Helium Soil Gas Surveys of Several Collapse Features and Breccia Pipes on the Hualapai Indian Reservation, Arizona

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.

Abstract

Helium soil-gas surveys were performed over sixteen known or potential breccia pipes on the Hualapai Indian Reservation, Arizona. This study has extended a data base previously obtained to aid in interpretation of the helium surveys. The technique has not provided an unequivocal means of determining whether or not a particular collapse feature contains uranium mineralization. A discussion of the uranium potential for each feature surveyed is provided based on the helium data. After several of the features are drilled, the helium data can be reinterpreted in view of the additional information gathered.

Introduction

Helium soil-gas samples were collected in 2 stages, at several collapse features and breccia pipes located on the Hualapai Indian Reservation, south of the Grand Canyon, Arizona. Six features were surveyed in June and July 1985 and ten were surveyed in May, 1986. A previous study included two collapse features, one of which was known to have uranium mineralization, and provided a pattern suggesting that the helium anomalies were related to uranium occurrence (Reimer, 1985). This present survey was intended to supply information on the distribution of helium above several additional collapse features, one of which is known to be a uranium-bearing breccia pipe, and to compare the data to the distribution of helium over features whose structure is unknown. This increase in the data base should permit an initial evaluation of the helium technique as an exploration guide in determining whether or not a particular collapse feature has the potential to contain economic-grade uranium. This evaluation will be confirmed after the structures have been examined by other geochemical and geophysical techniques and, ultimately, by drilling.

The collapse features studied are identified by numbers corresponding to descriptions provided by Wenrich and others (1988a, 1988b). Six collapse features were surveyed and are identified in Table 1.

Theoretical Background, Sampling, and Analytical Methods

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 mineralization occurs in that structure.

Each collapse feature was sampled in one day to minimize variations in soil-gas helium that might be introduced by meteorologic changes. Over 150 samples were collected at each location and several short traverses across the rim structure of the features were included.

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.

The gas was stored in the syringes and analyzed within 8 hours with the U.S. Geological Survey's mobile helium analyzer which was operating near the sampling locations.

Survey Locations, Data, and Discussion

The collapse features that were surveyed and their locations are listed in Table 1. The helium concentrations and collection positions with respect to the surface expression of the rim are shown in Figures 1-6. Four different size symbols represent concentration ranges. An evaluation of the helium results is presented for each structure surveyed. The helium data are interpreted solely on their own merit not correlating them to any other geophysical or geochemical data base. There are two criteria that have been selected for determining whether or not a particular collapse feature may be a uranium mineralized breccia pipe. The criteria are 1) relatively high concentrations of helium and 2) particularly well defined groupings or clusters of the higher helium values within any one collapse feature. An evaluation of the helium results is presented for each structure surveyed. Within the following figures, four symbol sizes are used to distinguish concentration groups. The sizes of the symbols are scaled for each figure and therefore each figure should stand alone.

Feature 220 (Figure 1). This feature has indications on the surface of copper minerals malachite and azurite. The helium survey had the second to lowest average concentration of any of the surveys. The central region has a band of higher helium concentrations but contrasts only because the background and surrounding values are so low. This feature is judged to have uncertain uranium potential.

Feature 493 (Figure 2). This feature had relatively low helium concentrations throughout most of the structure but there was a distinct central feature that had markedly higher helium concentration. On the basis of this central cluster and its high helium concentrations, this feature is judged to have a high potential for uranium.

Feature 494 (Figure 3). This structure had the highest helium concentrations of any of the features surveyed this time. Although there was no contrast to background. This features is a known breccia pipe and does contain some uranium mineralization (Wenrich and others, 1985c). On the basis of the high, overall, helium concentrations, this feature would be judged to have a high potential for uranium mineralization.

Feature 534 (Figure 4). This feature had the lowest average helium concentrations of any feature surveyed. Distinct areas of higher concentrations did occur within the structure so that this feature is regarded as having relatively high potential for uranium mineralization.

Feature 570 (Figure 5). The helium distribution at this feature quite vividly reflects the effects of diurnal heating. The zone of higher concentrations were collected early in the day, the area of lower concentrations were collected later. This is a very regular pattern and no group of higher helium

concentrations is evident. Therefore, this structure has a low potential for uranium. Discussion of diurnal effects have appeared previously (Bowles and Reimer, 1986) and will be addressed for these specific collapse features in a later paper.

Feature 1102 (Figure 6). This structure has relatively high helium concentrations with no distinct pattern. The high helium contrast suggests mineralization corresponding to the known occurrences at Feature 494. Because the concentrations are not as high and there is no distinct pattern, the uranium potential for this feature is classified as uncertain. The grouping of low concentrations in the central portion may suggest a silicic plug that reduces the free pathways for gas flux. No distinct rim was recognized for this collapse structure.

Conclusions

The results of the helium surveys on these additional collapse structures did not provide unequivocal information on whether or not the structure contained uranium mineralization. Two criteria have evolved that act as a guide for favorability. One is the distribution of higher helium concentrations grouped within a feature, the other is higher helium concentrations over the entire structure, both compared to background. These two criteria were observed for the breccia pipes known to have uranium mineralization, #534 and #562. It is likely that the smaller groupings of higher helium concentrations are an indication of a more open pathway in a portion of the structure. Only after a number of these features have been drilled will the utility of the helium surveying technique be known.

Acknowledgments

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Table 1. Identification number, location, average helium concentration, number of samples, and evaluation of uranium potential for the collapse features surveyed.

Identification Number	Location Lat./Long.	Average Helium Concentration parts per billion*	Number of samples	Uranium Potential
220	35°56'38" 113°05'34"	17 ± 42	165	uncertain
493	36°10'04" 112°57'18"	23 ± 41 44 ± 37**	121	high
494	36°07'30" 113°00'24"	61 ± 28	158	high
534	35°58'43" 112°52'54"	14 ± 38	178	high
570	35°52'34" 112°56'29"	19 ± 36	181	low
1102	36°10'24" 113°02'30"	34 ± 27	100	uncertain

* with respect to an air reference at 5240 parts per million
** inner rim structure, 16 samples

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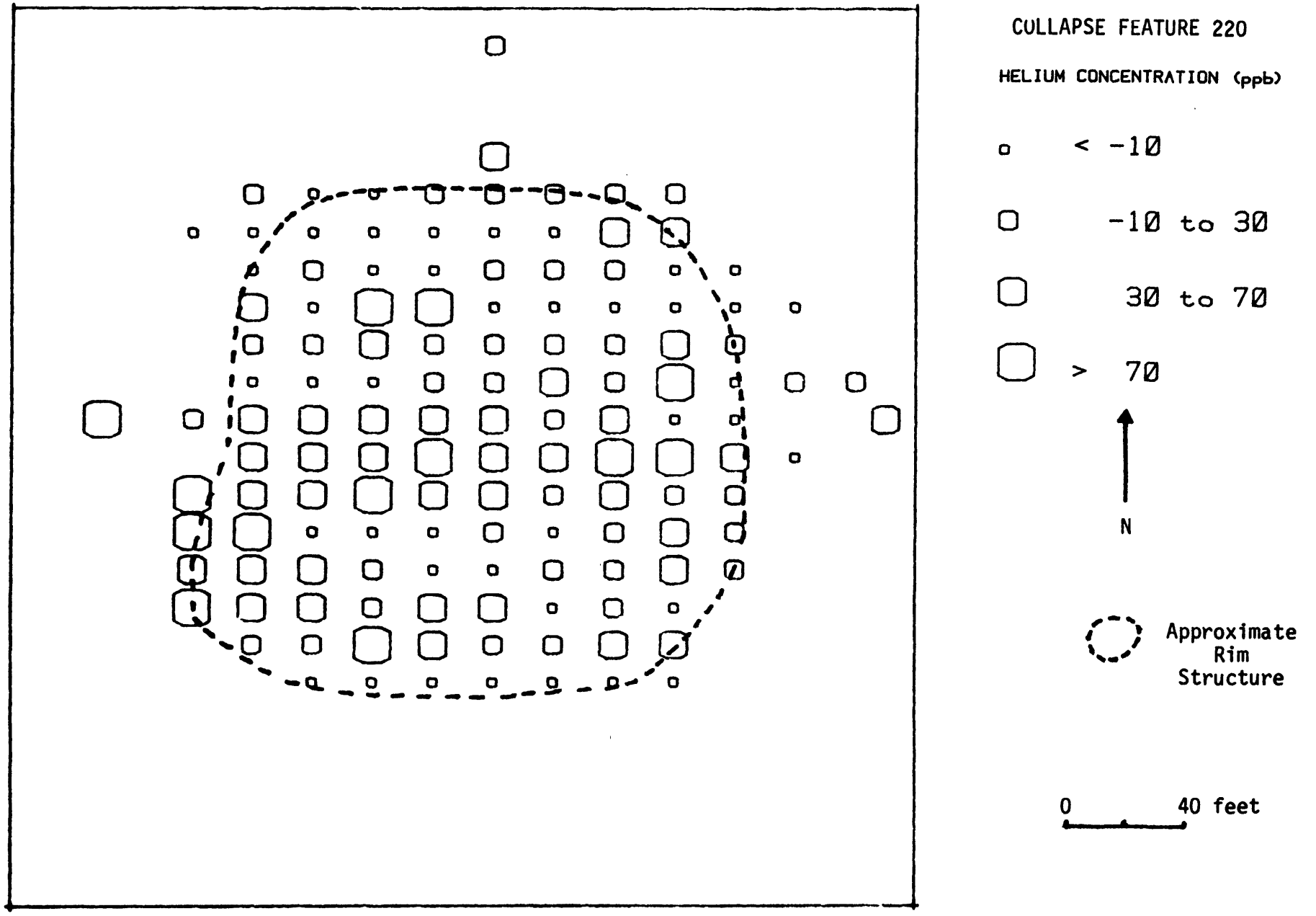


Figure 1. Helium concentration for collapse feature 220. The dashed line represents the approximate location of the rim structure.

Figure 2. Helium concentration for collapse feature 493. The dashed line represents the approximate location of the rim structure.

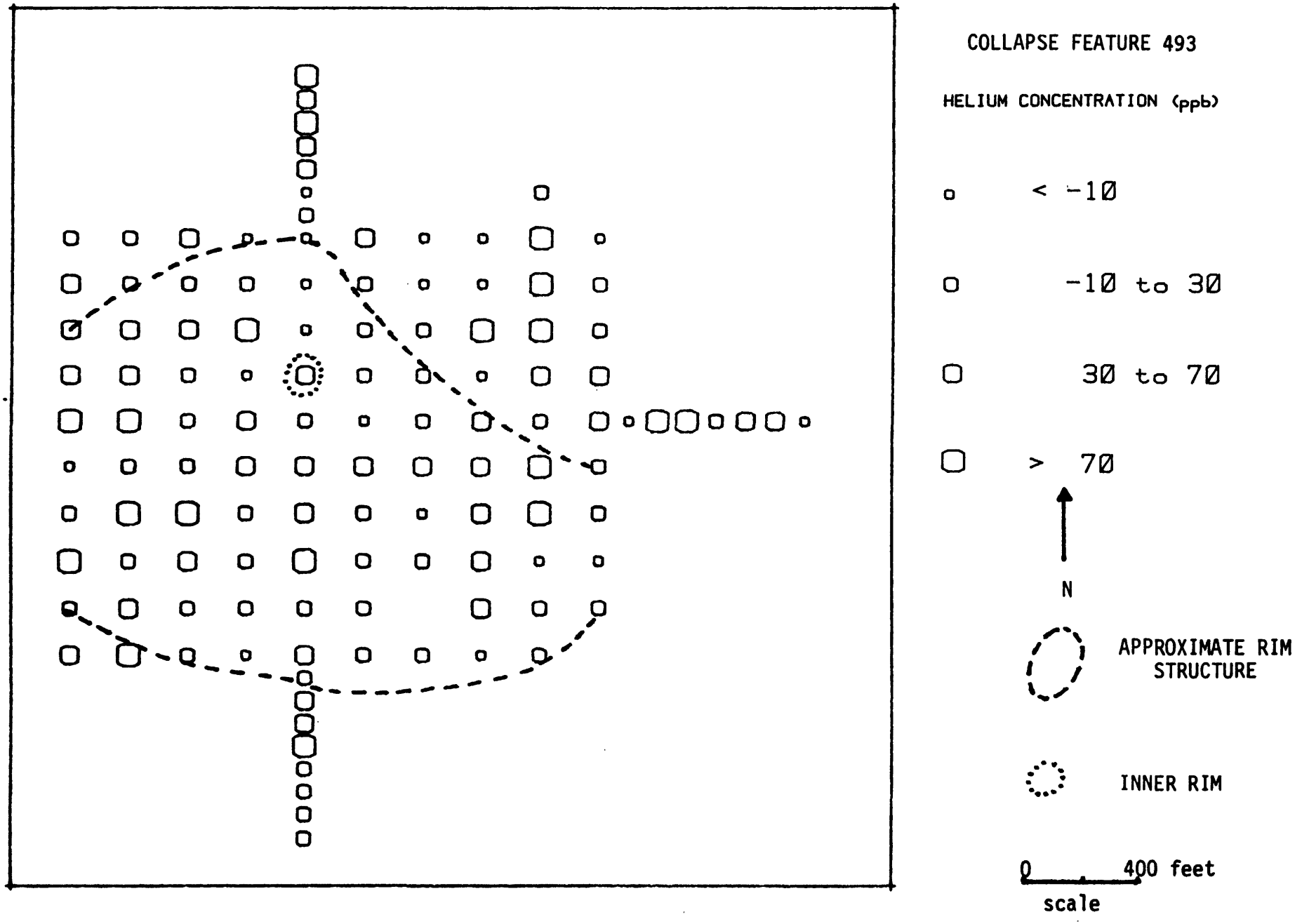
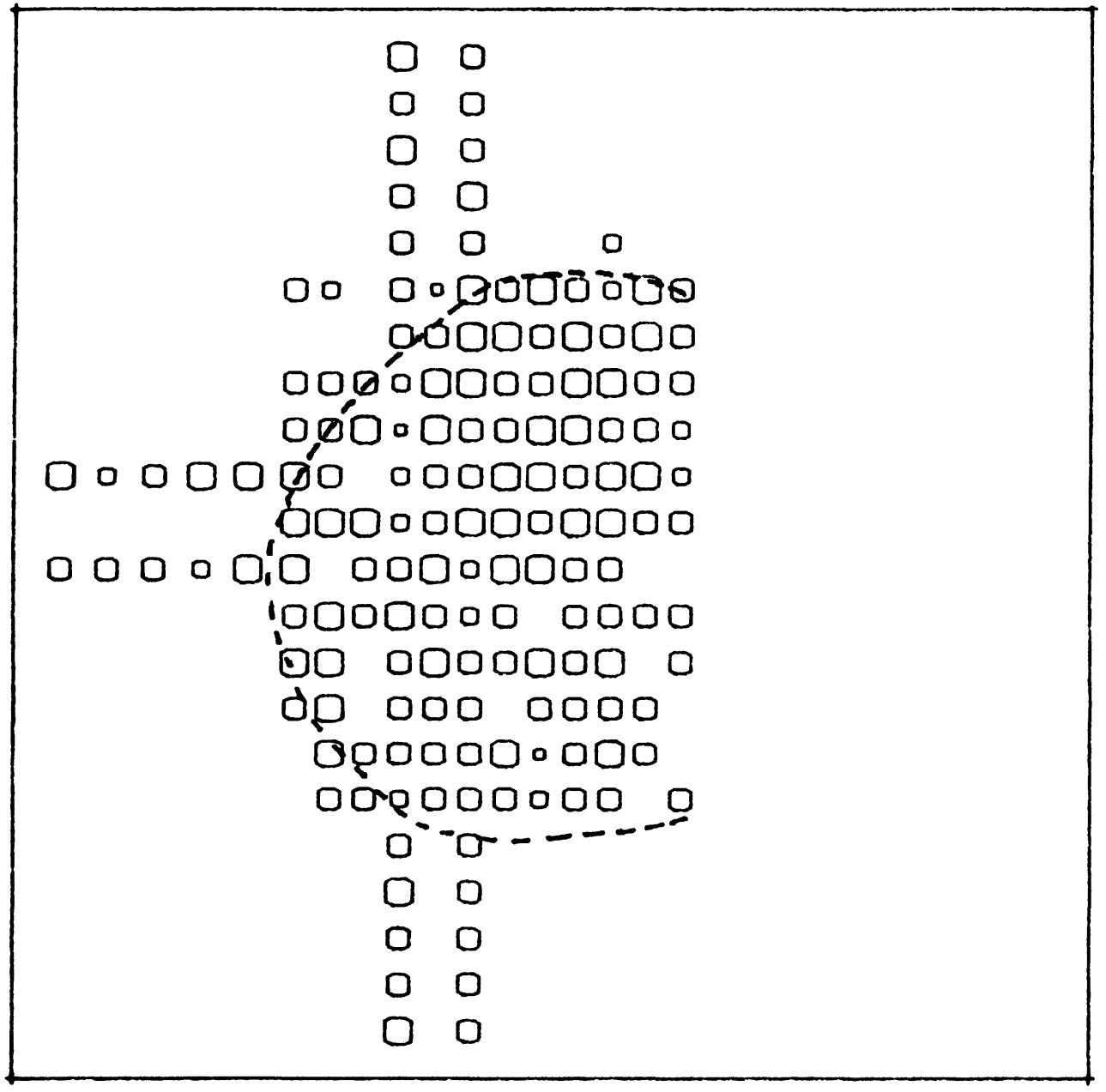


Figure 3. Helium concentration for collapse feature 494. The dashed line represents the approximate location of the rim structure.



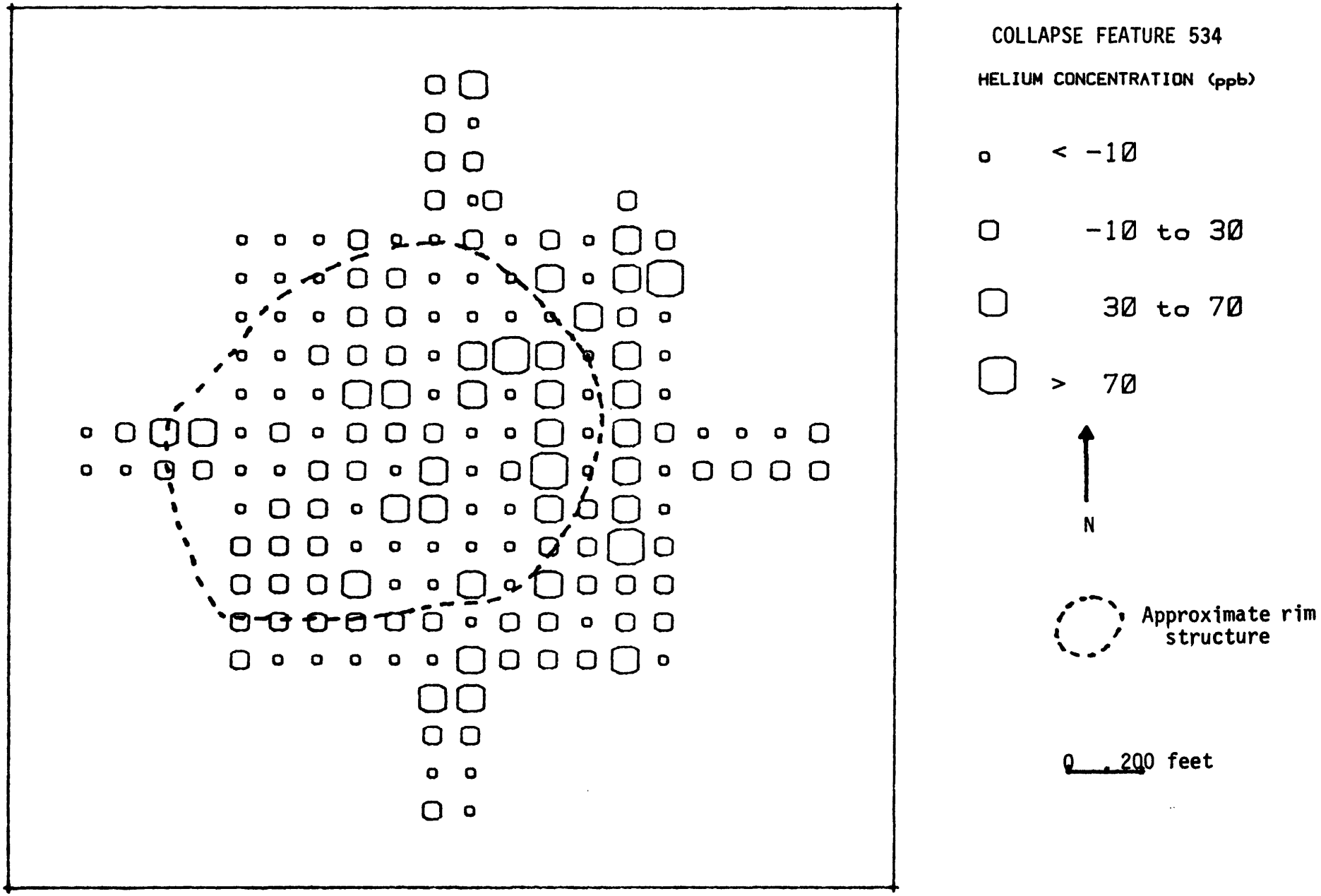


Figure 4. Helium concentration for collapse feature 534. The dashed line represents the approximate location of the rim structure.

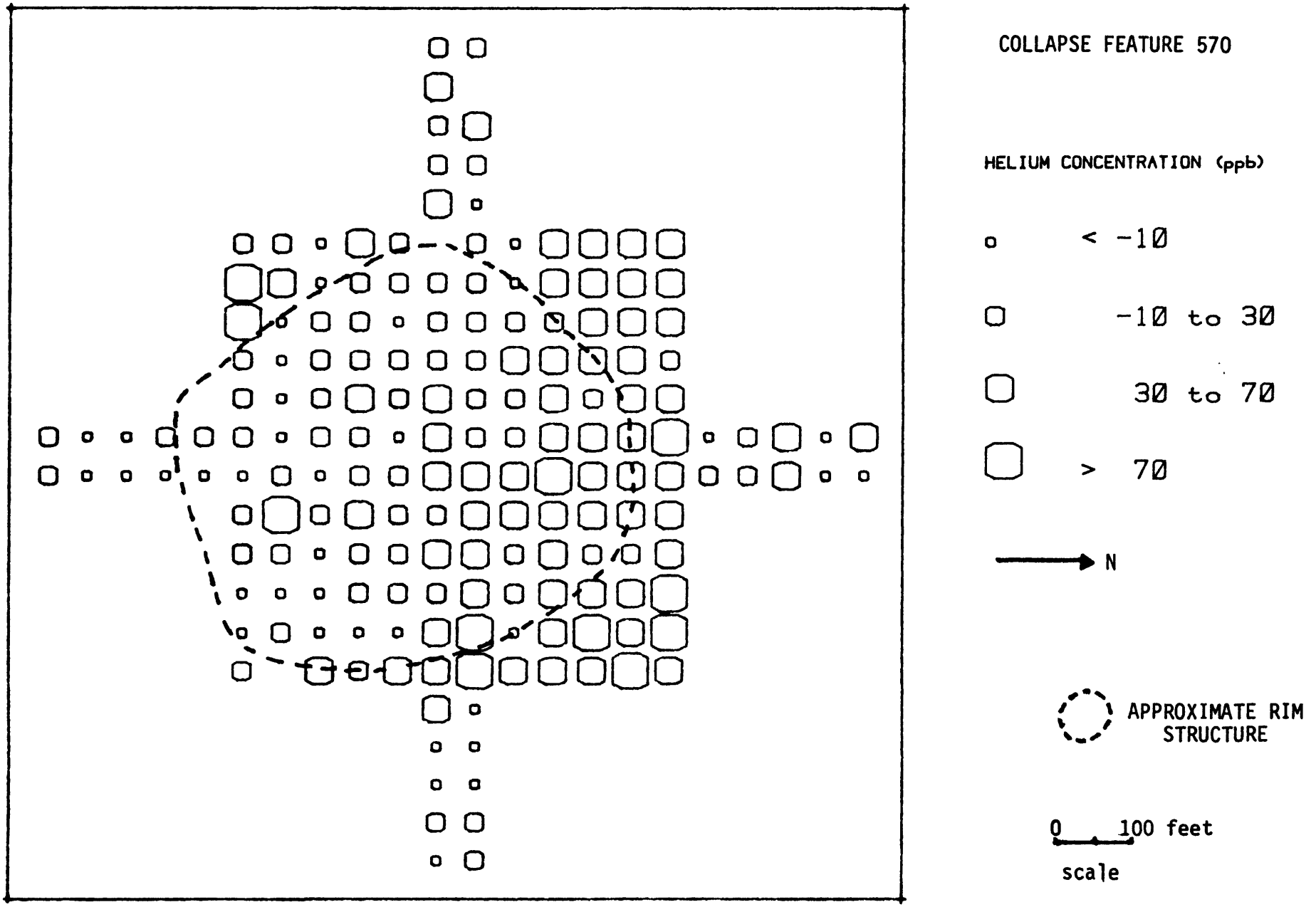


Figure 5. Helium concentration for collapse feature 570. The dashed line represents the approximate location of the rim structure.

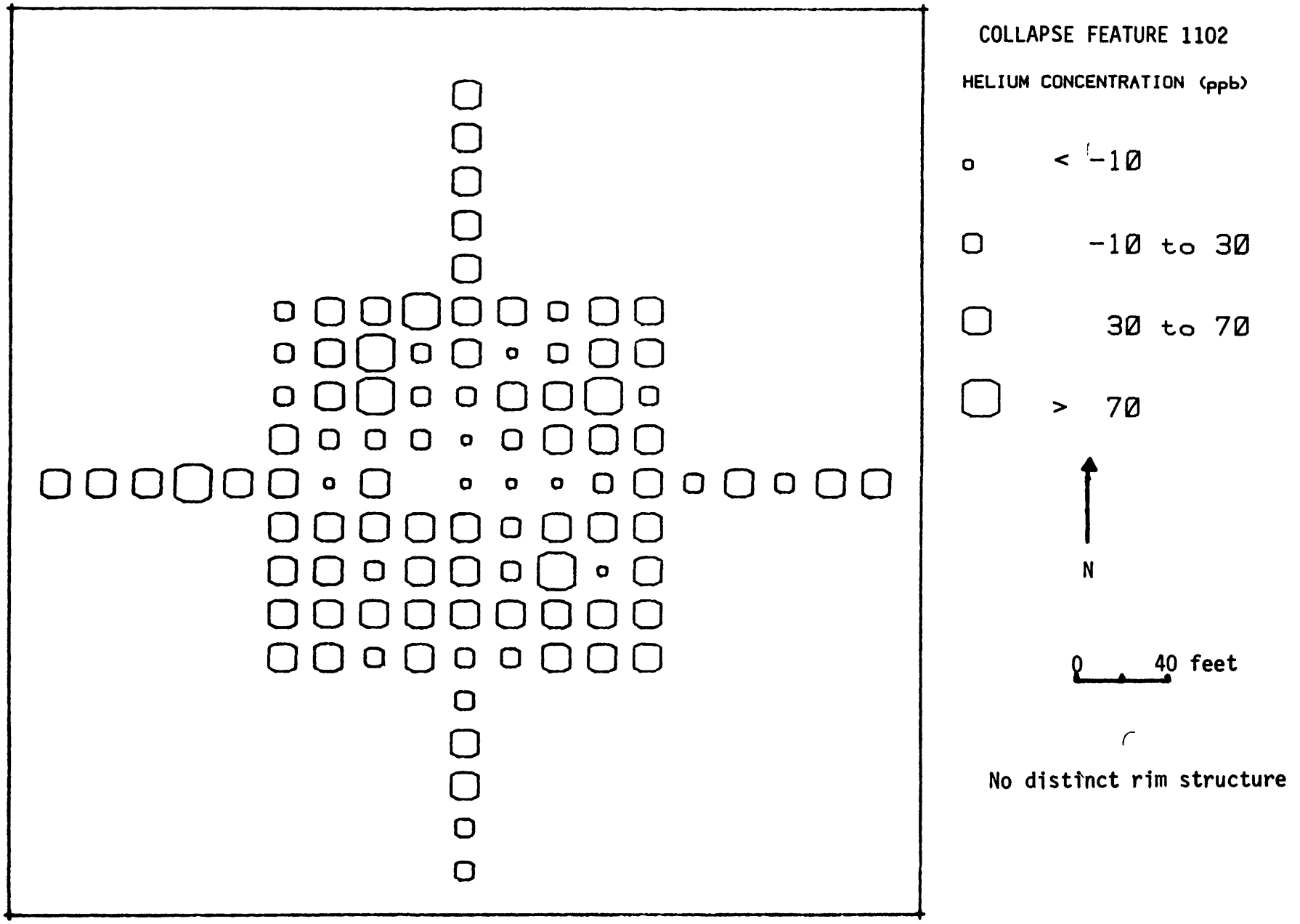


Figure 6. Helium concentration for collapse feature 1102. The dashed line represents the approximate location of the rim structure.