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Tabulation of meteorological variables and concentrations of helium, carbon dioxide, oxygen, and nitrogen in soil gases collected regularly from a site at Reston, Virginia, for one year

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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CONTENTS

TABLES

ABSTRACT

Concentrations of helium, carbon dioxide, oxygen, and nitrogen were measured over a period of 1 year from a single site at Reston, Virginia. Samples of soil gases were collected from a hollow probe at 0.75-m depth and from a hemisphere on the ground surface. Soil temperature, air temperature, percent humidity, barometric pressure, rain, and snowfall were also measured. Sampling and analysis of the soil gases are described and gas and meteorological measurements are listed.

INTRODUCTION

Measurement of volatile species in soil gases is often used in geochemical exploration for buried or blind ore deposits. Anomalies in concentrations of various volatile species detected in surficial soil gases may result from chemical reactions that occur during the process of weathering of ore and gangue minerals. However, interpretation of these anomalies is not always straightforward. For example, soil moisture and high concentrations of carbon dioxide in a soil gas sample may affect the concentrations of helium measured (Hinkle and Ryder, 1987). Meteorological changes also affect the concentrations of gases measured (Reimer, 1979; McCarthy and Reimer, 1986).

Hinkle and Ryder (1988) determined that soil and air temperatures have the greatest affect on concentrations of helium and carbon dioxide in the semi-arid environment of Denver, Colorado. The purpose of this study was to determine which meteorological conditions affect concentrations of helium, carbon dioxide, oxygen, and nitrogen in soil gases in a nonmineralized area in a more humid environment. Reston, Virginia, was selected for this study because it receives slightly more than twice the amount of rainfall as Denver (90-100 cm per year compared to 35-45 cm per year). The study was carried out in a wooded area on the grounds of the U.S. Geological Survey in Reston, from September 28, 1987, to October 7, 1988.

This report lists the sampling and analytical methods used in the study and the meteorological and gas concentrations measured. The report does not provide an interpretation of the results of the measurements.

SAMPLE COLLECTION AND ANALYSIS

Samples were collected (1) from a hollow probe driven 0.75 m into the ground, and (2) from a clear plastic hemisphere emplaced on the ground surface adjacent to the probe. The hollow probe used in this study was described by Reimer and Bowles (1979) and has been widely used in collecting soil gas samples. Use of the clear plastic hemisphere was described by McCarthy (1972).

The hollow probe was driven 0.75 m into the ground by means of a sliding hammer attached to the shaft of the probe. After it was driven into the ground, the probe was fitted with an air tight cap and septum for withdrawal of the soil gas sample. A PVC pipe was placed over the probe and cap, and the pipe was covered with an inverted plastic beaker to protect the probe from the weather. A small plastic tube about 5 mm in diameter was implanted in the top of the hemisphere for removal of the soil gas sample, and a plastic beaker was placed over the top of the tube to prevent rain and snow from entering it. Soil was packed around the base of the hemisphere. The air in the hemisphere was primarily surficial soil gas, but also contained atmospheric air which entered through the 5-mm open tube. Both the probe and the hemisphere were left inplace for the duration of the study.

Before removal of the first sample, 10 ml of air were withdrawn from the probe to remove air introduced when the probe was emplaced in the ground; 10 ml of air were also removed from the probe whenever the rubber septum was changed, approximately every 4 months, to remove air introduced during this operation. All soil gas samples had equilibrated for a minimum of 24 hours before collection. Samples were collected from the hollow probe by inserting the needle of a syringe through the septum in the cap and withdrawing 10 cc of the soil gas. Samples were collected from the hemisphere by withdrawing 10 cc of the surficial soil gas through the hollow tube in the top of the hemisphere into the syringe. The soil gas samples were transferred to evacuated blood sampling tubes for storage, by inserting the needle of the syringe containing the gas sample through the rubber cap of the evacuated tube and allowing the sample in the syringe to be drawn inside. The needle hole was covered with silicone glue. Soil gas samples can be stored in these evacuated tubes for as long as 2 months without leakage (Hinkle and Kilburn, 1979).

Barometric pressure was measured by a barometer located inside the building. Air temperature and relative humidity were measured by thermometer and humidity gauge outdoors. Soil temperature was measured by a metal dial-type thermometer, with the tip of the thermometer stem buried at 20-cm depth in the ground adjacent to the probe. Soil moisture was measured indirectly, as amounts of rain and snowfall. Rainfall was measured by a rain gauge attached to the plastic pipe protecting the probe. The depth of snow lying on the ground was measured with a ruler.

Gas in the vials was removed by injecting a volume of air equal to the volume of the vial into the vial and removing the mixture of air and soil gas. The samples were analyzed for helium using mass spectrometry (Reimer and Denton, 1978). Standard samples of air containing known concentrations of helium were run several times per day to insure stability of the instrument. Concentrations of helium were reported as differences compared to the concentration of helium in air; these differences were positive or negative, depending on whether the measured concentration was above or below the concentration of helium in air (5,240 parts per billion) (Glueckhauf, 1946; Oliver and others, 1984). The reproducibility of determination was 20 to 30 ppb above or below the concentration of helium in air. The tubes used for sample storage were approximately 80 percent evacuated. They contained a residual concentration of helium, introduced during the manufacturing process, that was the same for all the tubes in each lot produced by the manufacturer. This residual helium concentration was measured and subtracted from the raw measurement of helium in soil gas.

Samples were analyzed for carbon dioxide, oxygen, and nitrogen using gas chromatography; operating conditions for the gas chromatograph are shown in table 1. Concentrations of carbon dioxide, oxygen, and nitrogen were measured compared to standard curves, and are reported as volume percents of the total gas sample. Standard samples containing known concentrations of CO_2, O_2, and N_2 were analyzed several times per day to insure stability of the instrument.

DESCRIPTION OF DATA TABLES

Data from the analyses were entered into an IBM personal computer and stored on disks, using STATPAC programs developed for personal computers by the U.S. Geological Survey (1986). Data for all measurements obtained during the study are listed in table 2.

Data listed in table 2 include: date of sample collection, number of days after start of sample collection, time of day of collection (standard

time), soil temperature (°C), air temperature (°C), percent humidity, rainfall (cm), snowfall (cm), barometric pressure (cm), percent CO_2, O_2, and N_2 (probe), ppb He above or below the concentration of He in air (probe), percent CO_2, O_2, and N_2 (hemisphere), and ppb He above or below the concentration of He in air (hemisphere). The letter "b" in the data table indicates that no analysis was performed for that particular parameter.

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Table 1. Operating conditions for the gas chromatograph

Type of gas chromatograph	Carle AGC-100
Detector	thermistor detector
Lower limit of detection	0.03% CO2/approximately 0.1% O2 and 1.0% N2 (vol/vol)
Reproducibility	+/- 10%
Column	concentric stainless steel, outer column 72 in x 1/4 in molecular sieve inner column 72 in x 1/8 in porapak mixture (Alltech Associates, Deerfield, IL)
Carrier gas	helium at 90 mL/minute
Temperature	column: 60 °C detector: "low" mode

Table 2. Data for Soil Gases and Meteorology

Sample	Day	Date	Time of Day	Soil Temp.(C)	Air Temp.(C)	Humid(%)	Rain(cm)	Snow(cm)	BarP(cm)	%N2-p	%O2-p
1	1	91687	1230	20.0	23.0	82	10.16	0.00	75.41	75.6	21.9
2	6	92187	1205	20.0	23.5	66	1.27	0.00	75.34	76.1	22.4
3	7	92287	1410	20.0	22.0	55	0.00	0.00	75.21	75.0	21.7
4	8	92387	1310	19.5	22.0	21	0.00	0.00	75.18	b	20.2
5	9	92487	1300	18.5	25.0	50	0.00	0.00	75.08	b	19.5
6	13	92887	1250	20.0	21.5	40	0.00	0.00	76.20	77.9	21.4
7	14	92987	1215	20.0	22.5	52	0.00	0.00	75.46	76.4	21.1
8	15	93087	1320	19.0	20.5	47	0.13	0.00	76.20	78.7	21.3
9	16	100187	1300	18.5	16.5	52	0.00	0.00	76.20	78.7	21.5
10	20	100587	1230	17.0	21.5	36	2.03	0.00	75.44	76.2	21.7
11	21	100687	1230	17.5	20.0	42	0.00	0.00	74.90	75.4	21.4
12	22	100787	1230	15.0	17.0	46	0.38	0.00	74.80	75.8	21.5
13	23	100887	1255	14.0	14.0	50	0.00	0.00	75.64	76.8	21.6
14	29	101487	1230	12.0	16.0	30	0.00	0.00	76.20	75.2	20.5
15	30	101587	1300	13.0	20.0	41	0.00	0.00	76.15	74.6	21.2
16	34	101987	1230	14.0	22.0	31	0.00	0.00	75.41	77.5	20.5
17	35	102087	1230	15.0	20.0	55	0.00	0.00	75.34	78.6	21.0
18	36	102187	1230	14.0	13.5	33	0.01	0.00	75.44	78.6	20.7
19	37	102287	1300	12.0	14.0	38	0.00	0.00	76.20	77.9	20.8
20	41	102687	1400	13.0	15.0	15	0.00	0.00	75.95	78.0	21.4
21	42	102787	1400	11.0	15.0	100	1.02	0.00	75.11	77.9	20.7
22	43	102887	1330	12.0	14.5	36	2.03	0.00	75.26	78.0	20.1
23	44	102987	1330	12.0	14.0	46	0.00	0.00	75.59	77.7	b
24	49	110387	1130	13.0	23.0	56	0.00	0.00	75.95	78.4	19.9
25	50	110487	1410	13.0	22.0	41	0.00	0.00	76.20	78.5	19.9
26	51	110587	1400	15.0	17.0	43	0.00	0.00	76.20	78.3	19.9
27	52	110687	1230	11.0	11.0	32	0.00	0.00	75.95	77.8	20.2
28	56	111087	1345	10.0	10.0	100	5.08	0.00	75.44	76.9	20.2
29	58	111287	1345	7.0	10.0	48	10.16	7.62	75.31	73.8	19.6
30	62	111687	1245	10.0	18.0	30	0.00	0.00	76.78	67.2	17.8
31	64	111887	1410	13.0	18.0	44	2.54	0.00	75.79	74.0	20.0
32	65	111987	1400	10.0	14.0	54	0.00	0.00	75.95	77.9	20.9
33	66	112087	830	10.0	12.5	66	0.00	0.00	74.88	77.6	20.8
34	69	112387	1310	9.0	11.0	34	0.00	0.00	76.12	80.1	b
35	70	112487	1605	10.0	17.5	61	0.00	0.00	78.74	76.6	21.5
36	71	112587	1145	10.0	19.0	61	0.00	0.00	76.20	76.7	21.0
37	76	113087	1340	9.0	12.0	66	5.33	0.00	74.60	b	b
38	77	120187	1420	9.0	12.0	55	0.00	0.00	74.17	75.7	21.1
39	78	120287	1330	8.0	7.0	37	0.00	0.00	75.11	74.1	19.6
40	79	120387	1340	7.0	13.5	58	0.00	0.00	74.93	74.9	21.0
41	84	120887	1340	7.0	13.0	50	0.25	0.00	76.20	b	b
42	85	120987	1350	8.0	20.0	62	0.00	0.00	75.18	73.9	20.5
43	90	121487	1305	7.0	12.0	60	0.51	0.00	76.05	73.6	20.3
44	91	121587	1320	6.0	9.5	100	1.78	0.00	74.29	74.6	20.4
45	92	121687	1335	7.0	5.0	54	0.25	0.00	74.47	72.9	20.2
46	93	121787	1230	7.0	7.0	54	0.00	0.00	75.59	73.8	20.2
47	94	122187	1200	7.0	8.0	64	0.38	0.00	75.69	82.4	23.1
48	98	122887	1115	7.0	11.0	35	0.00	0.00	75.57	b	b
49	99	122387	830	5.0	6.5	48	0.25	0.00	75.92	85.1	24.7
50	111	10488	1320	5.0	-0.5	74	0.00	2.54	75.34	74.9	20.0
51	112	10588	1230	3.0	-2.0	49	0.00	2.54	76.45	74.1	20.2

Table 2. Data for Soil Gases and Meteorology

Sample	Day	Date	Time of Day	Soil Temp.(C)	Air Temp.(C)	Humid(%)	Rain(cm)	Snow(cm)	BarP(cm)	%N2-p	%O2-p
52	114	10788	1245	0.0	-5.0	52	0.00	1.27	77.06	76.5	20.3
53	118	11188	1410	2.0	2.0	51	0.00	9.52	76.43	76.3	20.4
54	119	11288	1250	3.0	6.0	38	0.00	8.89	76.05	74.1	20.1
55	120	11388	1315	3.0	7.0	43	0.00	6.35	75.39	73.7	19.5
56	121	11488	1315	0.0	2.0	45	0.00	5.08	76.96	74.8	20.4
57	126	11988	1445	3.0	8.0	60	0.25	0.00	76.00	68.6	20.7
58	127	12088	1230	4.0	7.0	84	3.81	0.00	74.83	71.7	20.4
59	128	12188	1300	5.0	11.0	45	0.00	0.00	74.93	69.4	20.8
60	132	12588	1230	4.0	11.0	100	0.51	0.00	74.93	71.8	20.8
61	133	12688	1315	3.0	-5.0	59	0.00	6.35	75.31	73.5	20.8
62	134	12788	1300	3.0	0.5	49	0.00	6.35	76.45	76.2	20.9
63	135	12888	1530	2.0	3.0	40	0.00	5.08	76.66	72.7	21.3
64	139	20188	1330	8.0	21.0	57	0.00	0.00	76.00	69.6	20.7
65	140	20288	1315	9.0	19.0	77	0.51	0.00	75.44	b	b
66	141	20388	1345	6.0	9.5	74	0.25	0.00	76.45	72.2	20.8
67	142	20488	1220	6.0	7.0	78	0.51	0.00	75.03	73.5	21.3
68	146	20888	1230	1.0	12.5	32	0.00	0.00	76.30	77.2	21.3
69	147	20988	1245	2.0	12.0	54	0.00	0.00	76.07	b	b
70	148	21088	1330	4.0	15.0	48	0.00	0.00	76.30	77.5	21.7
71	155	21788	1400	5.0	14.5	60	0.00	0.00	75.79	76.8	20.9
72	156	21888	1545	6.0	14.0	38	0.00	0.00	75.79	77.8	21.4
73	157	21988	900	3.0	6.0	49	0.00	0.00	75.59	76.0	20.4
74	161	22388	1230	5.0	13.0	49	0.00	0.00	75.06	75.3	21.1
75	162	22488	1400	5.0	12.5	43	0.00	0.00	75.44	76.3	21.2
76	163	22588	1425	3.0	4.5	38	0.00	0.00	75.57	75.6	21.0
77	164	22688	1230	2.0	4.0	39	0.00	0.00	75.79	71.5	20.5
78	167	22988	1330	4.0	12.0	38	0.00	0.00	75.44	76.9	21.4
79	168	30188	1230	3.0	8.0	32	0.00	0.00	76.02	78.1	21.7
80	169	30288	1340	5.0	13.0	15	0.00	0.00	75.57	77.4	21.9
81	170	30388	1245	5.0	13.0	60	0.00	0.00	75.59	77.6	21.6
82	174	30788	1330	5.0	18.0	44	0.00	0.00	75.79	78.3	21.2
83	175	30888	1630	6.0	14.0	59	0.00	0.00	75.97	78.7	21.8
84	176	30988	1300	7.0	18.5	100	0.00	0.00	74.93	77.5	21.7
85	177	31088	1230	7.0	13.0	36	0.00	0.00	74.55	77.1	21.7
86	181	31488	1150	6.0	6.0	44	0.00	0.00	74.83	76.7	20.8
87	182	31588	1300	5.0	2.0	70	0.00	0.00	74.80	73.6	19.7
88	183	31688	1630	5.0	5.0	32	0.00	0.00	75.44	76.9	21.0
89	184	31788	1230	5.0	10.0	32	0.00	0.00	75.97	76.2	21.0
90	188	32188	1250	5.0	10.5	30	0.00	0.00	76.10	75.1	20.9
91	189	32288	1445	6.0	8.5	27	0.00	0.00	78.89	76.5	21.1
92	190	32388	1345	6.0	15.0	32	0.00	0.00	76.38	76.6	20.9
93	194	32488	1250	9.0	25.5	38	0.00	0.00	75.97	75.3	21.1
94	195	32888	1320	8.0	22.5	24	1.27	0.00	76.35	75.7	21.6
95	196	32988	1345	9.0	24.5	22	0.00	0.00	76.02	74.4	21.4
96	197	33088	1320	10.0	25.5	36	0.00	0.00	75.87	76.2	21.6
97	198	33188	1350	11.0	22.0	38	0.00	0.00	76.17	75.9	22.1
98	203	40588	1230	12.0	26.0	34	0.00	0.00	75.34	76.4	20.9
99	204	40688	1415	12.0	25.5	46	0.00	0.00	74.65	75.5	21.2
100	205	40788	1440	9.0	9.0	100	3.81	0.00	74.04	76.2	21.1
101	209	41188	1115	9.5	20.0	43	0.50	0.00	75.18	77.3	21.4
102	210	41288	1230	9.0	10.0	67	0.00	0.00	75.26	77.1	21.3

Table 2. Data for Soil Gases and Meteorology

Sample	Day	Date	Time of Day	Soil Temp.(C)	Air Temp.(C)	Humid(%)	Rain(cm)	Snow(cm)	BarP(cm)	%N2-p	%O2-p
103	211	41388	1240	9.5	16.0	22	0.00	0.00	75.31	76.9	21.7
104	212	41488	1250	10.0	14.0	38	0.00	0.00	75.31	76.5	21.5
105	216	41888	1130	10.0	17.0	100	0.25	0.00	73.99	76.0	21.0
106	217	41988	1030	9.0	9.0	54	0.38	0.00	74.70	78.1	21.4
107	218	42088	1230	9.0	15.0	28	0.00	0.00	75.08	78.2	21.4
108	219	42188	1150	10.0	18.0	28	0.00	0.00	74.55	78.3	21.3
109	223	42588	1130	11.0	19.0	24	0.00	0.00	75.29	78.7	21.4
110	224	42688	1145	12.0	21.0	34	0.00	0.00	75.11	77.8	21.2
111	226	42888	1145	11.0	16.0	38	1.02	0.00	74.80	78.0	21.2
112	230	50288	1215	12.0	16.5	48	0.00	0.00	75.62	78.1	21.0
113	231	50388	1350	12.0	18.0	47	0.00	0.00	75.69	78.0	21.1
114	232	50488	1240	12.0	15.5	41	0.00	0.00	75.54	78.1	21.0
115	233	50588	1130	12.0	17.0	89	1.27	0.00	75.08	78.2	21.2
116	237	50988	1130	13.0	23.0	46	3.81	0.00	75.54	77.0	21.3
117	238	51088	1200	14.0	25.5	49	0.00	0.00	75.06	78.2	21.6
118	239	51188	1240	13.0	23.0	60	0.63	0.00	75.34	78.6	21.6
119	240	51288	1155	14.0	23.5	35	0.00	0.00	76.12	78.5	21.6
120	245	51788	1250	15.0	24.0	68	1.27	0.00	75.06	79.0	21.7
121	246	51888	1250	15.0	20.0	100	1.65	0.00	74.93	78.9	21.6
122	247	51988	1030	15.0	20.0	77	8.13	0.00	75.13	78.5	21.7
123	251	52388	1140	17.0	28.0	65	1.27	0.00	75.06	77.5	21.3
124	252	52488	1215	16.0	26.0	48	6.35	0.00	74.90	78.0	21.7
125	253	52588	1230	15.0	15.5	48	1.65	0.00	75.16	77.4	21.9
126	254	52688	1130	13.0	19.0	41	0.00	0.00	75.82	77.2	21.7
127	260	60188	1100	18.0	29.0	50	0.00	0.00	75.03	74.5	20.9
128	261	60288	1155	17.0	17.0	84	0.25	0.00	75.16	76.8	21.3
129	262	60388	730	16.0	14.0	70	0.13	0.00	75.01	71.2	21.4
130	265	60688	1200	16.5	28.5	38	0.00	0.00	75.03	77.5	22.3
131	266	60788	1240	18.0	31.5	44	0.00	0.00	75.65	75.1	21.6
132	267	60888	1250	18.0	26.0	47	0.00	0.00	74.68	77.6	20.2
133	268	60988	945	15.0	14.5	89	0.00	0.00	74.90	79.0	21.7
134	273	61488	1210	18.0	32.0	47	0.00	0.00	76.25	73.3	20.3
135	274	61588	1240	19.0	32.0	48	0.00	0.00	76.00	74.3	20.5
136	275	61688	1220	19.0	30.0	44	0.00	0.00	75.51	73.4	20.0
137	279	62088	1200	18.0	31.5	52	0.00	0.00	75.72	75.5	20.2
138	280	62188	1230	20.0	32.5	54	0.00	0.00	75.39	77.6	20.7
139	281	62288	1245	21.0	34.0	40	0.00	0.00	75.18	77.2	20.3
140	282	62388	735	20.0	29.0	62	0.00	0.00	75.03	76.4	20.0
141	286	62788	1140	18.0	25.0	43	0.00	0.00	75.34	76.6	20.1
142	287	62888	1250	18.0	26.5	30	0.00	0.00	75.31	76.1	20.0
143	288	62988	1200	18.0	26.5	42	0.00	0.00	75.03	76.5	20.5
144	289	63088	1300	17.0	29.0	36	0.00	0.00	74.88	76.1	21.4
145	294	70588	1300	19.0	30.0	43	0.00	0.00	76.20	77.2	21.5
146	295	70688	1330	20.0	31.5	39	0.00	0.00	75.95	77.3	21.5
147	296	70788	1200	20.0	35.0	29	0.00	0.00	75.82	77.5	21.7
148	300	71188	1200	21.0	33.0	45	0.50	0.00	75.34	76.6	21.1
149	301	71288	1420	22.0	26.5	92	0.20	0.00	75.29	78.1	21.2
150	303	71488	1140	21.0	29.0	57	0.00	0.00	75.36	78.3	20.2
151	307	71888	1230	23.0	29.0	70	0.76	0.00	75.51	76.6	20.2
152	308	71988	1145	22.0	28.0	74	0.38	0.00	76.20	78.1	20.7
153	309	72088	1235	22.0	29.0	70	0.13	0.00	75.57	76.8	20.9

Table 2. Data for Soil Gases and Meteorology

Sample	Day	Date	Time of Day	Soil Temp.(C)	Air Temp.(C)	Humid(%)	Rain(cm)	Snow(cm)	BarP(cm)	%N2-p	%O2-p
154	310	72188	1150	22.0	28.5	77	5.08	0.00	75.41	78.1	20.7
155	317	72888	1040	21.0	25.5	87	3.30	0.00	75.97	77.5	18.0
156	321	80188	1125	22.0	28.5	54	0.00	0.00	75.67	76.6	18.6
157	322	80288	1230	23.0	30.5	55	0.00	0.00	75.92	76.5	19.0
158	323	80388	1230	23.0	30.5	60	0.00	0.00	76.05	76.1	19.5
159	324	80488	1150	23.0	29.0	60	0.00	0.00	76.05	77.8	19.6
160	328	80888	1125	21.0	28.0	43	0.76	0.00	75.59	75.6	19.3
161	329	80988	1215	22.0	32.0	46	0.00	0.00	75.64	75.5	19.4
162	338	81888	1155	23.0	27.0	80	0.25	0.00	75.18	76.7	20.5
163	339	81988	1235	22.0	23.0	85	0.25	0.00	75.34	77.2	20.6
164	342	82288	1230	20.0	29.0	45	2.29	0.00	75.87	77.2	20.7
165	343	82388	1200	20.0	24.0	66	0.00	0.00	75.79	77.7	21.4
166	344	82488	1200	20.0	28.0	54	0.25	0.00	74.93	77.8	20.6
167	345	82588	700	20.0	22.5	76	0.25	0.00	74.83	78.5	21.1
168	349	82988	1100	22.0	24.5	100	1.27	0.00	75.01	78.8	21.2
169	350	83088	1200	20.0	22.5	68	0.13	0.00	75.57	79.2	21.5
170	351	83188	1230	20.0	26.5	44	0.00	0.00	75.82	80.5	21.6
171	357	90688	1145	18.0	21.0	62	0.51	0.00	75.36	77.7	20.8
172	358	90788	1230	17.0	22.5	38	0.00	0.00	75.57	78.0	20.9
173	359	90888	1230	17.0	23.5	47	0.00	0.00	75.92	77.9	21.1
174	360	90988	1000	17.0	24.0	69	0.00	0.00	75.69	78.2	21.0
175	364	91388	1320	17.0	28.0	54	0.00	0.00	75.11	76.9	21.0
176	365	91488	1230	17.0	24.0	43	0.00	0.00	75.48	77.4	21.0
177	366	91588	1200	17.0	23.0	48	0.00	0.00	76.20	77.3	21.2
178	372	92188	1315	18.0	23.5	56	0.00	0.00	75.46	76.8	20.9
179	373	92288	1230	18.0	23.0	56	0.00	0.00	75.57	77.5	21.2
180	374	92388	1300	20.0	28.5	48	0.00	0.00	74.90	76.8	21.2
181	377	92688	1400	17.0	23.0	65	1.02	0.00	75.92	79.2	21.6
182	378	92788	1330	17.5	24.0	54	0.00	0.00	76.02	76.9	20.9
183	379	92888	1430	17.5	25.5	53	0.00	0.00	75.87	79.4	21.9
184	380	92988	1300	16.5	16.5	72	0.00	0.00	76.68	78.1	21.1
185	384	100388	1230	17.0	18.5	74	0.00	0.00	75.44	79.4	22.1
186	385	100488	1325	16.5	20.0	70	0.00	0.00	75.57	80.5	22.0
187	388	100788	1415	13.5	15.0	49	0.00	0.00	76.38	80.6	22.9

Table 2. Data for Soil Gases and Meteorology

Sample	%CO2-p	ppbHe-p	%N2-h	%O2-h	%CO2-h	ppbHe-h
1	0.35	-63	b	20.2	0.48	-346
2	0.32	-405	b	b	b	-346
3	0.42	1584	b	20.3	0.45	-194
4	0.38	-528	b	20.5	0.34	-536
5	0.21	-1005	b	20.4	0.35	-384
6	0.25	135	78.4	21.1	0.21	-346
7	0.21	-240	78.6	21.2	0.20	-536
8	0.29	-1032	78.9	21.4	0.18	-346
9	0.19	-156	81.6	22.0	0.18	-308
10	0.17	-840	77.2	21.5	0.19	-192
11	0.23	-538	77.5	21.6	0.13	-192
12	0.22	0	77.4	21.4	0.19	-144
13	0.22	-48	77.9	21.6	0.23	-192
14	0.74	-168	78.0	21.5	0.19	-336
15	0.43	b	78.0	21.7	0.12	-336
16	0.90	-96	77.3	20.7	0.59	-48
17	0.84	-336	78.1	21.7	0.16	-288
18	0.86	-288	77.8	21.6	0.16	0
19	0.69	-336	77.8	21.7	0.13	-96
20	0.53	264	78.3	21.2	0.20	-96
21	0.73	864	78.3	21.1	0.23	24
22	0.69	-96	78.7	21.4	0.20	-336
23	b	24	78.3	21.2	0.20	-96
24	0.87	24	76.7	20.6	0.18	-96
25	0.86	-456	78.3	21.3	0.24	-336
26	1.00	144	78.5	21.4	0.17	-96
27	0.78	-336	78.5	21.4	0.21	-336
28	0.41	240	76.1	20.4	0.16	112
29	0.32	368	77.2	20.6	0.22	432
30	0.55	b	76.4	20.4	0.26	-416
31	0.45	-284	76.7	20.6	0.17	-416
32	0.28	b	b	b	b	b
33	0.23	-416	78.0	20.8	0.24	-460
34	b	b	78.9	21.6	0.17	-504
35	0.33	b	78.7	21.4	0.17	-1076
36	0.84	b	78.1	21.2	0.22	-328
37	b	-2151	75.0	19.9	0.19	-284
38	0.40	-4704	77.3	20.8	0.22	-330
39	0.68	-3738	79.6	b	b	-422
40	0.30	b	77.2	20.9	0.13	-468
41	b	b	77.0	20.8	0.18	-282
42	0.48	-2952	76.2	20.5	0.19	-321
43	0.37	-1782	76.3	20.5	0.19	-216
44	0.43	-162	77.5	20.9	0.17	-324
45	0.48	b	77.2	20.8	0.16	-216
46	0.36	216	77.7	21.1	0.21	-216
47	0.34	-6	b	b	b	-436
48	b	b	81.5	22.6	0.17	-350
49	1.10	166	83.4	23.5	0.20	-264
50	0.42	108	76.2	20.4	0.25	-246
51	0.55	-4392	76.7	20.5	0.15	-471

Table 2. Data for Soil Gases and Meteorology

Sample	%CO2-p	ppbHe-p	%N2-h	%O2-h	%CO2-h	ppbHe-h
52	0.31	108	76.7	20.5	0.21	-321
53	0.21	560	b	b	b	-321
54	0.32	-960	76.5	20.4	0.22	-246
55	0.53	108	77.1	20.6	0.20	-171
56	0.45	408	76.7	20.3	0.29	-471
57	0.50	-1200	75.4	20.9	0.17	176
58	0.35	-28	75.5	20.7	0.16	-80
59	0.36	720	75.5	20.7	0.17	-208
60	0.34	144	75.5	20.8	0.19	112
61	0.36	-312	75.0	20.6	0.17	48
62	0.15	-208	74.7	20.5	0.17	-144
63	0.45	1128	74.8	20.5	0.21	-144
64	0.46	-867	76.1	21.0	0.19	-144
65	b	b	76.3	21.1	0.18	-80
66	0.39	b	75.8	21.0	0.25	48
67	0.50	84	74.7	20.5	0.18	-208
68	0.48	91	76.8	20.8	0.16	112
69	b	1440	77.2	20.9	0.21	48
70	0.46	-1860	77.8	21.2	0.21	-272
71	0.27	-2748	78.8	21.3	0.20	-384
72	0.17	-358	76.9	20.5	0.12	-358
73	0.15	463	78.8	21.1	0.14	-460
74	0.23	392	77.1	21.3	0.13	-384
75	0.28	-234	77.1	21.0	0.22	-308
76	0.20	-208	b	b	b	-384
77	0.28	92	77.4	21.3	0.14	-308
78	0.27	-273	78.5	21.4	0.14	-384
79	0.20	-309	77.2	21.0	0.13	-308
80	0.31	-234	b	b	b	-384
81	0.24	-208	78.7	21.4	0.14	-460
82	0.20	-640	78.6	21.4	0.14	-349
83	0.17	-108	78.6	21.6	0.13	-480
84	0.28	-101	78.8	21.5	0.12	-288
85	0.33	-422	78.8	21.6	0.11	-240
86	0.17	-461	77.2	20.8	0.12	-240
87	0.45	-326	77.1	20.9	0.13	-240
88	0.22	-346	77.0	20.6	0.23	-96
89	0.21	-384	76.9	20.7	0.21	-96
90	0.29	-848	76.8	21.1	0.14	-156
91	0.19	-504	75.5	20.3	0.11	-156
92	0.30	-594	77.1	20.9	0.16	-96
93	0.29	-798	77.2	21.0	0.15	84
94	0.36	-805	77.8	21.3	0.14	-232
95	0.33	-1470	77.7	21.3	0.22	
96	0.31	-140	77.5	21.1	0.16	-232
97	0.33	0	77.4	21.2	0.17	-156
98	0.21	-767	77.4	20.9	0.14	-108
99	0.28	-234	77.7	21.1	0.15	-174
100	0.20	-558	77.7	20.8	0.24	-174
101	0.35	-578	78.6	21.6	0.14	-834
102	0.23	-440	78.4	21.5	0.15	-750

Table 2. Data for Soil Gases and Meteorology

Sample	%CO2-p	ppbHe-p	%N2-h	%O2-h	%CO2-h	ppbHe-h
103	0.27	-260	78.5	21.3	0.15	-246
104	0.28	-936	78.2	21.3	0.18	-288
105	0.37	-645	77.8	21.1	0.18	-536
106	0.15	-310	78.2	21.3	0.18	-252
107	0.13	-368	78.2	21.3	0.16	-252
108	0.17	-252	78.3	21.5	0.15	-252
109	0.22	-514	78.0	21.2	0.14	-446
110	0.14	-582	78.3	21.2	0.20	-310
111	0.16	-514	78.4	21.2	0.22	-412
112	0.25	-378	78.0	21.1	0.24	-344
113	0.24	-378	78.2	21.3	0.18	-378
114	0.32	-582	78.3	21.3	0.17	-616
115	0.27	-412	77.1	21.0	0.18	-378
116	0.21	-423	78.2	21.2	0.28	-336
117	0.16	-376	78.5	21.4	0.18	-336
118	0.17	-108	78.5	21.5	0.19	-376
119	0.17	-176	78.5	21.6	0.18	-256
120	0.17	-576	79.2	21.5	0.24	-176
121	0.17	-448	79.0	21.5	0.21	-296
122	0.16	-216	79.3	21.6	0.25	-296
123	0.21	981	77.5	21.1	0.25	420
124	0.22	1691	78.1	21.3	0.29	186
125	0.24	1080	79.2	b	b	732
126	0.15	768	78.4	21.5	0.20	498
127	0.63	-640	75.8	20.8	0.26	-152
128	0.19	-616	76.9	20.9	0.25	-100
129	0.46	948	76.6	20.8	0.23	-100
130	0.30	b	77.9	21.2	0.17	-438
131	0.35	b	77.9	21.2	0.19	-438
132	0.72	-435	77.8	21.2	0.17	-438
133	0.22	-240	79.0	21.6	0.18	-240
134	0.56	-240	73.6	20.8	0.21	-504
135	0.77	-306	74.4	21.0	0.20	-438
136	0.91	-306	74.2	21.0	0.24	-438
137	0.76	-366	77.3	21.1	0.15	-428
138	0.68	-242	77.7	21.5	0.12	-304
139	0.89	-676	77.4	21.3	0.14	-242
140	1.07	-428	77.4	21.3	0.15	-428
141	0.85	-376	76.8	20.9	0.19	-422
142	0.84	-468	75.9	20.4	0.25	-376
143	0.45	-422	77.4	21.3	0.17	-376
144	0.57	-330	76.5	21.7	0.20	360
145	0.46	472	76.9	21.5	0.28	680
146	0.42	108	77.3	21.7	0.25	524
147	0.64	472	77.2	22.4	0.19	420
148	0.66	966	77.2	22.1	0.18	498
149	0.82	420	77.4	22.0	0.52	498
150	1.04	576	77.4	22.2	0.23	654
151	1.03	576	77.0	21.8	0.22	502
152	1.03	444	77.3	21.8	0.26	386
153	1.03	96	77.3	21.6	0.23	386

Table 2. Data for Soil Gases and Meteorology

Sample	%CO2-p	ppbHe-p	%N2-h	%O2-h	%CO2-h	ppbHe-h
154	1.21	618	77.1	21.6	0.25	676
155	2.01	682	76.7	21.3	0.20	636
156	2.12	590	76.5	21.6	0.27	222
157	2.17	728	76.2	21.8	0.25	728
158	1.80	774	76.8	21.7	0.26	268
159	1.85	406	76.3	21.7	0.25	682
160	1.71	386	76.2	21.6	0.22	618
161	1.66	270	76.1	21.8	0.28	618
162	1.38	910	76.3	21.7	0.22	486
163	1.27	486	77.3	22.0	0.20	b
164	1.24	486	77.3	22.4	0.23	552
165	1.04	816	77.8	22.7	0.19	618
166	1.41	816	78.3	22.5	0.26	618
167	1.48	618	78.7	22.3	0.35	948
168	1.38	442	79.1	23.0	0.17	442
169	1.27	442	79.5	23.2	0.21	552
170	1.56	354	80.1	23.1	0.26	354
171	1.19	442	77.9	22.2	0.17	90
172	1.28	552	78.1	21.9	0.29	442
173	1.12	750	78.4	22.0	0.23	684
174	1.19	816	76.4	21.9	0.20	618
175	1.00	680	77.8	22.3	0.20	940
176	0.98	732	77.4	21.7	0.40	628
177	1.15	732	77.5	22.6	0.18	628
178	0.87	360	77.3	22.1	0.20	728
179	0.95	222	77.8	22.2	0.20	544
180	0.95	744	78.1	22.6	0.17	406
181	0.87	728	79.5	22.9	0.19	498
182	0.92	744	79.5	23.3	0.31	866
183	0.95	682	78.8	23.0	0.16	728
184	1.10	774	80.4	23.3	0.20	636
185	0.98	866	80.5	23.3	0.22	682
186	0.96	728	78.9	22.8	0.20	544
187	0.85	544	80.6	23.4	0.29	728