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Helium soil gas survey of a collapse feature on the Hualapai Indian Reservation, Arizona

by

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HELIUM SOIL GAS SURVEY OF A COLLAPSE STRUCTURE ON THE HUALAPAI INDIAN RESERVATION, ARIZONA

ABSTRACT

A helium soil-gas survey performed at a collapse feature on the Hualapai Indian Reservation was compared to a survey performed at a collapse structure of known uranium mineralization. There was a difference in the distribution of helium concentrations significant enough to suggest that helium analysis may be a useful technique to determine whether or not collapse structures contain economic uranium concentrations.

INTRODUCTION

A helium soil gas survey was performed in March, 1985 over a collapse feature on the Hualapai Indian Reservation in northern Arizona. This study is a follow-up study of reconnaissance surveys performed in July and October 1984 in an effort to evaluate the utility of helium surveys in identifying areas of potential economic uranium mineralization. The results of that previous survey involving nearly 2000 samples (Bowles and Reimer, 1985, in preparation) indicate that while helium may be used to identify large geographic areas of higher background uranium concentrations, an inordinate number of samples would be required to use the technique to locate various collapse features that may contain mineralization. Helium soil gas analysis would be more useful if suspected collapse structures are identified first and helium then used to determine whether or not the structure contained mineralization.

Helium is formed from the alpha particle that is a product of the natural radioactive decay of uranium and thorium. Uranium and thorium are ubiquitous in trace amounts throughout rock-forming minerals and in ground water. When the concentration of those elements is greater in a small geographic area, the production and concentration of helium is also greater in that area. Helium is also a very mobile gas. It can move rapidly through soil and overburden, and the more free pathways it has, for example, in a highly- fractured collapse structure, the faster it will move. Consequently, helium has the potential to be very useful in identifying collapse structures, especially those that are brecciated, and also to reveal whether any uranium or thorium mineralizatioan occurs in that structure. This present study was performed to evaluate those possibilities.

TECHNIQUE

Helium soil gas samples were collected from a 2.5 foot depth (0.75 m) by pounding a hollow steel probe into the ground and using a hypodermic syringe to withdraw the soil gas through an air-tight septum on top of the probe. This gas was transferred from the syringe to a valved metal cylinder for shipment to the U.S. Geological Survey in Denver, Colorado for analysis. Helium analyses were performed using a modified leak-detector mass-spectrometer (Reimer, 1976) and analyses for nitrogen, oxygen, carbon dioxide and methane were done using a gas chromatograph fitted with a thermal conductivity detector. Analytical sensitivity was 10 parts per billion for helium, 100 parts per million for carbon dixoide and 1000 parts per million for methane, nitrogen and oxygen.

SURVEY LOCATIONS AND DATA

The primary structure surveyed was structure 569 as defined in a study of the National Tank area by Wenrich and others (1985). Its location is in the National Tank Arizona 7-1/2 minute quadrangle, T. 29 N., R. 6 W., in the north-central portion of Section 21. It is unknown at this time whether the structure is mineralized. A small area outside structure 569 was also surveyed to serve as background control of the main survey. This area was approximately 500 yards (450 m) southwest of the main survey area. Another collapse structure, one known to be a breccia pipe containing uranium mineralization, was also surveyed to act as an additional reference for the primary survey. Due to confidentiality understandings with the company operating at the reference structure, its location cannot be revealed at this time. Both collapse structures are relatively small, not exceeding 500 feet (150 m) in diameter. Nearly 200 samples were collected at structure 569, and about 40 samples each were collected at the other locations. All samples were analyzed for helium, and about 1 in 3 were analyzed on the gas chromatograph for oxygen, nitrogen, carbon dioxide, and methane. The concentration of methane for all samples was lower than our detection limit. The helium data for the three surveys are presented in figures 1, 2, and 3. The mean helium concentration for structure 569 is identical to that observed in the background area within the precision of measurement at 5226 ± 28 and 5237 ± 26 parts per billion, respectively. This is approximately 50 parts per billion less than the survey over the mineralized structure (5282 ± 53 parts per billion). Although this difference is hardly significant in itself, it is the overall distribution of the values from the individual surveys that is significant. The survey over the area of known mineralization had a grouping of five adjacent samples that were anomalous in that they were about 80 parts per billion greater than the mean. It is the pattern recognition that is significant in this case and reveals the difference in the two areas. It is not unusual for the gas anomaly to occur toward the center of the collapse feature even though mineralization might occur in the rim. The location of the gases would be strongly controlled by the direction of the water movement which, in a collapse structure, would be toward the center.

The data for the oxygen and carbon dioxide analyses are presented in Table I. The values are all ratioed to nitrogen. From a preliminary evaluation of the entire data set, there is no significant correlation. An inverse relationship between oxygen and carbon dioxide was anticipated as a function of biological metabolism, but none was found. The value of these data is that variations and correlations might be seen during different seasons and data such as the He/N ratio might permit data collected from various times of the year to be compared directly. Testing of this possibility must await future studies.

CONCLUSION

If the data from this very limited study are representative of what differences in helium concentration might be expected from collapse structures that are mineralized with uranium compared to those that are not, then helium soil-gas analyses will prove to be a very valuable tool in providing information on possible economic potential of collapse structures. There is still not enough information to be able to distinguish the effect of permeability differences on the gas distribution and placement of the anomaloy with respect to the highly mineralized areas. It should be stressed that helium detection is not by itself definitive, but has the potential of providing very rapid, primary evaluation. The He results do not suggest that collapse feature 569 would be a favorable exploration drilling target. The surveys performed here were completed in slightly more than one day. A small area of structure 569 required a few hours of a second day to finish. Diurnal influences should be considered when evaluating the data as temperature, wind, soil moisture and barometric pressure changes all can have varying degrees of influences on soil gas concentrations (Bowles and Reimer, 1985, in preparation).

Future test surveys over areas known to have economic mineralization, or known to be barren of mineralization, will be necessary to confirm the findings reported here. It may be sufficient to perform a survey of about 100 samples within an identified collapse structure, and about 50 outside the structure for background reference. These samples can be collected easily within a one-day period by a sampling crew of four people, and when combined with the capability of on-site analysis, additional samples could be collected if deemed necessary.

Table 1. Carbon dioxide (CO_2) and oxygen (O_2) concentrations ratioed to nitrogen (N_2). The sample numbers are located on figures 1b, 2b, and 3b.

sample #	CO2/N2	O2/N2
16	3.880E-03	2.591E-01
23	3.545E-03	2.702E-01
40	2.121E-03	2.705E-01
41	2.613E-03	2.687E-01
52	1.769E-03	2.695E-01
54	4.707E-03	2.682E-01
66	4.848E-03	2.596E-01
71	4.104E-03	2.729E-01
109	6.062E-03	2.737E-01
114	4.530E-03	2.607E-01
120	3.493E-03	2.720E-01
121	9.457E-03	2.548E-01
123	4.847E-03	2.700E-01
125	3.334E-03	2.591E-01
128	4.312E-03	2.597E-01
134	9.339E-03	2.564E-01
136	7.525E-03	2.652E-01
137	1.605E-03	2.571E-01
140	2.775E-03	2.691E-01
144	1.936E-03	2.676E-01
154	4.551E-03	2.620E-01
155	1.843E-03	2.740E-01
156	5.802E-03	2.658E-01
167	1.973E-03	2.594E-01
170	5.770E-03	2.695E-01
175	1.427E-03	2.564E-01
179	2.731E-03	2.639E-01
180	5.202E-03	2.538E-01
181	3.527E-03	2.658E-01
184	1.420E-03	2.554E-01
196	9.837E-04	2.663E-01
197	3.565E-03	2.766E-01
199	3.393E-03	2.631E-01
202	2.940E-03	2.750E-01
203	4.125E-03	2.700E-01
205	2.331E-03	2.589E-01
213	2.373E-03	2.688E-01
226	4.157E-03	2.720E-01

Table 1. continued

sample #	CO2/N2	O2/N2
232	3.795E-03	2.668E-01
235	3.478E-03	2.698E-01
237	2.580E-03	1.544E-01
249	5.119E-03	2.639E-01
257	1.278E-02	2.543E-01
258	3.934E-03	2.661E-01
276	2.136E-03	2.699E-01
277	1.509E-03	2.749E-01
278	2.059E-03	2.716E-01
290	1.431E-03	2.681E-01
292	2.447E-03	2.711E-01
304	4.040E-03	2.685E-01
311	1.580E-03	2.692E-01
317	2.560E-03	2.661E-01
322	3.879E-03	2.687E-01
325	4.836E-03	2.604E-01
326	1.274E-03	2.677E-01
327	5.095E-03	2.637E-01
331	3.593E-03	2.668E-01
341	3.323E-03	2.748E-01
349	3.317E-03	2.673E-01
353	1.308E-03	2.684E-01
357	3.753E-03	2.716E-01
362	1.823E-03	2.694E-01
365	1.577E-03	2.639E-01
371	3.658E-03	2.688E-01
373	1.419E-03	2.683E-01
374	2.681E-03	2.720E-01
377	1.313E-03	2.673E-01
381	4.227E-03	2.579E-01
383	3.141E-03	2.706E-01
384	3.804E-03	2.742E-01
390	3.978E-03	2.694E-01
391	2.999E-03	2.695E-01
396	3.533E-03	2.705E-01
397	1.889E-03	2.682E-01
399	1.135E-02	2.685E-01
407	3.773E-03	2.648E-01
414	1.310E-03	2.670E-01
425	4.356E-03	2.684E-01
430	2.081E-03	2.646E-01
435	9.222E-03	2.560E-01
441	1.584E-03	2.668E-01
443	9.061E-03	2.513E-01
446	2.640E-03	2.694E-01
449	4.132E-03	2.698E-01
503	1.440E-03	2.670E-01
504	1.466E-03	2.685E-01

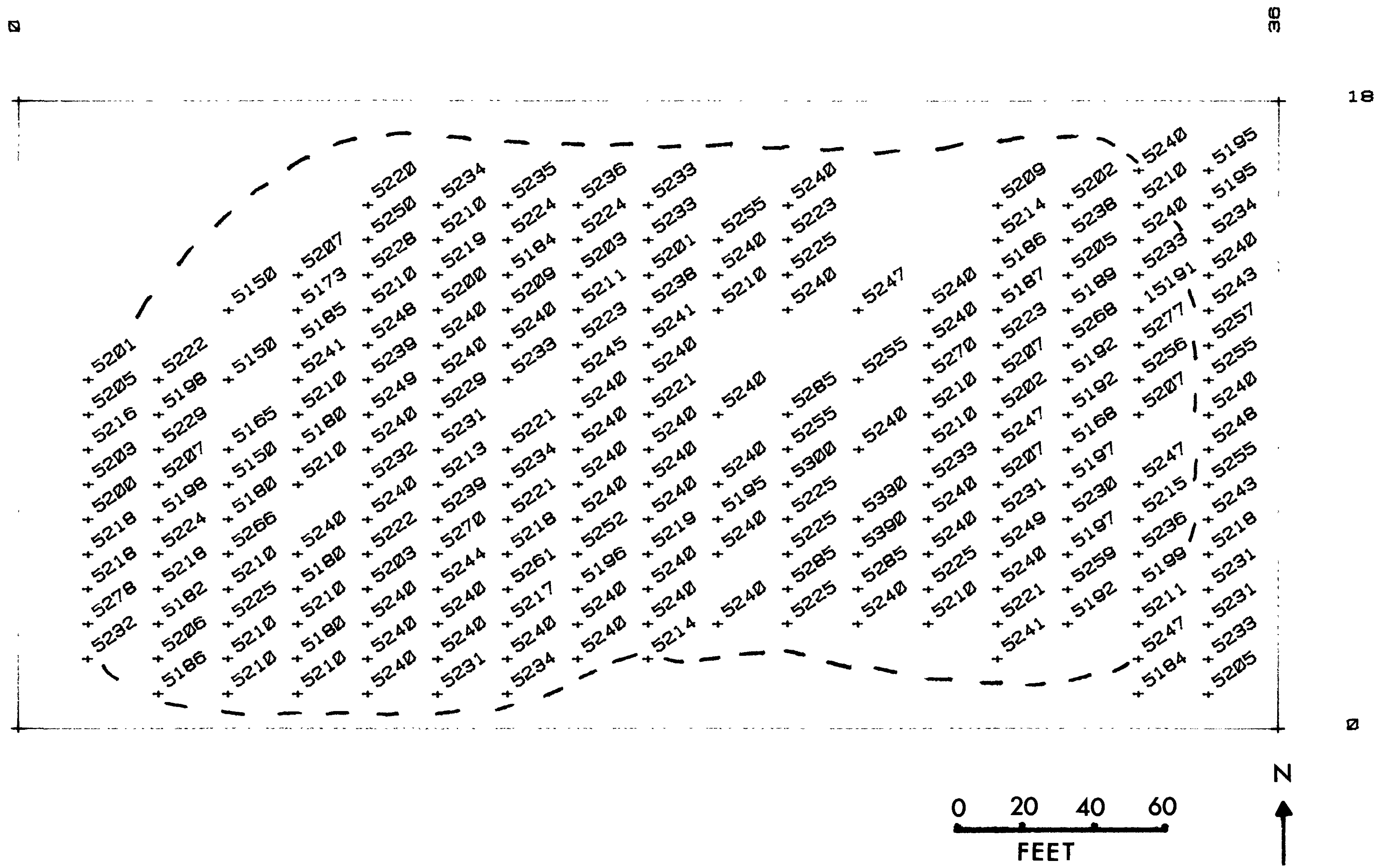

Figure 1a. Helium soil-gas concentrations in parts per billion for collapse structure 569. The dashed line is the approximate boundary of the collapse structure. Very few samples were taken across this boundary.

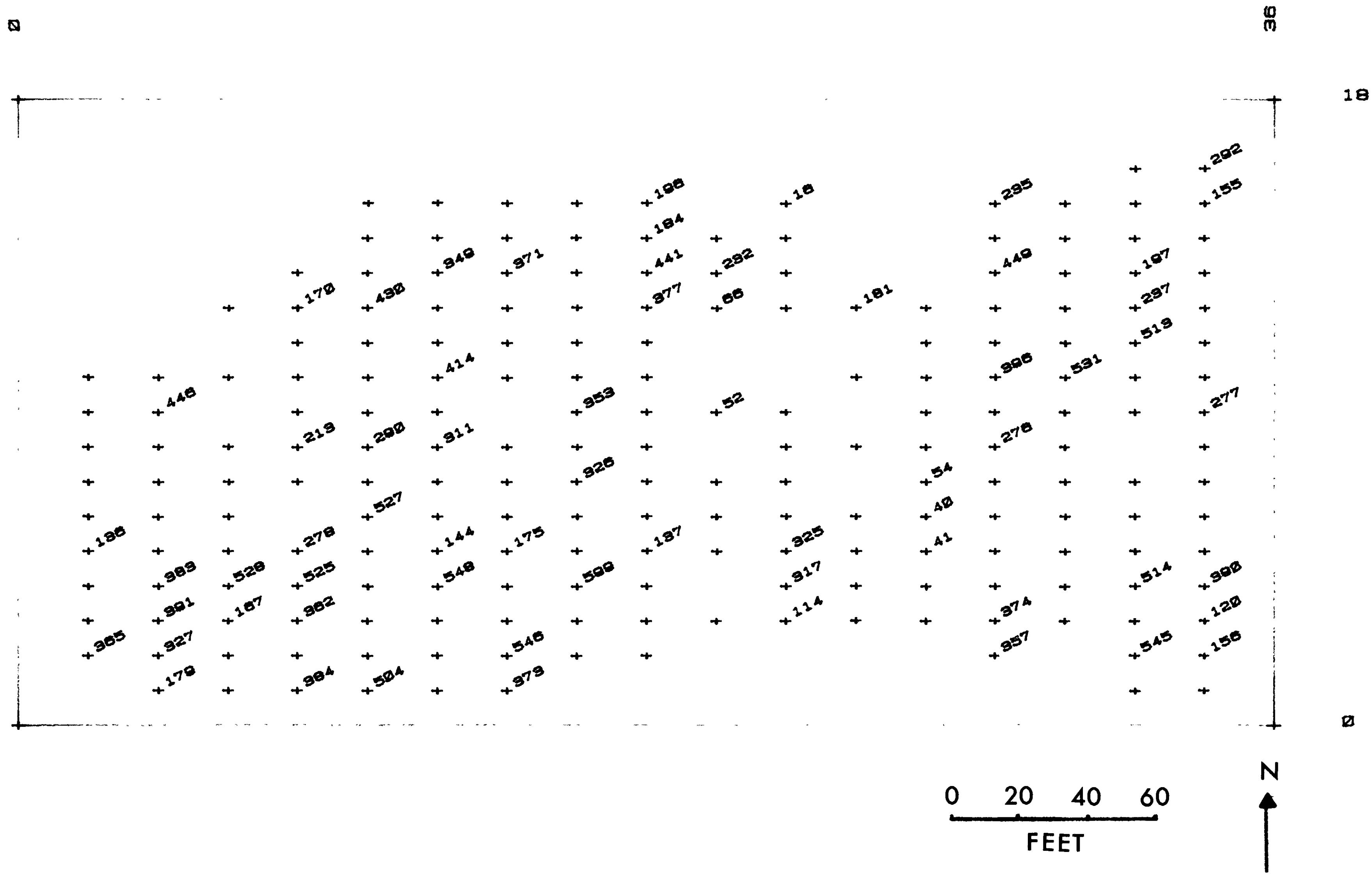

Figure 1b. Location and sample number for samples analyzed for oxygen, carbon dioxide, and nitrogen as well as helium. These numbers are referenced to Table 1. The dashed line is the approximate boundary of the collapse feature.

Figure 2a. Helium soil-gas concentrations in parts per billion for the background reference samples collected 500 yards southwest of collapse structure 569.

Figure 2b. Location and sample number for samples analyzed for oxygen, carbon dioxide, and nitrogen as well as helium. The numbers are referenced to Table 1.

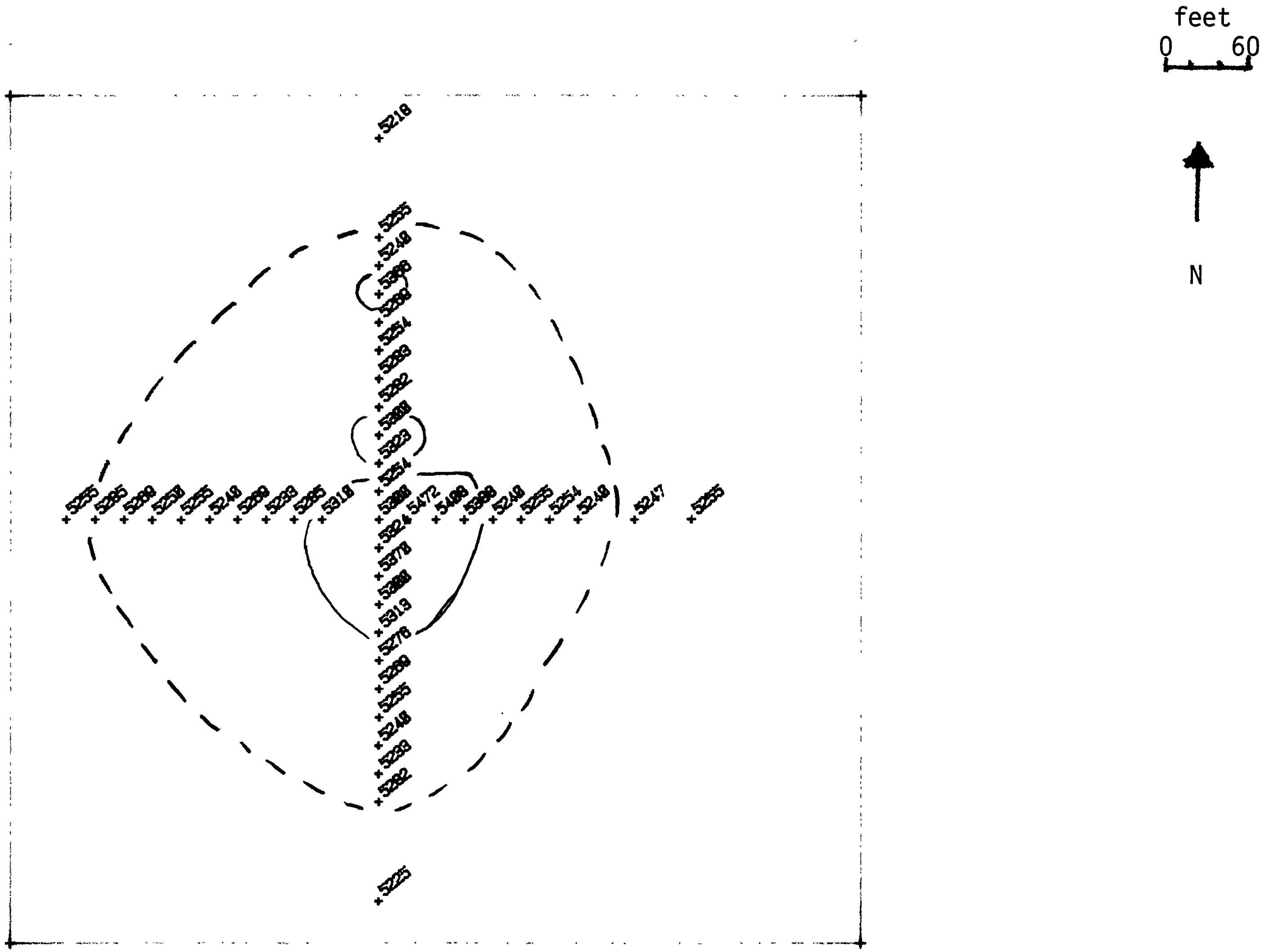

Figure 3a. Helium soil-gas concentrations in parts per billion for the collapse structure of known mineralization. Highest concentrations occur mostly east and south of the center of the sampling pattern. The line traced on the figure outlines the location of the higher helium concentrations. The dashed line is the approximate boundary of the collapse structure.

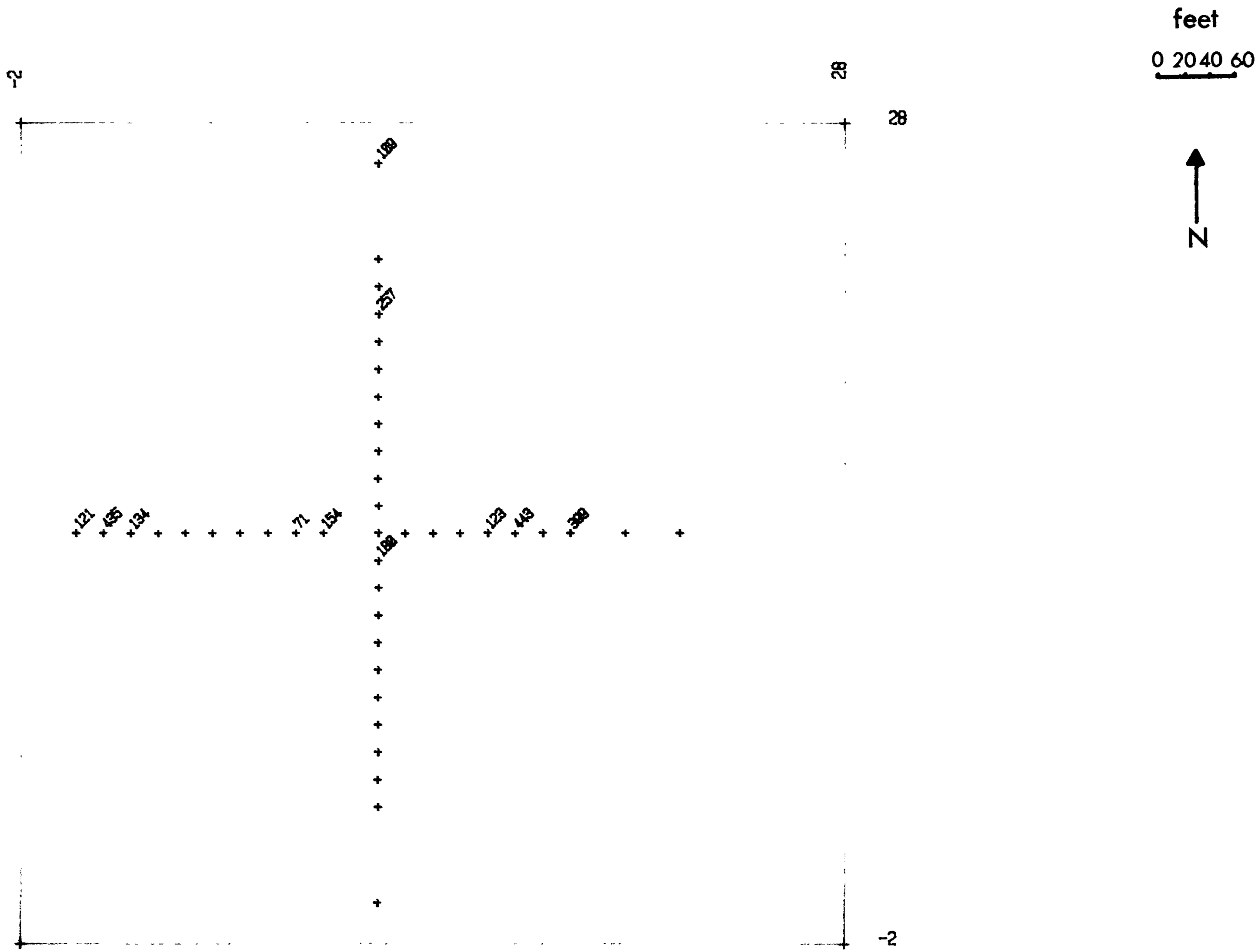

Figure 3b. Location and sample number for samples analyzed for oxygen, carbon dioxide, and nitrogen as well as helium for the mineralized structure. The numbers are referenced to Table 1. The dashed line is the approximate outline of the collapse feature.

REFERENCES

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