Distribution of Uranium in Rich Phosphate Beds of the Phosphoria Formation

GEOLOGICAL SURVEY BULLETIN 988-D

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By M. E. THOMPSON

A CONTRIBUTION TO THE GEOLOGY OF URANIUM

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DISTRIBUTION OF URANIUM IN RICH PHOSPHATE BEDS OF THE PHOSPHORIA FORMATION

By M. E. THOMPSON

ABSTRACT

Five sets of "close" samples were analyzed radiometrically for uranium, and chemically for P_2O_5, CaO, organic matter, and loss on ignition. A Rosiwal analysis was made of thin sections of one set of samples. The results of the analyses have been plotted on graphs and on scatter diagrams, and coefficients of correlation are given for uranium with CaO, P_2O_5, organic matter, and loss on ignition. Preliminary studies indicate that the concentration of uranium in these samples of phosphate rock is not due wholly to phosphate content, but may depend in part on organic matter or on other components. The correlations of uranium with P_2O_5 are poor in the groups of samples with smaller amounts of uranium but are good in the groups of samples containing more uranium.

INTRODUCTION

In the summer of 1949, some special samples, called "close" samples, were collected from the Phosphoria formation to measure variations, both chemical and mineralogical, across a small, apparently uniform lithologic unit of phosphate rock. A close sample is defined as one of a large number of small, contiguous samples taken across a single unit, where all the samples together represent the entire unit. Such samples were taken from four sections in Idaho, Wyoming, and Utah, as summarized in table 1.

Altogether, 123 samples were studied; they were analyzed chemically for CaO, P_2O_5, and organic matter. The methods of analysis for organic matter and loss on ignition are described by F. S. Grimaldi. Uranium was determined radiometrically; a few of the radiometric determinations were checked by chemical analysis. The differences between the results obtained by chemical and radiometric analyses are so slight that the terms uranium and equivalent uranium are used interchangeably in some parts of this report.

Thin sections of some of the samples were made, and Rosiwal analyses were made of 24 thin sections from Trail Canyon, Idaho. These mineral counts agreed closely with the chemical analyses for

P_2O_5 and CaO; consequently, it did not seem necessary to obtain other sets of thin sections.

The results of the analyses have been plotted on semilogarithmic graphs (figs. 19, 20, 22, 24, and 26) for convenient comparison of the various components. Scatter diagrams (figs. 18, 21, 23, 25, and 27) show the comparison of equivalent uranium (eU) in phosphate rock samples with other components.

TABLE 1.—*Location of analyzed samples of phosphate rock*

Name of section	County and state	Field unit no.[1]	Laboratory nos.	Thickness (feet)
Trail Canyon	Caribou County, Idaho	RAH-183	WT-365-1 through WT-365-26	0.8
		RAH-184		
Reservoir Mountain	Caribou County, Idaho	DFD-4769	WT-910-1 through WT-910-31.	1.0
Coal Canyon	Lincoln County, Wyo.	2061	WT-700-1 through WT-700-12.	.5
Brazer Canyon	Rich County, Utah	RAH-105	WT-605-1 through WT-605-3	.1
		RAH-106	WT-604-3 through WT-604-30.	1.0
		RAH-107	WT-603-1 through WT-603-24.	1.2

[1] Abstracts of stratigraphic sections of the Phosphoria formation measured and sampled in Montana, Idaho, Wyoming, and Utah: U. S. Geol. Survey, field manual, 1947.

To express numerically the order of correlation of U with other components, as shown by these diagrams, correlation coefficients have been calculated. The formula used is that given by Snedecor.[1]

$$r=\frac{\Sigma x_1 x_2}{\sqrt{(\Sigma x_1^2)(\Sigma x_2^2)}}$$

where x_1 is equivalent uranium and x_2 is either P_2O_5, CaO, loss on ignition, or organic matter.

In general, this investigation has shown that the amount of uranium deposited is dependent not only upon apatite, but also upon one or more other factors. It is thought that the nature and amount of organic matter present may have had a considerable effect upon the concentration of the uranium. Further variation in the uranium content of the rock may have been due to variations in the amount of uranium available for deposition.

ACKNOWLEDGMENTS

The chemical analyses were made by the following chemists of the U. S. Geological Survey: Harry Levine, Jesse Greene, Henry Mela, Alice Caemmerer, and Marie Eiland. The author is especially grateful to Harry Levine, who made most of the determinations for CaO, P_2O_5,

[1] Snedecor, G. W., 1946, Statistical methods applied to experiments in agriculture and biology, Iowa State College Press, p. 138.

and loss on ignition; to Jesse Greene, who made most of the organic determinations; and to F. S. Grimaldi, who developed the method of analysis for organic matter used on these samples.

SAMPLES FROM TRAIL CANYON, IDAHO

[WT-365-1 through WT-365-26]

At Trail Canyon, Idaho, 26 close samples were collected over a stratigraphic thickness of 0.8 ft from the lower phosphate zone of the phosphatic shale member of the Phosphoria formation. The samples, numbered WT–365–1 through WT–365–26 from base to top, are from field unit no. RAH–184–47. Where possible, the stratigraphic top was marked on each sample, and the thickness of the sample and its height above the base of the unit were measured.

Thin sections of 24 samples were obtained for microscope study and for use with alpha plates. In the Rosiwal analysis of these thin sections four types of lithologic material were counted. The first, and generally the major part of each section, is referred to as pellet phosphate. It is gray brown, isotropic, and has an index of refraction of about 1.61. It occurs as grains which generally are rounded and is nonhomogenous in appearance owing to inclusions of small black round particles of organic matter.

The second material counted is called "cement" phosphate. Its index of refraction is about 1.61; it is isotropic and in contrast to the pellet phosphate is brown, is homogenous in appearance, and lacks visible organic particles. It occurs both interstitially and as grains. Despite the occurrence of cement phosphate as grains and the fact that some of it makes up parts of grains, most of it is interstitial or lacks definite outline, and for these reasons, is called cement phosphate.

The third type of material counted includes all material that is too fine-grained to be counted separately. This material consists chiefly of fine-grained quartz and muscovite, and some clays, detrital minerals, and phosphate.

Grains of quartz that were large enough to count separately were counted as the fourth group. Calcite was observed in only one section and was counted separately. The results of the Rosiwal analyses are presented graphically (fig. 17) and in tabular form (table 2).

The Rosiwal analyses of the thin sections agree with the chemically determined P_2O_5, although not all thin sections are entirely representative of the samples analyzed. The breakdown into mineral percentages does not reveal any relationships between the various minerals and the distribution of the uranium.

TABLE 2.—*Rosiwal analyses of Trail Canyon samples WT–365–1 through WT–365–7 and WT–365–10 through WT–365–26 (percent)*

Sample no.	Pellet phosphate	"Cement" phosphate	Fine-grained phosphate and silt	Quartz
26	75	17	6	2
25	60	26	11	3
24	52	35	10	3
23	57	34	8	1
22	59	26	10	5
21	64	22	11	3
20	67	23	8	2
19	65	20	11	4
18	61	21	14	4
17*	42	10	23	9
16	49	12	29	10
15	48	12	28	12
14	54	14	25	7
13	45	23	25	7
12	52	22	19	7
11	36	26	32	6
10	30	16	48	6
7	41	17	36	6
6	36	21	38	5
5	24	17	52	7
4	70	16	12	2
3	72	16	9	3
2	69	20	8	3
1	64	23	10	3

* Sample 17 contains 16 percent calcite.

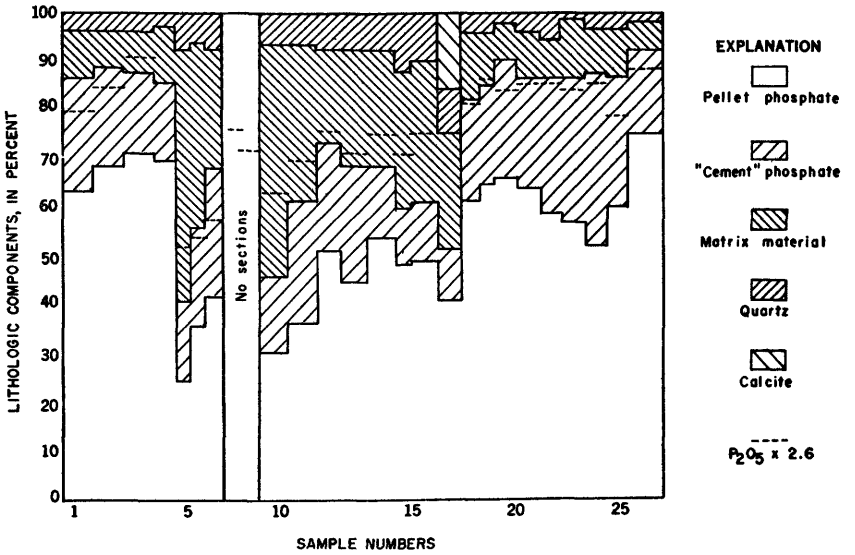

FIGURE 17.—Results of Rosiwal analyses of samples from Trail Canyon, Idaho.

The scatter diagrams and the correlation coefficients (figs. 18 and 19), compiled from data in table 3, show a much better correlation between the organic matter and uranium than between the P_2O_5 and uranium.

These Trail Canyon samples are the only group of analyzed samples that shows a positive correlation of organic matter with uranium.

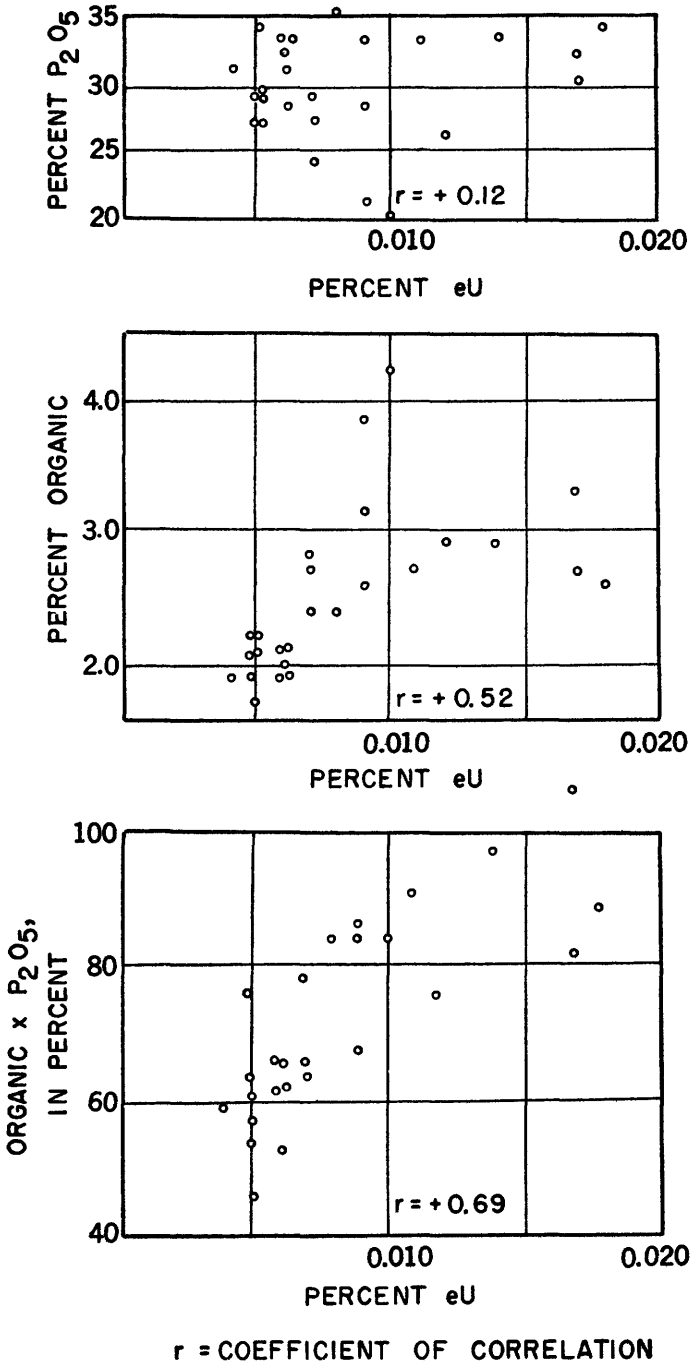

FIGURE 18.—Scatter diagrams of Trail Canyon samples WT-365-1 through WT-365-26.

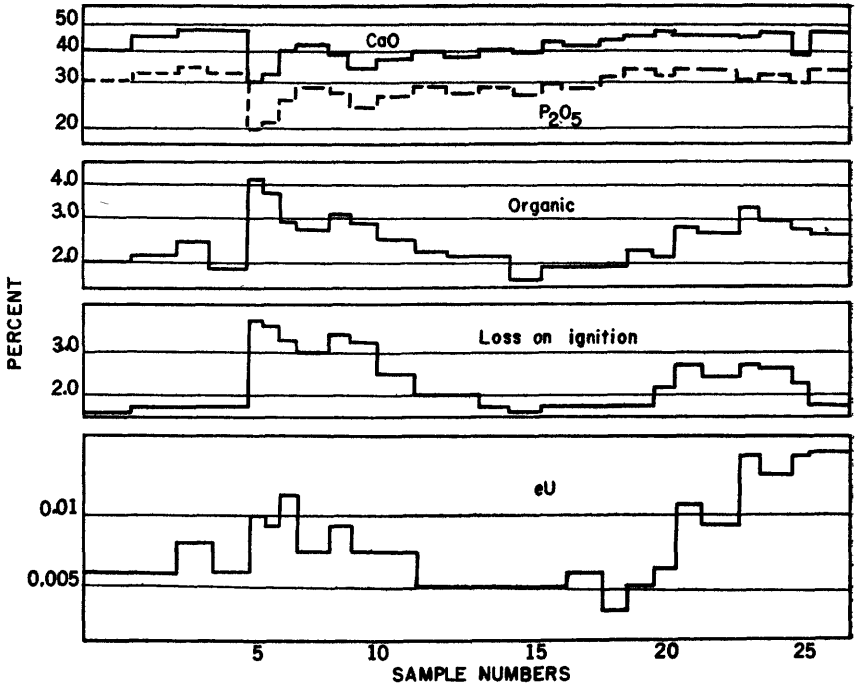

FIGURE 19.—Variation in chemical components of Trail Canyon samples WT-365-1 through WT-365-26.

TABLE 3.—*Chemical and radiometric analyses of Trail Canyon samples WT-365-1 through WT-365-26 (percent)*

Sample no.	eU	U	CaO	P_2O_5	Loss on ignition	Organic
26	0.018	----------	47.5	33.9	1.82	2.6
25	.017	----------	43.7	29.8	2.22	2.7
24	.014	----------	48.4	32.6	2.46	2.9
23	.017	----------	46.0	32.4	2.58	3.3
22	.009	----------	46.8	32.9	2.40	2.6
21	.011	----------	46.9	32.8	2.62	2.7
20	.006	----------	47.7	32.2	2.10	2.1
19	.005	----------	46.8	33.5	1.82	2.2
18	.004	----------	44.3	31.1	1.75	1.9
17	.006	----------	41.6	27.5	1.84	1.9
16	.005	----------	42.8	29.1	1.78	1.9
15	.005	----------	38.8	27.3	1.58	1.7
14	.005	----------	40.5	28.8	1.80	2.1
13	.005	----------	38.3	27.2	1.96	2.1
12	.005	----------	39.4	29.3	2.02	2.2
11	.007	----------	37.5	27.0	2.42	2.4
10	.007	----------	33.9	24.1	3.20	2.8
9	.009	----------	38.4	27.7	3.38	3.1
8	----------	0.007	41.6	29.3	2.92	2.7
7	----------	.012	39.7	26.2	3.34	2.9
6	----------	.009	31.6	20.8	3.72	3.8
5	----------	.010	28.7	19.9	3.90	4.2
4	----------	.006	47.8	33.0	1.84	1.9
3	----------	.008	48.3	35.1	1.76	2.4
2	----------	.006	46.0	32.9	1.78	2.1
1	----------	.006	44.3	30.7	1.70	2.0

The product of the percent P_2O_5 and the percent organic matter shows a better correlation with uranium than either of the two separately. The correlation coefficient was calculated for the product

instead of the sum of the P_2O_5 and the organic matter against uranium, for the following reason. To use the sum of the two components in this correlation would not be practical because the P_2O_5 is present in the range of 20 to 35 percent, and the organic matter is present in the range of 2 to 4 percent. Therefore the product of the two components is a better representation of their combined effect with respect to the uranium. When these two components of different magnitudes are multiplied, each is given its share of weight in the final figure.

The results suggest that the amount of uranium in this unit of phosphate rock is dependent chiefly upon organic matter and subordinately upon P_2O_5.

SAMPLES FROM RESERVOIR MOUNTAIN, IDAHO

[WT-910-1 through WT-910-31]

Thirty-one close samples were collected over a stratigraphic thickness of one foot from the lower phosphate zone of the phosphatic shale member of the Phosphoria formation at Reservoir Mountain, Idaho. The samples, numbered WT-910-1 through WT-910-31 from base to top, from field unit no. DFD-4769, were each of the same approximate thickness, and individual thicknesses were not measured.

The correlation coefficients and scatter diagrams for this set of samples (figs. 20 and 21), made up from data in table 4, show a very

TABLE 4.—*Chemical and radiometric analyses of Reservoir Mountain samples, WT-910-1 through WT-910-31 (percent)*

Sample no.	U	eU	CaO	P_2O_5	Loss on ignition	Organic
31	0.008	0.007	48.22	33.60	2.1	2.3
30	----------	.008	50.59	35.48	1.8	1.5
29	----------	.008	48.83	34.32	1.7	1.6
28	----------	.007	49.98	35.46	1.6	1.4
27	----------	.008	48.76	34.62	1.5	1.4
26	----------	.011	48.83	34.79	1.1	.9
25	----------	.011	48.53	34.32	1.2	1.0
24	----------	.008	50.13	35.61	1.3	1.3
23	----------	.009	49.67	35.49	1.2	1.2
22	----------	.010	46.39	32.81	1.2	1.3
21	.023	.022	47.76	33.38	1.1	.9
20	----------	.019	47.84	33.57	1.1	1.1
19	----------	.017	48.53	34.09	1.2	1.2
18	----------	.017	49.52	35.30	1.2	1.2
17	----------	.015	50.13	35.22	1.2	1.1
16	----------	.012	49.29	34.42	1.1	1.3
15	----------	.016	47.92	33.32	1.1	1.0
14	----------	.021	49.67	34.41	1.0	1.1
13	----------	.023	47.31	32.81	1.0	1.2
12	----------	.025	47.00	33.29	1.1	1.0
11	.033	.030	49.98	35.80	1.3	.7
10	----------	.030	48.68	34.72	1.0	.8
9	----------	.026	48.45	34.47	1.2	.9
8	----------	.023	51.12	34.71	1.0	1.1
7	----------	.022	46.85	32.58	1.4	1.3
6	----------	.018	48.76	33.78	1.2	.7
5	----------	.013	47.46	33.23	1.4	.7
4	----------	.013	48.07	33.06	1.4	1.3
3	.013	.013	48.22	31.14	1.4	1.1
2	----------	.019	48.68	31.89	1.2	.7
1	----------	.022	48.15	32.05	1.0	1.1

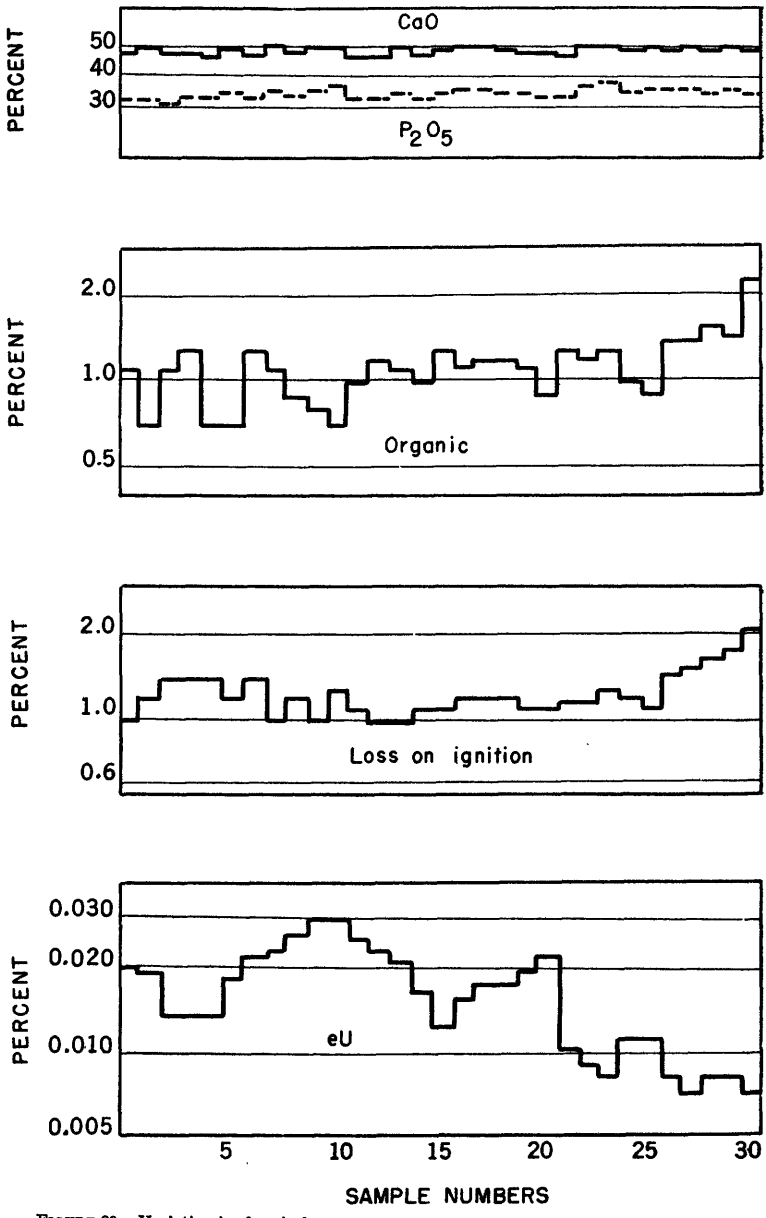

FIGURE 20.—Variation in chemical components of Reservoir Mountain samples WT-910-1 through WT-910-31.

poor correlation, if any, between the uranium and CaO or P_2O_5. The CaO and P_2O_5 content is high and remains almost constant. The uranium content, on the other hand, varies considerably and seems to be independent of the P_2O_5. Samples 5 through 11 show a stepped

increase in equivalent uranium content from 0.013 percent to 0.030 percent; then there is a similar decrease to 0.012 percent equivalent uranium (sample 16), as illustrated in figure 20. Variations of this nature (cyclic?) have been noted in other sets of samples, and may reflect a seasonal control of deposition.

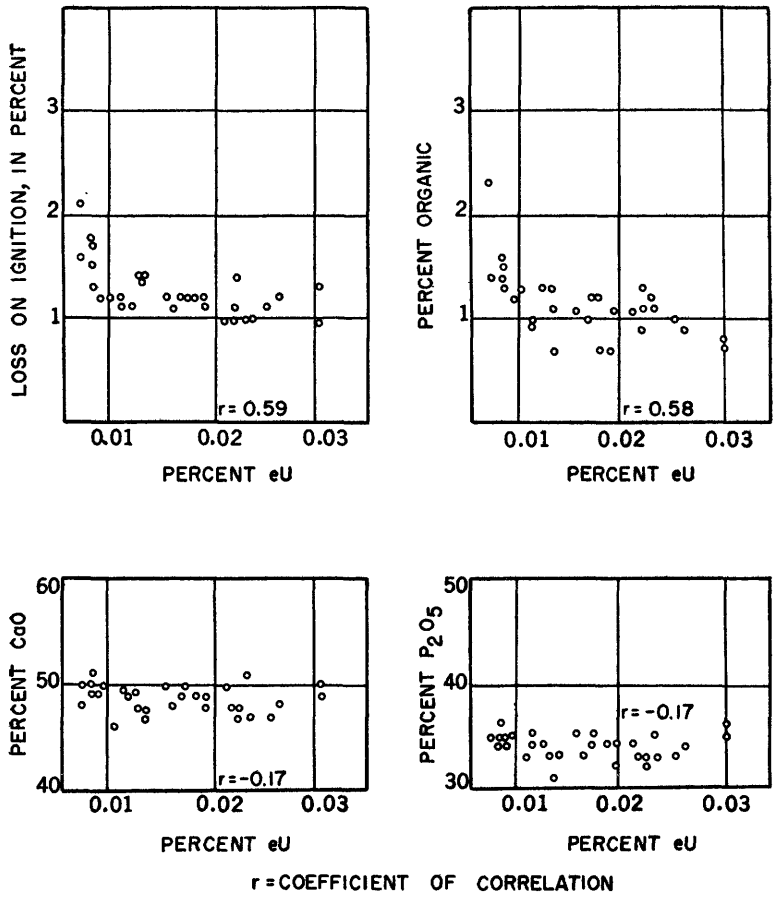

FIGURE 21.—Scatter diagrams of Reservoir Mountain samples WT-910-1 through WT-910-31.

SAMPLES FROM COAL CANYON, WYOMING

[WT-700-1 through WT-700-12]

At Coal Canyon, Wyo., 12 close samples were collected over a stratigraphic thickness of half a foot from the upper phosphate zone of the phosphatic shale member of the Phosphoria formation. The samples were numbered WT–700–1 through WT–700–12, from the base to the top of field unit no. 2061. The samples were approxi-

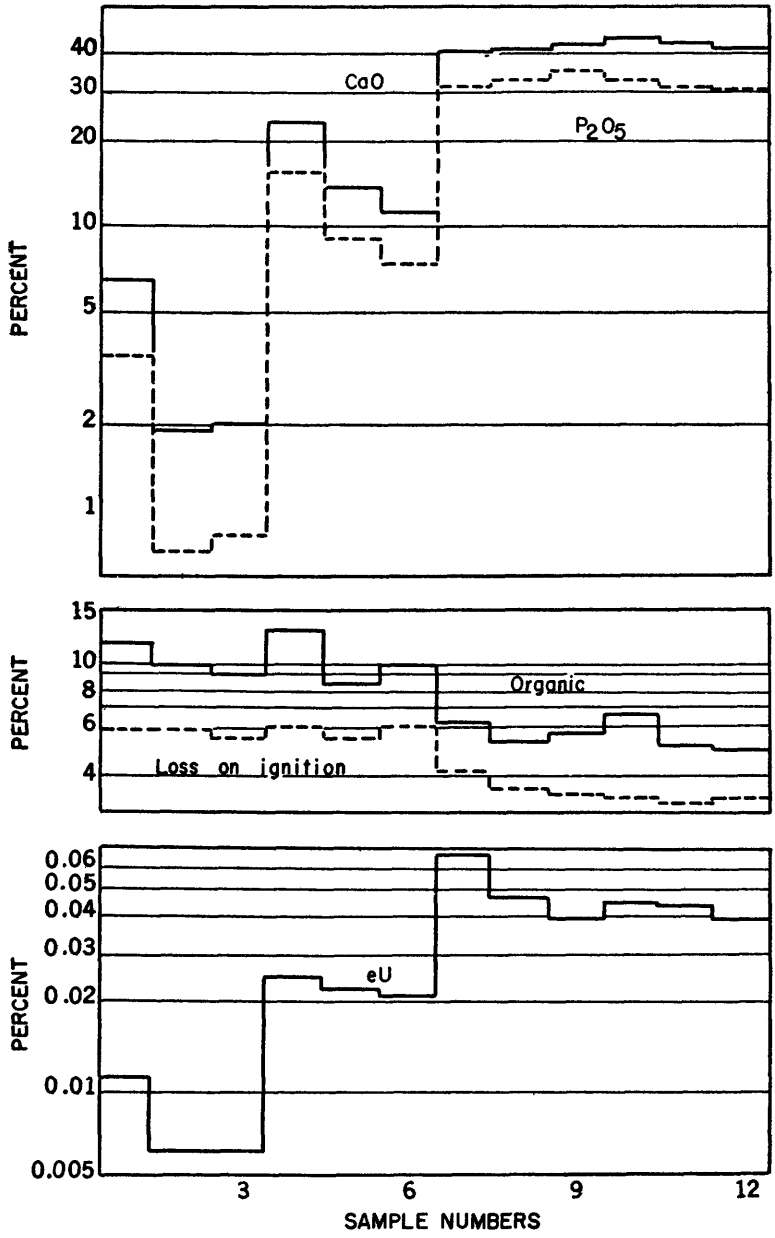

FIGURE 22.—Variation in chemical components of Coal Canyon samples WT-700-1 through WT-700-12.

mately the same thickness, and individual thicknesses were not measured.

The scatter diagrams and correlation coefficients for this set of samples (figs. 22 and 23), based on data in table 5, show a very high positive correlation between uranium content and CaO or P_2O_5 Both the calcium phosphate content and the uranium content have a wide variation. It is probably this wide variation that makes obvious the definite correlation between uranium and calcium phosphate. At the same time, however, there is a negative correlation between the organic matter and uranium.

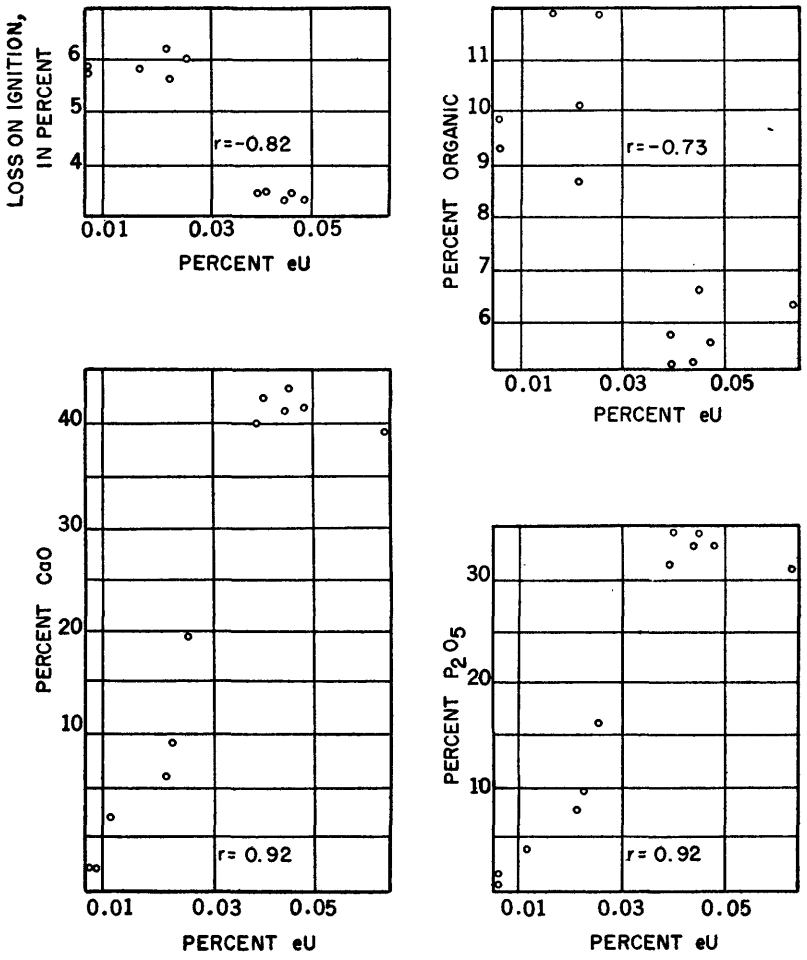

FIGURE 23.—Scatter diagrams of Coal Canyon samples WT-700-1 through WT-700-12.

TABLE 5.—*Chemical and radiometric analyses of Coal Canyon samples WT–700–1 through WT–700–12 (percent)*

Sample no.	U	eU	CaO	P_2O_5	Loss on ignition	Organic
12	0.037	0.039	44.51	31.45	3.4	5.1
11		.044	45.76	32.71	3.3	5.2
10		.045	47.75	34.35	3.4	6.6
9		.040	46.72	33.55	3.5	5.7
8		.048	46.05	33.15	3.6	5.5
7	.060	.065	43.77	31.37	4.2	6.3
6	.014	.021	11.48	7.64	6.2	10.1
5		.022	13.96	9.50	5.6	8.7
4		.025	23.97	16.21	6.0	12.6
3		.006	2.06	.83	5.7	9.3
2	.004	.006	1.98	.73	5.8	9.9
1		.011	6.62	3.71	5.8	12.1

SAMPLES FROM BRAZER CANYON, UTAH

[WT–605–1 through WT–605–3, WT–604–4 through WT–604–30, and WT–603–1 through WT–603–24]

Thirty close samples were collected across a stratigraphic thickness of 1 ft in the upper phosphate zone of the phosphatic shale member of the Phosphoria formation at Brazer Canyon, Utah. The samples were numbered WT–605–1, 2, 3, and WT–604–4 through WT–604–30 from the upper 1 inch of field unit no. RAH–105 to the top of field unit no. RAH–106. The samples represent layers of the same approximate thicknesses, although the individual thicknesses were not measured.

The correlation coefficients and scatter diagrams (figs. 24 and 25), compiled from data in table 6, for these samples show very poor correlations of uranium with CaO, P_2O_5, and organic matter.

TABLE 6.—*Chemical and radiometric analyses of Brazer Canyon samples WT–605–1, 2, 3, and WT–604–4 through WT–604–30 (percent)*

Sample no.	U	eU	CaO	P_2O_5	Loss on ignition	Organic
WT–604–30		0.014	16.43	10.85	6.0	9.6
29		.014	38.53	23.36	5.0	7.3
28		.011	18.65	12.30	5.5	8.9
27		.011	23.31	14.90	5.3	8.7
26		.010	42.04	29.51	3.2	4.6
25		.010	46.25	32.77	3.0	4.1
24		.014	47.01	33.58	3.0	4.3
23		.015	44.95	32.09	3.2	4.6
22		.017	46.02	32.76	3.4	5.3
21	0.033	.029	47.62	33.70	3.0	4.7
20		.014	43.72	31.21	2.5	3.8
19		.015	43.57	30.78	3.6	4.7
18		.013	44.48	31.31	2.9	3.8
17		.011	45.63	32.91	3.1	3.9
16		.012	23.50	15.59	6.2	7.5
15		.010	21.98	14.96	6.2	7.8
14		.023	38.15	26.73	5.3	7.1
13		.015	35.02	24.37	5.1	6.4
12		.011	31.44	21.89	5.1	6.8
11		.012	33.95	23.86	5.2	6.8
10		.010	34.11	23.05	5.2	6.3
9		.010	34.87	23.37	5.5	6.8
8	.010	.008	41.13	29.04	5.7	7.7
7		.010	40.90	28.50	5.8	7.7
6		.010	41.66	29.50	6.5	6.6
5		.009	42.35	29.91	5.5	6.6
4		.010	41.58	28.88	5.4	6.6
WT–605–3		.009	40.74	28.47	5.4	6.7
2		.010	39.68	27.57	4.8	6.3
1		.014	46.09	32.15	4.9	5.4

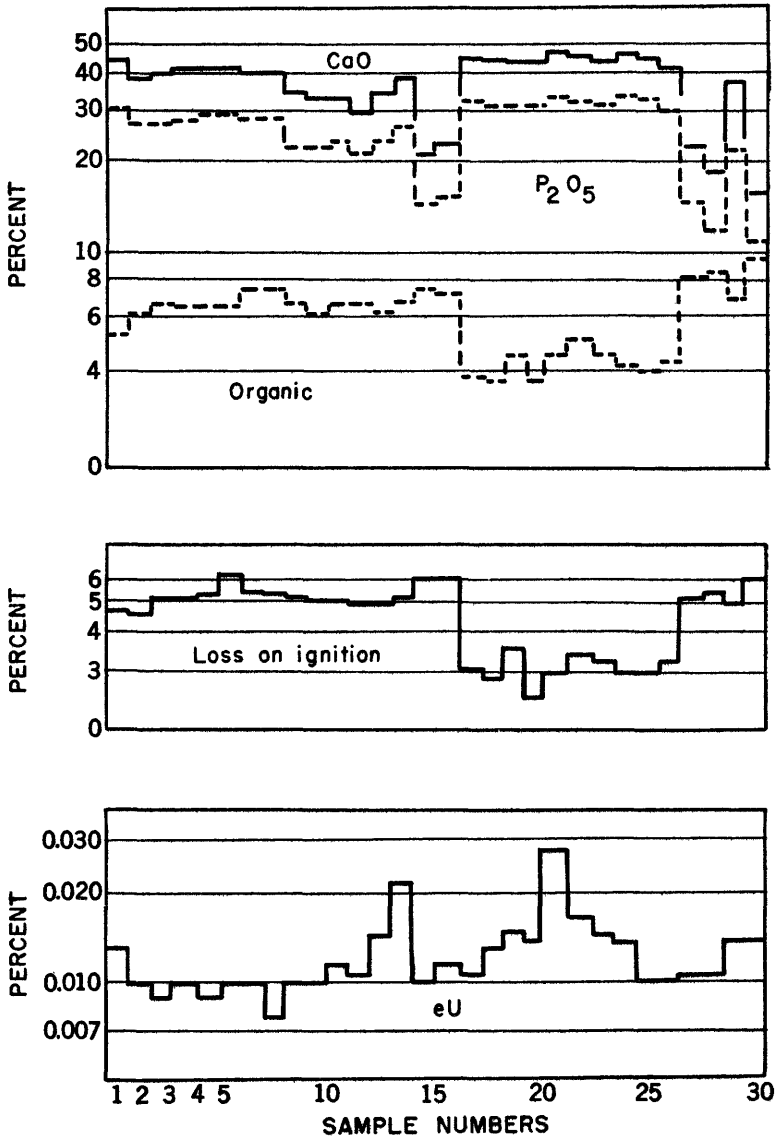

FIGURE 24.—Variation in chemical components of Brazer Canyon samples WT-605-1, 2, 3, and WT-604-4 through WT-604-30.

From the base to the top of field unit no. RAH–107, 24 close samples were collected over a stratigraphic thickness of 1¼ ft in the upper phosphate zone of the phosphatic shale member of the Phosphoria formation at Brazer Canyon, Utah. The samples were numbered WT–603–1 through WT–603–24. The samples were approximately the same thickness, and the individual thicknesses were not

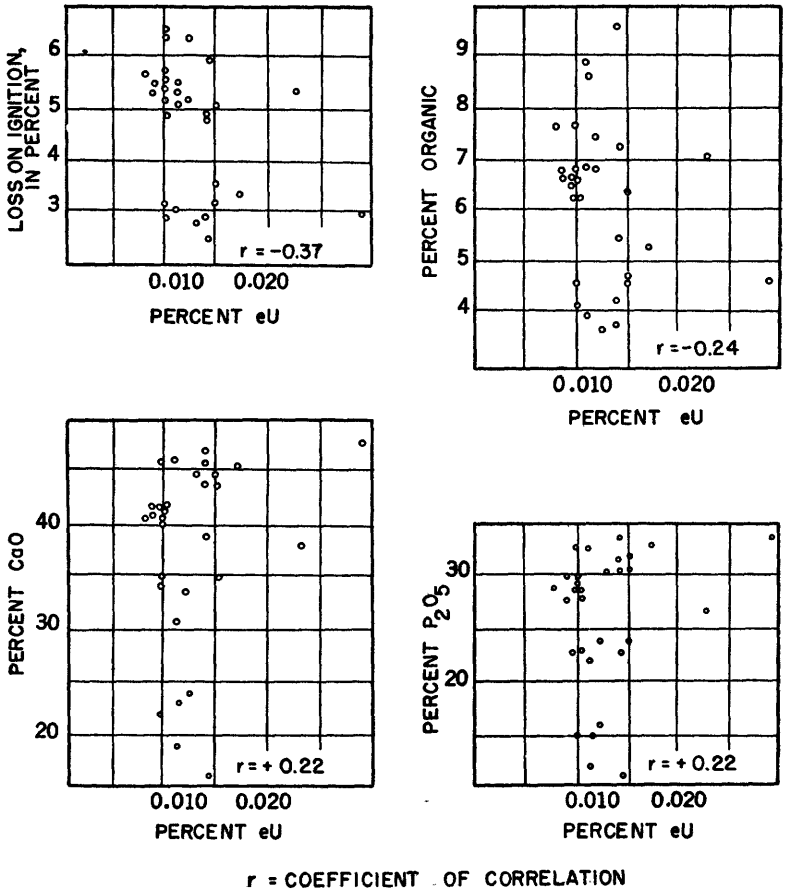

FIGURE 25.—Scatter diagrams of Brazer Canyon samples WT-605-1, 2, 3, and WT-604-4 through WT-604-30.

measured. These samples were taken stratigraphically immediately above the 30 samples in WT–604 and 605.

The scatter diagrams and the correlation coefficients (figs. 26 and 27, from table 7) show a very good correlation between uranium content and CaO or P_2O_5. The correlation coefficient for CaO with U is +0.79 and for P_2O_5 with U is +0.78 (fig. 27). The negative correlation between uranium and organic matter, although not as strong, is nevertheless noticeable. The imrovement in correlation between uranium and the other measured constitutents in these samples over the first-mentioned set of samples from Brazer Canyon (WT–605–1, 2, 3, and WT–604–4 through 30) is difficult to explain, but it may be due to an increase in the supply of uranium made available for deposition by unmeasured factors.

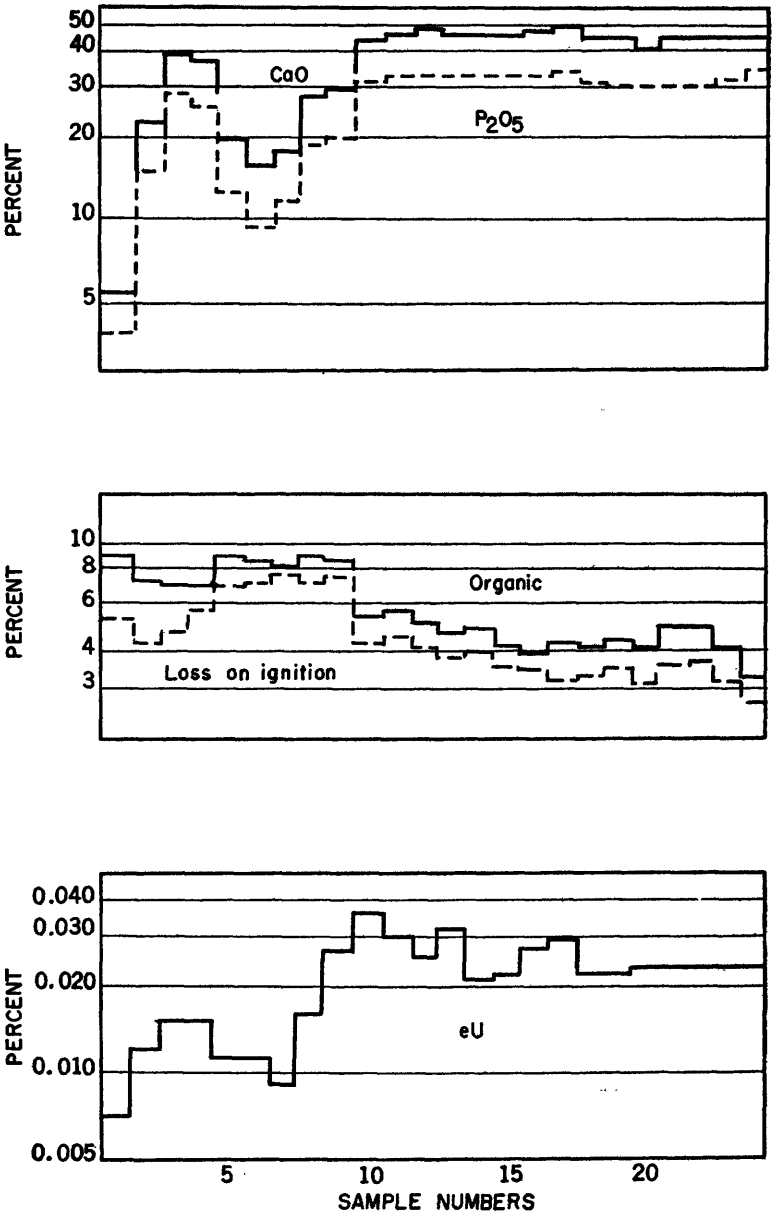

FIGURE 26.—Variation in chemical components of Brazer Canyon samples WT-603-1 through WT-603-24

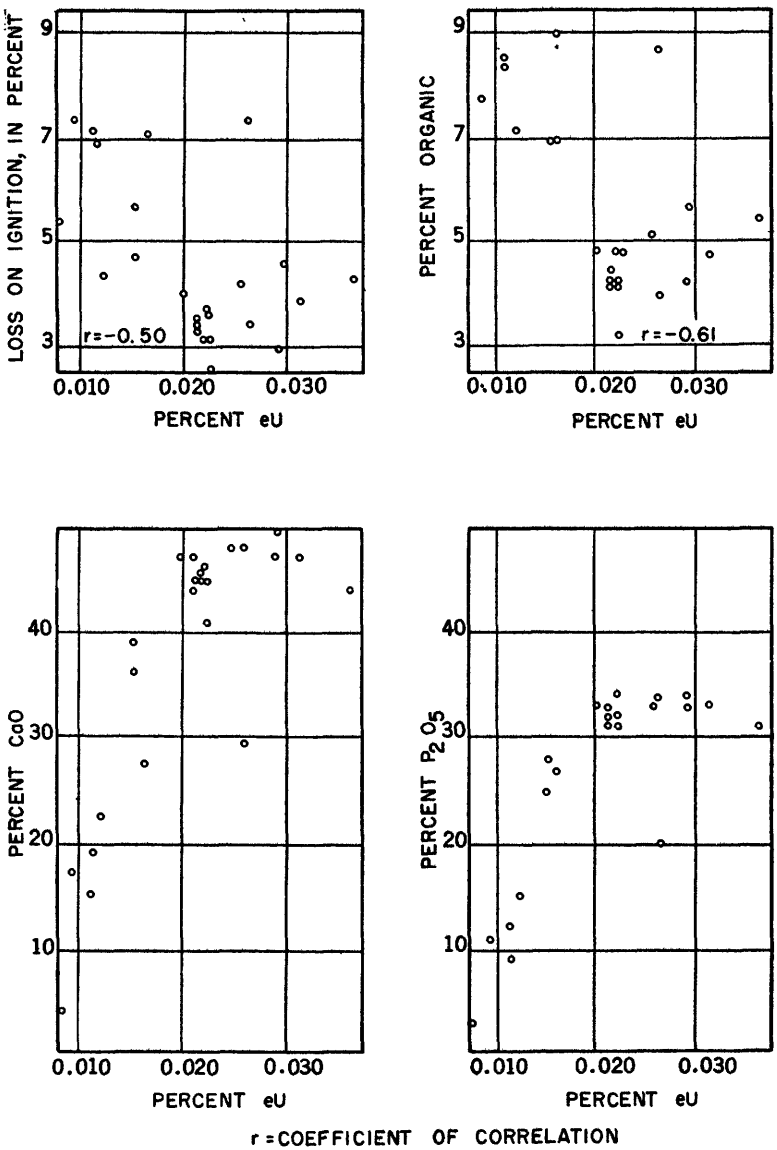

FIGURE 27.—Scatter diagrams of Brazer Canyon samples WT-603-1 through WT-603-24.

TABLE 7.—*Chemical and radiometric analyses of Brazer Canyon samples, WT–603–1 through WT–603–24 (percent)*

Sample no.	U	eU	CaO	P_2O_5	Loss on ignition	Organic
24	0.023	0.022	45.08	33.91	2.6	3.2
23	----------	.022	45.48	31.72	3.1	4.1
22	----------	.022	44.79	31.33	3.7	4.8
21	----------	.022	44.64	31.32	3.6	4.8
20	----------	.022	40.67	31.22	3.1	4.2
19	----------	.021	44.26	31.01	3.4	4.4
18	----------	.021	45.18	31.51	3.3	4.1
17	----------	.029	49.98	33.68	3.2	4.2
16	----------	.026	48.01	33.62	3.4	3.9
15	----------	.021	46.78	32.87	3.5	4.2
14	----------	.020	46.71	33.01	4.0	4.8
13	----------	.031	46.78	32.75	3.9	4.7
12	----------	.025	47.62	33.41	4.2	5.1
11	----------	.029	46.48	32.91	4.6	5.6
10	.038	.036	43.49	30.49	4.3	5.4
9	----------	.026	28.89	19.53	7.4	8.7
8	----------	.016	27.21	18.69	7.1	9.0
7	----------	.009	16.74	11.38	7.4	7.8
6	----------	.011	15.44	9.41	7.2	8.4
5	----------	.011	18.73	12.39	7.0	8.5
4	----------	.015	35.93	25.16	5.7	7.0
3	----------	.015	39.29	27.74	4.7	7.0
2	----------	.012	21.87	14.97	4.4	7.2
1	.005	.007	4.13	2.98	5.4	9.1

CONCLUSIONS

The results of these analyses must be evaluated with caution. Some of the correlations may be spurious, not due to any direct genetic relationship. In high-grade phosphate rock of the Phosphoria formation there are generally only three major components: apatite, organic matter, and quartz silt, which make up nearly 100 percent of the rock. (Calcite may be a fourth major component.) If apatite and organic matter together composed most of the rock, and if uranium content were directly proportional to apatite content, then the uranium would appear to be related to organic matter by inverse proportion. However, the third major component of phosphate rock—quartz silt—may be considered a diluting agent. If, as in these samples, much silt is present, the amount of organic matter is not necessarily a function of the amount of apatite. Thus the correlations are probably reliable.

As it has been found that the uranium in the Phosphoria formation generally occurs in the highest-grade phosphate beds, positive correlations between uranium and apatite are to be expected. Poor correlations between uranium and apatite probably mean that unmeasured factors made available only a small amount of uranium for deposition.

Correlations between uranium and organic matter are less easily explained. A positive correlation between uranium and organic matter may indicate that uranium and organic matter accumulated under the same conditions or that one acts as a precipitant for the other. It has been suggested by K. B. Krauskopf (personal communication)

that several of the apparent negative correlations of uranium with organic matter may be due to stratigraphic control. The points plotted in the scatter diagrams of uranium against organic matter show, in general, not a tendency to linearity, but rather a tendency to group together in bunches. The samples are divided into bunches principally according to their stratigraphic position. This tendency to bunch is demonstrated particularly well in the group of samples from Coal Canyon, WT–700. In the scatter diagram (fig. 23) where loss on ignition is plotted against uranium, the stratigraphically lower six samples are bunched in the upper left-hand corner of the diagram, and the higher six samples are bunched in the lower right-hand corner. The samples from Brazer Canyon, WT–603, (fig. 27) also exhibit this tendency. In these two groups of samples, at least, the negative correlations of uranium with organic matter may be due in large part to stratigraphic control.

The essential information gained from these analyses is presented in table 8. General conclusions that may be drawn from inspection of the information in this table are as follows:

1. Uranium and P_2O_5 correlations are better in the groups where the average percent equivalent uranium is high (WT–603, WT–700), and poorer in the groups where the average percent equivalent uranium is lower (WT–365, WT–910, WT–605, 604).

2. The only positive correlation between uranium and organic matter is in the group that has the lowest average percent equivalent uranium (WT–365).

3. The inverse correlations between uranium and organic matter are poor for the groups that have low average percent equivalent uranium (WT–604, WT–605) and better for the groups that have higher average percent equivalent uranium (WT–603, WT–700, WT–910).

TABLE 8.—*Relation of correlation coefficients to organic matter, phosphate, and uranium content*

Sample no. and locality	eU x 10^3 (percent)		P_2O_5 (percent)		Organic (percent)		Correlation coefficients	
	Range	Average	Range	Average	Range	Average	U/P_2O_5	U/Organic
WT–605, 604 Brazer Canyon	8–29	13	12–34	26	4–10	6	+0.2	−0.2
WT–603 Brazer Canyon	7–36	20	3–34	26	4–9	6	+.8	−.6
WT–700 Coal Canyon	6–65	31	1–34	20	6–12	8	+.9	−.7
WT–365 Trail Canyon	4–28	8	20–35	30	2–4	2.5	+.1	+.5
WT–910 Reservoir Mountain	7–30	16	31–36	34	1–2	1	−.2	−.6

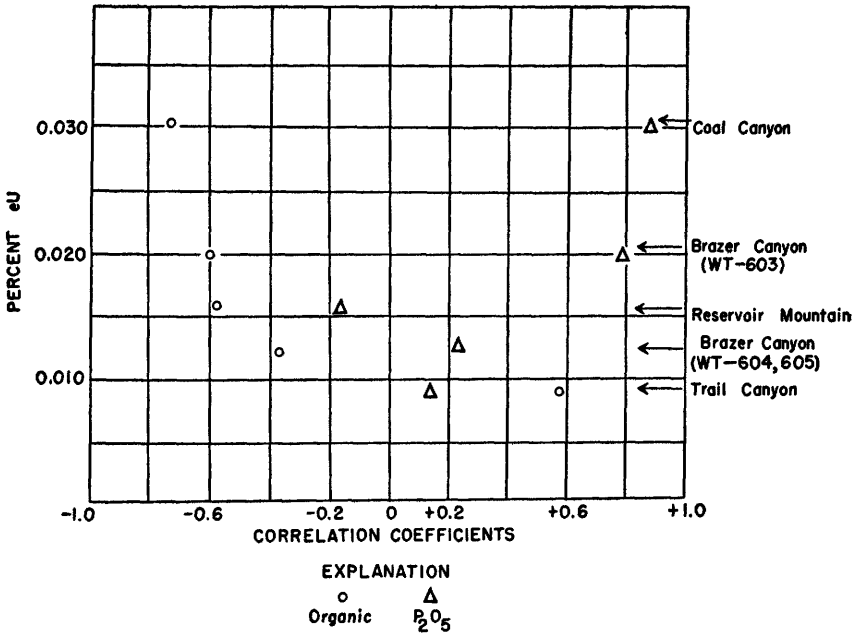

FIGURE 28.—Comparison of correlation coefficients with average uranium content.

In figure 28, the correlation coefficients for organic matter and P_2O_5 with equivalent uranium have been plotted against the average amount of uranium in each group of samples.

The coefficients of correlation of P_2O_5 with uranium, as plotted on this graph, tend to form a simple pattern of improving correlation with increasing percent uranium. The coefficients of correlation of organic matter with uranium form a curve that crosses the zero axis at about 0.010 percent equivalent uranium. According to this graph, a group of such samples averaging 0.010 percent equivalent uranium would show no correlation of uranium with organic matter, and little or no correlation of uranium with P_2O_5.

Work of this nature yields only tentative conclusions. Other approaches will be necessary to solve the problem of the part that organic matter may have played in the precipitation of uranium. Attempts will be made to correlate uranium content with time by assuming that the size of the phosphate pellets reflects the length of time of their formation. The validity of this assumption is, of course, open to question.

The samples that have been discussed in this report, are now being analyzed for F and CO_2. The results of these investigations will be reported later.

METHODS FOR DETERMINATION OF ORGANIC MATTER IN PHOSPHATE ROCK

By F. S. Grimaldi

METHOD I

1. Weigh 0.5 g of sample into a Monroe crucible. Add 15 ml of (1+2) HCl and place the crucible (upright) in a platinum dish containing enough (1+2) HCl (1 part H_2O+2 parts conc HCl) to cover one-third of the crucible.
2. Place the dish on a steam bath for about 15 min.
3. Remove the crucible and drain it on a suction filter. Wash with 1 percent HCl.
4. Remove the crucible from the filter apparatus. Add 5 ml HF and 5 ml of (1+2) HCl to the crucible.
5. Place the crucible in a platinum dish on the steam bath for 1 hr. Filter and wash with 1 percent HCl.
6. Fill the crucible with (1+2) HCl and again place it upright in a platinum dish containing some (1+2) HCl. Heat on the steam bath long enough (30 min to 1 hr) to decompose any insoluble fluorides. Add more HCl if necessary.
7. Filter and wash with 1 percent HCl.
8. Dry at 110 C and weigh.
9. Ignite and weigh again.

The percent organic matter equals the loss in weight from steps 8 to 9 multiplied by 100 and divided by the weight of the sample.

Notes on method I.—Steps 1 to 3 are designed to remove acid-soluble constituents such as calcite and apatite.

Steps 4 and 5 are used to decompose silicates, to remove silica, and to dissolve such oxides as those of Fe and Al.

Step 6 is necessary to dissolve any fluorite or other fluorides formed in steps 4 and 5.

Appraisal of method I.—Errors that produce too low a result are due to the attack and dissolution, by the chemical reagents, of organic matter. Errors that produce too high a result are due to certain sulfides and silicates that remain undissolved and are counted as organic matter.

METHOD II

1. The sample is heated to constant weight at 230 C and again to constant weight at 450 C. The percent organic matter is taken as the difference in weights at the two temperatures divided by the weight of the sample and multiplied by 100.

Notes on method II.—The heating at 230 C is designed to remove loosely held water. A temperature this high is necessary because of the clay minerals that may be present.

The heating at 450 C is designed to burn off the organic matter and yet not decompose carbonates or distill off combined (fixed) water.

Appraisal of method II.—Errors that give too high a result are due to the fact that all loosely held water is not driven off at 230 C but is lost at 450 C and is therefore counted as organic matter. Another reason for too high a result is that some fixed water is lost at 450 C and is counted as organic matter.

Too low an answer may result if all the organic matter is not burned off at 450 C.

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