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GEOLOGICAL SURVEY

Anomalous Occurrence of Uranium in Alpine Peats, Summit County, Colorado and Results of a Simple Sample Fractionation Procedure

By

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Abstract--Samples from Summit County, Colo., were fractionated for analyses of organic content and uranium. The uranium is related to organic content but not to type of organic matter. In one area uranium values are around 100 ppm in bulk samples and as much as 200 ppm in certain separated fractions of the samples; this is much higher than the 1-10 ppm normal uranium values for peat.

Introduction

In 1974 and 1975 we obtained samples from several peat accumulations at elevations of 11,000 feet (3,500 m) in the Rocky Mountains of Colorado. The main purpose of these samples was to provide a rich source of organic matter for our laboratory work on the fixation of uranium by humic material (Jennings and Leventhal, 1976). Some of the samples were found to have as much as 100 ppm uranium and we felt they merited further study. We also analyzed several depth profiles and varied samples in order to see if any geochemical affinity for uranium or changes with environment (pH, Eh) were evident.

Sample Collection

Samples were collected in alluvial material from and above the Snake River and Deer Creek junction (fig. 1) where organic material was present (Theobald and others, 1963). Additional samples were collected from Boulder County in 1975 by Joe Sarnecki, U.S. Geological Survey, and from Jackson County in 1974 by us.

Samples of 5-10 kg were collected in large heavy polyethylene bags and were frozen upon return to the laboratory. As needed, samples were thawed and a portion was removed.

Laboratory Treatment

Portions of the samples were oven dried at 40°C in air and analyzed for uranium and thorium by the delayed neutron technique (Millard, 1976).

Splits of the bulk sample were extracted with 0.1N NaOH to remove the humic material. Centrifugation was used to remove the fine mineral matter from the dissolved humic acid which was then precipitated with HCl at pH 2.

Carbon, hydrogen, and nitrogen (CHN) analyses were made with a Perkin Elmer Model 360[1] elemental analyzer.

More detailed analyses of fractions from Deer Creek were performed by modifying a procedure of Polach and Costin (1971) as described here. The sample was placed in a mechanical blender with distilled water for several minutes and then poured into a beaker.

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[1]Use of a specific brand name does not necessarily constitute endorsement of the product by the U.S. Geological Survey.

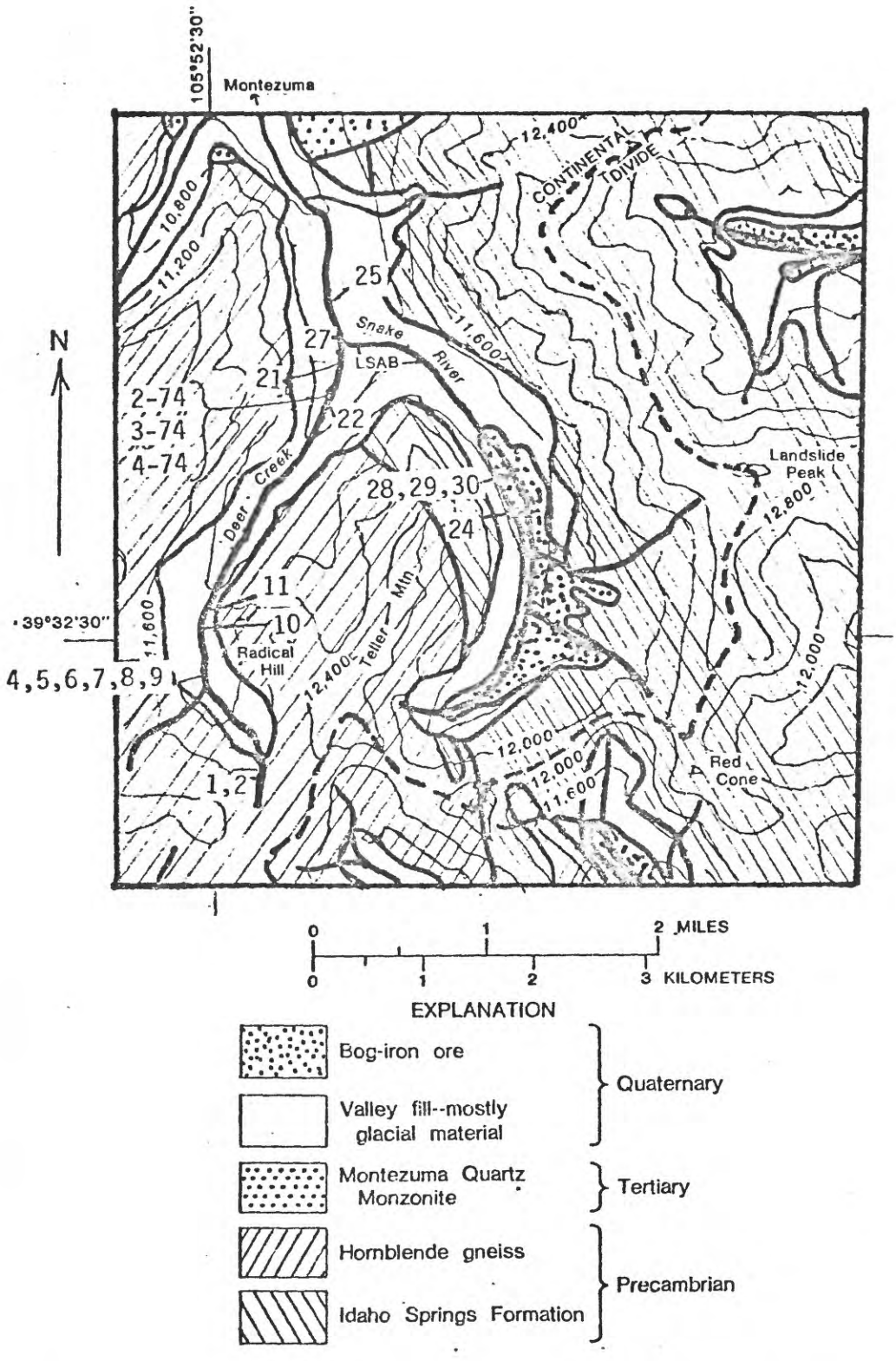


Figure 1-- Map showing locations of collection of samples in Summit County, Colorado.

As the sample settled, a density and size separation occurred. The liquid was siphoned or poured off and the density layered solid was air dried in an oven overnight (70°-80°C). The sample was then sliced into pieces according to visually observed grain size or color. These fractions were analyzed by the delayed neutron technique for uranium and thorium. The samples were ashed at 410°C for 16 hours to determine amount of organic matter after the removal of water at 80°C.

Four samples were prolyzed using the method described by Leventhal (1976). This technique includes prolysis at 750°C for 10 sec in helium, and gas chromatographic separation of the prolysis products.

Results

The uranium, thorium, Th/U ratios, and organic matter of bulk samples were shown in tables 1 and 2. Samples with TH/U <1 have poorer precision (±25-100 percent) for both thorium and Th/U values than the samples with Th/U >1. These poorer precision results are indicated by parenthesis. The uranium results are within ±10 percent precision.

Results of settling-fractionation are shown on figure 2. Only sample 10 yielded a cloudy solution above the solid material after blending and settling. This cloudy liquid was decanted to a centrifuge tube and centrifuged for 10 minutes; this yielded a clear solution and a solid material (samples DC-10-1c and DC-10-1d). The Th/U ratio, Th, U and organic contents for the fractions are given in table 3.

Table 1.--The Th and U contents and Th/U ratio of organic-rich samples from Deer Creek and Snake River, Summit County, Colorado.

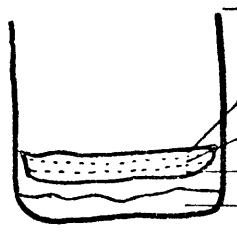
[Parentheses denote poorer precision, see text]

Sample No.	Th (ppm)	U (ppm)	Th/U	Location
		1974 Samples		
21	39.1	18.6	2.1	Surface.
22	88.2	51.1	1.7	
23	91.0	49.4	1.8	Surface.
2-74	75.0	28.0	2.7	7-20 cm.
3-74	84.2	68.0	1.2	20-40 cm.
4B-74	(84.5)	89.2	(0.9)	40-60 cm.
24-1	6.6	1.3	5.2	Surface.
24	22.4	5.1	4.5	Surface.
25	11.3	2.9	4.0	Surface.
26	32.0	17.6	1.8	Surface.
27	36.7	6.3	5.8	Surface.
28	24.9	9.1	2.7	23 cm.
29	33.4	14.3	2.3	23-46 cm.
30	54.6	18.0	3.0	46-64 cm.
		1975 Samples		
1	(15.1)	16.2	(0.9)	Surface-23 cm.
2	(31.3)	50.1	(0.6)	23-50 cm.
4	12.3	6.0	2.1	76-92 cm.
5	17.6	9.1	2.0	53-76 cm.
6	14.9	8.5	1.8	38-53 cm.
7	17.6	11.8	1.5	23-38 cm.
8	14.5	12.7	1.1	7-23 cm.
9	22.6	16.8	1.3	Surface-7 cm.
10	(5.7)	9.1	(0.6)	Creek bottom.
11	0	118.1		Creek bottom.

Table 2.--The Th and U contents and Th/U ratio of organic-rich samples from Jackson and Boulder Counties, Colorado

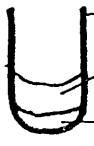
Sample No.	Th (ppm)	U (ppm)	Th/U	Depth
Alluvium and peat on Horse Creek, Jackson County, Colo. (40°30'N., 106°10'W.)				
31	25.3	5.6	4.5	Surface.
32	18.1	4.9	3.7	Surface.
33	19.6	4.1	4.8	Surface.
Caribou Park, north of Caribou, Boulder County, Colo. (30°59'N., 105°35'W.)				
75-13-1	0	1.3		0-30 cm.
75-13-2	5.6	1.3	4.3	30-60 cm.
75-13-3	0	3.6		60-90 cm.
75-13-4	11.1	4.0	2.8	90-120 cm.
75-13-5	0	0.1		Disturbed surface.
75-13-6	4.2	0.6	6.6	0-30 cm.
Mammoth Creek, northwest of Elk Park, Boulder County, Colo. (39°53'N., 105°37'W.)				
75-12-1	0	1.1		0-30 cm.
75-12-2	10.1	2.6	3.9	30-60 cm.
Elk Park, Boulder County, Colo. (39°52'N., 105°37'W.)				
EP7-1	26	2.7	9.8	0-30 cm.
On South Boulder Creek north of Tolland, Boulder County, Colo. (39°54'N., 105°36'W.)				
T-8-1	27	7.7	3.6	0-30 cm.
T-8-2	35	18.2	1.9	30-90 cm.
T-9-1	36	29.7	1.2	0-30 cm.
T-10-1		1.7		0-15 cm.

SAMPLE 8



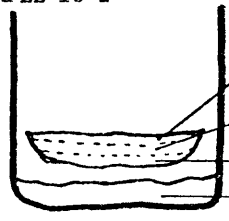
	ppm U	%org
a-fine	32	30
b-fine	29	34
c-coarse	16	13
d-sandy	5	2

SAMPLE 10-1



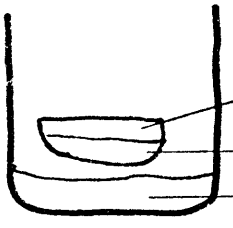
	ppm U	%org
Centrifuge tube		
c-black fines	38	39
d-white fines	31	27

SAMPLE 10-2



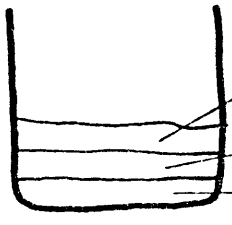
	ppm U	%org
a-fine	19	31
b-roots & fine	12	18
e-coarse	10	7
b-sandy	3	1

SAMPLE 11



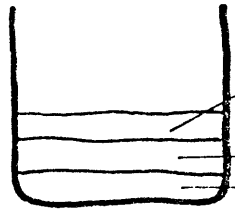
	ppm U	%org
a-fine	173	28
b-coarse	115	21
c-sandy	11	1

SAMPLE 4-74



	ppm U	%org
upper	63	25
lower	26	9
heavy	19	4

SAMPLE 3-74



	ppm U	%org
upper	137	27
lower	109	20
heavy	82	28

Figure 2-- Schematic diagram of separated samples and their uranium and organic contents.

Table 3.--The Th, U, and organic contents and Th/U ratio of separated fractions of samples from Deer Creek, Colorado.

[See table 1 for total sample. For explanation of sample nos., see figure 2. Parentheses denote poorer precision, see text]

Sample No.	TH (ppm)	U (ppm)	Th/U	Organic content (percent)
		1974 Samples		
DC 4-74 heavy	(17.0)	18.5	(0.9)	4
DC 4-74 lower	31.0	26.3	1.2	9
DC 4-74 upper	63.3	62.4	1.0	25
DC 3 & 4 humic acid	(75.9)	133.1	(0.6)	32
DC 3-74 lower	(47.2)	109.4	(0.4)	20
DC 3-74 upper	(65.6)	137.2	(0.5)	27
DC 3-74 heavy	(38.5)	82.5	(0.5)	28
		1975 Samples		
DC-8a	(18.6)	32.4	(0.6)	30
DC-7b	(13.0)	29.5	(0.5)	34
DC-8c	21.4	16.0	1.3	13
DC-8d	14.9	5.1	2.9	2
DC-10-2a	(19.2)	33.5	(0.5)	31
DC-10-2b	7.7	3.1	2.5	1
DC-10-1c	(38.6)	56.7	(0.7)	39
DC-10-1d	(31.6)	38.3	(0.8)	27
DC-10-1e	11.6	10.7	1.1	7
DC-10-1f	(12.0)	20.8	(0.6)	18
DC-11a	(40.9)	173.2	(0.2)	28
DC-11b	(26.9)	115.4	(0.2)	21
DC-11c	15.3	10.7	1.4	1

Table 4 gives the results of carbon, hydrogen and nitrogen measurements of several samples and organic material as determined by weight loss upon ashing.

Figure 3 shows the results for prolysis-gas chromatography (Leventhal, 1976) of organic material for samples which had been fractionated (samples 3-74 heavy, DC-10-1d and 8a).

The gas chromatographic "fingerprints" on figure 3 show predominently straight chain alkanes and alkenes. The carbon chain length of these alkanes is indicated by the number, thus the 17 on figure 3 indicates the position of the $C_{17}H_{34}$ alkene and $C_{17}H_{36}$ alkane. The other peaks represent prolysis products that may be either branched, cycic, or aromatic hydrocarbon molecules.

Discussion

Our initial results showed some of the Deer Creek samples to be anomalously high in uranium, so we returned in 1975 to sample more extensively to try to locate the source of the uranium. Figure 1 shows the 1974 and 1975 localities. Table 1 shows that the highest values for uranium is the organic matter in sediment in one of the streams feeding into Deer Creek from Radical Hill (sample 11).

The separation scheme (blende, gravity settle, oven dry) appears to work well for our purposes. The top fraction (fines or least dense) has the highest organic content and the organic content decreases with coarser or denser fractions. The uranium content shows a direct correlation with the organic content (table 3 and fig. 2). Figure 4 shows the uranium content and organic content for the fractionated samples. Lines are drawn (by hand) through the data

Table 4.--Carbon, hydrogen, and nitrogen analyses and organic content of samples from Summit and Jackson Counties, Colorado

Sample No.	N (percent)	C (percent)	H* (percent)	Percent organic content (wt loss)
22	0.44	6.69	1.11	16
3-74	0.66	9.39	1.52	16
25	1.70	35.58	4.17	61
26	1.10	1.61	0.47	4.8
30	0.86	14.87	2.43	32
31	0.14	3.54	0.60	5.6
32	0.07	1.39	0.22	**
33	0.02	0.70	**	**

* May include water.

**Not determined.

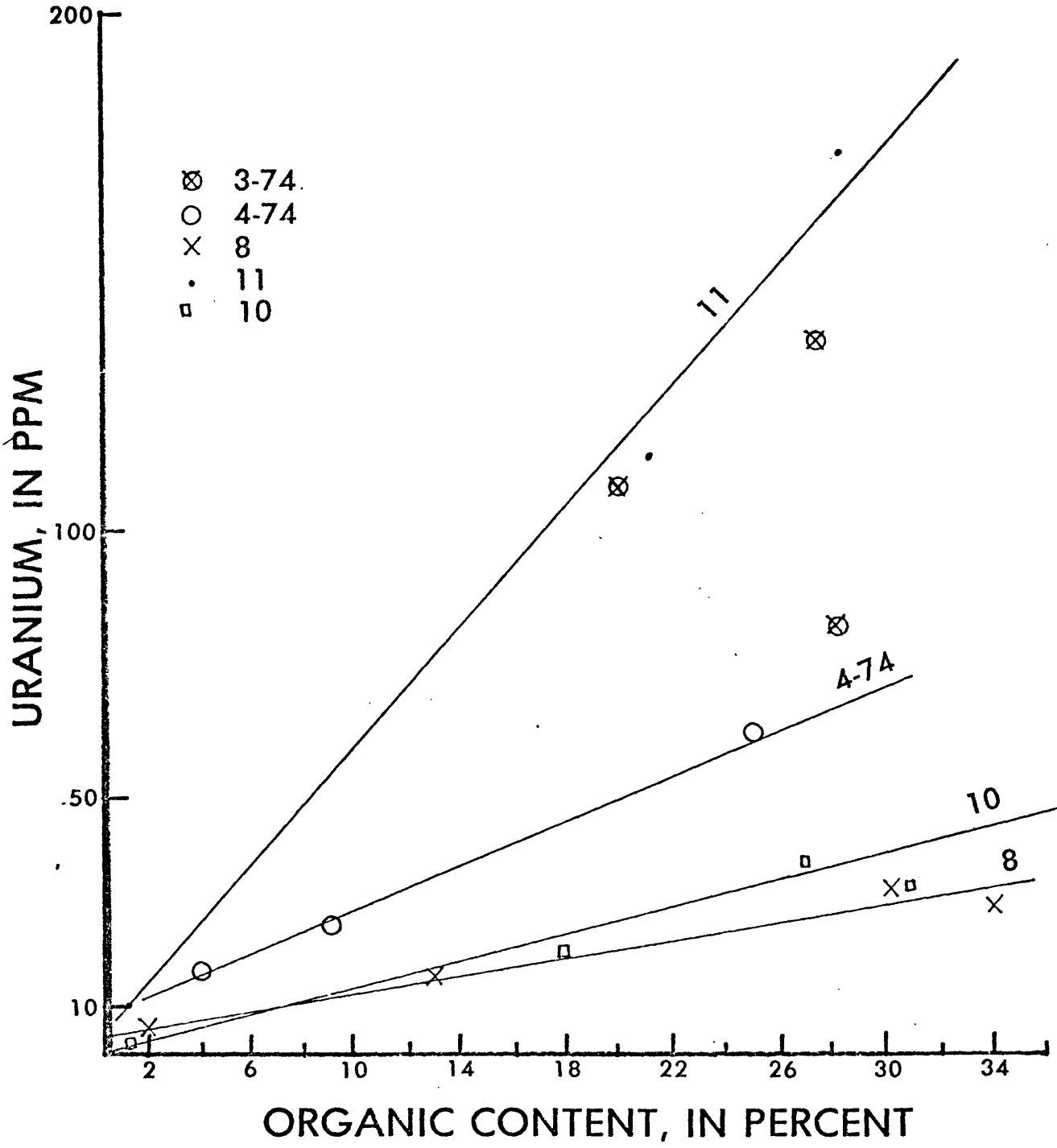


Figure 4-- Relations between uranium content of separated portions of samples and their organic content.

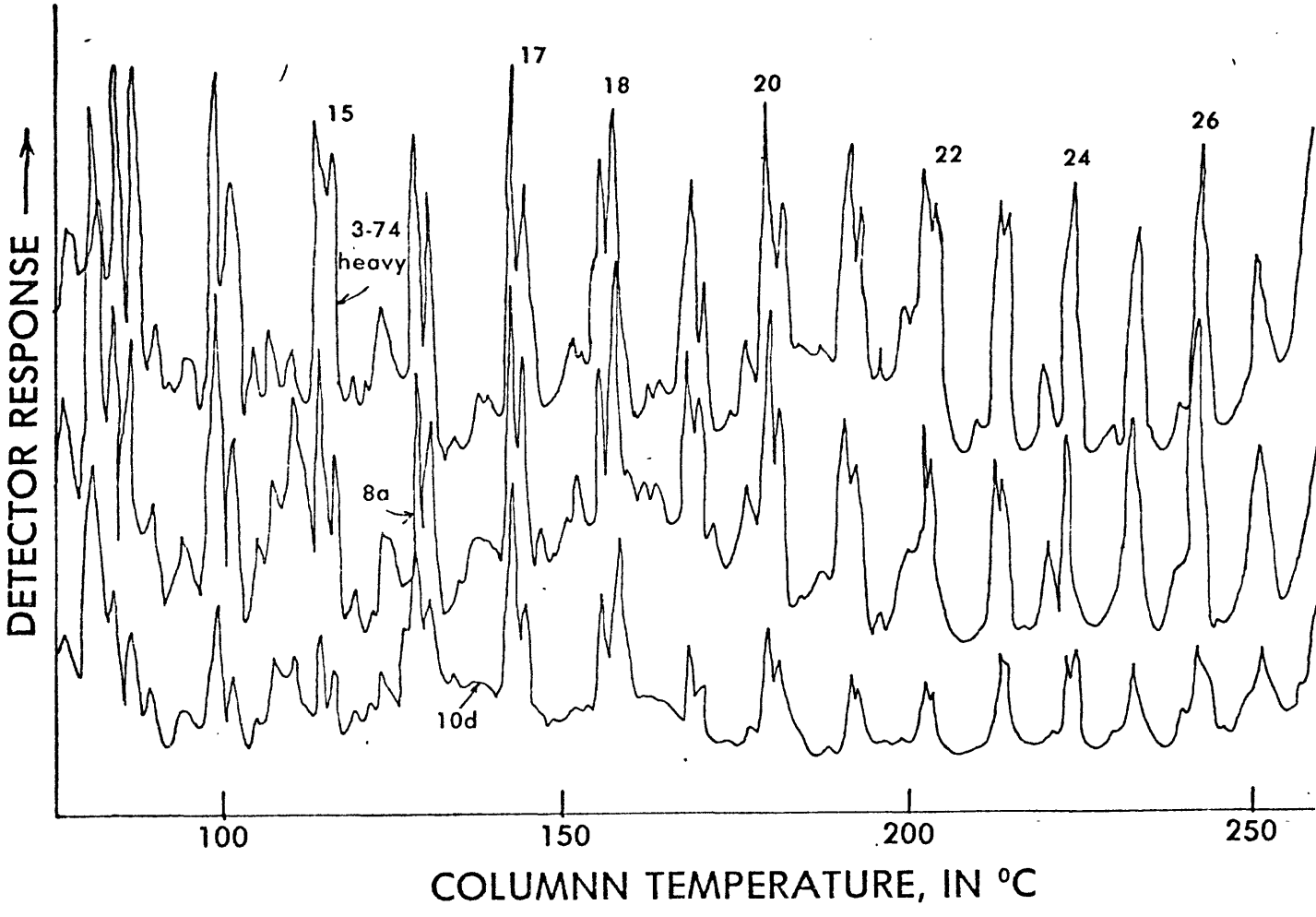


Figure 3-- Pyrolysis chromatogram of 750°C step of samples 3-74 heavy, 10d and 8a. Numbers refer to n-alkane peaks.

for samples 11, 4-74, 10 and 8 where covariance between organic matter and U content is indicated.

Samples 23, 2-74, 3-74, 4B-74, and samples 4, 5, 6, 7, 8, and 9 represent two series through 1 m thick deposits. In both suites the samples show a general relation between Th/U or U content with depth; in one suite, however, the top sample is greatest in U and in the other, the top sample is least in U content (fig. 5). The trend (fig. 5) of increasing U and decreasing Th/U ratios denotes an increase in U without an increase in Th. This implies either fixation of mobile U by organic material or a change in the detrital uranium (but not thorium) minerals. Because the uranium is present in the organic rich-low density fraction we favor the former.

The uranium and organic content and the uranium to organic content ratios vary considerably both among bulk samples and various fractions of single samples. Is this due to different types of organic matter with different affinities for uranium, or due to different sources of mobile uranium? The bulk of the organic matter is insoluble and cannot be analyzed by conventional techniques. A procedure of stepwise prolysis gas chromatography (Leventhal, 1976) was used to fingerprint the organic matter. If the uranium/organic ratio is dependent on the type of organic material, then stepwise prolysis gas chromatography should reveal significant differences between samples. Chromatograms of samples 3-74 heavy, 8a, and 10d, all with about 30 percent organic matter, were compared and all show the same peaks and similar ratios of peak heights about 95 percent of the time (fig. 3). Thus, the organic matter appears to be of the

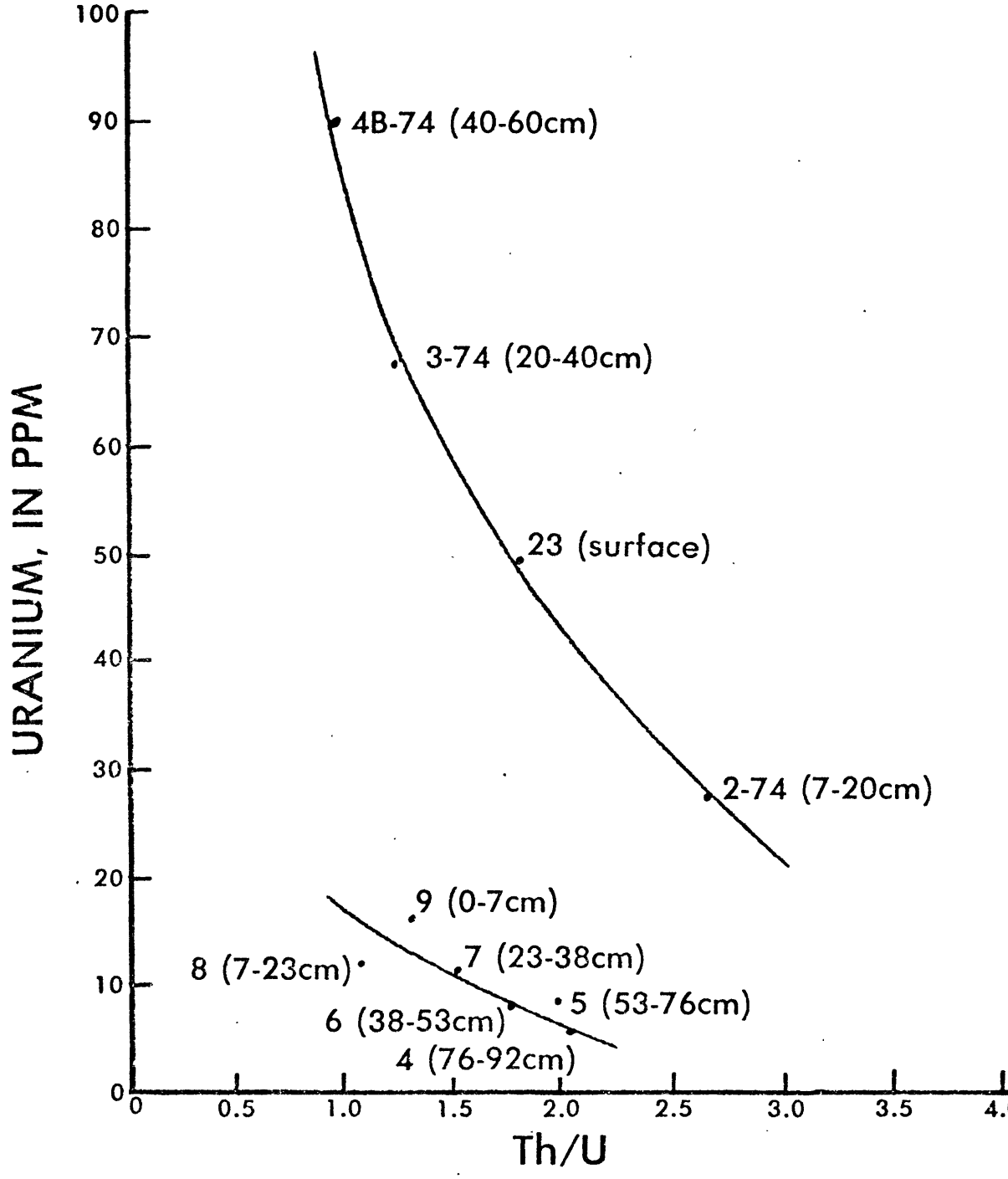


Figure 5-- Plot of Th/U vs U (ppm) for two suites of peat samples showing variation with depth.

same type, which indicates that it is the source of the uranium that accounts for the differing uranium contents.

Conclusion

We have demonstrated a fast and easy fractionation scheme for organic-rich material (peats, stream sediments) to separate the most uranium-rich portion. We have found that the variation of uranium content of these sample fractions is from 3.1 ppm to 173 ppm and it is related to the organic content. We have shown that the insoluble organic matter in these samples is very similar in composition and thus large difference in uranium content cannot be attributed to the type of organic matter.

We have found much higher than normal uranium contents for our samples. Mineralization of Mo, Cu, and Bi has been noted in the Montezuma district (Neuerburg, 1971, Neuerburg and Botinelly, 1972; Neuerburg and others, 1976), however, uranium has not been reported (Neuerburg, 1976, oral commun.), or extensively searched for. We suggest that the area drained by Deer Creek be considered for future reconnaissance for uranium mineralization.

References

Jennings, J. K., and Leventhal, J. S., 1976, Interaction of oxidized uranium with humic acids, ion exchange resins, and chelating resins to determine conditions of fixation: Geol. Soc. America Abs. with Programs, v. 8, no. 5, p. 940.

Leventhal, J. S., 1976, Stepwise prolysis-gas chromatography of kerogen in sedimentary rocks: Chem. Geology, v. 18, p. 5-20.

Millard, H. T., Jr., 1976, Determination of uranium and thorium in USGS standard rocks by the delayed neutron technique: U.S. Geol. Survey Prof. Paper 860, p. 61-66.

Neuerberg, G. J., 1971, Maps showing distribution of selected accessory minerals on the Montezuma stock, Summit County, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-608.

Neuerberg, G. J., and Botinelly, T., 1972, Map showing geologic and structural control of ore deposits, Montezuma district, central Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-750.

Neuerberg, G. J., Botinelly, T., and Watterson, J. R., 1976, Ocher as a prospecting medium in the Montezuma district of central Colorado: U.S. Geol. Survey Jour. Research, v. 4, no. 3, p. 359-365.

Polach, H. A., and Costin, A. B., 1971, Validity of soil organic matter dating, in Paleopedology, D. H. Yaalon, ed.: Internat. Soc. Soil Sci. and Israel Univ. Press, Jerusalem, p. 89-96.

Theobald, P. K., Lakin, H. W., and Hawkins, D. B., 1963, The precipitation of aluminum, iron, and manganese at the junction on Deer Creek and Snake River in Summit County, Colorado: Geochim. et Cosmochim. Acta, v. 27, p. 121-132.

Layman's Summary

Anomalous Occurrence of Uranium in Alpine Peaks, Summit County, Colorado and Results of a Simple Sample Fractionation Procedure, by Joel S. Leventhal, Joan K. Jennings, and Alan J. Lemke, Open-file Report 78-235.

Samples of organic rich sediment and water-logged soil were fractionated by mechanical blending. They were analyzed for uranium and organic content. The amount of uranium was positively related to the amount of organic matter. In one sample the uranium content was ~100 ppm and the separated organic-rock fraction had ~200 ppm. Detailed organc analysis by pyrolysis-gas chromatography shows the organic matter to be similar even where the uranium content varies considerably.