UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A Possible Petroleum Related Helium Anomaly in the Soil Gas, Boulder and Weld Counties, Colorado

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Open-File Report 76-544
1976

ABSTRACT

A survey of the concentrations of helium in the soil gas conducted over a portion of the Denver Basin in Boulder and Weld Counties, Colorado, supports the existence of a potential petroleum prospect that was suggested by earlier geochemical analyses of the outcropping sandstones. The helium survey technique may prove to be a rapid, inexpensive, and valuable surface prospecting tool for detecting buried petroleum deposits.

INTRODUCTION

A survey of the concentration of helium in the soil gas overlying a portion of the Denver Basin was conducted to determine the utility of helium surveys in prospecting for oil and gas. The distribution of anomalously high helium values in the Boulder-Weld County region may reflect an undiscovered petroleum deposit.

Considerable evidence in the literature documents the existence of surface or near surface geochemical manifestations of hydrocarbon seepage over petroleum deposits. (Horvitz, 1959; Kartsev and others, 1959; Davidson, 1963; McCulloh, 1969; McCrossan and others, 1972). Other geochemical manifestatio of hydrocarbon seepage such as a decrease in iron concentration or light carbon isotope ratios have also been observed over known oil fields. (Donovan and others, 1974; Donovan, 1974).

Because helium concentrations from 500 to 60,000 ppm are found in most petroleum reservoirs and because helium is chemically inert, is not biogenically produced and would effuse comparatively easily through the overlyin strata it may be a good surface indicator of petroleum deposits. We therefore undertook a survey over a petroleum prospect that has been outlined by other geochemical anomalies (Donovan and others, 1975).

The area of interest is a 350 square kilometre section south of Longmont, and northeast of Boulder, Colorado. Previous geochemical studies (Donovan and others, 1975) on iron and manganese concentrations and carbon and oxygen isotope ratios of calcareous cements in outcropping sandstones suggest a geochemical anomaly in the form of a halo centered southwest of Panama Reservoir #1. Their carbon isotope data are reproduced in plate 1. with the potential petroleum prospect outlined by the -4/mil carbon isotope contour line. The sample sites are limited to areas of outcropping sandstones and therefore cannot be taken in the form of a relatively evenly spaced grid over the entire area. The helium survey technique, however, can be applied to any surface area that is accessible by foot, the only limitation is that each site should contain at least 0.6 m of soil cover. It is therefore possible to get a more representative sampling pattern with this method.

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES

At each sample station a 9 cm diameter hole was drilled to a depth of about 45 cm with a gasoline powered auger. A 15 cm by 4 cm soil sample was collected at the bottom of this hole with either a hand auger or a gasoline powered sediment coring device. Each soil sample was hermetically sealed in an aluminum core collector and was subsequently transported to the laboratory for analysis.

After the sealed core containers and their contents had been subjected to a period of equilibration at constant temperature (30° C) two gas samples were extracted from each container and sealed in gas samplers. Helium contents of the containers were determined by mass spectrometry. During each analysis the concentration of helium in the sample was compared to that of an air standard containing 5.2 parts per million helium by volume. Appropriate temperature, pressure corrections were made to correct the laboratory conditions back to the field conditions of collection, with a precision of ± 0.1 parts per million.

RESULTS AND DISCUSSION

Helium concentrations at each sample site are given in plate 2 and those concentrations above 6 ppm are contoured. These data are alternatively presented in the form of a computer-generated helium surface-block diagram in plate 3 with the hills representing high helium concentration areas and the valleys representing lows.

Geochemical anomalies over petroleum reservoirs are manifested in two different types of surface patterns (Davidson, 1963, Horvitz, 1959). The anomaly can either be found directly above the oil or gas pool due to seepage through the cap rock, or in the form of a halo due to leakage around the perimeter of the seal. It is therefore sometimes difficult to interpret correctly the geochemical data. Our helium data could fit either of these two mechanisms of gas leakage.

The distribution of helium concentrations is consistent with the suggestion of Donovan and others (1975) that a geochemical anomaly exists in the form of a halo around an undrilled petroleum prospect. This halo, located around the two depressions of helium concentration in the center of plate 2, coincides well with the carbon isotope geochemical anomaly represented in plate 1. Thus, this interpretation suggests that the area to be drilled would be just southwest of Panama Reserovir #1.

The data, however, are also consistent with an interpretation that the helium highs are caused by seepage through the top of the cap rock. The concentrations of helium in the soil gas surrounding producing wells in the survey area (6.7 ± 0.4 ppm) was found to be significantly higher than that around dry wells (5.9 ± 0.5 ppm) Thus, this interpretation suggests that the areas to be drilled are those areas of highest helium concentration.

This problem of deciding between direct vertical seepage and seepage forming a halo type of anomaly is one of the major obstacles yet to be overcome in utilizing any direct detection technique. We feel that this obstacle is not insurmountable and that a helium survey technique may well prove its utility both as a quick and inexpensive reconnaissance tool and as a supportive measure for other geophysical and geological prospecting techniques.

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