HELIUM AT KILAUEA VOLCANO

Part I
Spatial and Temporal Variations at Sulphur Bank

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ABSTRACT

A survey of helium in soil gas was conducted at Sulphur Bank, Kilauea Volcano. The resulting helium-isograd map shows the highest helium abundance in an area about 75 m southwest of the experimental well drilled about 50 years ago.

Variation of helium abundance over time was investigated using an automated helium analyzer installed adjacent to Sulphur Bank. The gas effluent from a new well drilled at Sulphur Bank was piped to the instrument. The gas was analyzed every 3 hours and the equipment was operated periodically for 2 years. Helium data from July 1982 to August 1984 show periods of higher helium from August 1982 to January 1983 and again from February to August 1984.

INTRODUCTION

In 1978, a helium sniffer shipped from Denver to the Hawaiian Volcano Observatory was used by Irving Friedman and Ted Denton to conduct a survey of helium in soil gas at Sulphur Bank, on Kilauea Volcano. In order to conduct this survey, sampling was carried out by first pounding a thick-wall steel tube of 6-mm (0.25-in) diameter into the ground to a depth of about 0.5 m. A rubber septum was attached to the top of the tube and a plastic hypodermic syringe was used to withdraw a gas sample. Immediately upon withdrawal of the sidehole hypodermic needle from the septum, the hole in the needle was sealed by placing a piece of close-fitting, soft silicone-rubber tubing over the needle. At the laboratory, the gas sample was injected from the syringe through another rubber septum into the inlet system of the helium mass spectrometer. The spectrometer response was calibrated by frequent injections of gas standards of known helium content. Errors in the sampling and analysis process are estimated to be less than ± 5 percent of the amount of helium present. The data from this survey at Sulphur Bank are given in figure 33.1.

The uranium and thorium contents of soil derived from Hawaiian basalt are very low, and the parent rocks at Kilauea are very young. Thus, these soils contain very little helium derived in place from radioactive decay of uranium and thorium. The content of helium in the soil gas at Sulphur Bank, however, is very high, even compared to that in soils developed on old granitic rocks, in which the concentrations of uranium and thorium are orders of magnitude greater than at Sulphur Bank.

The high helium content of the soil gas at Sulphur Bank reinforced the authors' earlier inference that Sulphur Bank taps a deep magma source, even though it does not appear to be along a major rift zone.

ACKNOWLEDGMENTS

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PRESENT SURVEY

Shortly after the completion of the (earlier) survey of Friedman and Denton, Thomas and Naughton (1979) observed changes in the ratio of helium to carbon dioxide at both Sulphur Bank and Halemaumau before inflation and eruptive events at Kilauea.

In 1979 we decided to install at Sulphur Bank an automated helium analyzer similar to that at a site 5 miles north of Gardiner, Montana, near Yellowstone National Park (Friedman and others, in press).

A new well at Sulphur Bank was successfully drilled about 100 m east of the old well (see fig. 33.1). The well was drilled to a depth of about 25 m, and the upper 13 m was cased with heavy-wall stainless steel pipe. The new well is shown in figure 33.2. Although the well casing was not cemented in place, alteration of the surrounding rock by the acid gases emitted along the casing has resulted in self-sealing of the casing. A slight positive gas pressure is observed in the casing.

The helium sniffer was placed in a trailer parked in the Park Service service area above Sulphur Bank Pali (see fig. 33.3). A 12-mm-diameter polyethylene tube inside a protective polyethylene pipe was used to convey the gas sample from well to trailer, a distance of 100 m, including 30 m of vertical rise.

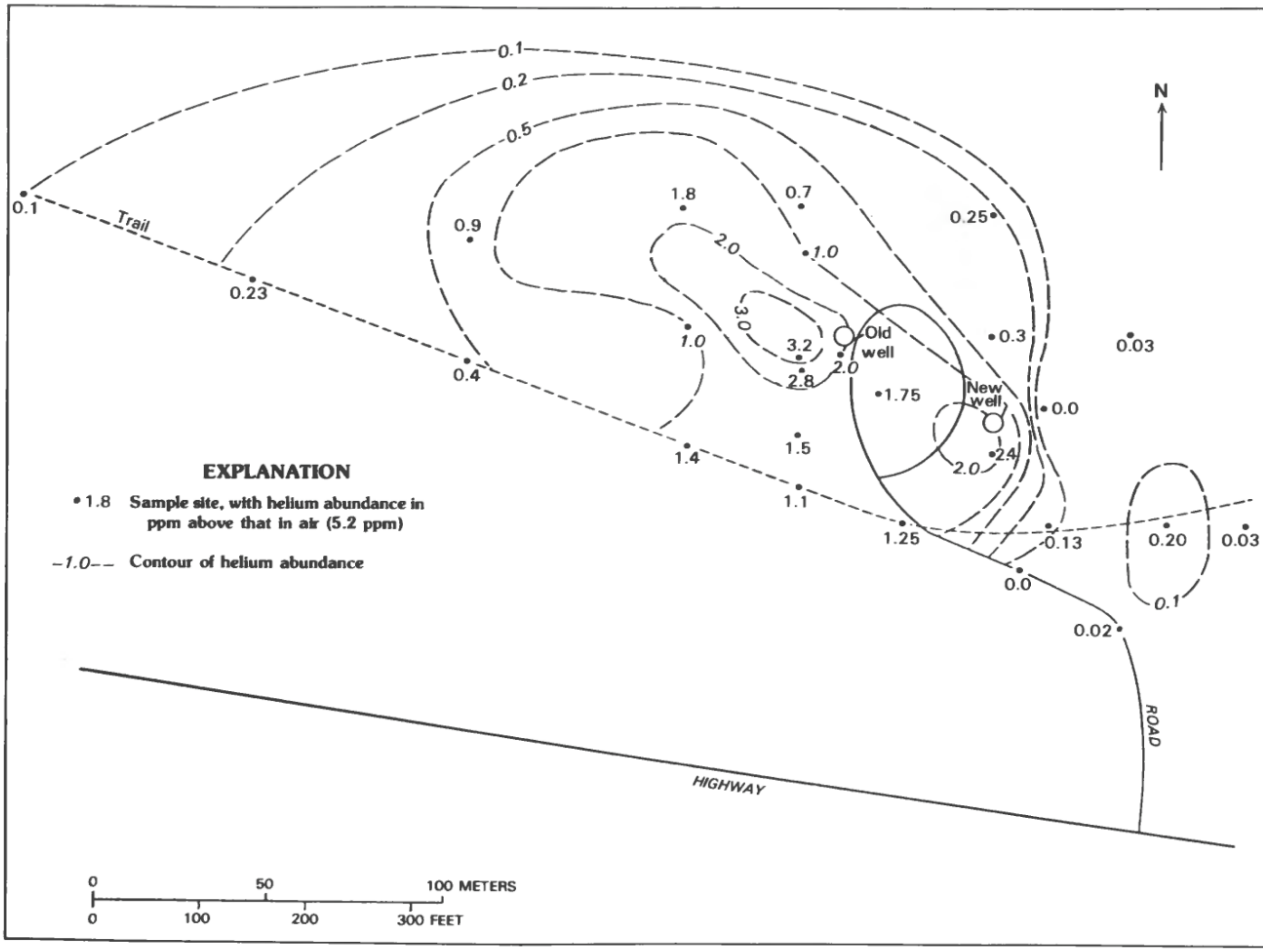

FIGURE 33.1.—Distribution of helium abundance in soil gas in the Sulphur Bank area, Kilauea Volcano, Hawaii. For location of Sulphur Bank, see figure 33.6.

Several attempts were made to condense the steam emitted by the well before it entered the polyethylene tube. Some schemes would work during dry periods when the steam flow was minimal, only to fail during increased steam flow associated with rainy intervals. In addition, metal condenser parts corroded at a very rapid rate, particularly at junctions of dissimilar metals. This problem was eventually solved by making all the wellhead fittings of Kynar plastic. A teflon tube connects these wellhead fittings to the steam condenser, which consists of 13 m of 37-mm-diameter thick wall copper pipe drained through a U-shaped tube. We found that the first few meters of copper pipe would corrode completely through in about 6 months, and it was replaced as needed. All parts, except for the two copper pipes joined with a plastic coupling, are now plastic.

FIGURE 33.2.—Wellhead of new well, completed 1979, for sampling soil gas at Sulphur Bank, Kilauea Volcano. White teflon tube carries gas from actual wellhead (left) to end of dark copper condensing tube. Note U-shaped glass tube (about 15 cm high) that allows condensed water to escape but prevents air from entering.

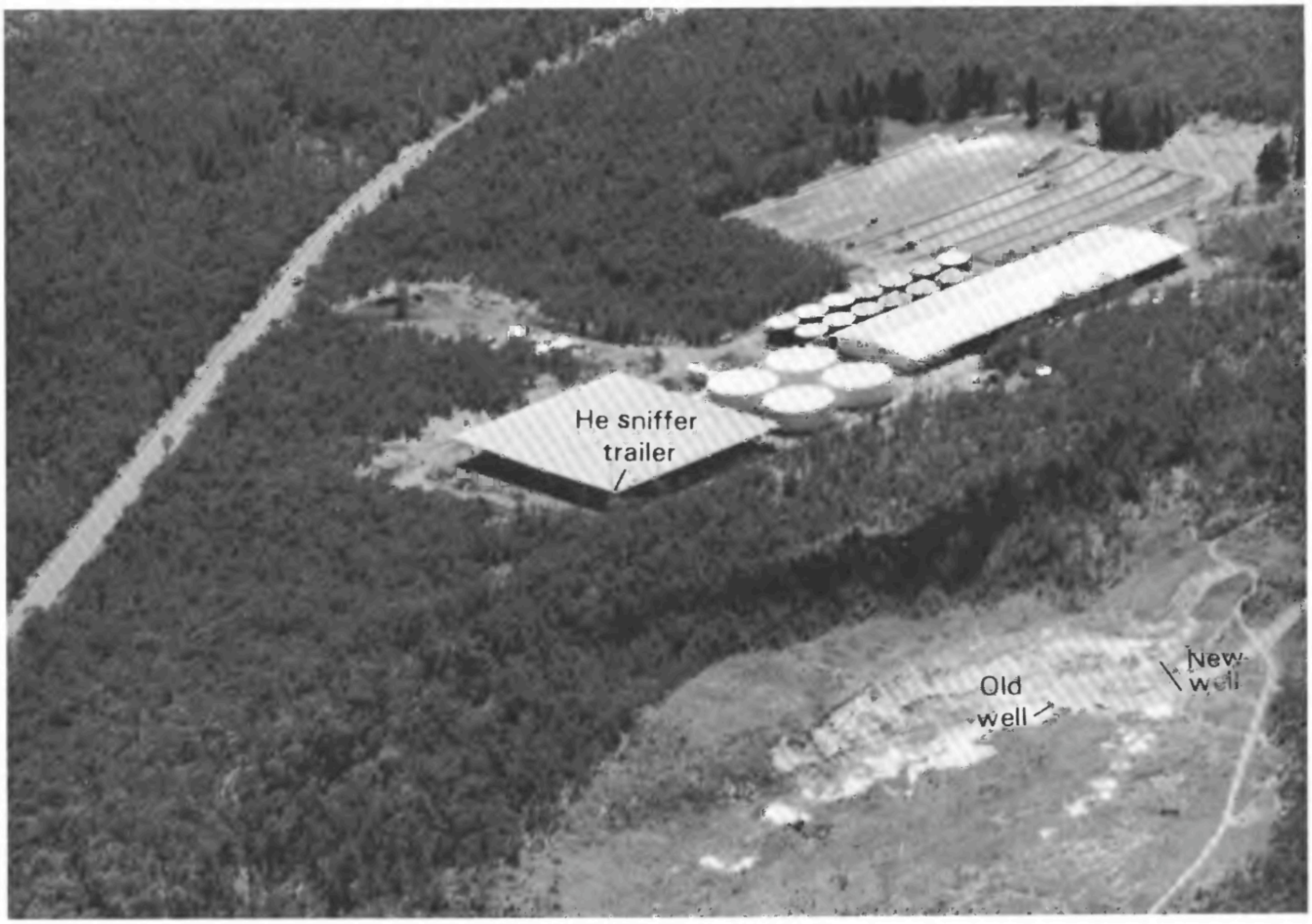

FIGURE 33.3.—Aerial view of Sulphur Bank area, Kilauea Volcano, showing location of old and new gas wells and of trailer containing helium sniffer (under corner of rain shed).

A small vacuum pump continuously pumped the well at about 100 mL/min. In order to remove water vapor that was not removed by the copper condenser pipe at the well site, the gas was passed through a silica-gel trap before entering the mass spectrometer sampling system.

At regular intervals (hourly at first, later changed to every 3 hours) the valve was opened automatically to admit a sample into the helium spectrometer for analysis. Immediately before and after each sample analysis, an aliquot of standard gas was analyzed, and after the second standard, a sample of ambient air was also analyzed. The results of these analyses were recorded on analog charts, an example of which is shown in figure 33.4.

Besides this automated mode of operation, it was possible to manually inject samples and compare the results to those for the standard gas. Approximately once a day, a sample of gas was collected manually at the wellhead by a sidehole hypodermic needle through a rubber septum; it was then analyzed manually on the automated instrument. These manually collected samples were used as a check on the operation of the automated system. In general, results from the two types of samples agreed within experimental error (± 50 ppb).

For a time, until the failure of the western GOES satellite, we were able to telemeter the results of the analysis via satellite to Wallops Island, Virginia and by land-line to Denver.

RESULTS

The helium concentrations in the samples show both short-term and long-term changes, as well as one abrupt change that preceded the January 1983 east-rift-zone eruption (fig. 33.5). From August 1982 through December 1983. the helium content decreased from about 11 ppm to 8 ppm. The helium content then rose again from about 8 ppm in mid-January 1984, to 16 ppm in mid-July 1984 at which time the instrument was decommissioned. An abrupt decrease occurred during December 21–28, 1982, coinciding with a hydrogen-gas increase noted on Kilauea (McGee and others, 1984) and preceding the January 1983 eruption.

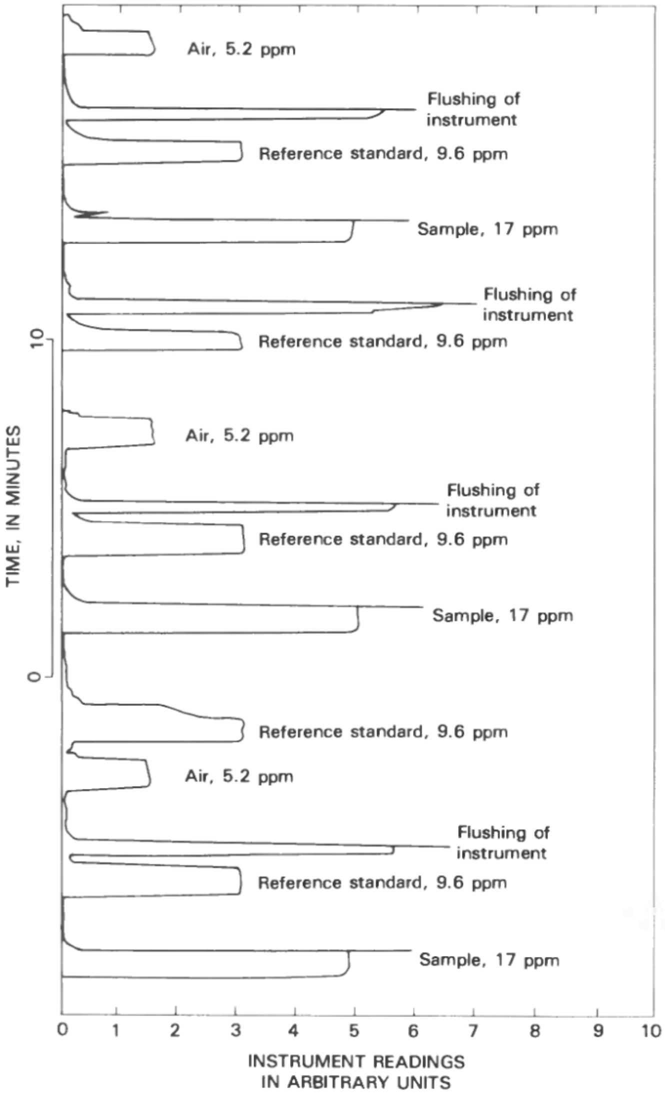

FIGURE 33.4.—Example of segment of instrument chart from the helium sniffer at Sulphur Bank, showing a typical helium analysis.

Other large and abrupt changes in helium abundance have been observed for which there is no obvious correlation with eruptive or meteorological events. If there is a link between the gas events and the east-rift-zone eruptions, we suspect that a change in the pressure regime of the magma source feeding the eruption should have been sufficient to be seen throughout the caldera.

Although the installation was automatic, it required weekly maintenance of the filters and occasional servicing of the mass spectrometer. Because the project investigators resided in Denver and could only visit the field site periodically, suitable personnel were not continuously available near the site, and even the usual teething problems required a long time to solve. These difficulties finally led us to abandon the effort and to substitute daily manual sample collection, the samples being mailed to Denver for analysis.

CONCLUSIONS

The map of helium abundance in soil gas at Sulphur Bank (fig. 33.1) shows a high concentration of helium in the vicinity of the old experimental well drilled in the 1920's.

Although helium abundance in the gases emitted from the newly drilled well vary with time (fig. 33.5), we were not able to correlate these variations conclusively with eruptive events during the two years in which we have collected data. A longer term record would be desirable, and this is now being collected.

REFERENCES

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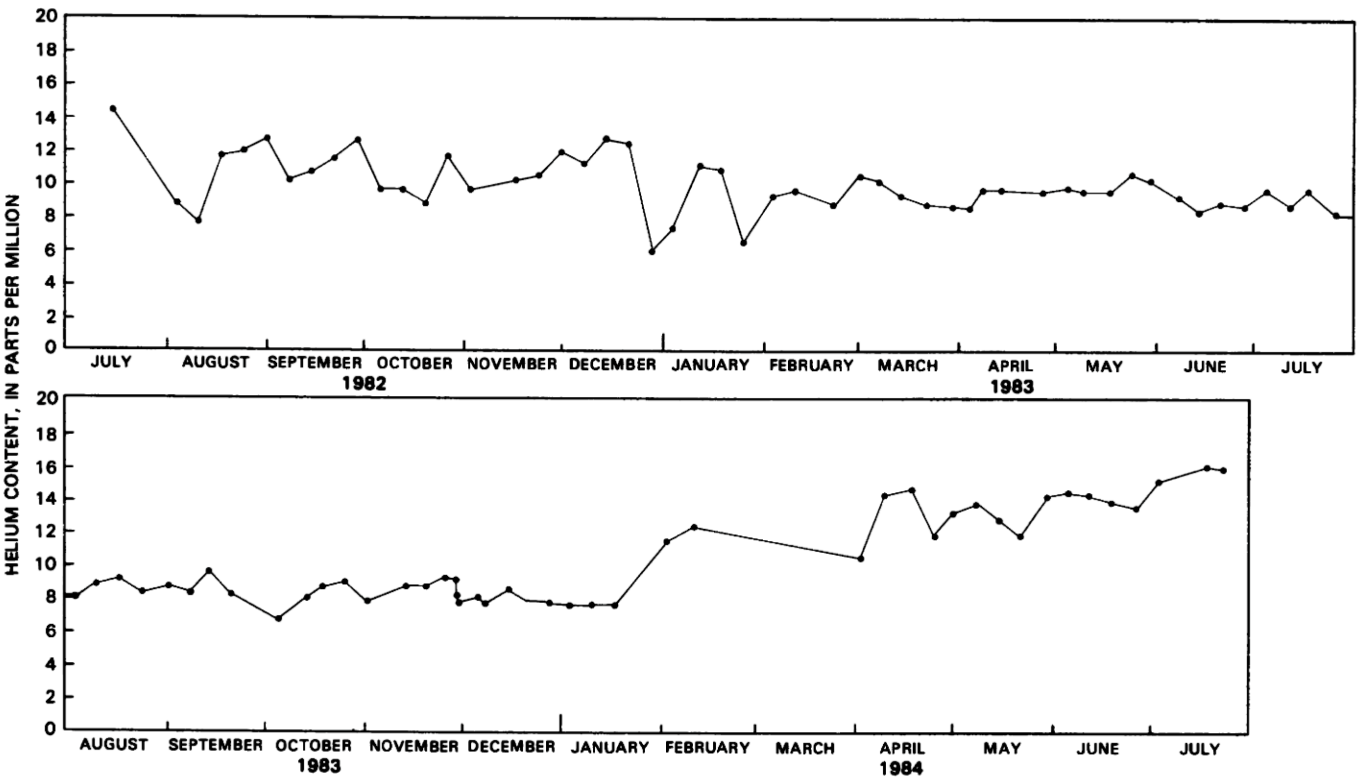

FIGURE 33.5.—Variation of helium abundance in soil gas at Sulphur Bank, Kilauea Volcano, from July 1982 to July 1984. All readings on samples from new gas well.