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GEOLOGICAL SURVEY

Reconnaissance survey of the helium content of soil gas in Black Hawk, Eldorado Springs, Evergreen, Golden, Morrison, Ralston Buttes, and Squaw Pass quadrangles, Colorado

Jefferson

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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Reconnaissance Survey of the Helium Content of Soil Gas in Black Hawk, Eldorado Springs, Evergreen, Golden, Morrison, Ralston Buttes and Squaw Pass quadrangles, Colorado

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ABSTRACT

A reconnaissance survey of the helium content of soil gas was performed in parts of Black Hawk, Eldorado Springs, Evergreen, Golden, Morrison, Ralston Buttes, and Squaw Pass quadrangles, Colorado. The intent of this survey was to obtain initial background information on the gross effects of structure, underlying rock type, and soil moisture content on the helium content of the soil gas. Sample localities were adjacent to roads and trails. The results, tentatively categorized as qualitative, suggest that structure and soil moisture content have pronounced observable effects, whereas effects of rock type could not be recognized in this study.

INTRODUCTION

A reconnaissance study of the helium content of soil gas in parts of Black Hawk, Eldorado Springs, Evergreen, Golden, Morrison, Ralston Buttes, and Squaw Pass quadrangles, Colorado, was performed mainly during March-June 1976. The intent of the survey was to obtain background information on the effects of structure, underlying rock type, and soil moisture content on the helium content of the soil gas. The analytical system used has been described elsewhere (Reimer, 1976). Samples of soil gas collected in plastic syringes, were withdrawn from a probe that had been driven 60 cm into the soil. The syringe needles were then hermetically capped and stored for several hours prior to analysis. The capped syringes have been shown to lose only insignificant amounts of helium under these conditions (E. H. Denton, oral commun., 1976). All sample localities are adjacent to roads and trails (fig. 1) and were selected, in part, because of various identifiable structural features indicated on a geologic map (Scott, 1972; Sheridan and others, 1967, 1972; Taylor, 1975).

DATA

The helium-in-soil-gas data are presented in tables 1 and 3. The values are reported in Leak Detector Units (L.D.U.), where 1 L.D.U. equals about 20 parts per billion helium in air with respect to the ambient air concentration (5,239 4 ppb; Glueckauf, 1951). One L.D.U. is slightly greater than the sensitivity limit of the instrument.

Table 2 contains helium values from various sample groupings. These groupings are (1) near faults, samples taken within 0.5 km of

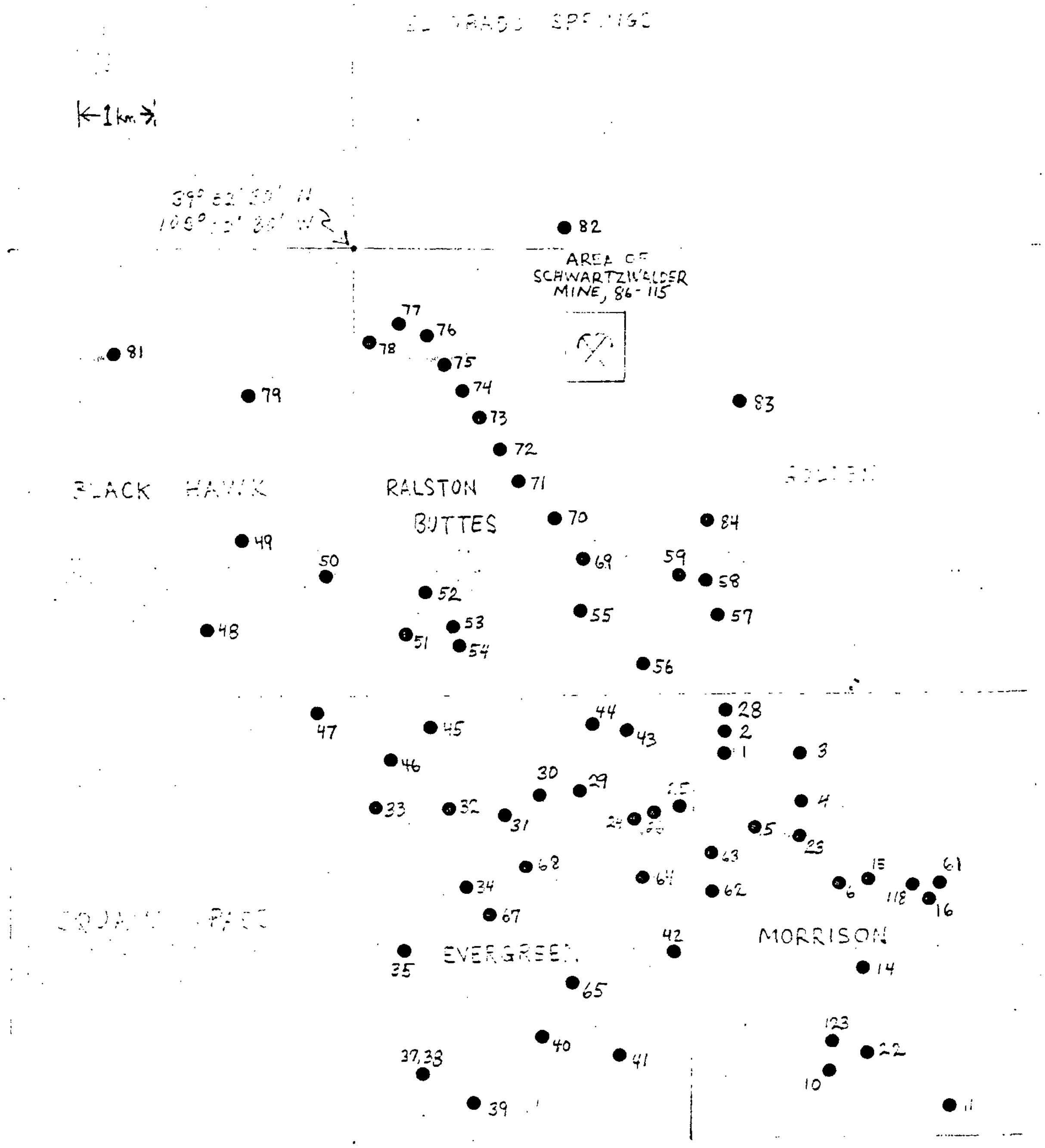

Figure 1.--Location of helium-in-soil gas sample localities, represented by dots and sample numbers, in Black Hawk, Eldorado Springs, Evergreen, Golden, Morrison, Ralston Buttes, and Squaw Pass quadrangles, Colorado. Samples 86-115 were taken from the vicinity of the Schwartzwalder uranium mine (Ralston Buttes quadrangle); these sample localities are shown on figure 2.

Table 1.--Location and analysis of the helium-in-soil-gas samples.

[In some cases, sample numbers have been reassigned from the original field number to permit the grouping of repetitive samples. The numbering sequence is therefore discontinuous. Samples 86-115 from the Schwartzwalder uranium mine in the Ralston Buttes quadrangle are excluded from this table; their locations are indicated on figure 2]

Sample No.	Date collected (1976)	Quadrangle	Latitude N.	Longitude W.	Helium values in L.D.U.	
1	3/31	Morrison	39°43'44"	105°14'20"	1	
2	3/31	--do----	39°42'33"	105°14'22"	1	
3	3/31	--do----	39°42'33"	105°12'36"	0	
4	3/31	--do----	39°42'34"	105°12'17"	2	
5	3/31	--do----	39°41'55"	105°13'42"	1	
6	3/30	--do----	39°40'53"	105°11'54"	3	
11	3/30	--do----	39°38'07"	105°09'22"	3	
14A	3/30	--do----	39°39'55"	105°11'06"	2	
14B	5/24	--do----	39°39'55"	105°11'06"	3	
14C	6/3	--do----	39°39'55"	105°11'06"	2	
15	3/30	--do----	39°41'05"	105°11'01"	2	
16A	3/30	--do----	39°40'55"	105°10'38"	4	
16B	4/5	--do----	39°40'55"	105°10'38"	0	(AIR)
16C	5/24	--do----	39°40'55"	105°10'38"	2	
16D	6/3	--do----	39°40'55"	105°10'38"	0	
22	3/30	--do----	39°38'41"	105°10'36"	2	
23	3/30	--do----	39°41'54"	105°12'11"	2	
24A	3/31	Evergreen	39°42'48"	105°16'00"	3	
24B	5/24	--do----	39°42'48"	105°16'00"	4	
24C	6/3	--do----	39°42'48"	105°16'00"	3	
25A	3/31	--do----	39°42'43"	105°15'19"	1	
25B	5/24	--do----	39°42'43"	105°15'19"	1	
25C	6/3	--do----	39°42'43"	105°15'19"	2	
26A	3/31	--do----	39°42'51"	105°15'33"	1	
26B	5/24	--do----	39°42'51"	105°15'33"	0	
26C	6/3	--do----	39°42'51"	105°15'33"	0	
28	3/31	Morrison	39°44'54"	105°14'22"	1	
29	4/1	Evergreen	39°43'06"	105°17'33"	0	
30	4/1	--do----	39°42'58"	105°18'38"	2	
31	4/1	--do----	39°42'49"	105°19'28"	0	
32	4/1	--do----	39°42'53"	105°20'42"	1	
33	4/1	--do----	39°44'05"	105°22'24"	3	

Table 1.--Location and analysis of the helium-in-soil-gas samples--continued.

Sample No.	Date collected (1976)	Quadrangle	Latitude N.	Longitude W.	Helium values in L.D.U.
34A	4/1	Evergreen	39°41'25"	105°20'21"	0
34B	5/24	--do----	39°41'25"	105°20'21"	1
35A	4/1	--do----	39°40'29"	105°21'49"	1
35B	5/24	--do----	39°40'29"	105°21'49"	1
35C	6/3	--do----	39°40'29"	105°21'49"	3
36	4/1	--do----	--do----	--do----	0 (AIR)
37	4/1	--do----	39°38'36"	105°21'20"	1
38	4/1	--do----	39°38'31"	105°21'15"	1
39	4/1	--do----	39°37'58"	105°20'24"	0
40	4/1	--do----	39°39'15"	105°18'21"	0
41	4/1	--do----	39°38'20"	105°17'20"	0
42A	4/1	--do----	39°40'06"	105°15'16"	0
42B	6/3	--do----	39°40'06"	105°15'16"	4
42C	5/24	--do----	39°41'27"	105°15'16"	2
42D	6/3	--do----	39°41'27"	105°15'16"	0
43	4/2	Evergreen	39°44'10"	105°16'36"	1
44	4/2	--do----	39°44'33"	105°17'06"	1
45	4/2	--do----	39°44'32"	105°20'59"	1
46	4/2	--do----	39°44'06"	105°21'37"	1
47	4/2	Squaw Pass	39°44'10"	105°23'07"	1
48	4/2	Black Hawk	39°45'40"	105°24'47"	1
49	4/2	--do----	39°47'41"	105°24'28"	1
50	4/2	--do----	39°46'44"	105°22'53"	0
51	4/2	Ralston Buttes	39°46'55"	105°21'19"	0
52	4/2	--do----	39°47'51"	105°21'30"	0
53	4/2	--do----	39°47'08"	105°20'10"	0
54	4/2	--do----	39°46'59"	105°19'46"	0
55	4/2	--do----	39°46'46"	105°17'17"	0
56	4/2	--do----	39°46'11"	105°15'32"	0
57	9/2	Golden	39°46'21"	105°14'45"	0
58A	9/2	--do----	39°48'00"	105°14'49"	2
58B	5/24	--do----	39°48'00"	105°14'49"	3
58C	5/24	--do----	39°48'00"	105°14'49"	3
58D	5/24	--do----	39°48'00"	105°14'49"	2
58E	6/3	--do----	39°48'00"	105°14'49"	3
59	9/2	Ralston Buttes	39°48'20"	105°15'10"	0
61	4/5	Morrison	39°41'06"	105°10'35"	0
62	4/5	--do----	39°40'50"	105°14'31"	0
63	4/5	--do----	39°41'09"	105°14'12"	0
64	4/5	Evergreen	39°41'40"	105°15'41"	1

Table 1.--Location and analysis of the helium-in-soil-gas samples--continued.

Sample No.	Date collected (1976)	Quadrangle	Latitude N.	Longitude W.	Helium value in L.D.U.	
65A	4/5	Evergreen	39°40'00"	105 17'54"	0	
65B	4/5	--do----	39°40'00"	105°17'54"	0	(AIR)
65C	5/24	--do----	39°41'14"	105°17'54"	2	
65D	6/3	--do----	39°41'14"	105°17'54"	0	
67	4/5	Evergreen	39°41'01"	105°19'46"	0	
68	4/5	--do----	39°41'31"	105°19'14"	1	
69	4/6	Ralston Buttes	39°47'15"	105°17'11"	0	
70	4/6	--do----	39°47'41"	105°17'35"	0	
71	4/6	--do----	39°48'16"	105°17'57"	0	
72	4/6	--do----	39°41'14"	105°18'43"	0	
73	4/6	--do----	39°50'08"	105°19'49"	0	
74	4/6	--do----	39°50'44"	105°20'16"	0	
75	4/6	--do----	39°50'54"	105°20'31"	2	
76	4/6	--do----	39°51'02"	105°20'40"	0	
77	4/6	--do----	39°51'03"	105°21'08"	0	
78	4/6	--do----	39°50'48"	105°21'42"	0	
79	4/6	Black Hawk	39°49'59"	105°24'29"	2	
80	4/6	--do----	39°50'27"	105°27'57"	0	(AIR)
81	4/6	--do----	39°50'27"	105°27'57"	3	
82	4/6	Eldorado Springs	39°53'03"	105°18'07"	2	
83	4/6	Golden	39°50'35"	105°14'02"	0	
84	4/6	--do----	39°47'50"	105°14'45"	2	
85	4/6	--do----	39°47'50"	105°14'45"	0	(AIR)
117	5/24	Morrison	39°41'06"	105°10'56"	1	
118	5/24	--do----	39°40'59"	105°11'05"	1	
123	5/24	--do----	39°39'41"	105°11'45"	1	

Table 2.--Sample locality groups showing wet or dry conditions during sampling and helium values

[W indicates wet soil conditions; D indicates dry soil conditions. Helium values are in Leak Detector Units (L.D.U.)]

Near faults

Sample	Condition	Helium (L.D.U.)
24A	W	3
24B	D	4
24C	W	1
25A	W	1
25B	W	1
25C	W	2
25D	W	1
26A	W	1
26B	W	1
26C	D	0
42A	D	0
42B	D	4
42C	W	2
42D	D	0

Traverses across faults

Sample	Condition	Helium (L.D.U.)
24A	W	3
25A	W	1
26A	W	1
74	D	0
75	D	2
76	D	0
81	D	3
24B	W	4
26B	W	0
25B	W	1
24C	W	3
142	D	1
26C	D	0
25C	W	2

Other replicate samples

Sample	Condition	Helium (L.D.U.)
34A	D	0
34B	W	1
35A	D	1
35B	D	1
35C	W	3
58A	D	2
58B	W	3
58C	W	3
58D	W	2
16A	W	4
16B	(Air)	0
16C	W	2
16D	D	0
65A	D	0
65B	D	0
65C	W	2
65D	D	0
14A	W	2
14B	W	3
14C	D	2

Schwartzwalder mine

Sample	Condition	Helium (L.D.U.)	Sample	Condition	Helium (L.D.U.)
86	D	0	105	W	0
87	D	1	106	W	2
88	D	0	107	W	9
89	D	1	108	W	1
90	D	0	109	W	2
91	D	0	110	W	1
92	D	2	111	W	1
93	D	1	112	W	3
94	D	1	113	W	1
95	D	0	114	W	1
96	D	0	115	W	0
97	D	1			
98	D	0			
99	D	0			
100	D	0			
101	D	1			
102	D	0			
103	D	1			
104	D	0			

Table 3.--Precipitation for the Denver area for March, April, May, and June 1976 (from the National Weather Service, Stapleton International Airport.

[Trace is less than 0.01 inch. Dates not listed have no measureable precipitation]

March		April		May		June	
2	0.19	5	0.02	3	trace	1	0.21
3	.06	6	.02	5	.01	3	.01
4	.20	7	.01	6	.05	4	.01
11	trace	12	trace	7	.01	6	trace
12	.04	15	.03	8	trace	7	trace
14	.06	16	trace	9	trace	8	trace
15	.09	17	.35	10	trace	9	trace
25	.17	19	.01	11	.01	17	.12
26	trace	23	.03	12	trace	18	.18
28	.47	26	.01	15	.05	22	.01
29	.06	27	.25	16	trace	23	.09
		28	.01	19	trace	24	trace
		29	.16	20	.01	30	trace
		30	.37	21	.56		
				22	.36		
				23	trace		
				24	.15		
				25	.10		
				28	trace		
				29	.02		
				30	.01		

a known fault; (2) traverses across faults, samples intentionally collected to traverse a known fault; (3) other replicate samples, taken within 3 m of each other on different days; and (d) Schwartzwalder mine, samples taken within a 1-km^2 area around the mine. Figure 2 shows approximate locations and the helium-in-soil-gas values for samples collected in the vicinity of the mine. Samples 85-104 were collected at the Schwartzwalder uranium mine during August 1975, and samples 105-115 were collected in June 1976. The August 1975 samples were analyzed using a different inlet system than that used for all the other samples, and the helium values may represent a lower sensitivity. Values from these two groups, therefore, should not be directly compared.

Table 3 presents the official precipitation recorded in Denver for March, April, May, and June 1976. Precipitation in the spring generally covers a wide area, although local amounts can vary considerably.

DISCUSSION

General observations of helium behavior in soil gas can be made from the results of the reconnaissance study. The range of helium-in-soil-gas values in this study is from 0 to 9 L.D.U. The average value for all 128 soil-gas samples is 1.1 L.D.U. The variation in helium values of gas samples taken from soil overlying one type of bedrock is as great as for any other type of bedrock.

Six sample localities were sampled repetitively to determine if environmental factors, such as soil moisture, affected the helium concentration. A marked difference between wet and dry soil conditions was observed: higher average helium values were associated with wet conditions (2.6 L.D.U.) than with dry conditions (0.6 L.D.U.). The wet/dry association of helium in soil gas was also observed in a study in the vicinity of a uranium roll deposit in Weld County, Colorado (Reimer and Otton, 1976). Samples collected in May, June, and July were from the same Weld County area. Only a trace of rainfall occurred at any one time in that area. In that study, the average helium content during dry conditions was about 1 L.D.U. lower than in wetter (spring) conditions. The samples collected within 0.5 km of known faults did have a slightly higher average helium concentration (1.3 L.D.U.) than those collected in areas not known to have any faulting (1.1 L.D.U.), regardless of the wet or dry conditions. However, in each of the traverses taken over known faults at least one sample showed a significantly higher than average helium-in-soil-gas content.

The Schwartzwalder uranium mine area (fig. 2) had the highest helium-in-soil-gas value recorded in this study; it was 9 L.D.U. for wet conditions and may be a result of sampling over a fault

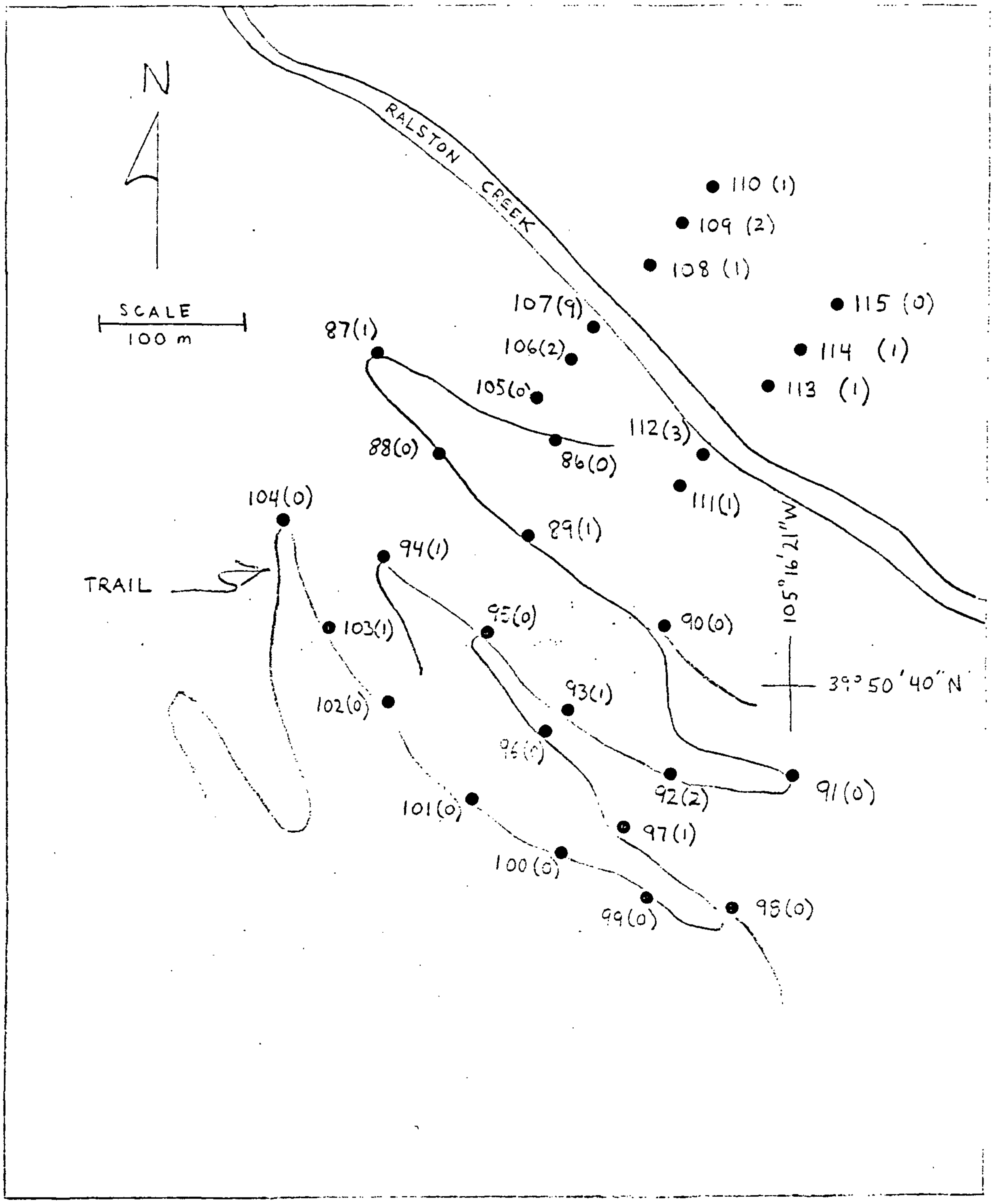

Figure 2.--Location of samples 86 through 115, taken at the Schwartz-walder uranium mine, Ralston Buttes quadrangle, Colorado. Helium values, in Leak Detector Units, are in parentheses adjacent to the sample locality number.

(E. J. Young, oral commun., 1976). Soil-gas values from the June 1976 study at the Schwartzwalder uranium mine averaged higher (1.9 L.D.U.) than the general helium-in-soil-gas background values (1.1 L.D.U.), but may represent the effects imposed by wet soil conditions and local faults.

SUMMARY

In general, a systematic relationship appears to exist between soil moisture and the helium content of soil gas. Higher helium contents are associated with wetter soil conditions. Two possible explanations are that the water may be either filling pore spaces directly or swelling the clays that may be present in the soil, thereby temporarily altering the rate at which helium in soil gas mixes with the atmosphere.

High helium values are recorded at some known faults and suggest that faulted zones may act as a channel for helium flow from depth. The relationship between helium-in-soil-gas values and underlying rock type is not clear from this study. The range of helium values is not great, and the variation over any one type of bedrock is as great as over any other type of bedrock. Soil type and soil moisture content may be the primary factors controlling helium content. Data will continue to be collected and analyzed to determine if a relationship exists between helium-in-soil-gas background values and type of bedrock.

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