Journal of the Arkansas Academy of Science

Volume 38 Article 9

1984

Implications of Hydrocarbon and Helium Gas Analyses of Springs from the Ouachita Mountains, Arkansas

Randel T. Cox
University of Arkansas, Fayetteville

Kenneth F. Steele
University of Arkansas, Fayetteville

IMPLICATIONS OF HYDROCARBON AND HELIUM GAS ANALYSES OF SPRINGS FROM THE OUACHITA MOUNTAINS, ARKANSAS

RANDEL T. COX and KENNETH F. STEELE
Department of Geology
University of Arkansas
Fayetteville, Arkansas

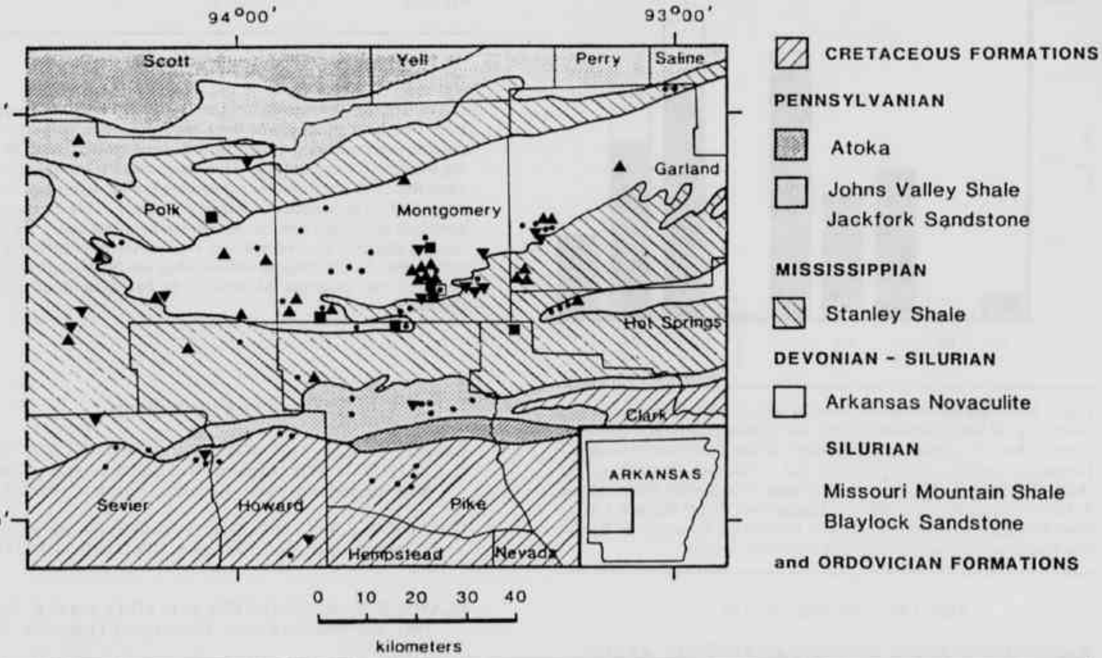
ABSTRACT

One hundred and three ground water samples (predominantly springs) were analyzed for headspace light hydrocarbon gases and helium. Four of the formations (Arkansas Novaculite, Bigfork Chert, Stanley Shale, and Womble) having the highest mean methane values are the only Ouachita Mountain facies to produce petroleum or exhibit marginally commercial production. This observation suggests that the mean methane values are useful as an indication of the relative hydrocarbon content of these formations. Anomalous helium values are generally associated with mapped faults.

INTRODUCTION

Light hydrocarbon and helium concentrations for 103 ground water samples from the western Ouachita Mountains, Arkansas were obtained by a hydrogeochemical survey conducted as part of the National Uranium Resource Evaluation. In order to obtain meaningful analyses of the metals in the ground water in this mineralized area, spring water was utilized predominantly so as to avoid plumbing contamination. Sample sites (92 springs and 9 wells) were selected to emphasize the mineralized districts, and the locations were also controlled by availability and accessibility of springs (Figure 1). The samples were analyzed for pH, conductivity, total alkalinity and concentrations of selected elements (Steele, 1982). Analysis of the headspace gas of the ground water samples for light hydrocarbon and helium was performed as a peripheral portion of the survey. It is the purpose of this paper to interpret these data and to assess usefulness of this method in evaluation of the potential hydrocarbon productivity of the area.

Figure 1. Map showing concentration ranges of ground water headspace methane value with regards to location and geologic formations. The concentration ranges are in ppm by volume as follows: (▲) > 700, (▼) 500-700, (■) 300-500, (□) 100-300, and (•) < 100.



GEOLOGY

Paleozoic rocks ranging from Pennsylvanian to Lower Ordovician in age occupy the major parts of the study area; whereas, Lower Cretaceous rocks occur in the southernmost part (Figure 1). The Paleozoic rocks include thick successions of Carboniferous sandstone and shale flysch facies, and pre-flysch successions of shale, chert, and sandstone. Structurally, the Paleozoic strata are characterized by generally east-west oriented intense folding and associated imbricate thrust faulting. The core region of the Arkansas Ouachita Mountains (the Benton Uplift) exposes the Lower Paleozoic sequence. The Cretaceous rocks are an essentially undeformed flat-laying overlap on the southern flank of the Paleozoic rocks (Flawn et al., 1961).

METHODS OF INVESTIGATION

The parameters used for this present study include light hydrocarbon gas (through butane) and helium concentrations, surface temperature, subsurface temperature (based on silica geothermometry), location, the geologic formation from which the spring issues and whether the site is within 150 feet of a fault. Although the movement of ground water in this area is complex, it is assumed the ground water will reflect the characteristics of the formation from which it issues and also will be affected by faults. It is also assumed that biogenic methane will have minimal effect on the water sample. The ground water samples for gas analyses were collected in soft drink bottles leaving about 2cc of air space, immediately capped and stored in an inverted position (to minimize loss of gases) for shipment to the laboratory where the headspace gases were analyzed by gas chromatography and mass spectrometry. Silica was determined colorimetrically on a separate water sample that had been filtered through 0.4 micron pore size membrane in the field. See Dromgoole (1982) and Steele (1982) for more information on collection and analytical methods.

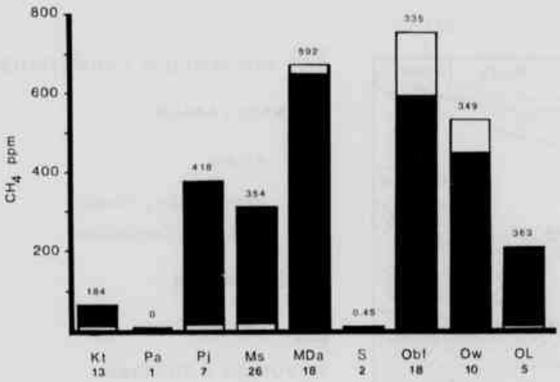


Figure 2. Histogram comparing median (top of white portion of bar), mean (top of black portion of bar) and standard deviation (number at top of bar) of methane concentrations for the individual formations. Formation symbols are as follows: (Kt) Cretaceous Formations, Pa (Atoka Formation), (Pj) Jackfork Sandstone, (Ms) Stanley Shale, (MDa) Arkansas Novaculite, (S) Silurian Formations, (Obf) Bigfork Chert, (Ow) Womble Shale and (OL) Lower Ordovician Formations. Sampling frequency is given below each formation symbol.

RESULTS AND DISCUSSION

A summary of the data for this study is given in Table 1. All of the methane, about one-third of the propane, only one (6.7 ppm) ethane, and no butane analyses were above the detection limit of approximately 1.0 ppm for these hydrocarbons. Helium concentrations are relatively uniform across the study area with a mean value of 6.0 ppm (Table 1).

There is a definite difference in the median and mean methane values for most of the formations (Figure 2), reflecting their organic contents. Of the five formations exhibiting the highest methane values for this survey (Figure 2), the Arkansas Novaculite, Bigfork Chert, Stanley Shale, and Womble Shale are the only Ouachita facies to produce oil and/or gas, or exhibit marginally commercial potentials in their western extentions in Oklahoma and Texas (Morrison, 1981). The production histories of these formations suggest that the mean methane values are an indication of the relative hydrocarbon content of these formations, i.e. those with higher mean methane contents have had greater production.

Highly mobile free helium atoms readily move up permeable zones, and therefore anomalous helium gas concentrations in ground water can be used for structural mapping (Eremeev et al., 1973). Although the helium concentrations are relatively low (6.0 ppm) and uniform across the study area, 84% of the anomalous helium concentrations are associated with mapped faults.

Table 1. Summary of data for study area. In calculations for propane values below detection were treated as zero. Concentrations are ppm based on volume.

	Methane	Propane	Helium
Mean	386	1.7	16.5
Standard Deviation	450	3.2	70.6
Median	125	<1	6.0
Maximum	2100	15	530
Minimum	1	<1	5.0

CONCLUSIONS

The fact that the highest methane values are associated with formations that have produced or have some potential for petroleum production is encouraging regarding the use of ground water as a sampling medium for exploration. This observation is especially important since there are uncertainties concerning the movement of the ground water and the importance of biogenic methane. This conclusion is also especially significant considering that the sampling design for the survey was not designed for hydrocarbon exploration in mineralized areas. It also appears that anomalous helium values can be utilized to locate major faults in the Ouachita Mountains as has been done successfully elsewhere.

LITERATURE CITED

EREMEEV, A. N., V. A. SOKOLOV, A. A. SOKOLOU, and I. N. YANTISKII. 1973. Application of helium surveying to structural mapping and ore deposit forcasting. London, IGES:183-192.

DROMGOOLE, E. L. 1982. Report of analyses for light hydrocarbons in ground water. Grand Junction, U.S.D.O.E. GJBX-131-82, 14 pp.

FLAWN, P. T., A. GOLDSTEIN, P. B. KING, and C. E. WEAVER. 1961. The Ouachita System. University of Texas, Pub. No. 6120, 401 pp.

MATTHEWS, S. M., and D. W. HOUSEKNECHT. 1983. Thermal maturity of Carboniferous strata, Ouachita Thrust Fault Belt (abst.). Amer. Assoc. Petrol. Geol. 67:509.

MORRISON, L. S. 1981. Oil in the fascinating Ouachitas. Oil and Gas Journal. May 11:170-179.

STEELE, K. F. 1982. Orientation study, Ouachita Mountain area, Arkansas. Grand Junction, U.S.D.O.E. GJBX-208-82, 38 pp.