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Linear-traverse surveys of helium and radon in soil gas as a guide for uranium exploration, central Weld County, Colorado

By

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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

Linear-traverse surveys of helium and radon in soil gas were performed and evaluated as a guide for uranium exploration in central Weld County, Colo. Repeated sampling over a 5-month period eventually delineated a helium anomaly along the main 11.2 km traverse, and that anomaly may be related to a uranium occurrence. A single traverse is difficult to interpret. A grid sampling pattern, no more time consuming than a repeated linear traverse, is preferred. Radon anomalies along the traverses are from radon-220, the thorium decay series member, and do not show a positive correlation with the helium analyses.

Introduction

A May 13, 1976, reconnaissance survey of helium in soil gas and well water in central Weld County, Colo., revealed an unusually high helium content in several water wells (Reimer and Otton, 1976). Subsequently, helium in soil-gas (HeSG) surveys were run in linear traverses in the vicinity of the well having the highest helium content.

An alpha-particle scintillometer was used for some of the later traverses. The purposes of the surveys were: (1) to see if a HeSG anomaly could be observed in the same region as the helium in well water anomaly, (2) to observe changes of the HeSG values with time, (3) to evaluate the usefulness of a linear traverse relative to a grid sampling survey, and (4) to compare the helium and radon analyses.

A major survey was made on four separate days: June 30, July 22, August 31, and November 24, 1976. Radon in soilgas (RnSG) measurements were incorporated during the July and August surveys. Sample stations generally ranged from 160 to 400 meters apart. A minor survey for HeSG was performed only on November 24, 1976, 4.8 km east and parallel to the major survey.

Techniques

Helium measurements were made on site using the equipment and sampling technique described elsewhere (Reimer, 1976).

The radon measurements were made using an alpha-particle scintillometer. Soil gas was introduced into the open ZnS(Ag) scintillometer cell by hand pumping it through a 0.62-cm inside-diameter plastic hose that was connected to the same sample probe used for extracting the sample for helium analysis. The cell has a volume of about 150 cc, and approximately 500 cc of soil gas was pumped through the cell to flush out the previous sample and to provide a new sample for counting.

Data

The helium values in table 1 were compared to an air standard reference gas and are reported in Leak Detector Units (L.D.U.) with respect to the standard reference. One L.D.U. is about 20 ppb helium-in-air. The helium concentration in the atmosphere has been established as 5239 ±4 ppb (Glueckauf, 1946). All helium analyses are in triplicate; each measurement is compared to the air standard. The values reported in table 1 are the averages of the analyses. The precision of reading the helium measurement from the recorder chart is about 0.25 L.D.U., which is also the reproducibility of measurements.

Table 1.--Helium concentration in soil gas, in Leak Detector Units, for the major north-south traverse

[Asterisk (*) indicates samples taken in the afternoon, all others taken in the morning]

5/13/76		6/30/76		7/22/76		8/13/76		11/24/76	
Sample	Helium	Sample	Helium	Sample	Helium	Sample	Helium	Sample	Helium
[1]112	169	203	0.7	255a	1.0	283	1.0	301	0.6
110	1.4	204	.1	256a	1.0	284	1.4	302	.5
		205	.7	257a	2.0	285	.6	303	1.0
		206	.2	258a	2.5	287	1.8	305	1.0
		209	1.0	261	1.0	288	2.4	306	.9
		211	1.0	263	1.0	289	.9	307	1.4
		212	.6	264	.6	290	1.8	308	1.4
		213	.1	265	.5	292	1.6	309	1.1
		214	1.4	266	.6	293	1.7	310	1.2
		*258	- .5	268	1.0	295	1.0	311	1.3
		215	.9	269	.5	296	.8	312	1.9
		*257	.5	271	- .1	297	.7	313	1.6
		216	1.1	270	.0			314	.7
		*255	.4	273	.2			315	1.5
		217	.6	274	- .8			316	1.0
		*254	1.2	275	- .4				
		218	.9	277	.0				
		*253	.2	278	- .1				
		219	1.3	279	- .3				
		220	1.3						
		221	.9						

[1] Water sample.

Radon concentrations, listed in table 2, are reported as counts-per-minute and are relative values only. The gross count after 1 minute represents contributions from ^{222}Rn (^{238}U daughter) and ^{220}Rn (^{232}Th daughter), whereas the residual count after 5 minutes essentially represents ^{222}Rn only.

Figure 1 shows the distribution of the helium and radon values along the traverse. Statistical comparisons may not be valid owing to variations resulting from different sampling methods for radon and helium.

The helium measurements range from -0.8 L.D.U. to +2.5 L.D.U. The greatest range in sample values taken from the same locality is 1.4 L.D.U. (samples 255a, 288); the average range of sample values from the same locality is 0.7 L.D.U. The higher helium values are located on the southern end of the traverse, the average value for all sample points between 204 and 309 is 1.3 L.D.U., whereas the average for those points north of and including 204 is 0.5 L.D.U.

The radon values are generally higher north of sample 266, and the higher responses are mostly due to ^{220}Rn activity. This high activity delineates a radon anomaly that may be related to thorium-rich heavy-mineral concentrations in shallow channels that occur in the area (Reade, 1976).

A minor north-south traverse, not shown in figure 1, was run parallel to the major traverse on November 24, 1976. The HeSG values are shown in table 3. Samples were collected at 320-m intervals on this 4.8-km traverse. This additional traverse was made to see if high helium values obtained on the major traverse were related to any sedimentary features, such as a channel, that might trend in the direction of groundwater flow. The only trend observed in this traverse is a very gradual decrease in helium values from north to south, but the trend is not significant within the precision of measurement (±0.25 L.D.U.).

Table 2.--Radon concentration in soil gas for the major north-south traverse

[Background has been subtracted. Values are alpha counts per minute. No value reported (--) means no count was made after 5 minutes]

Sample No.	Alpha-count immediately after collection (gross radon)	Alpha-count 5 minutes after sample collection (^{222}Ra only)
	7/22/76	
255a	17	0
256a	49	9
261	180	--
263	45	--
264	143	--
265	97	21
266	25	--
268	214	35
269	283	--
271	377	--
272	320	52
273	81	--
274	193	--
275	98	--
277	347	--
278	260	34
279	288	--
280	190	--

Table 2.--Radon concentration in soil gas for the major north-south traverse--Continued

Sample	Alpha-count immediately after collection (gross radon)	Alpha-count 5 minutes after sample collection (^{222}Ra only)
	8/31/76	
284	49	--
285	105	37
287	69	11
288	21	--
289	8	5
290	90	26
292	80	22
293	230	49
295	171	42
296	85	8
297	140	39

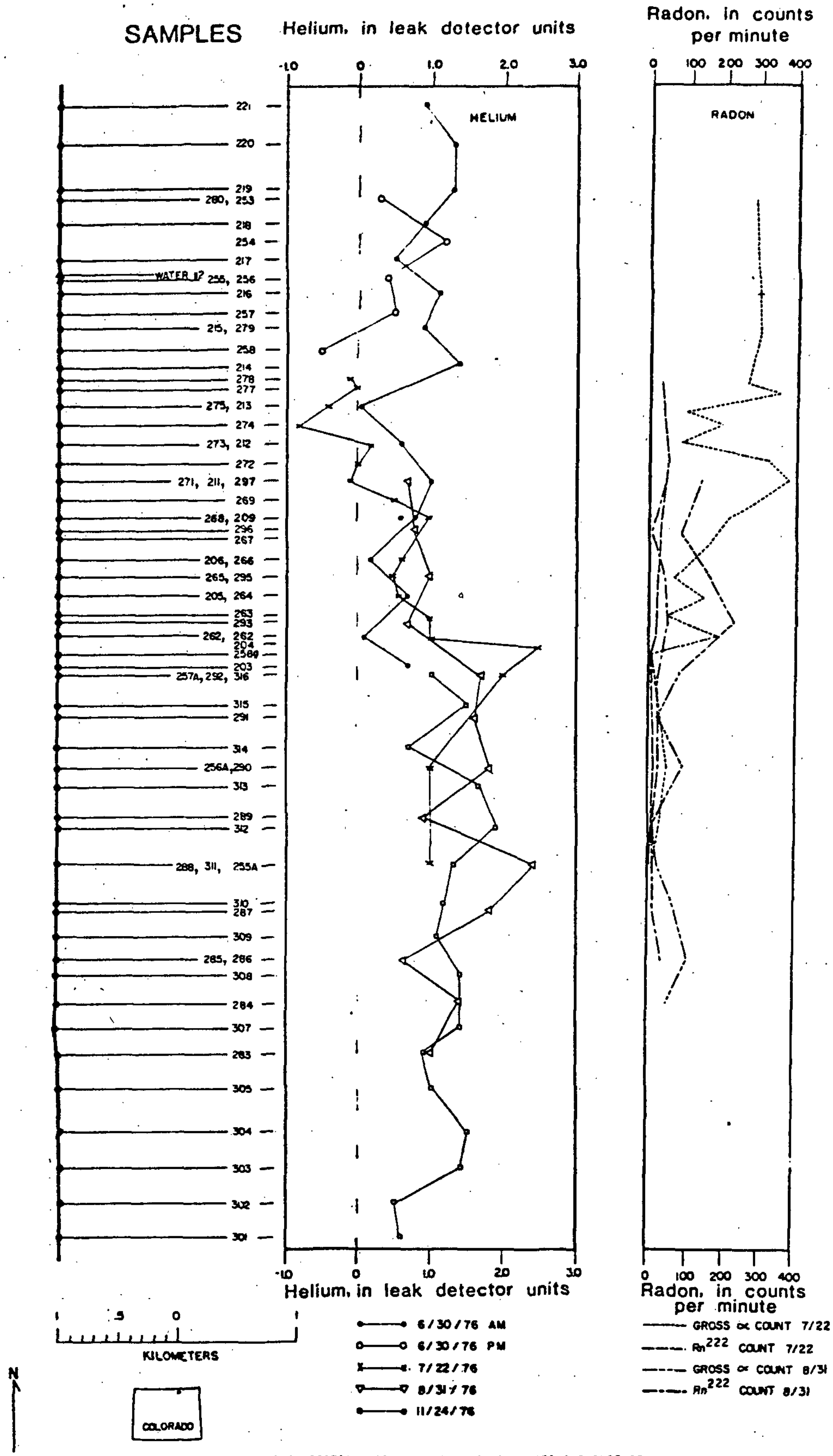

FIGURE 1--SAMPLE LOCATION MAP OF MAJOR TRAVERSE AREA AND PLOT OF HELIUM AND RADON VALUES, WELD COUNTY, COLORADO.

Table 3.--Helium concentration in soil gas in Leak Detector Units for the minor north-south traverse run on November 24, 1976

Sample No.	Helium in soil gas (±0.5 L.D.U.)
330	0.7
331	1.2
332	.9
333	.6
334	.9
335	1.1
336	1.1
337	.6
338	- .1
339	.5
340	.4
341	.4
342	.4
343	.3
344	.1
345	.4

Discussion

The mechanism of helium transport and entrapment is unknown, and any single value or traverse may reflect unknown sedimentary effects, differences in soil porosity, moisture content, barometric pressure, or other factors (Reimer and others, 1976; Reimer and Adkisson, 1977); and, of course, a background value is difficult to establish. Repetitive traverse measurements, closely spaced, over a period of time seem to produce a general pattern that may have some meaning. A grid pattern for sampling, as performed over a known uranium occurrence, also located in central Weld County, did show a pattern of high HeSG values associated with that deposit (Reimer and Otton, 1976). If a similar interpretation of data as done in that report is applied to this survey, the high HeSG values in the southern part of the major traverse would suggest a uranium occurrence in a direction opposite to the direction of groundwater flow, that is, in a north-northwesterly direction. An interpretation cannot be made from these data whether or not the helium response is caused by a uranium deposit of high-grade or by a diffuse, low-grade uranium occurrence. No pronounced HeSG anomaly was found in the vicinity of the domestic well that had such a high helium concentration.

Summary

The preliminary conclusions of this study are that a single-line traverse of HeSG measurements is difficult to interpret, a survey over a known uranium occurrence 10 km from this study provides an aid to evaluating the data presented in this report, the high helium concentration in groundwater is not necessarily related to high HeSG values, the gross radon distribution along this traverse is not directly related to the HeSG values, and the greatest contribution to the radon activity of the samples collected in this study is from ^{220}Rn, the radon daughter of thorium.

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