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Biogeochemical Prospecting for Uranium with Conifers--Results from the Midnite Mine Area, Washington

By

J. Thomas Nash and Frederick N. Ward

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

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ABSTRACT

The ash of needles, cones, and duff from Ponderosa pine (Pinus ponderosa Laws) growing near uranium deposits of the Midnite mine, Stevens County, Wash., contain as much as 200 parts per million (ppm) uranium. Needle samples containing more than 10 ppm uranium define zones that correlate well with known uranium deposits or dumps. Dispersion is as much as 300 m but generally is less. Background is about 1 ppm. Tree roots are judged to be sampling ore, low-grade uranium halo, or ground water to a depth of about 15 m. Uptake of uranium by Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) needles appears to be about the same as by Ponderosa pine needles. Cones and duff are generally enriched in uranium relative to needles. Needles, cones, and duff are recommended as easily collected, uncomplicated sample media for geochemical surveys. Samples can be analyzed by standard methods and total cost per sample kept to about $6.

INTRODUCTION

Geochemical and radiometric exploration for uranium in many parts of the northwest are severely hampered by deep weathering, and by great variations in soil character. In an effort to obtain a rapid and reliable measure of subsurface uranium content biogeochemical sampling employing Ponderosa pine and Douglas fir trees was undertaken in the Midnite mine area in 1974 and extending to 1976. Pine and fir trees are abundant in the mine area, and both old and young trees are growing above rocks known to contain uranium mineralization. In this study we have sampled needles and cones because they are known to accumulate metals in other environments (Goldzstein, 1957), and are easily collected. A total of 389 samples were collected, including 36 cone samples and 4 of duff from pine trees.

The Midnite mine is located on the Spokane Indian Reservation, about 64 km northwest of Spokane (fig. 1). Uranium deposits of the Midnite mine occur in the Precambrian Togo Formation adjacent to a Cretaceous(?) porphyritic quartz monzonite pluton (Becraft and Weis, 1963, Nash and Lehrman, 1975). Production during 16 years of operation has been about 9 million pounds (4.1 kg) of U_3O_8 from oxidized and reduced ores averaging 0.23 percent U_3O_8. Uranium minerals, chiefly autunite and pitchblende, occur as disseminations along foliation, replacements, and stockwork fracture fillings. Deposits have

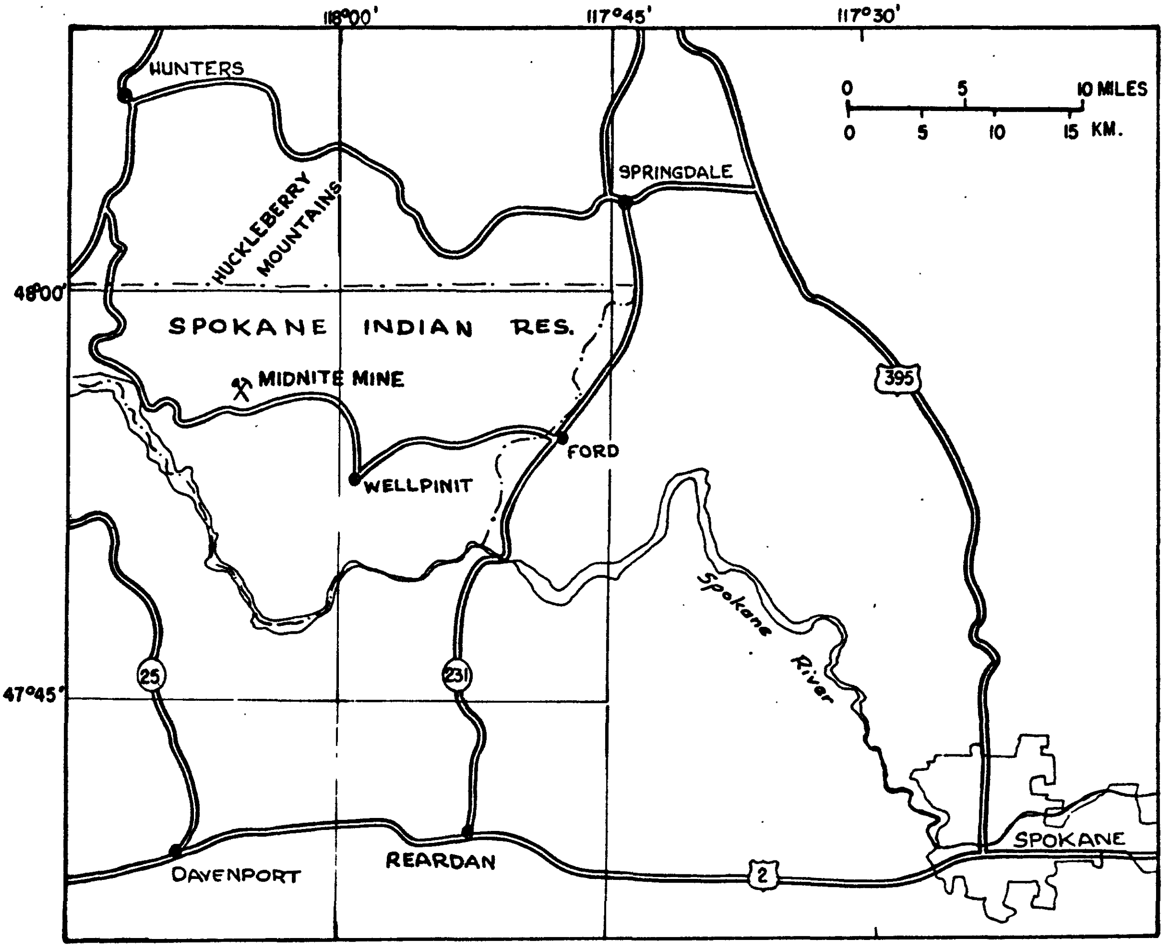

Figure 1.--Location of the Midnite uranium mine, Stevens County, Washington.

tabular form and dimensions ranging up to 380 m long, 210 m wide, and 50 m thick. Ore zones are interpreted to have been secondarily enriched during mid- to late-Tertiary time.

BIOGEOCHEMICAL PROSPECTING

Techniques and theories which involve the use of vegetation to prospect for mineral deposits have been capably reviewed by Cannon (1960), Cannon and Kleinhampl (1956), Goldzstein (1957), Hawkes and Webb (1962), and Brooks (1972). Only the uranium-in-vegetation method is considered in this report as no indicator plants are known to occur over uranium deposits in Washington. Previous studies, summarized in the preceding references, have shown that certain metals are selectively taken in by plants. In the case of uranium uptake is relatable to pH of cell sap; plants and trees with cell sap pH less than 5.2 absorb relatively large amounts of uranium, some of which ultimately reaches leaves and needles. Because roots on one side of a tree convey nutrients to a particular set of branches, uranium content can vary around a tree. Hence, needles should be collected from branches on all sides of the tree to obtain a representative sample.

Ward and Marranzino (written commun., 1959) successfully employed pine-needle sampling for uranium in the Marshall Pass area, Saguache County, Colo. The Pitch (or Pinnacle) vein-type deposit was discovered by its radioactive expression, and sampling of soil and pine needles was completed in 1959 before the surface was disturbed. The soil samples did not reflect the uranium content of underlying bedrock unless taken at depths of about 2/3 meter. However, uranium enrichment was noted in the ash of pine needles over an area that corresponded very well to the vertical projection of the orebody.

Pine trees generally have a well developed tap root (Mirov, 1967, p. 367), but the depth of the root system is highly variable and dependent upon factors such as climate and character of bedrock. Judging from uprooted pines in the mine area, penetration of main roots was probably about 3 to 5 meters. On the Colorado Plateau some Ponderosa pine roots penetrate to 25-m depth and Juniper to more than 60 m (H. L. Cannon, written commun., 1977). Roots of pines near the Adit and Hill 4 deposits (plate 1) possibly penetrate 0.0X percent uranium, but mineralization under most anomalous trees is known to be at greater than 30 m depth. Trees near the Boyd 2 deposit probably were sampling low-grade rocks above and beyond the orebodies. From gamma spectrometric and chemical analyses of rocks adjacent to the Adit pit we know the near-surface rocks contain about 50- to 200-ppm uranium. Oxidized calc-silicate rocks above the Boyd

No. 2 orebody contain less than 25 ppm uranium, and some oxidized phyllitic rocks contain more than 100 ppm uranium, but most contain much less. In other words, there is not much of a uranium halo beyond the orebodies, but it may be enough to be sampled by the trees. The water table in most of the mine area is deeper than about 25 m, hence vadose water must be involved if there is any transport of uranium. In several low lying areas, trees are enriched in uranium--here transport by vadose or possibly even phreatic water may be involved.

METHODS

Samples of needles, cones, and duff were collected from Ponderosa pine and Douglas fir. Needles collected were generally first-year growth and were stripped from the twigs. A pole-mounted pruner was used when necessary, and needles were collected from several branches around the tree. Approximately 1 pint of needles was collected. Whenever needles were visibly covered by dust or pollen, the branches were rapped several times to remove most dust prior to bagging. The cones collected were of various sizes and ages, on and off trees, as will be discussed later. Four samples of partly composted needles (duff) were collected to allow comparison with needles still on trees. Samples were air dried, shredded in a Wiley mill, dried at 100°C, and ashed at 450°C prior to analysis. No samples were allowed to burn. The ash of needles and cones was digested in nitric acid and analyzed by fluorimetry.

Analytical results for this study were delayed and hampered by the fire in Building 25, Denver Federal Center that occurred in March 1976. Approximately 125 samples awaiting analysis were destroyed as was material remaining from about 150 samples; some of the trees were resampled after the fire loss. Also, the fire completely destroyed Ward's laboratory, and it was necessary for us to have 191 samples analyzed by a commercial firm. No standard samples remained after the fire for use in testing the commercial analytical values; however, nearly identical methods were used and Ward has since corroborated their determinations in samples he has checked.

URANIUM IN NEEDLES

Results of analyses of 387 samples of needles of Ponderosa pine and Douglas fir are in table 1. Uranium content ranges from less than 0.4 to 200 ppm. Background values in the study area are considered to be about 1 ppm judging from data for samples collected from sites having no known nearby uranium mineralization. Values in excess of about 10 ppm are considered anomalous, and values greater than about 100 ppm may reflect contamination. Throughout the investigation the matter of contamination was in mind, but no unequivocal tests could be made during sampling or interpretation; the problems are discussed below.

Contamination

Contamination by airborne particles rich in uranium is a real possibility considering the fact that there are five exposed open-pit mines and several large dumps in the area, and it is obvious that trucks carrying ore create a lot of dust.

Identification of contamination seems to be subjective and necessarily involves circular reasoning. We have tried five tests: (1) variation in ash weights, (2) behavior during leaching with dilute acid, (3) variation in other elements, (4) comparison of data from samples collected at different times of year, and from large and small trees, and (5) consideration of spatial trends.

Inspection of the data for percent ash (table 1) suggests to us that contamination is not a major problem. There is no obvious variation in percent ash with uranium content and the ash contents are considered normal. Remember also that contamination by ore- grade material (average 0.25 percent U_3O_8) would add about 1 weight percent to ash for each 25 ppm U added; this amount would be notable.

Leaching tests by Ward did not disclose the presence of a surficial or adsorbed uranium-rich phase. Repeated leaching with dilute nitric acid gave the same results rather than decreasing amounts as would be expected if pitchblende grains were dusted on the surface of needles. Likewise, emission spectrographic analyses of the ash show no increase in other elements in uranium- rich samples.

Samples near the open-pit mines were collected at four different times--September 1974, May 1975, August 1975, and June 1976--and there is no correlation of uranium with date, even though the samples collected in late summer were somewhat dusty and those collected in May and June were freshly washed by spring rains. Repeated samples from the same tree do not show conclusive trends, as shown below:

Sample No.	U in ash (ppm)	Date
29-------	36	9/74
38-------	23	5/75
39-------	39	5/75
191-------	56	8/75
41-------	24	5/75
354-------	14	8/75
71-------	2	5/75
390 ------	16	8/75

Contamination was suspected _a priori_ in the area east of Boyd 2 pit, which was being mined during the period of sampling, and eastward along the haulage road. The prevailing wind direction is toward the east, and during the dry summer months one can watch dust drift away from the road after ore trucks pass. At this time we suspect several values in excess of 100 ppm U may reflect airborne contamination, but even for these examples the evidence is not conclusive. For one thing ground radiometric readings with hand-held scintillometer and by a truck-mounted gamma spectrometer with large crystal volume detect anomalous radioactivity only in the main haulage road used by ore trucks bound for the mill at Ford; radioactivity over calc-silicate rocks east of the pit and north of the haul road is actually lower than over Togo phyllite. The high value of 66 ppm in needles from a small tree, next to the haul road, sample 304, probably is a measure of contamination, but we suspect that the airborne contamination does not carry more than 10 to 20 m distance from either road or pits. The other high values east of Boyd 2 pit can possibly be real and resulted from ground water carrying anomalous amounts of uranium from shallow deposits or dumped waste and ore. Tree 305 (150 ppm U) is second growth and has its roots in an 18-year-old stockpile of calc-silicate ore. Several other trees with very high values (306, 110 ppm; 391, 53 ppm; 199, 200 ppm; 196, 87 ppm; 195, 68 ppm; 184, 54 ppm) are away from visible windborne dust patterns and are growing in or downslope from dumps. We would expect to observe similar uptake in trees growing near an oxidizing uranium deposit.

Nineteen smaller trees (A and B size in table 1) were sampled for comparison with larger trees nearby; at the outset it was thought this might provide a possible estimate of contamination. We note that many of these small trees contain more than 30 ppm U in their needles, comparable to levels found in nearby larger trees. Because most of these trees are growing well away from actively mined or disturbed areas, their uranium content does not appear to be from airborne contamination. The uptake of relatively large amounts of uranium by these smaller trees indicates that they too can be used for prospecting.

Uranium Concentrations in Needles Across the Mine Area

Several features of the pattern of uranium values in the mine area (plate 1) deserve description and interpretation. All of the values in the southwestern part of the area sampled (plate 1) are anomalous as might be expected because this is the area of uranium orebodies. Anomalous trees extend about 300 m east and northeast of the Boyde 2 ore zone. Trees above the Hill 4 mineralized area (plate 1 and fig. 2) have erratic values--many are anomalous but many are not. The area between Hill 4 and No. 3 orebody, in which drilling tests to date have been negative, has no anomalous trees. As mentioned earlier, trees 195, 196, and 199 probably are enriched in uranium from a waste dump northeast of pit no. 3.

The relatively detailed sampling of the Hill 4 mineralized area (fig. 2) reveals very few anomalous trees and no "halo" around the mineralized zone. Of the 78 samples, only 4 (5 percent) contain 20 or more ppm U; 8 (10 percent) contain 10-19 ppm U and 12 (15 percent) contain 7-9.9 ppm U. The trees with more than 10 ppm U are predominantly on the west side and south end of the ridge-- this is probably explained by the eastward dips in the area and the occurrence of low-grade (0.0X percent U_3O_8) mineralization within a few feet of the surface between sites 132 and 116. Surface radioactivity decreases from west to east and mineralized zones encountered in drilling are known to become deeper eastward from the trace of intrusive contact. These features may explain the lack of anomalies on the east side of Hill 4; nonetheless the areal extent of anomalous trees is much smaller than in the mined area to the south.

Three areas were tested with the pine needle technique to see if any anomalous ground would be outlined as an exploration target. Trees on the ridge of Togo phyllite west of Hill 4 show only background values; broad-spaced drilling in this general area has not disclosed uranium mineralization near the surface. The northeast quarter of section 1 (plate 1) is known to have some anomalously radioactive schist along the intrusive contact and some drill holes have penetrated ore-grade mineralization; no anomalous uranium values are observed in the pine needle samples.

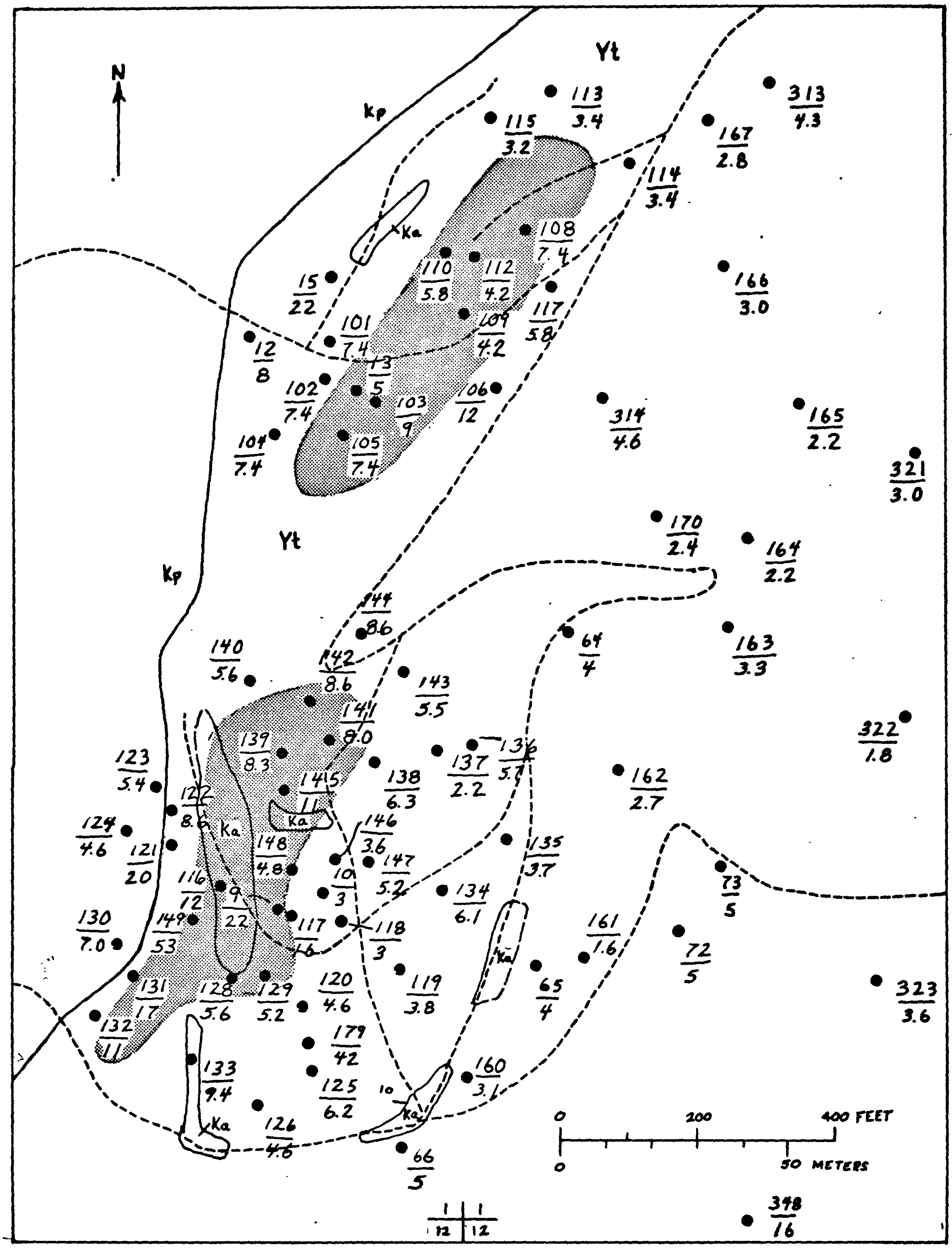

Figure 2.--Location of needle samples in the Hill 4 mineralized area (See plate 1 for location).

Explanation: Patterned area is mineralized zones, Solid line, geologic contact, approximately located; dashed line, road; Kp, porphyritic quartz monzonite (Cretaceous?); Ka, aplite dikes (Cretaceous?); Yt, Togo Formation (Precambrian). Sample localities shown by solid dot, upper number is sample number, lower is uranium content of needle ash in parts per million.

The area southeast of the Spokane Mountain (plate 1) is virtually untested, but there are no surface indications of uranium mineralization; needles from the area contain only background amounts of uranium.

Uranium in Fir Needles

Although most needle samples were taken from Ponderosa pine, 29 were from Douglas fir. Most fir-needle samples contain less than 6 ppm uranium, but five are in the range 13-26 ppm. Relatively few fir trees are growing near known mineralized areas, and we believe our sampling does not test the tolerance of fir for uranium. No paired samples of pine and fir were collected from a mineralized area so we cannot compare relative uptake by the two species. In areas containing low concentrations of uranium, adjacent pine- and fir-needle samples have similar uranium contents. Because fir needles can accumulate uranium to at least the 26 ppm level, we believe that data from fir needles can be used in the same manner as that from pine needles. Needles from these two species accumulate approximately equal amounts of base metals (Cannon and others, 1972), and we suspect uranium uptake should be roughly the same in pine and fir needles.

Uranium in Pine Cones and Duff

Cones of Ponderosa pine were collected from 35 trees for comparison with uranium enrichment in needles. As seen on figure 3, the data suggest that uranium in the ash of cones is generally equal to, or somewhat greater than, that in the ash of needles from the same tree. If the data for 33 samples are averaged (samples 2 and 309 excluded), the cones contain an average of 24 percent more uranium than the needles from the same tree. The two cone samples with very high uranium contents were picked from the ground and are judged to be contaminated with uranium-rich particles.

These results suggest that pine cones are an effective sample media and probably are enriched relative to needles in their uranium content. Cones can be collected more rapidly than needles, hence might be considered a better choice in a large geochemical program.

Four samples of duff were collected for comparison with needles growing on the tree above it. In three of the samples, there is more than twofold enrichment of uranium in the duff relative to needles; in the fourth sample the duff contains slightly less uranium. Preliminary studies of other metals in duff samples collected elsewhere indicate it is a good medium, although care must be taken to avoid contamination by rock and

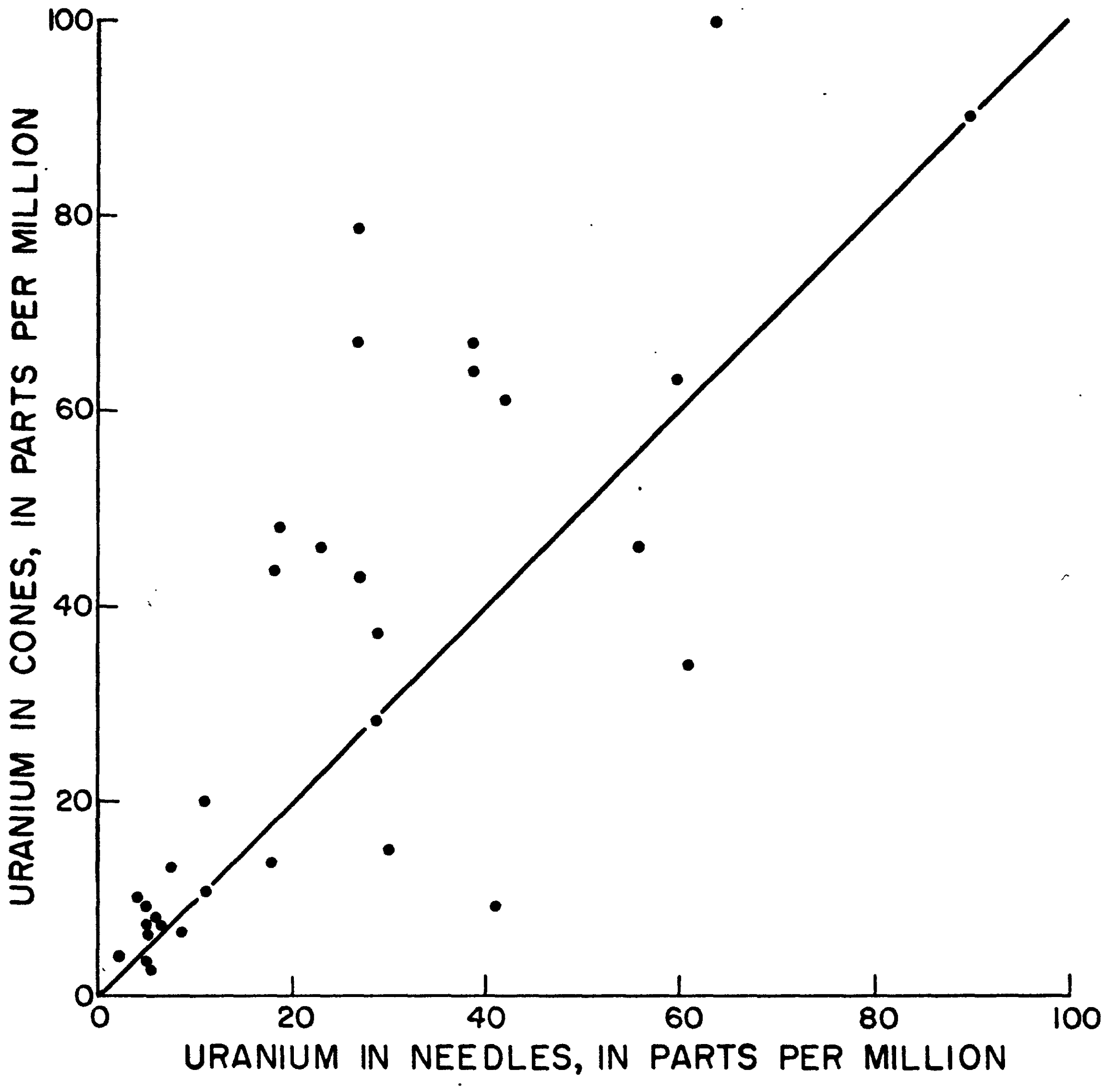

Figure 3.--Correlation of uranium in ash of pine cones with that in ash of pine needles. Data for samples 2, 35, and 309 not plotted. Diagonal line is 1:1 correlation.

soil particles. Duff samples are particularly useful in areas of very tall trees having high branches that are not easily reached from the ground.

CONCLUSIONS

Needles and cones from pine trees are an effective sample media for uranium geochemical exploration. These media can be collected quickly by relatively unskilled people, and the samples do not require any special handling prior to analysis. Chemical determinations can be made by standard methods at low cost. Uranium appears to be enriched in pine-needle duff, and that sample medium is recommended in situations where branches cannot be reached. Contamination by rock and soil particles is more likely to be a problem for duff than for needle and cone samples. The maximum uptake of uranium by pine needles appears to be about 200 ppm, and although not observed here, uranium in ash of cones and duff may reach somewhat higher concentrations. In planning and interpreting this type of biogeochemical prospecting, one should anticipate the dispersive effect of vadose and phraetic ground water as seems to have occurred adjacent to orebodies and dumps at the Midnite mine. In reconnaissance sampling, it may be advantageous to collect samples in valley bottoms to seek possible down gradient transport of uranium.

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Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E,>12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Sample description Species	Size	Anal.	Other
MP 1	34		P	B	W	
2	43		P	D	W	
2c	440		P	D	W	Cones
3	41		P	E	W	
4	47		P	E	W	
5	30		P	E	W	
6	30		P	E	W	
6c	15		P	E	W	Cones
7	20		P	E	W	
8	14		P	D	W	
9	22		P	E	W	
10	3		P	E	W	
11	7		P	E	W	
12	8		P	E	W	
12D	18		P	E	W	
13	5		P	E	W	
15	22		P	E	W	
16	5		P	D	W	
17	3		P	D	W	
18	3		F	D	W	
19	4		P	D	W	
20	1		P	D	W	
21	4		F	D	W	
22	1		P	D	W	
23	2		P	D	W	
24	5		P	D	W	
25	2		F	C	W	
26	<1		P	C	W	6 km S. of Wellpinit
27	<1		P	C	W	6 km S. of Wellpinit
28	<1		P	C	W	6 km S. of Wellpinit
29	36		P	E	W	
30	55	3.4	P	D	W	
31	100	3.9	P	D	W	
31R	48		P	D	W	
31D	78		P	D	W	
32	64	3.7	P	D	W	
32c	100	1.5	P	D	W	Cones
33	100	4.0	P	E	W	
34	90	4.0	P	E	W	
34c	90	1.2	P	E	W	Cones
35	180	5.6	P	E	W	
35c	200	1.3	P	E	W	Cones
36	61	3.6	P	E	W	
36c	34	2.8	P	E	W	Cones
37	60	3.5	P	E	W	
37c	63	1.0	P	E	W	Cones
38	23	4.1	P	E	W	Same as #29
38c	46	1.3	P	E	W	Cones
39	39	4.2	P	E	W	
39c	64	1.2	P	E	W	Cones

Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington--Continued

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E, >12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Sample description Species	Size	Anal.	Other
MP 40----	55	3.8	P	E	W	
41----	24	3.8	P	E	W	
42----	22	3.4	P	D	W	
43----	27	3.3	P	E	W	
43c---	43	1.1	P	E	W	Cones
44----	24	3.8	P	D	W	
45----	30	3.3	P	E	W	
46----	42	3.7	P	E	W	
46c---	61	1.2	P	E	W	Cones
47----	27	4.0	P	E	W	
48----	19	4.8	P	E	W	
49----	25	4.2	P	D	W	
50----	25	3.4	P	D	W	
51----	30	3.3	P	D	W	
51c---	37	1.2	P	D	W	Cones
52----	39	3.3	P	E	W	
52c---	67	1.0	P	E	W	Cones
53----	26	3.3	P	E	W	
54----	27	3.2	P	D	W	
54c---	79	1.0	P	D	W	Cones
55----	28	2.9	P	E	W	
56----	29	4.0	P	E	W	
56c---	28	1.4	P	E	W	Cones
57----	22	3.6	P	E	W	
58----	18	3.8	P	E	W	
58c---	14	1.0	P	E	W	Cones
59----	19	4.1	P	E	W	
59c---	48	0.8	P	E	W	Cones
60----	14	3.5	P	E	W	
61----	18	3.6	P	E	W	
62----	13	3.8	P	E	W	
63----	21	3.4	P	E	W	
64----	4	3.4	P	E	W	
65----	4	3.4	P	E	W	
65c---	10	1.0	P	E	W	Cones
66----	5	3.6	P	D	W	
67----	9	3.1	P	E	W	
68----	6	3.7	P	D	W	
68c---	8	1.1	P	D	W	Cones
69----	11	4.2	P	D	W	
70----	6	3.0	P	C	W	
71----	2	2.1	P	D	W	Same as 390
71c---	4	2.2	P	D	W	Cones
72----	5	2.5	P	B	W	
73----	5	3.0	P	E	W	
74----	4	2.3	P	E	W	
75----	21	3.8	P	E	W	
76----	27	2.7	P	C	W	
76c---	67	1.5	P	C	W	Cones
77----	41	3.4	P	D	W	
77c---	9	1.2	P	D	W	Cones
78----	7	3.4	P	E	W	
79----	9	3.5	P	C	W	
80----	9	3.2	P	D	W	
81----	21	4.7	P	D	W	

Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington--Continued

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E,>12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Sample description Species	Size	Anal.	Other
Numbers 82-100 skipped						
101	7.4	2.8	P	D	W	
102	7.4	3.2	P	D	W	
103	9.0	3.4	P	C	W	
104	7.4	3.4	P	D	W	
105	7.4	3.9	P	D	W	
106	12.2	4.8	P	D	W	
107	5.8	4.7	P	D	W	
108	7.4	2.9	P	E	W	
108c	13.8	1.8	P	E	W	Cones
109	4.2	2.3	P	B	W	Post-mine
110	5.8	2.8	P	C	W	
111	5.8	2.8	P	B	W	
112	4.2	3.1	P	D	W	
113	3.4	3.7	P	D	W	
114	3.4	3.9	P	D	W	
115B	3.2	3.3	P	E	W	
116	12	3.0	P	B	W	
117	16	4.2	P	C	W	
118	3.0	4.4	P	D	W	
119	3.8	4.1	P	E	W	
120	4.6	3.5	P	E	W	
120c	7.8	1.0	P	E	W	Cones
121	20	2.5	P	C	W	
122	8.6	3.2	P	B	W	
123	5.4	4.8	P	E	W	
124	4.6	3.5	P	B	W	
125	6.2	3.8	P	E	W	
125c	7.8	1.1	P	E	W	Cones
126	4.6	3.8	P	E	W	
126c	3.8	1.1	P	E	W	
127	9.4	3.3	P	D	W	
128	5.4	3.2	P	C	W	
129	5.2	3.2	P	D	W	
129c	7.5	1.2	P	D	W	Cones
130	7.0	3.9	P	E	W	
131	17	3.3	P	C	W	
132	11	3.0	P	B	W	
132c	11	1.2	P	B	W	Cones
133	9.4	2.6	P	B	W	
134	6.1	4.0	P	E	W	
135	3.7	2.8	P	C	W	
136	5.7	3.2	P	B	W	
137	2.2	5.0	P	D	W	
138	6.3	4.1	P	D	W	
138D	16	---	P	D	W	duff under 138
139	8.3	3.3	P	D	W	
139c	5.6	3.2	P	D	W	Cones

Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington --Continued

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E, >12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Sample description Species	Size	Anal.	Other
140	5.6	3.2	P	D	W	
140c	9.4	1.1	P	D	W	Cones
141	5.0	3.2	P	D	W	
142	8.6	3.3	P	D	W	
143	5.5	3.3	P	E	W	
143c	3.4	1.4	P	D	W	Cones
144	8.6	3.1	P	D	W	
145	11	3.0	P	D	W	
145c	20	1.2	P	D	W	
146	3.6	3.0	P	D	W	
147	5.2	4.0	P	D	W	
148	4.8	3.2	P	C	W	
149	53	2.8	P	B	W	
150	52		P	E	C	
151	20		P	E	C	
152	40		P	D	C	
153	58		P	D	C	
154	200		P	D	C	dusty from haul rd.
155	105		P	E	C	
156	110		P	E	C	
158	7.8		P	E	C	
160	3.1		P	D	W	
161	1.6		P	E	W	
162	2.7		P	C	W	
163	3.3		P	E	W	
164	2.2		P	D	W	
165	2.2		P	E	W	
166	3.0		P	E	C	
167	2.8		P	D	W	
167D	8.7		P	D	W	duff under 167
170	2.4		P	D	W	
171	3.4		P	D	W	
172	6.1		P	D	C	
172w	17		P	D	C	
172R	2.8		P	D	W	resample 172
173	2.7		P	D	W	
174	5.2		P	D	W	
175	4.0		P	D	W	
176	5.0		P	D	W	
177	3.1		P	D	W	
178	3.5		P	D	C	
178R	3.8		P	D	W	resample 178
179	4.2		P	A	C	
180	10		P	A	C	
181	13		P	E	C	
182	13		P	E	C	
183	5.3		P	C	C	growing on dump
184	54		P	A	C	growing on dump
185	9.0		P	E	C	
186	2.6		P	D	C	
187	3.8		P	D	C	
188	18		P	A	C	
189	30		P	A	C	growing on dump

Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington--Continued

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E,>12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Species	Size	Anal.	Other
190A	36		P	A	C	old needles
190B	31		P	A	C	new needles
191	56		P	E	C	resample MP 39
191c	46		P	E	C	Cones
192	94		P	A	C	
193	7.2		P	A	C	
194	14		P	E	C	
195	68		P	E	C	
196	87		P	E	C	
197	9.7		P	E	C	
198	8.7		P	E	C	
199	200		P	E	C	
204	2.8		P	E	C	
209	1.4		P	D	C	
210	1.7		F	E	C	
211	1.4		P	E	C	
212	1.0		F	C	C	
213	1.4		P	E	C	
214	2.3		P	E	C	
215	1.4		P	D	C	
216	0.8		F	C	C	
217	<.4		P	E	C	
218	1.6		P	E	C	
219	.9		P	C	C	
220	.8		P	E	C	
221	1.2		P	E	C	
222	1.2		P	E	C	
223	1.2		F	D	C	
224	<.4		P	D	C	
225	1.3		F	E	C	
226	<.4		P	E	C	
227	<.4		P	C	C	
228	1.1		F	C	C	
229	.5		P	D	C	
230	2.2		P	D	C	
231	<.4		P	E	C	
232	2.0		F	E	C	
233	2.6		P	C	C	
234	<.4		F	D	C	
235	<.4		F	E	C	
236	<.4		P	E	C	
237	<.4		P	E	C	
238	1.0		P	E	C	
239	1.2		F	C	C	

Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington--Continued

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E, >12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Sample description Species	Size	Anal.	Other
240	<.4		F	B	C	
241	.4		F	C	C	
242	<.4		P	D	C	
243	1.8		P	E	C	
244	3.3		P	D	C	
245	3.8		P	D	C	
246	.4		F	C	C	
247	2.8		F	C	C	
248	1.0		F	C	C	
249	.6		P	C	C	
250	<.4		P	C	C	
251	.8		P	E	C	
252	.4		P	C	C	
253	.4		P	C	C	
254	1.3		P	D	C	
255	1.8		P	D	C	
256	1.5		P	D	C	
257	1.7		P	C	C	
258	2.0		P	D	C	
259	1.0		P	D	C	
260	5.5		P	E	C	
261	2.8		P	E	C	
262	3.7		P	E	C	
263	1.2		P	E	C	
264	1.3		P	E	C	
265	3.1		P	E	C	
266	1.8		P	E	C	
267	3.1		F	E	C	
268	3.6		P	C	C	
269	1.8		P	E	C	
270	2.1		P	D	C	
271	2.8		P	E	C	
272	2.7		P	D	C	
273	5.0		P	D	C	
274	1.1		P	C	C	
275	2.9		P	D	C	
276	1.7		P	D	C	
277	1.7		P	E	C	
278	2.9		P	E	C	
279	2.9		P	E	C	
280	2.1		P	D	C	
281	2.5		P	D	C	
282	2.1		P	E	C	
283	2.1		P	E	C	
284	1.9		P	E	C	
285	3.3		P	E	C	
286	3.3		P	C	C	
287	1.3		P	D	C	
288	2.9		P	E	C	
289	1.7		P	E	C	

Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington--Continued

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E, >12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Sample description Species	Size	Anal.	Other
290	2.1		P	E	C	
291	2.5		P	E	C	
292	2.1		P	D	C	
Skip to 301						
301	2.1		F	C	W	Growing in Blue Creek
302	3.7		F	D	W	Growing in Blue Creek
303	2.7		F	C	W	Growing in Blue Creek
304	66		P	A	W	By haul road
305	150		P	C	W	Growing in ore pile
306	110		P	E	W	
307	2.6		P	C	W	
308	5.3		P	E	W	
309	33		P	B	W	
309CN	4.6		P	B	W	New cones
309CO	320		P	B	W	Old cones
310	8.2		P	B	W	
311	20		P	C	W	
313	4.3		F	E	W	
314	4.6		P	D	W	
321	3.0		P	E	C	
322	1.8		P	E	C	
323	3.6		P	D	C	
324	4.2		P	D	C	
325	4.0		P	D	C	
326	2.7		P	E	C	
327	7.0		P	D	C	
328	7.6		P	C	C	
329	3.0		P	E	C	
330	8.8		P	B	C	
331	3.8		F	D	C	
332	13		F	D	C	
333	6.2		P	C	C	
334	3.8		P	D	C	
335	4.6		P	D	C	
336	4.6		P	E	C	
337	5.4		F	B	C	
338	2.7		P	D	C	
339	3.0		P	E	C	
340	4.6		F	D	C	
341	3.0		P	E	C	
342	5.0		P	E	C	
343	8.7		P	E	C	
344	2.6		P	E	C	
345	4.6		P	E	C	
346	4.0		P	D	C	
347	8.7		P	D	C	
348	16		P	D	C	
349	7.4		P	D	C	

Table 1.--Analytical data for pine needle, cone, and duff samples from the Midnite mine area, Washington--Continued

[All uranium determinations by fluorimetric procedure. Percent ash not determined on all samples. Key to sample description: Species: P, Ponderosa pine; F, Douglas fir. Size: A, height less than 2 m; B, height 2 to 4.5 m; C, 4.5 to 8 m; D, 8 to 12 m; E, >12 m. Analyst: W, F. N. Ward; C, commercial firm under supervision of F. N. Ward]

Sample no.	U in Ash ppm	Percent Ash	Sample description Species	Size	Anal.	Other
350	18		P	D	C	
351	6.6		P	E	C	
352	11		P	C	C	
353	15		P	E	C	
354	14		P	E	C	resample no. 41
355	56		P	D	C	
356	34		P	D	C	
357	16		P	E	C	
358	23		P	E	C	
359	9.4		P	D	C	
360	9.0		P	E	C	
361	7.8		P	E	C	
362	26		F	C	C	
363	9.4		P	D	C	
364	11		P	E	C	
365	12		P	E	C	
366	4.6		P	E	C	
367	6.2		?	D	C	
368	7.0		P	D	C	
369	9.4		P	D	C	
370	4.6		P	C	C	
371	3.4		P	D	C	
372	12		P	E	C	
373	5.8		P	E	C	
374	3.0		P	D	C	
375	5.0		P	D	C	
376	8.2		P	C	C	
377	8.6		P	D	C	
378	5.8		P	D	C	
379	5.4		P	D	C	
380	5.2		P	E	C	
381	5.8		P	D	C	
382	4.2		P	E	C	
383	.6		P	C	C	
384	5.8		P	C	C	
385	4.2		P	D	C	
386	3.4		P	D	C	
387	2.2		P	C	C	
388	3.4		P	D	C	
389	4.6		P	D	C	
390	1.6		P	D	C	resample no. 71
391	53	5.1	P	E	W	