

Radiological Characterization of phosphate rock and soils of the northern region of Peru

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Introduction

One of the largest phosphate deposits in South America is located in Sechura, northern Peru. Only in its first five layers has a reserve of 38 million tons of phosphate rock (Figure 1).

Preliminary studies have been taken place in order to identify the radioactivity levels in the soils from the deposit and in its area of influence. This information will serve as a reference for the upcoming industry of phosphate. This study included different stages as radioactivity measurements of samples of soils from the deposit itself, phosphate rock and soil from the surrounding places.

The objectives of this study are to evaluate the radioactivity levels in the phosphate soils, phosphate rock and the soil from the surrounding places, and to have a baseline study, considering the upcoming mining operations.

Methods

Many sampling areas were established inside and outside the phosphate deposit. In the influence area, samples of surface soil (20x20 cm) were collected at a depth of 2 cm. Also, samples from the trenches and from the outcrop layers were taken in the mining site. The collected samples were dried, homogenized and placed into plastic containers. The beakers were sealed and stored for 30 days before being measured in order to assure that the radon daughters have reached to secular equilibrium. All gamma measurements were performed using CANBERRA HpGe detectors. Also, CANBERRA Genie 2000 software was used for the analysis. Samples properly conditioned in aluminum planchets were measured in a low background beta radiometric system (LAS-3A).



Results

The results of the gamma spectroscopy measurements in the collected samples are shown in the tables 1, 2, 3 y 4. The global beta activity is shown in the table 5.

The results show that U-238 activity concentrations in phosphate rock were in a range of 570 and 1350 Bq/kg and in soil samples, between 50 and 480 Bq/kg. Higher than 830 Bq/kg Ra-226 values were obtained in samples of surface soil and phosphate rock, after reaching the secular equilibrium with its decay products. Higher than 95 Bq/kg Th-232 values were also found. Gross beta activity concentrations in phosphate rock were three times higher than in soil samples collected in the areas adjacent to the mining sites.

Discussion and Conclusion

The uranium concentration in phosphate soils is variable according to its origin. According to this study, in the Bayovar phosphates, the uranium average amount is 46.15 ppm, for the samples of layers in the quarry, 47.15 ppm in samples from witness perforation layers and 58 ppm in concentrate samples.

The results of the chemical analysis show that the uranium amount in the Bayovar phosphates is below the average uranium amount from most of the phosphate deposits in the world. Regarding to the correlation conditions radioactivity/ tenor of uranium values from the analyzed samples, a certain equilibrium conditions can be observed in the uranium minerals from the phosphates.

This report provides a systematic approach referenced to the immediate surrounding areas and the environment, which shall be taken into account in mining as well as in conventional treatment of minerals, others processes of production and every industrial manufacture in which radioactive materials are involved.

Radioactive characterization (Bq / kg) of phosphate soil in the northern Peru (Sechura, Bayovar)

Sample Code	Average Activity (Bq/kg)					
	Ra-226	U-238	U-235	U-234	K-40	Th-232
1	78	136	1	137	191	
2	170	121	0	121	231	
3	94	136	0	137	156	
4	109	111	0	111	163	
5	130	140	3	140	149	
6	57	53	4	53	446	
7	799	521	45	523	144	
8	202	195	9	196	380	
9	143	87	6	87	106	
10	55	27	17	27	668	
11	63	137	0	137	245	
12	55	126	0	126	1402	
13	440	81	26	81	167	
14	81	106	6	107	684	
15	100	110	5	11	400	
16	121	75	4	75	598	
17	94	120	8	121		
18	99	131	7	132		
19	88	48	2	49	430	
20	121	75	4	75	598	
21	90	1	0	1	372	
22	151	82	4	83	433	
23	68	55	3	58	221	
24	141	110	5	110	397	
25	128	86	4	87	431	
26	62	4	0	4	291	
27	830	334	15	336	207	
28	125	66	3	66	276	
29	238	124	6	124	436	
30	44	13	1	13	459	
31	41	21	1	21	514	
32	126	61	3	62	807	
33	193	90	4	91	217	
34		1328	63	1447		
35		54	3	68		
36		62	3	67		
37		29	2	32		
38		56	3	66		
39		50	2	40		
40		118	6	140		
41		165	8	200		
42		502	23	530		
43		130	5	128		
44		197	9	200		
45		54	3	63		
46		84	4	83		
47		41	2	40		
48		136	6	116		
49		110	5	101		
50		61	4	93		
51		24	2	34		
52		157	7	157		
53		755	35	789		
54		743	35	831		
55		181	9	221		
56		356	19	487		
57		357	19	481		
58		109	5	128		
59	209	171	9	171		
60	84	64	4	64		
61	319	117	8	178		
62	557	367	19	369		
63	48	66	4	66		
64	54	63	4	63		
65	110	126	7	126		
66	150	163	9	164		
67	80	56	4	57		
68	104	98	6	99		
69	137	88	5	88		
70	782	476	23	478		
71	54	71	4	72		
72	166	129	6	130		
73	94	127	7	128		
74	97	124	7	124		
75	105	136	8	137		
76	47	56	4	56		
77	47	19	1	19		
78	550	123	7	123		
79	54	25	1	25		
80	53	22	1	22		
81	93	112	6	112		
82	80	111	6	111	680	
83	66	75	5	76	568	
84	47	68	3	38	108	
85	57	80	5	80		95
86	72	95	5	96		15
87	60	82	5	82		17
88	55	73	4	73		16
89	67	76	5	76		16

Table 1: Total uranium levels in phosphate soil

	U ppm
Max Value	34.70
Min Value	0.22

Table 2: Total uranium levels in phosphate rocks (ppm)

Max Value	64.00
Min Value	23.00

Table 3: Radioactivity levels in phosphate soil (Bq/Kg)

	U-238	Ra-226	Th-232
Max Value	480	41	95
Min Value	50	830	15

Table 4: Radioactivity levels of U-238 in phosphate rock (Bq/Kg)

Max Value	1350
Min Value	570

Table 5: Global Beta Activity in Soil and rock

Sample	Average Activity (Bq/Kg)
Soil	44.7
Deposit soil	133.4

Sampling and chemical analysis of Uranium from the phosphate deposit (Northern Peru)

Sample	Coord UTM	Thickness (m)	Rad (c/s)	U (ppm)
1	N-9329074 E-516560	0.85	150	46
2	N-9329074 E-516560	0.85	150	42
3	N-9328988 E-516586	-	120	44
4	N-9328832 E-515928	0.7	150	56
5	N-9328822 E-515931	0.2	80	40
6	N-9328574 E-515648	-	130	40
7	N-9326520 E-515478	1	150	49
8	N-9326108 E-515087	-	160	43
9	N-9326126 E-515081	0.6	140	61
10	N-9326098 E-515058	>0.85	130	23
11	N-9326134 E-514880	2.5	220	64
12	N-9328716 E-516881	1.1	150	44
13	N-9328798 E-516902	0.9	145	48
14	N-9332198 E-518742	0.05	140	26
15	N-9328316 E-516425	0.4	100	21
16	N-9328314 E-516419	0.3	150	62
17	N-9328296 E-516418	2.35	50	5
18A	N-9342652 E-512604	0.15	100	32
18B	N-9342652 E-512604	0.15	100	36
19	N-9342590 E-512587	0.25	100	43
20	N-9342590 E-512587	0.25	110	28
21	N-9342590 E-512587	0.25	110	28
21	N-9342590 E-512587	0.25	110	28
22	N-9331570 E-518380	0.3	120	53
23	N-9331570 E-518380	0.2	180	63
24	N-9331940 E-518540	0.4	150	48
25	N-9331240 E-517706	0.3	180	66
26	N 9330552 E 515400	39.57-40.19	45	64
37			50	55
38			150	63
39			120	60

Global beta activity in the surface soil and phosphate rock from Bayovar

Sampling site	Average activity (Bq/Kg)
PS-01	23,8
PS-02	37,8
PS-03	27,5
PS-04	11,4
PS-05	104,1
PS-06	44,5
PS-07	40,7
PS-08	47,0
PS-09	41,5
PS-10	29,4
PS-11	41,2
PS-12	51,5
PS-13	46,3
PS-14	60,6
PS-15	72,5
PS-116	35,2
MV-01	83,7
MV-02	197,3
MV-03	119,3
MV-04	133,2