 H/2	Lower sandstone of Carbonate Layer	Warchha Sandstone	Fine grained pinkish sandstone.	-
4	VFS-21/02	Saloi Area (Salt Range)	523190 43 H/2	Carbonate layer	Warchha Sandstone	Vitric flow.	-
5	VFS-22/02	Saloi Area (Salt Range)	523190 43 H/2	1st Shale (top of Carbonate Layer)	Warchha Sandstone	Shale	-
6	VFS-23/02	Saloi Area (Salt Range)	523190 43 H/2	2nd Shale (top of Carbonate Layer)	Warchha Sandstone	Shale	-
7	WK-24/02	Karuli (near school)	905447 43 D/14	Phosphatic Nodules?	Warchha Sandstone	Upper part (within shale) of Warchha Sandstone dull red to black color pebble size concretion found within the shale. It has anguler edges & give effervescence with HCl, while some are none-reactive & have radiating needle like structure on breaking.	100/100

(Table 1 continued)

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
8	WK-25/02	Karuli	898441 43 D/14	Phosphatic Nodules	Warchha Sandstone	(Upper shale of Warchha Sandstone) Pebble to cobble size, dull red to brownish black angular to sub-angular blocky to rounded concretion.	100/100
9	WK-26/02	Karuli (east area)	451907 43 D/14	Phosphatic Nodules	Warchha Sandstone	(Second top shale of Warchha Sandstone). Pebble size dull red to blackish red radio-active sub-angular to sub-rounded concretion found along the section line BN-39 to BN-45. This is the lowest level of phosphatic nodules. Physiographic feature of these nodules occurence within the shale(upper most part) is basin shale. The shale is gently dipping.	600/100
10	WK-27/02	Karuli (east area)	451907 43 D/14	Phosphatic Nodules	Warchha Sandstone	(Upper shale of Warchha Sandstone). Large size Pebbles angular to sub angular blocky to sub rounded dull red concretion found within the upper most shale, along the section line BN-60 toBN-62. These are radio active and also give effervescence with HCl.	400/100
11	WR-35/02	Simbal area	879452 43 D/14	Phosphatic Nodules	Warchha Sandstone (upper part)	Pebble size, sub-angular to sub rounded, pink colour with black specks (younger level).	1200/100

(Table 1 continued)

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
12	WR-37/02	Simbal area	879452 43 D/14	Phosphatic Nodules	Warchha Sandstone (upper part)	Pebble size, sub-angular to sub rounded, pink colour with black specks (older level).	-
13	WR-38/02	Simbal area	879452 43 D/14	Sandstone	Warchha Sandstone	Purplish white, weathered color, reddish brown, fine grained & thinly laminated. Radioactivey is associated with volcanic ash & carbonaceous matter. Sandstone is interbedded between two shales containing phosphatic nodules.	1400/100
14	WR-40/02	Gahi area	400838 43 D/10	Phosphatic Nodules	Warchha Sandstone	Pebble size, sub-angular to sub rounded, pink colour with black specks (younger level).	1000/100
15	WR-41/02	Gahi area	400838 43 D/10	CO_3-Concretions	Warchha Sandstone	Cobble size concretion, dull red color (whitish green specks), anguler with sharp edges, immature form of nodules?	-
16	WR-42/02	Gahi area	403840 43 D/10	Sandstone	Warchha Sandstone	Greenish to purplish white, fine grained, thinly laminated sandstone, containing volcanic ash speckes & black carbonaceous layers. It is sandwitched between two phosphatic bearing shale.	1400/200
17	WR-43/02	Matin area	821384 43 D/10	Phosphatic Nodules	Warchha Sandstone (upper part)	Pebble size, sub-angular to sub rounded, pink colour with black specks (older level).	600/100

(Table 1 continued)

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
19	WR-45/02	Matin area	821384 43 D/10	Phosphatic Nodules	Warchha Sandstone (upper part)	Black nodules from Warchha Sandstone. Pebble to granule size, black colour, non-radioactive concretion found at the same level WR-43/02 (younger level).	200/75
20	WRM-51/02	Malot	923448 43 D/14	Phosphatic Nodules	Shale	Upper part (within shale) of Warchha Sandstone. Pebble size, sub angular to sub rounded, pinkish brown, blackish grey and high specific gravity.	800/60
21	WRN-52/02	South of Nurpur	7344394 43 D/10	Phosphatic Nodules	Warchha Sandstone (upper part)	Pebble size, sub angular to sub rounded pinkish brown, blackish grey and high specific gravity.	800/60
22	WRN-53/02	South of Nurpur	735394 43 D/10	Phosphatic Nodules	Warchha Sandstone (upper part)	Pebble size, sub angular to sub rounded pinkish brown, blackish grey and high specific gravity.	2200/60
23	WRN-54/02	South of Nurpur	737394 43 D/10	Phosphatic Nodules	Warchha Sandstone (upper part)	Pebble size, sub angular to sub rounded pinkish brown, blackish grey and high specific gravity.	1500/60
24	SRN-55/02	South of Nurpur	737394 43 D/10	Glauconitic Sandstones?	Sardhai Formation	(Lower part of Sardhai Formation) 60 cm thick interbedded dark greenish grey, very fine sandstone.	-

(Table 1 continued)

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
25	SRG-56/02	Dhok Hani Bukhsh (Ghai area)	400838 43 D/10	Glauconitic Sandstones?	Sardhai Formation	(Lower part of Sardhai Formation) Less than 1m thick interbedded greenish grey fine grained, found in off-white color sandstone of Sardhai Formation.	-
26	TD-57/02	Dandot Village	085426 43 D/14	Sandstone	Tobra Formation	Yellow brown, medium to gritty sandstone.	-
27	DD-58/02	Dandot Village	085426 43 D/14	Sandstone Younger 4 3 2 1 Older	Dandot Formation sample no.1	Olive green, fine grained thinly cross-laminated containing black carbonaceous lamina.	-
28	DD-59/02	Dandot Village	085426 43 D/14	Sandstone Younger 4 3 2 1 Older	Dandot Formation sample no.2	Olive green, fine grained, thinly cross-laminated, containing black carbonaceous lamina.	-
29	DD-60/02	Dandot Village	085426 43 D/14	Sandstone Younger 4 3 2 1 Older	Dandot Formation sample no.3a	Olive green, fine grained, thinly cross-laminated, containing black carbonaceous lamina.	

(Table 1 continued)

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
30	DD-61/02	Dandot Village	085426 43 D/14	Sandstone Younger 4 3 2 1 Older	Dandot Formation sample no.3b	Olive green, fine grained, thinly cross-laminated, containing black carbonaceous lamina.	-
31	DD-62/02	Dandot Village	085426 43 D/14	Sandstone Younger 4 3 2 1 Older	Dandot Formation sample no.4a	Olive green, fine grained, thinly cross-laminated, containing black carbonaceous lamina.	-
32	DD-63/02	Dandot Village	085426 43 D/14	Sandstone Younger 4 3 2 1 Older	Dandot Formation sample no.4b	Olive green, fine grained, thinly cross-laminated, containing black carbonaceous lamina.	-
33	DD-64/02	Dandot Village	085426 43 D/14	Sandstone Younger 4 3 2 1	Dandot Formation sample no.4c	Olive green, fine grained, thinly cross-laminated, containing black carbonaceous lamina.	

(Table 1 continued)

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
34	SRZ-66/02	Zaluch Nala (WSR)	723405 38 P/9	Older Glauconitic Sandstone?	Sardhai Formation	Very coarse to gritty, green, poorly sorted sandstone, found in the basal part of Sardhai Formation.	-
35	SRS-67/02	Sarin Nala (WSR)	797370 38 P/10	Glauconitic Sandstone?	Sardhai Formation	Medium grained, poorly sorted, green, basal part of Sardhai Formation.	-
36	SRL-68/02	Larkaki Nalal (WSR)	729369 38 P/10	Glauconitic Sandstone?	Sardhai Formation	Light purple to green color, fine grained sandstone, thinly laminated, found in basal part of Sardhai Formation.	-
37	SLD-69/02	Lunda Nala (WSR)	722363 38 P/10	Glauconitic Sandstone?	Sardhai Formation	Medium to fine grained, green, poorly sorted sandstone in the lower part of Sardhai Formation.	-
38	WRS-70/02	Swans Nala (WSR)	722349 38 P/10	Phosphatic Radioactive Sandstone?	Warchha Sandstone (upper part)	Dark maroon color, hard band sandstone, which is radio-active & associated with green color band of glauconitic sandstone?	200/60
39	SRW-71/02	Lunda to Swans Nala (WSR)	722355 38 P/10	Nodules	Sardhai Formation	Pebble size, sub-angular nodules of Pyrite?, non-radioactive, high specific gravity.	-
40	SRW-72/02	Lunda to Swans Nala (WSR)	722355 38 P/10	Nodules	Sardhai Formation	Angular to sub-angular platy, black color churt nodules.	-
42	WNW-74/02	Nawabi Kas (south western side)	973453 43 D/14	Phosphatic Nodules	Warchha Sandstone (upper part)	Granule to pebble size, pinkish to greyish black, high sp. gravity.	700/50

(Table 1 continued)

S.No.	Sample No.	Locality/Area	NGR/ Toposheet No.	Lithology	Geological Formations	Filed Description	Surface/BG Radioactivity CPS
43	WNW-75/02	Nawabi Kas (south western side)	970452 43 D/14	Calichi	Warchha Sandstone (upper part)	Reddish brown to choclate color, limestone nodules, calichi within the red shale.	-
44	SRK_76/02	Katha (road section)	607307 43 D/6	Nodules	Sardhai Formation	Pebble size, light marron, elliptical shape, silty nodules which contain greenish core.	-
45	WRK-77/02	Katha (road section)	607307 43 D/6	Black Glassy Nodules	Warchha Sandstone (upper part)	Pebble size, sub angular, high sp.gravity, black glassy nodules.	100/50
46	TR-4/1	Trench Sample Simbal Area (ESR)	884454 43 D/14	Shale	Warchha Sandstone (upper part)	Chocalate red claystone, massive, fragile, phosphatic nodules.	-
47	TR-4/2	Trench Sample Simbal Area (ESR)	884454 43 D/14	Shale	Warchha Sandstone (upper part)	Chocalate red claystone, massive, fragile, phosphatic nodules.	-
48	TR-4/3	Trench Sample Simbal Area (ESR)	884454 43 D/14	Shale	Warchha Sandstone (upper part)	Chocalate red claystone, massive, fragile, phosphatic nodules.	-

Malot area

In Malot area near Malot village at NGR 924449 to 924448 Toposheet No. 43-D/14, phosphatic nodules occur within the two upper most shale beds of the Warchha Sandstone overlain conformably by the Sardhi Formation. In both horizons, the phosphatic nodules are pebble sized, sub-angular to sub-rounded, pinkish brown, blackish gray with high specific gravity. The radioactivity ranges from 700-800 cps with the background of 80 cps on SSP-2 NF scintillation counter.

Karuli area

Field party has found phosphatic nodules at three different places as follows:

a. Karuli near school (NGR 905447 Topo sheet No.43-D/14).
b. Karuli (NGR 89441 Topo Sheet No. 43-D/14).
c. Karuli East (NGR 451907 Topo sheet No. 43-D/14).

Karuli near school: Phosphatic nodules are found in the upper part (within shale) of the Warchha Sandstone. They are dull red to black colored, pebble sized and angular. They give effervescence when treated with HCL while some are none-reactive having radiating needle like structure on breaking. These give radioactivity of 1100 cps with 80 cps background.

Karuli: Phosphatic nodules are found within upper shale of the Warchha Sandstone. They are pebble to cobble sized, dull red to brownish black colored, angular to sub-angular and blocky to rounded shape. They give radioactivity of 100 cps with background of 80 cps.

Karuli east: Two types of phosphatic nodules are found within the Warchha Sandstone.

- First type is found within the second top shale of the Warchha Sandstone. The shale is gently dipping. This is the lower most horizon of phosphatic nodules. They give radioactivity of 600 cps with the background of 100 cps. They are pebble sized, red to blackish red colored and sub-angular to sub sounded shaped.
- Second type phosphatic nodules are found within the upper most shale of the Warchha Sandstone. These pebbles are large in size, angular to sub angular, blocky to sub-rounded and dull red in colour. They are radioactive and give effervescence with HCl. They give radioactivity of 400 cps with the background of 100 cps.

These nodules are found within the shale bed in the upper part of Warchha Sandstone. The phosphatic nodules found in younger and older horizons of the Warchha Sandstone having the same lithology.

They are reddish black to dark maroon color, pebble size, sub-angular to sub-rounded with black specks and commonly associated with caliches. They give spot radioactivity of 400 cps with the background value of 80 cps on SPP2-NF scintillation counter. On breaking they give higher radiation and concentric internal structure.

Simbal area

These nodules are found within the shale bed in the upper part of the Warchha Sandstone (Fig. 2). The phosphatic nodules found in younger and older horizons of the Warchha Sandstone having the same lithology.

They are reddish black to dark maroon color, pebble size, sub-angular to sub-rounded with black specks and commonly associated with caliches. They give spot radioactivity of 400 cps with the background value of 80 cps on SPP2-NF scintillation counter. On breaking they give higher radiation and concentric internal structure.

Fig. 2. Presence of Phosphatic Nodules within the upper part of the Warchha Sandstone in Simbal Area

Ghahi area Dhok Hani Bakash

Two types of phosphatic nodules are found in the upper part (within shale) of the Warchha Sandstone. They have the same lithology as described in Simbal area.

Matin area

There are two horizons of phosphatic nodules in the upper post part of (within shale) the Warchha Sandstone.

a. Older horizon: They are pebble sized, sub-angular to sub-rounded, pink colour with black specks. The radioactivity reaches upto 600 cps with background of 100 cps.
b. Younger level: Pebble to granule size, black colored phosphatic nodules are found. The radioactivity ranges from 100 to 200 cps with background value of 75 cps.

Nurpur area

Phosphatic nodules in association with the pedogenic carbonate nodules occur within the shale bed in the upper part of the Warchha Sandstone. There is only single stratigraphic horizon of phosphatic nodules. They are pebble size, sub-angular to sub-rounded, pinkish brown, blackish grey with high specific gravity. The radioactivity ranges from 800 to 2200 cps with background value of 60 cps is found.

Nawabi Kas

This is the eastern most phosphatic nodules-bearing locality in which phosphate bearing nodules occur in the upper most shale beds of the Warchha Sandstone. The 2nd top shale of the Warchha Sandstone contains pedogenic carbonate concretions of pebble to cobble size, reddish brown to chocolate colour non-radioactive concretions.

The top of the Warchha Sandstone contains phosphatic nodules, which are granule to pebble sized, pinkish to grayish black with high sp. gravity. The radioactivity ranges upto 700 cps with background of 50 cps is found.

CENTRAL SALT RANGE

Katha-Pal road section

The Warchha Sandstone almost 100 meters thick at Katha-Pal road section. Walnut weathering behavior is not prominent like eastern Salt Range area. Moreover, the shales are less commonly containing pedogenic carbonate. The Sardhi Formation along the roadside is mostly faulted and covered with scree of overlying limestone bed. In the above-mentioned NGR sixty meters thick sequence of Sardhi Formation lies over the Warchha Sandstone. Phosphatic nodules are absent in this area. The field party collected two other types of nodules in this area.

Type 1: Pebble to cobble size, silty, non-radioactive, low specific gravity, elliptical shaped nodules, on breaking they show green colour core.

Type 2: Granule to pebble size, black glassy nodules, high specific gravity, and having sharp edges. They are similar to phosphatic nodules but lacking pinkish specks and having very low radioactivity.

WESTERN SALT RANGE

The field party searched out the phosphatic nodules in the Warchha Sandstone and the Sardhi Formation. In this connection the following sites have been visited:

- Zaluch Nala Topo Sheet No. 38 P/9
- Lunda Nala Topo Sheet No.38 P/9
- Larkakki Nala Topo Sheet No. 38 P/10
- Surans Nala Topo Sheet No. 38 P/10
- Sarin Nala Topo Sheet No. 38 P/10
- Nammal Road Section Topo Sheet No. 38 P/14
- Sakessor Road Section Topo Sheet No. 38 P/14

It is found that though both the Warchha Sandstone and the Sardhi formations are present in the above-mentioned areas, but they are lacking phosphatic nodules.

PETRO-CHEMICAL RESULTS

Petrographic studies of the different kinds of nodules have indicated that there are five kinds of nodules present within the Warchha Sandstone of the Salt Range area (Table 2, 3). These are (i) phosphatic nodules, (ii) calcareous nodules (iii) iron nodules, (iv) barite nodules and (v) clay nodules. Furthermore, the sandstone samples have shown that the major variety is arkosic i.e. the feldspar content is more than 15%. It is mainly potash feldspar, which has strong affinity with the uranium. The content of P_2O_5 within the phosphatic nodules varies from 13.37 in Matin area to 24.39%in Nurpur area. As far as the chemical U_3O_8 result, of the phosphatic nodules are concerned they vary from 430 ppm in Ghahi area to 787ppm in Nurpur area (Table 2). Iron nodules also have chemical U_3O_8 upto 65 ppm in nodules of Katha Road section and 215 ppm of U_3O_8 in nodules of Karuli area. The calcareous nodules contain chemical U_3O_8 upto 1ppm in Nawabi Kas area and 65ppm U_3O_8 in Matin area. One barite nodule found from the Lunda Nala has 8 ppm of U_3O_8. One clay nodule found from the Katha Road section has 13ppm U_3O_8.

It is significant that some samples of sandstone belong to arkosic variety have shown very high percentage of chemical U_3O_8. Such as a sample of arkosic sandstone from the Nurpur area has shown chemical U_3O_8 of 70 ppm. Similarly a sandstone sample from Ghahi area has shown 12 ppm of U_3O_8. A sample from Saloi area has shown 14ppm of U_3O_8. While in the sandstone samples from other areas, the chemical U_3O_8 varies from 1 to 5 ppm. This value is significantly higher and thought provoking as compare to the Clarke value of 1.5 to 2 ppm U_3O_8 generally present within the common sandstones (Clarke & Washington, 1924).

It is generally observed that some areas such as Karuli Nurpur, Matin and Ghahi have higher value of chemical U_3O_8 in phosphatic nodules, arkosic sandstone and calcareous nodules. Moreover, deep alterations of feldspars at some places, intense hematization/limonitization, and bleaching, coloring bandings due to uraniferous solution movements may lead to some favourable site for uranium precipitation.

TABLE 2. PETRO-CHEMICAL DATA SHEET OF SAMPLES FROM THE NILAWAHAN GROUP (LOWER PERMIAN) SALT RANGE

Field Data			Petrographic Analyses																				Chemical Analyses			
Sr. No.	Sample No.	Field Location with NGR/ Toposheet No.	Quartz	Sodic Plagioclase	Orthoclase	Microcline	Perthite	Clays	Biotite	Muscovite	Chlorite	Magnetite/ Hematite/ Limonite	Calcite	Clay grade minerals	Silt/Sand grade minerals	Collophane	Barite	Feldspar	Unidentified minerals	Jarosite	Cement	Rock Name	U_3O_8	eU$_3$O$_8$	ETh	P_2O_5
			(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(ppm)	(ppm)	(ppm)	(%)
1	VFS-20/02	Saloi Area 523190 43 H/2	34	4	5	3	6	28	3	1	2	6	-	-	-	-	-	-	-	-	-	Arkose	14	ND	< 10	0.3
2	VFS-21/02	Saloi Area 523190 43 H/2	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	Limestone	5	< 10	ND	0.34
3	VFS-22/02	Saloi Area 523190 43 H/2	18	3	4	-	5		4	-	-	-	-	66	-	-	-	-	-	-	-	Mudstone/ Shale	10	90±9	< 10	0.7
4	VFS-23/02	Saloi Area 523190 43 H/2	-	-	-	-	-	-	-	-	-	-	-	30	60	-	-	-	-	-	-	Silt Stone	4	< 10	ND	0.34
5	WK-24/02	Karuli (Near School) 905447 43 D/14	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	Calcareous Nodule	5	-	-	0.067
6	WK-25/02	Karuli 898441 43 D/14	-	-	-	-	-	-	-	-	-	2	95	-	3	-	-	-	-	-	-	Calcareous Nodule	60	-	-	1.74
7	WK-26/02	Karuli (East Area) 451907 43 D/14	-	-	-	-	-	-	-	-	-	12	8	-	-	62	18	-	-	-	-	Phosphate Nodule	526	-	-	21.92

(Table 2 continued)

Field Data			Petrographic Analyses																				Chemical Analyses			
Sr. No.	Sample No.	Field Location with NGR/ Toposheet No.	Quartz	Sodic Plagioclase	Orthoclase	Microcline	Perthite	Clays	Biotite	Muscovite	Chlorite	Magnetite/ Hematite/ Limonite	Calcite	Clay grade minerals	Silt/Sand grade minerals	Collophane	Barite	Feldspar	Unidentified minerals	Jarosite	Cement	Rock Name	U_3O_8	eU_3O_8	ETh	P_2O_5
			(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(ppm)	(ppm)	(ppm)	(%)
8	WK-27/02	Karuli (East Area) 451907 43 D/14	14	-	-	-	-	-	-	-	-	62	4	-	-	10	2	8	-	-	-	Iron Nodule	215	-	-	6.12
9	WR-35/02	Simbal Area 879452 43 D/14	-	-	-	-	-	8	-	-	-	8	-	-	-	66	10	-	8	-	-	Phos phate Nodule	469	-	-	22.98
10	WR-37/02	Simbal Area 879452 43 D/14	-	-	-	-	-	-	-	-	-	41	2	-	-	45	12	-	-	-	-	Phos phate Nodule	411	-	-	21.51
11	WR-38/02	Simbal Area 879452 43 D/14																					84			
12	WR-40/02	Gahi area 400838 43 D/10	-	-	-	-	-	-	-	-	-	18	2	-	-	65	-	15	-	-	-	Phos phate Nodule	430	-	-	13.37
13	WR-41/02	Gahi area 400838 43 D/10	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	Calca reous Nodule	4	-	-	0.081
14	WR-42/02	Gahi area 403840 43 D/10																					143			
15	WR-43/02	Matin area 821384 43 D/10	-	-	-	-	-	-	-	-	-	3	-	-	-	64	8	-	25	-	-	Phos phate Nodule	569	-	-	16.56

(Table 2 continued)

Field Data			Petrographic Analyses																				Chemical Analyses			
Sr. No.	Sample No.	Field Location with NGR/ Toposheet No.	Quartz	Sodic Plagioclase	Orthoclase	Microcline	Perthite	Clays	Biotite	Muscovite	Chlorite	Magnetite/ Hematite/ Limonite	Calcite	Clay grade minerals	Silt/Sand grade minerals	Collophane	Barite	Feldspar	Unidentified minerals	Jarosite	Cement	Rock Name	U_3O_8	eU_3O_8	ETh	P_2O_5
			(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(ppm)	(ppm)	(ppm)	(%)
16	WR-44/02	Matin area 821384 43 D/10	-	-	-	-	-	-	-	-	-	5	95	-	-	-	-	-	-	-	-	Calcareous Nodule	65	-	-	2.09
17	WR-45/02	Matin area 821384 43 D/10	-	-	-	-	-	5	-	-	-	17	20	-	-	58	-	-	-	-	-	Phosphate Nodule	606	-	-	19.56
18	WRM-51/02	Malot area 923448 43 D/14	12	11	-	-	-	-	-	-	-	27	-	-	-	40	8	-	2	-	-	Phosphate Nodule	522	-	-	18.59
19	WRN-52/02	South of Nurpur 734394 43 D/10	-	-	-	-	-	-	-	-	-	10	12	-	-	64	10	-	4	-	-	Phosphate Nodule	483	-	-	20.53
20	WRN-53/02	South of Nurpur 735394 43 D/10	-	-	-	-	-	-	-	-	-	22	8	-	-	66	-	-	4	-	-	Phosphate Nodule	787	-	-	22.35
21	WRN-54/02	South of Nurpur 737394 43 D/10	-	-	-	-	-	-	-	-	-	23	30	-	-	47	-	-	-	-	-	Phosphate Nodule	454	-	-	24.39
22	SRN-55/02	South of Nurpur 737394 43 D/10	28	4	14	1	6	8	3	2	-	6	5	-	-	-	-	-	-	-	22	Arkose	70	-	-	0.13
23	SRG-56/02	Dhok Hani Bukh (Ghai) 400838 43 D/10	26	4	13	1	5	4	1	4	-	4	10	-	-	-	-	-	-	-	28	Arkose	12	-	-	0.08

(Table 2 continued)

Field Data			Petrographic Analyses																				Chemical Analyses			
Sr. No.	Sample No.	Field Location with NGR/ Toposheet No.	Quartz	Sodic Plagioclase	Orthoclase	Microcline	Perthite	Clays	Biotite	Muscovite	Chlorite	Magnetite/ Hematite/ Limonite	Calcite	Clay grade minerals	Silt/Sand grade minerals	Collophane	Barite	Feldspar	Unidentified minerals	Jarosite	Cement	Rock Name	U_3O_8	eU_3O_8	ETh	P_2O_5
			(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(ppm)	(ppm)	(ppm)	(%)
24	TD-57/02	Dandot Village 085426 43 D/14	30	5	8	1	7	32	2	1	-	5	-	-	-	-	-	-	-	-	-	Arkose (Argillaceous)	3	-	-	0.18
25	DD-58/02	Dandot Village 085426 43 D/14	32	7	8	3	8	22	4	1	1	7	-	-	-	-	-	-	-	-	-	Arkose (Argillaceous)	5	-	-	0.08
26	DD-59/02	Dandot Village 085426 43 D/14	34	6	10	3	7	25	3	2	1	5	-	-	-	-	-	-	-	-	-	Arkose (Argillaceous)	4	-	-	0.07
27	DD-60/02	Dandot Village 085426 43 D/14	35	6	9	1	7	25	8	1	1	7	-	-	-	-	-	-	-	-	-	Arkose (Argillaceous)	4	-	-	0.07
28	DD-61/02	Dandot Village 085426 43 D/14	35	7	10	3	8	25	1	-	-	7	-	-	-	-	-	-	-	-	-	Arkose (Argillaceous)	2	-	-	0.02
29	DD-62/02	Dandot Village 085426 43 D/14	34	6	11*	3	8	22	6	3	1	6	-	-	-	-	-	-	-	-	-	Arkose (Argillaceous)	3	-	-	0.04
30	DD-63/02	Dandot Village 085426 43 D/14	35	7	8	2	7	15	7	1	2	5	10	-	-	-	-	-	-	-	-	Arkose	4	-	-	0.1
31	DD-64/02	Dandot Village 085426 43 D/14	38	8	8	2	7	22	3	2	2	4	-	-	-	-	-	-	-	-	-	Arkose (Argillaceous)	5	-	-	0.05

(Table 2 continued)

	Field Data		Petrographic Analyses																				Chemical Analyses			
Sr. No.	Sample No.	Field Location with NGR/ Toposheet No.	Quartz	Sodic Plagioclase	Orthoclase	Microcline	Perthite	Clays	Biotite	Muscovite	Chlorite	Magnetite/ Hematite/ Limonite	Calcite	Clay grade minerals	Silt/Sand grade minerals	Colliophane	Barite	Feldspar	Unidentified minerals	Jarosite	Cement	Rock Name	U_3O_8	eU_3O_8	ETh	P_2O_5
			(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(ppm)	(ppm)	(ppm)	(%)
32	SRZ-66/02	Zaluch Nala(WRS) 723405 38 P/9	30	10	20	3	4	30	-	-	-	3	-	-	-	-	-	-	-	-	-	Arkose	1	-	-	0.02
33	SRS-67/02	Sarin Nala(WRS 797370 38 P/10	40	10	15	-	3	30	-	-	-	-	-	-	-	-	-	-	-	-	-	Arkose	1.5	-	-	<0.01
34	SRL-68/02	Larkaki Nala(WRS) 729369 38 P/10	32	5	8	3	12	26	1	1	1	-	-	-	-	-	-	-	-	4	-	Arkose	3	-	-	<0.01
35	SLD-69/02	Lunda Nala 722363 38 P/10	40	5	10	3	14	22	1	1	1	-	-	-	-	-	-	-	-	2	-	Arkose	5	-	-	<0.01
36	WRS-70/02	Swans Nala 722349 38 P/10	25	6	8	2	10	5	-	-	-	32	-	-	-	-	-	-	-	-	-	Arkose (Ferro)	3	-	-	<0.01
37	SRW-71/02	Lunda to Swans Nala 722355 38 P/10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	Barite Nodule	8	-	-	<0.01
38	SRW-72/02	Lunda to Swans Nala 722355 38 P/10	-	-	-	-	-	-	-	-	-	75	-	-	25	-	-	-	-	-	-	Iron Stone	19	-	-	0.16

(Table 2 continued)

Field Data			Petrographic Analyses																				Chemical Analyses			
Sr. No.	Sample No.	Field Location with NGR/ Toposheet No.	Quartz	Sodic Plagioclase	Orthoclase	Microcline	Perthite	Clays	Biotite	Muscovite	Chlorite	Magnetite/ Hematite/ Limonite	Calcite	Clay grade minerals	Silt/Sand grade minerals	Collophane	Barite	Feldspar	Unidentified minerals	Jarosite	Cement	Rock Name	U_3O_8	eU_3O_8	ETh	P_2O_5
			(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(ppm)	(ppm)	(ppm)	(%)
39	SRW-73/02	Warala Nala (ESR) 943457 43 D/14	32	4	8	3	10	30	2	1	-	2	-	-	-	-	-	-	-	-	-	Arkose	2	-	-	0.01
40	WNW-74/02	Nawabi Kas 973453 43 D/14	-	-	-	-	-	-	-	-	-	13	2	-	-	63	20	-	2	-	-	Phosphate Nodule	479	-	-	21.07
41	WNW-75/02	Nawabi Kas 970452 43 D/14	-	-	-	-	-	-	-	-	-	5	95	-	-	-	-	-	-	-	-	Calcareous Nodule	1	-	-	0.06
42	SRK-76/02	Katha(road section) 607307 43 D/6	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	Clay Nodule	13	-	-	22.8
43	WRK-77/02	Katha(road section) 607307 43 D/6	-	-	-	-	-	-	-	-	-	94	-	-	5	-	-	-	1	-	-	Iron Nodule	65	-	-	7.27
44	TR-4/1	Trench Sample 884454 43 D/14	-	-	-	-	-	-	-	-	-	5	-	60	35	-	-	-	-	-	-	Mud Stone	3	-	-	<0.01
45	TR-4/2	Trench Sample 884454 43 D/14	-	-	-	-	-	-	-	-	-	-	-	60	40	-	-	-	-	-	-	Mud Stone	2	-	-	<0.03
46	TR-4/3	Trench Sample 884454 43 D/14	6	1	2	-	1	-	-	-	-	5	84	-	-	-	-	-	-	-	-	Calcareous Concretion	3	-	-	0.03

TABLE 3. WHOLE ROCK CHEMISTRY OF SAMPLES FROM THE NILAWAHAN GROUP (LOWER PERMIAN) SALT RANGE

Sr #	Sample No.	Chem. U_3O_8 (ppm)	eU_3O_8 (ppm)	eTh (ppm)	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	H_2O^+ (%)	H_2O^- (%)	CO_2 (%)	LOI (%)	Trace Elements (%)
1	WR-11/02	509±10	800±28	N.D	3.73	0.14	2.7	25.39	0.25	0.1	37.73	0.36	0.44	0.07	21.9	0.57	0.28	6.2	-	-
2	VFP-19/02	13±1	32±6	N.D	7.06	0.13	5.25	0.5	0.29	0.54	51.02	0.54	0.22	0.29	0.91	0.09	0.36	31.8	-	-
3	VFS-20/02	14	N.D	<10	53.52	0.68	16.89	8.49	0.19	0.03	0.31	0.93	2.03	2.14	0.3	3.96	2.54	0.14	11.09	-
4	VFS-21/02	5	< 10	N.D	61.05	0.98	12.95	3.5	0.14	0.13	1.4	0.35	3.57	2.68	0.34	1.31	1.41	3.82	8.38	-
5	VFS-22/02	10	90±9	<10	54.65	1.01	16.89	5.14	0.24	0.05	0.37	0.86	1.83	2.06	0.7	0.55	6.75	0.37	15.78	-
6	VFS-23/02	4	< 10	N.D	4.31	0.29	3.09	1.04	0.18	0.5	51.6	0.5	0.87	0.23	0.34	0.49	1.36	35.64	-	-
7	WRM-51/02	522	-	-	9.46	0.53	4.32	23.79	0.26	<0.01	33.01	0.46	1.44	0.39	18.59	0.75	0.25	6.93	-	-
8	WRN-52/02	483	-	-	2.57	0.38	1.87	24.7	0.36	0.51	33.45	0.96	0.94	0.11	20.53	0.94	0.11	7.63	-	-
9	WRN-53/02	787	-	-	2.28	1.03	2.06	23.95	0.24	0.59	35.64	0.51	0.75	0.13	22.35	0.5	0.1	4.87	-	-
10	SRN-55/02	70	-	-	73.32	0.78	9.97	2.23	4.28	0.1	0.59	1.22	0.96	0.67	0.13	0.53	0.42	<0.4	-	-
11	SRG-56/02	12	-	-	69.15	1.47	8.82	3.19	8.12	0.13	1.54	2.98	0.68	0.53	0.08	0.88	0.17	<0.4	-	-
12	TD-57/02	3	-	-	72.68	0.42	8.84	4.36	0.52	0.03	0.44	0.48	3.23	1.85	0.18	1.1	0.42	0.48	-	-
13	DD-58/02	5	-	-	72.69	0.43	10.88	3.95	1.4	0.02	0.45	0.98	3.34	2.12	0.08	0.17	0.13	<0.4	-	-
14	DD-59/02	4	-	-	69.15	0.4	11.07	5.03	2.12	0.02	0.99	0.98	3.28	1.8	0.07	0.28	0.27	<0.4	-	-
15	DD-60/02	4	-	-	65.32	0.55	11.64	6.42	1.2	0.03	0.59	1.33	3.08	1.83	0.07	0.03	0.52	<0.4	-	-
16	DD-61/02	2	-	-	73.78	0.28	6.94	4.13	1.36	0.04	0.33	0.72	32	1.61	0.02	0.75	0.15	<0.4	-	-
17	DD-62/02	3	-	-	69.67	0.43	12.28	3.95	1.4	0.03	0.38	0.46	3.37	1.77	0.04	0.86	0.24	<0.4	-	-
18	DD-63/02	4	-	-	72.57	0.53	7.88	3.49	1	0.07	1.68	0.6	3.07	1.48	0.1	0.82	0.33	3.66	-	-
19	DD-64/02	5	-	-	73.18	0.57	10.13	4.19	1.67	0.03	0.9	1.05	3.41	1.58	0.05	0.64	0.41	<0.4	-	-

(Table 3 continued)

Sr #	Sample No.	Chem. U_3O_8 (ppm)	eU_3O_8 (ppm)	eTh (ppm)	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	MnO (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	H_2O^+ (%)	H_2O^- (%)	CO_2 (%)	LOI (%)	Trace Elements (%)	
																				Ba	9.94
																				SO_4	7.05
20	WNW-74/02	479	-	-	2.05	0.43	3.66	16.67	0.44	0.21	31.41	<0.1	0.5	0.09	21.07	0.16	0.9	5.47	-	V(ppm)	382
																				Fe(T)	11.65
																				Fe+2	0.34
																				Fe+3	11.31
																				Ba	-
																				SO_4	-
21	WNW-75/02	1	-	-	7.77	0.15	5.33	1.22	0.07	0.29	46.95	0.8	0.4	0.55	0.06	0.03	0.98	35.05	-	V(ppm)	77
																				Fe(T)	0.92
																				Fe+2	0.07
																				Fe+3	0.85
																				Ba	-
																				SO_4	-
22	SRK-76/02	13	-	-	17.7	8.59	10.3	3.96	0.09	0.08	33.33	0.52	1.18	0.1	22.8	0.6	0.9	6.1	-	V(ppm)	96
																				Fe(T)	2.84
																				Fe+2	0.07
																				Fe+3	2.77
																				Ba	-
																				SO4	-
23	WRK-77/02	65	-	-	6.49	0.48	8.32	55.46	0.2	0.35	13.5	<0.1	1.51	0.12	7.27	0.47	1.33	3.08	-	V(ppm)	590
																				Fe(T)	38.78
																				Fe+2	0.16
																				Fe+3	38.62

DISCUSSION

Keeping in view the presence of more than thirty uranium deposits in Permo-Carboniferous rocks in different parts of world, the Permian rocks of the home country was checked. It is significant that large number of uranium anomalies have been found within the Nilawahan Group (Lower Permian) of the Salt Range area. The anomalies are mainly associated with (i) carbonate layer in the eastern Salt Range within the Warchha Sandstone, (ii) within the Warchha Sandstone itself, (iii) along the shale/sandstone contact of the Warchha Sandstone, (iv) within the phosphatic nodules present in the upper part of the Warchha Sandstone from Warala in the east to Katha Road section in the west and (v) within the Paleocene Unconformity.

As far as the origin of phosphatic deposits is concerned different theories have been presented. Such as the phosphatic beds have been considered as accumulation of coprolites of fish and higher animals. Therefore, the deposits are submarine in nature. Non deposition caused by failure of land-derived sediments is involved the concentration of coprolitic material while some writers believe that unfavorable conditions for the formation of carbonate of lime permitted the accumulations of phosphatic hard part of organism during a period of non-deposition.

Phosphatic nodules are found not only in phosphate deposits but are widely distributed in some limestone and especially in the calcareous chalk and other sediments. They are also occur on present see floor. These nodules are varying in size, typically black in color, irregular form and have hard shining surface. Metasomatic phosphates are formed by the replacement of limestone by phosphatic bearing solutions (Chatterjee, 1970; Cole, 1980; Baturin, 1982).

During the field season (2002) the main emphasis was given to the anomalies associated with the uranium bearing phosphatic nodules. These nodules are mainly present at Warala in the east to Nurpur in the west. Some phosphatic nodules are also present further west upto Katha Road Section. The strike wise extension of strata bearing these nodules is 25km from Warala to Nurpur and 35Km from Warala to Katha Road Section. The P_2O_5 content varies 13.37 to 24%. The uranium content varies from 430 to 787 ppm U_3O_8. Furthermore, in the areas such as Simbal, Moregangh and Matin the sandstone lying below the phosphatic nodules bearing shale horizon is radioactive, also showing bleaching and solution movements in the form of color bandings of limonite and hematite staining. The carbonaceous pockets present within the Warchha Sandstone have chelate U_3O_8 from a few ppm to 227 ppm in Matin area. As the sandstone is mostly porous and friable therefore there is strong possibility that unchecked uranium has been moved to the water table.

Similarly the transgression and regression of sea has caused the development of shale and phosphatic nodules in the Warchha Sandstone horizons. Formation of lagoons also occurred as result of marine transgression. Uranium present within the seawater has chelated by the phosphatic material. During diagenesis due to squeezing of uranium bearing water from the shale horizon has impregnated underlying sandstones. On exposure to surface the phosphatic material converted to the phosphatic nodules. But the high value of U_3O_8 upto 787 ppm within these nodules is an important question, which needs to be addressed during the future exploration work.

CONCLUSIONS

As the prospection and exploration activities remained operative within the Nilawahan Group (Lower Permian) from 1993 to present day. Some important conclusions made are as following

a. The chemical results of Karuli area are significant for further exploration work. The same has been supported by the positive result of Track-etch survey. Positive integral value of standardized data of this anomalous zone has reached upto 8, indicating that this zone is of worth consideration and it may be indicative of some subsurface radon-emitting source. This area should be checked by drilling 2-3 core boreholes.

b. In Simbal area phosphatic nodules have shown high chemical values of, U_3O_8 such as 1008 ppm, 928 ppm and 772 ppm. A sample from shale/ sandstone has shown 315 ppm of chemical U_3O_8. These samples indicate that considerable movements of uraniferous solutions have taken place in this area. Therefore, Track-etch/geophysical surveys are required to select the proper drilling sites in this area.

c. Ghahi anomaly needs special attention in future. Four out of five samples of shale and sandstone have shown from 132 to 250 ppm of chemical U_3O_8, with very small amount of thorium (5 to 25 ppm). The concentration of vanadium is quite high ranging from 38 ppm to 203 ppm, which indicates that there is strong possibility of finding some oxidized ore body in the form of vanadate. One nodule sample of this area has shown 496 ppm of chemical U_3O_8, which is ironstone in nature.

d. As studies indicate very strong leaching phenomenon which has caused intense limonitic/hematitic coloration within the sandstone. Track-etch results have also confirmed this field observation. Carbonaceous pockets, which are present within the sandstone horizons, have checked this movement of solutions. Therefore, they have chelated the uranium. Chemical results of these pockets have shown that they have chelated as much as 227 ppm of chemical U_3O_8.

e. Paleocene Unconformity has a thickness of 50 meters west of the Nilawahan gorge. Along its western extent this unconformity shows radioactivity. During the prospection work, seven samples were collected from this area. Two of them have shown 13 to 18 ppm of chemical U_3O_8 while the remaining were thorium dominated. It means that uranium has leached from them, and remained only in those samples, which have strong reductants. The Amb Formation is below this unconformity, which contains calcareous sandstones and is deeply altered due to the solution movement, which passed through them.

f. In Chitti Dand area VLF and magnetic survey have picked a sub-surface anomaly along F-2 profile at a distance of 150 meters from starting point. This anomaly is quite marked and registered in both of this data set: This anomaly seems to be related to some sub-surface hidden conductor. It needs proper exploration to understand its nature. Apart from above anomaly, there are few signatures in EM-VLF survey, which are very weak. Such anomalies could be due to the presence of a weak near surface or a good conductor body at deeper depth. Their strike wise continuity could not be determined due to wide apart profile lines.

g. During the field season (2002) it was planned to explore the areas, which have phosphatic nodules with higher chemical U_3O_8. It was thought that these

phosphatic nodules might act as pathfinder for some uranium deposit. The areas from eastern to western part of Salt Range have been checked by foot survey and numbers of sites have been delineated with phosphatic nodules with significant amount of chemical U_3O_8.

RECOMMENDATIONS

1. Exploration map on 1:5000 scale from Warala in the east to Nurpur in the west may be prepared.

2. Water tables monitoring borehole at Karuli, Moregangh and Matin areas may be drilled to know the water table of the Warchha Sandstone in these areas.

3. In the light of structural/tectonic studies in the above-mentioned areas, some geographical surveys and ROAC and Track-etch studies might be conducted to know some subsurface conductors and structures to delineate some drilling targets in future.

4. Initially some shallow core drilling in the oxidized part is recommended in this area.

5. In Matin Kalan area further 2 to 3 holes are recommended within the down thrown block.

6. Therefore, it is recommended that Amb Formation should be checked thoroughly west of the Nilawahan gorge.

7. It is, therefore, recommended 2 to 3 fence lines may be laid in between already surveyed line and the data be processed in total. This will provide some strike continuity of the conductors being picked up by EM-VLF and will make the future exploration easy.

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