

Project 720067

W. Dyck,¹ S.H. Whitaker,² and R.A. Campbell¹Introduction

The geological similarities of the Cypress Hills, Saskatchewan and the Gas Hills, Wyoming areas have long been used to postulate the existence of uranium deposits in the first area similar to those in the Gas Hills. Uranium-enriched coal and lignite seams (Cameron and Birmingham, 1970), not unlike those in the Dakotas (Denson and Gill, 1965; Deason, *et al.*, 1959), and radioactive fossil bones (Bell, *et al.*, 1976) in the Cypress Hills lend further support to this hypothesis. However, extensive overburden has made it difficult or impossible to detect uranium mineralization in bedrock by the conventional scintillometer tests of outcrops. Wells penetrate the overburden in many places and therefore can serve as windows to see deeper. The well water orientation survey carried out in the Carboniferous basin of Eastern Canada (Dyck, *et al.*, 1976) has proven to be useful in detecting U and other mineralization.

The orientation survey described in this report, a joint venture of the Geological Survey of Canada, the Saskatchewan Geological Survey, and the Saskatchewan Research Council, is funded by the newly established Federal-Provincial Uranium Reconnaissance Program (Darnley, *et al.*, 1975). The purpose of the survey is to determine regional trends in the U content of ground-water, and by relating these trends to known mineral occurrences, to determine whether such surveys are useful for prospecting.

This report presents some field and field laboratory results obtained mainly from the northeast quarter of map-area 72F and draws tentative conclusions from these results. Complete synthesis of all data including the dissolved gases He and CH₄, other trace elements, and minor constituents will be presented at a later date.

Sampling and Analytical Procedures

Approximately 940 well and 60 spring water samples were collected from a 17 900 km² (6900-square miles) area bounded by boundaries of maps 72F, 72K/1, and 72K/2. On the average, one site per 13 km² was sampled where possible. Depth of well and type of pressure system and material were recorded where available.

In the field laboratory, set up in the skating rink in the town of Eastend, the samples were analyzed for U, Rn, F, O₂, Eh, pH, alkalinity, and conductivity. U was analyzed by the fluorimetric method without removal of U quenching components. Rn was determined

by degassing an 120-ml aliquote into a ZnS (silver activated) cell and measuring the alpha particle emanation rate with a Rn counter. Alkalinity was determined by titrating a 25-ml aliquote to a pH of 4.65 with 0.01N H₂SO₄. F, O₂, Eh, pH, and conductivity were measured with appropriate electrodes. To check on the sampling and analytical precision of the results there was inserted in every group of 17 samples one blank (distilled water), one reference (home-made trace element standard mixture) and one unknown duplicate sample.

Results and Discussion

The ranges of the variables and estimates of backgrounds are listed in Table 47.1. While the U values are appreciably higher and the Rn values lower than those encountered in the Carboniferous basin of Eastern Canada (Dyck, *et al.*, 1976), they are still much lower than the 18 000 ppb U observed in the U ore-bearing Morrison Formation of the Colorado Plateau (Phenix, 1960), or the 200 000 pc/l Rn observed by Harshman in the U-bearing district of Wyoming (Harshman, 1968). Admittedly such highs reflect ore grade environments, hence none of the samples collected in this survey likely came from ore grade environments.

The U and Rn distribution in wells of the northwest quarter of map-area 72F is shown in Figures 47.1 and 47.2 respectively. The geological information for these figures was taken from Whitaker (1966). Contour levels were estimated from the values in Table 47.1. This map-area was sampled earlier in the season. It is the most interesting section geologically and also turned out to be the most populated area of map-area 72F, thus a fairly uniform sample density of 1 per 13 km² could be achieved over most of it. As was discovered during the rest of the season, the remainder of map-area 72F

TABLE 47.1

Ranges and estimated background modes of variables determined in the field

Variable	Dimensions	Range	Background
U	ppb	0.00 - 240.00	0.5
Rn	pc/l	0.00 - 4135.00	250.0
Depth	m	2.00 - 457.00	15.0
F	ppm	0.00 - 4.10	0.2
O ₂	ppm	0.40 - 14.00	3.0
Eh	mv (H ₂ el.)	-127.00 - 906.00	400.0
pH	-	4.86 - 8.82	7.6
Total Alkalinity	ppm (CaCO ₃)	8.00 - 1867.00	300.0
Conductivity	μ mhos/cm	110.00 - 8300.00	900.0

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Figure 47. 1.

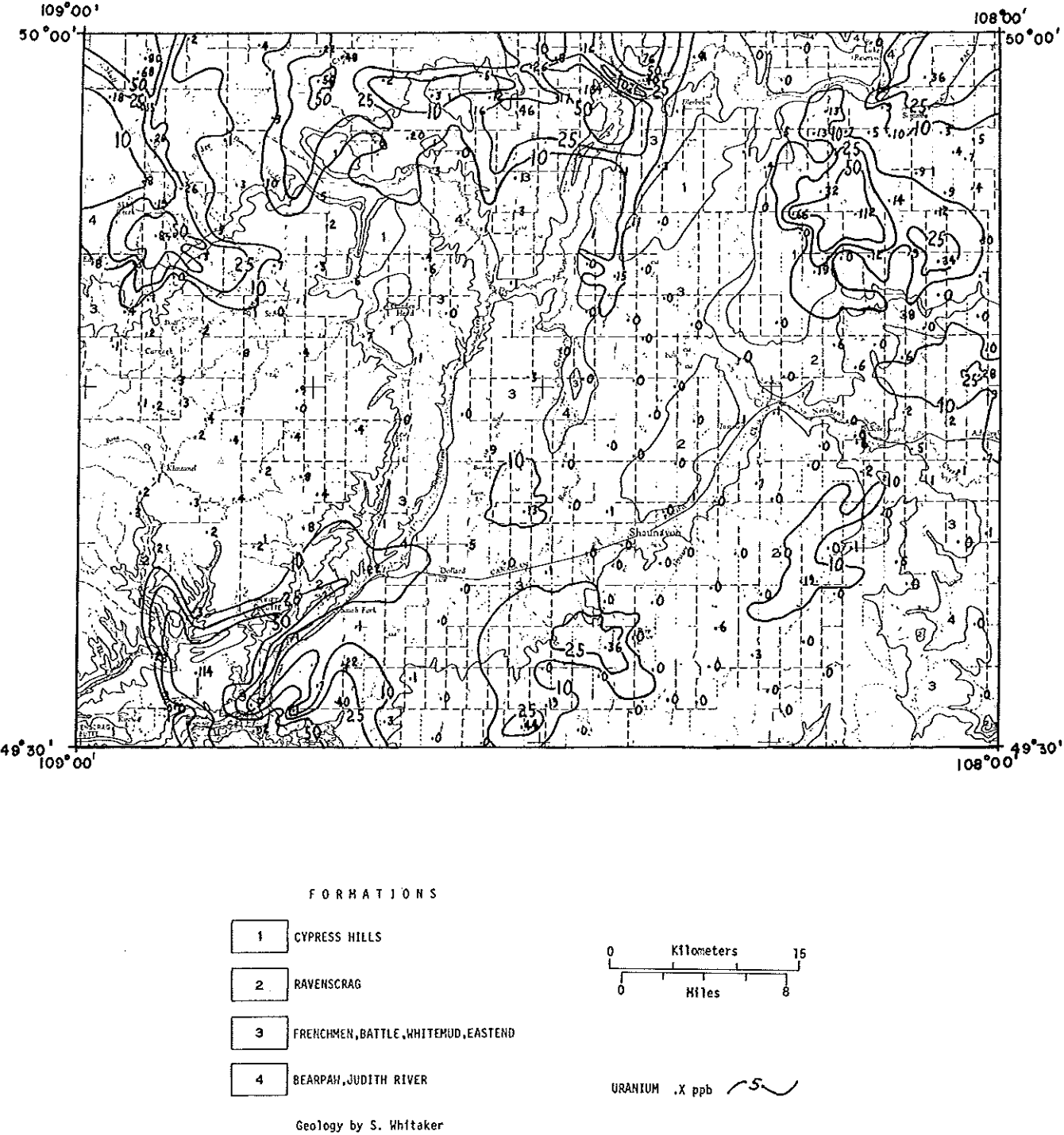


Figure 47. 2.

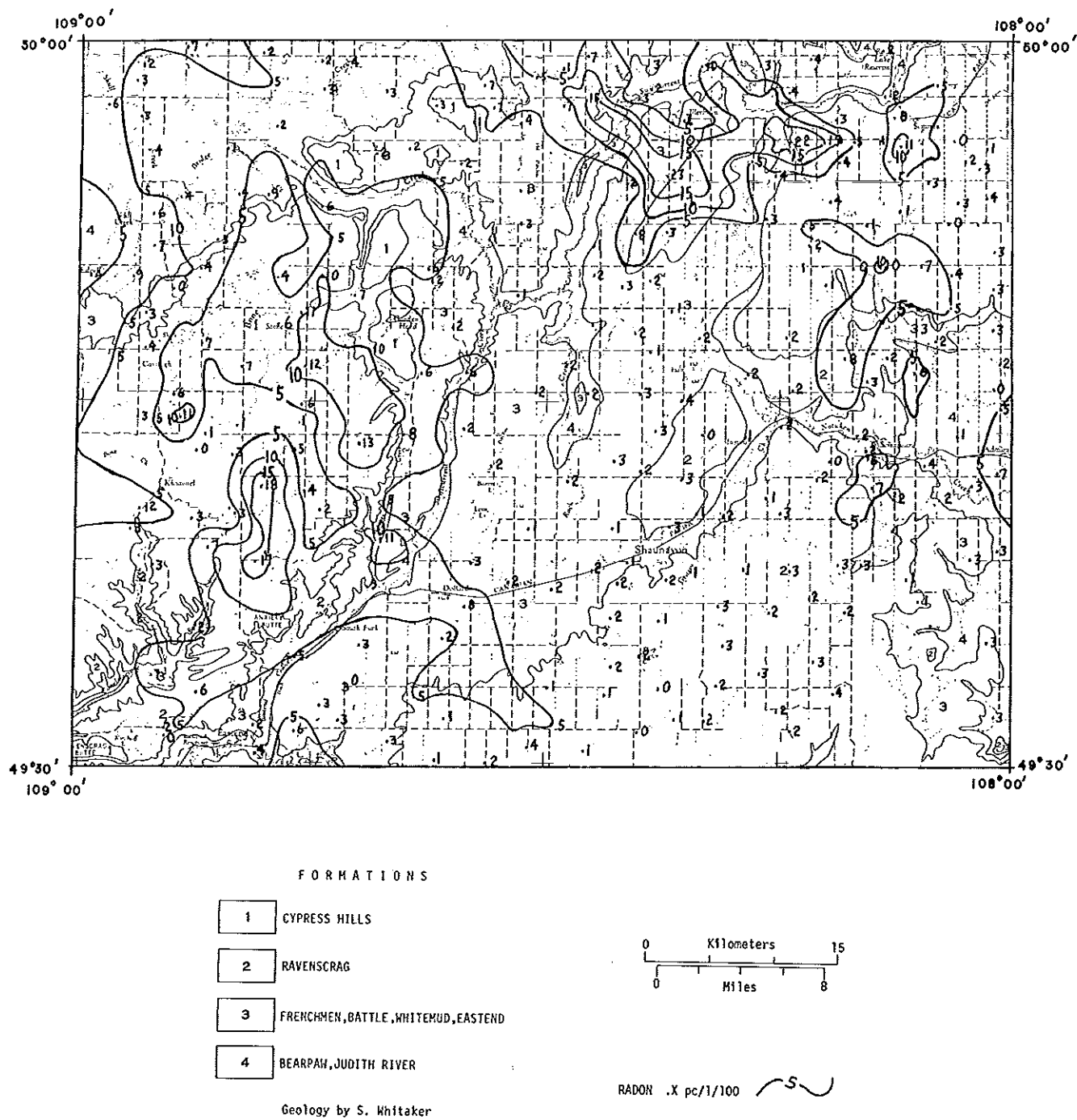


TABLE 47. 2

Comparison of Uranium, Radon and Depth By Rock Formation

A - 12 Deepest Wells compared to 12 Shallowest Wells

Rock Formation	DEEPEST						SHALLOWEST						¹ "t"			PROBABILITY ²		
	Depth		Uranium		Radon		Depth		Uranium		Radon		Depth	U	Rn	Depth	U	Rn
	\bar{X}	S	\bar{X}	S	\bar{X}	S	\bar{X}	S	\bar{X}	S	\bar{X}	S						
Cypress Hills	62.8	11.3	3.8	4.8	493	562	11.7	6.7	20.9	30.9	405	363	13.5	-1.89	0.46	0.00	0.07	0.75
Ravenscrag	92.2	29.3	1.1	2.9	310	229	14.3	5.3	11.0	15.0	564	1135	9.06	-2.23	-0.76	0.00	0.03	0.45
Eastend, Whitemud & Frenchman	53.6	10.5	0.6	0.9	261	199	6.1	1.8	7.13	7.18	451	315	15.5	-3.12	-1.77	0.00	0.00	0.09
Bearpaw	54.5	26.7	7.1	11.3	285	123	5.3	1.6	22.2	26.9	521	259	6.38	-1.80	-2.76	0.00	0.08	0.01

B - 12 Highest U Sites compared to 12 Lowest U Sites

Rock Formation	HIGHEST				LOWEST															
	Depth	U	Rn	S	Depth	U	Rn	S	Depth	U	Rn	S	Depth	U	Rn	S	Depth	U	Rn	S
Cypress Hills	28.2	15.1	30.1	30.9	578	420	53.8	23.5	0.4	0.9	255	159	- 3.17	3.33	2.50	0.00	0.00	0.02		
Ravenscrag	24.4	19.0	31.4	31.4	650	1230	96.9	45.3	0.0	0.0	164	104	- 4.71	3.48	1.37	0.00	0.00	0.17		
Eastend, Whitemud & Frenchman	24.3	23.0	50.7	33.8	429	419	48.2	28.5	0.5	0.9	326	209	- 2.27	5.14	0.76	0.03	0.00	0.45		
Bearpaw	16.0	18.5	45.3	30.0	401	195	65.1	89.8	1.6	1.2	205	92	- 1.86	5.05	3.07	0.08	0.00	0.00		

¹"t" - Test of significance between means²Probability - Of having "t" this large or larger by chance.

was much more sparsely populated with the result that fairly large holes in the sample site pattern are present. To make up for these, at least partially, certain areas were sampled in somewhat greater detail. No distinction has been made between wells and springs in these areas. Most of the springs were located near the edge of the Cypress Hills in the western part of map-area 72F. In general the chemical composition of such waters suggest that a spring can be equated with a shallow well.

Regionally the Rn highs are more closely associated with the Cypress Hills Formation than are the U highs. In the northeast corner of the sample area there is good agreement between the U and Rn highs; in the western part of Figures 47. 1 and 47. 2 the U is displaced to the north and south with respect to the Rn. The short range of Rn in the natural environment relative to U and the high relief in this area suggest that the Cypress Hills Formation is the source of much of this U, but it is migrating in the ground to lower elevations. In the northeast corner where relief is weak, Rn and U highs coincide. Leaching of radioactive lignite seams in the Ravenscrag and older formations by the highly alkaline waters must also contribute to high U values but the extent and location of these, other than at exposed river bank cuts, is not known. The two U anomalies in the southeastern part of Figure 47. 1 seem to be due to such leaching and concentration without an undue rise in the Rn level. A careful analysis and comparison of the results with depth, alkalinity, and location of lignite is required to confirm the above interpretation.

The importance of depth, or rather, the changes in the chemical character of the groundwater with depth, is evident in the results listed in Table 47. 2. Most of the results used in calculating the means listed in Table 47. 2 come from sites within the area portrayed

in Figures 47. 1 and 47. 2. Only in the case where there were fewer than 24 sites available from a rock formation, were sites outside that area included. Both the depth-ranked and the U-ranked results show clearly for all four formations that the deeper wells are lower in U and Rn. The following mechanism could explain this observation: leaching of near-surface material by oxygenated alkaline waters and gradual downward movement of water and dissolved constituents. Since Ra is less mobile than U, less is dissolved and transported. Hence the difference in the Rn values is less pronounced. As the sinking waters enter reducing environments U^{6+} is reduced to U^{4+} and precipitated, resulting in the low U values in the waters from the deepest wells. Lateral transport from the sampled area via intermediate or shallow aquifers could also account for the lack of U at greater depth.

The results in Table 47. 2 also shows that the waters of the two youngest formations, i. e., the Cypress Hills and the Ravenscrag, contain more Rn than the older ones but for U the reverse is evident. One is tempted to conclude from this that the younger formations contain a greater proportion of the U minerals. But there are a number of factors, such as grain size, porosity, Rn emanation efficiency, oxidation potential, alkalinity, U content of the rock, type of U mineral in the rock, etc., that can influence the Rn and U content in the water.

Looking in somewhat more detail at the U and Rn maps one can see U and Rn correspondence at individual sites, but more often there is a lateral shift, with the higher U sites downslope from the high Rn sites. Such drifts can be explained by the different physico-chemical properties of these two elements resulting in different mobilities and ranges.

Conclusions

Regional well water U and Rn surveys in populated areas such as the Cypress Hills, Saskatchewan region are practical in delineating U highs.

Leaching of U from near-surface materials by groundwater and reprecipitation in deeper formations or lateral transport over long distances appear to be active mechanisms of redistribution of U in the area surveyed.

In view of the relatively low Rn levels, the arid climatic conditions of the area, the highly alkaline waters, and the existence of weakly radioactive coals and lignites, none of the U anomalies are strong enough to postulate a significant ore body in the study area. This opinion should be tempered by the preliminary nature of well water geochemistry in the area.

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