VOLUME XXXXIIII NUMBER 1 AUGUST 2007

SIPES QUARTERLY

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President's Column

George S. Johnson, #2724
Amarillo, Texas

"Let the Good Times Roll"


George S. Johnson

After much prayer and consideration, I accept the responsibility of being your president for the year of 2007-2008. The leadership before me has been awesome. I have had the privilege of watching Bill Goff, Brian Calhoun, David Eyler and Mike Austin in action. Their contributions to SIPES will never be forgotten and will carry on for many years. I consider it an honor and a privilege to serve as your president, especially since I'm the first At-Large Member to hold this office. Pete MacKenzie of Worthington, Ohio has succeeded me as a director representing At-Large Members on the SIPES Board

One of the strong points of SIPES is networking. Therefore, I will make an effort to visit every chapter and headquarters during the coming year. SIPES has introduced me to some of the finest people in the industry. In Monterey, I had breakfast with Ray and Melba Scurlock from Shreveport, Louisiana. I learned that Ray had worked for Gulf Oil in New Orleans before becoming an independent in Shreveport.

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GEOCHEMICAL EXPLORATION:

Sample Collection and Survey Design

by Chuck K. Goudge, GrayStone Exploration Labs, Inc. — Golden, Colorado

Note: This article is from the Denver Chapter, and is the fifth in a new series submitted by SIPES Chapters.

Near surface petroleum geochemistry involves the detection of hydrocarbon gases and other molecules and/or elements that have been affected by hydrocarbons emanating from below. Although there are many potential methods to detect this phenomenon, only a small fraction of them have been fully investigated. Mistakenly, in this author's opinion, geochemistry has largely focused on hydrocarbon gases. Measuring hydrocarbons directly would seem to be the most obvious and effective way to detect hydrocarbon seepage, however, many of these methods are difficult and expensive and may be partly responsible for the slow adoption of near surface petroleum geochemical exploration technology.

All surface geochemical tools measure the effects of the same phenomena; either an area is experiencing seepage or it is not. The only variable is the amount of the gas reaching the soil. Therefore, differences between methods, other than the unique characteristics of a particular component, must arise from either collection or analysis. However, analytical chemistry is an established science with well developed, quality control protocols, and is unlikely the source of survey variations. Therefore, most survey differences must derive primarily from sample collection and survey design, and this will be the subject of this paper.

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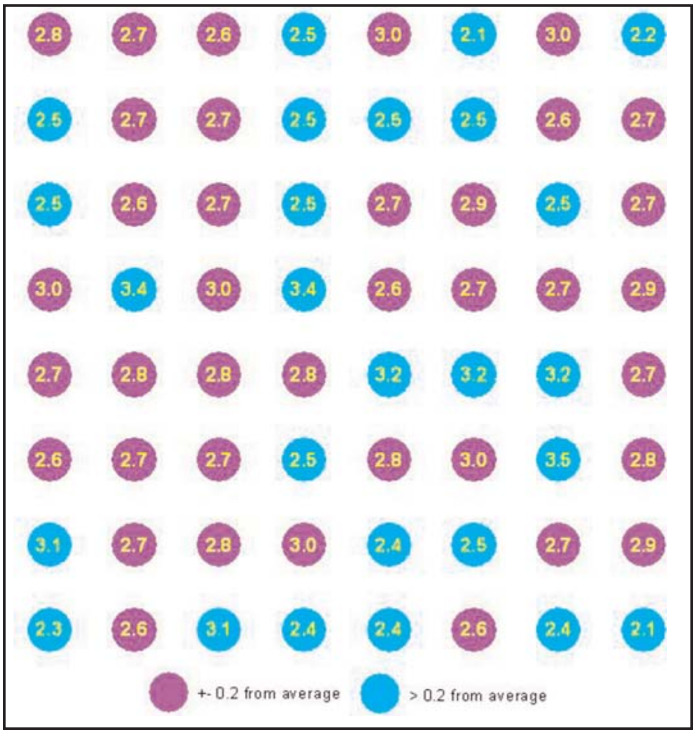

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2.5	2.7	2.7	2.5	2.5	2.5	2.6	2.7
2.5	2.6	2.7	2.5	2.7	2.9	2.5	2.7
3.0	3.4	3.0	3.4	2.6	2.7	2.7	2.9
2.7	2.8	2.8	2.8	3.2	3.2	3.2	2.7
2.6	2.7	2.7	2.5	2.8	3.0	3.5	2.8
3.1	2.7	2.8	3.0	2.4	2.5	2.7	2.9
2.3	2.6	3.1	2.4	2.4	2.6	2.4	2.1

Figure 1

SAMPLE COLLECTION

Gas migration from an accumulation to the soil is a response to pressure gradients, buoyant forces and immiscibility proceeding through micro and macro fractures. The system breaks down as the gases emerge from the underlying consolidated rocks to the regolith and soil. At this transition, the gases will begin to segregate and concentrate as they move around rocks and other barriers present in the unconsolidated near surface materials.

Many geochemical tools, including hydrocarbon gases, rely on a single point of collection, an issue for these techniques that has largely gone unaddressed. What is the variability of samples over short distances? Because there is no research published on the variability of gas samples, I have used data generated using the iodine technique to illustrate this issue. The discussion will not directly address the variability of hydrocarbon gases but it does provide a starting point for evaluating the issues with single point collection methods.

Normally the collection of Iodine samples blends four to five separate scoops of soil to form a single sample. In the following example, 64 samples were taken on 4 ft centers using a single collection point. The data range of these samples is from 2.1 to 3.5 or 1.4 ppm I_2 with all of the points being less than 40 ft apart. Statistically this is an anomalous area. Samples beginning at 1.9 ppm I_2 are above the local iodine background and are considered anomalous. All 64 sample points are statistically anomalous with some just slightly above background, however, samples a few feet away are almost double the background. The average for all 64 samples is 2.8 but only 38 of 64, or 59%, of the single collection point samples are within +- 0.2 ppm of this average.

The wide variation of the 64 samples can be reduced by utilizing an integrative sample technique. Simulating the iodine collection method and using this same data set: **Figure 2** shows the average of each group of four adjacent samples yielding 49 new values. This method compresses the single point range by half, now spanning 2.5 to 3.2 or 0.7 ppm I_2 with 43 of 49, or 88%, within +-0.2 ppm of the average.

This data set suggests that a single point collection methods may not measure the average seepage of an area on four of ten samples, and sizable variations between samples a few feet apart is possible.

SURVEY DESIGN: SAMPLE DENSITY

A few years ago, a paper was presented at AAPG involving complex and sophisticated hydrocarbon and elemental analysis evaluating the use of geochemistry in the North Sea. This extensive research project consisted of 17 samples.

Geochemical methods with high analytical costs will necessarily limit the number and density of samples taken on any given project. Intuitively more samples would be better than fewer samples but how important is sample density to the effectiveness of geochemistry?

In an attempt to quantify an answer to this question, an iodine survey, conducted in early 2007, will be used to make this evaluation. Permission has been granted to utilize this survey under the condition that the location and

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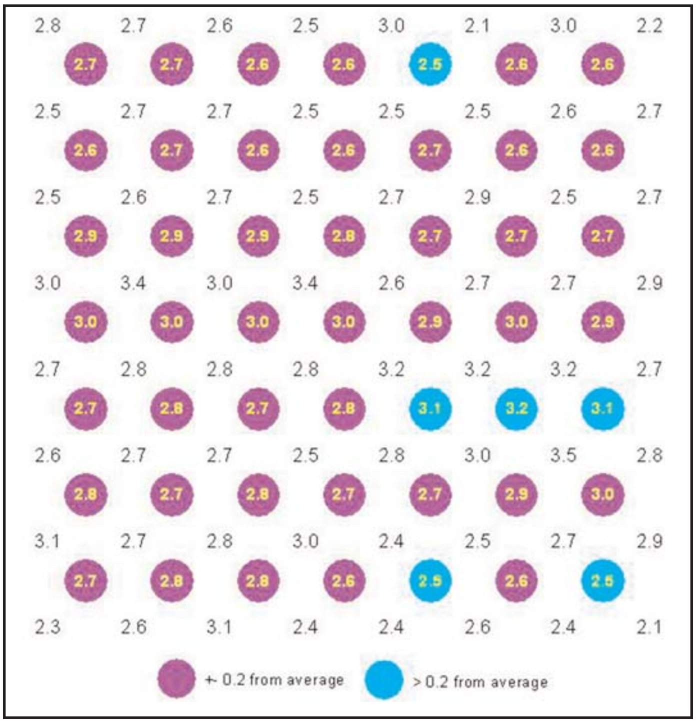

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2.6	2.7	2.6	2.6	2.7	2.6	2.6	
2.5	2.6	2.7	2.5	2.7	2.9	2.5	2.7
2.9	2.9	2.9	2.8	2.7	2.7	2.7	
3.0	3.4	3.0	3.4	2.6	2.7	2.7	2.9
3.0	3.0	3.0	3.0	2.9	3.0	2.9	
2.7	2.8	2.8	2.8	3.2	3.2	3.2	2.7
2.7	2.8	2.7	2.8	3.1	3.2	3.1	
2.6	2.7	2.7	2.5	2.8	3.0	3.5	2.8
2.8	2.7	2.8	2.7	2.7	2.9	3.0	
3.1	2.7	2.8	3.0	2.4	2.5	2.7	2.9
2.7	2.8	2.8	2.6	2.5	2.6	2.5	
2.3	2.6	3.1	2.4	2.4	2.6	2.4	2.1

Figure 2

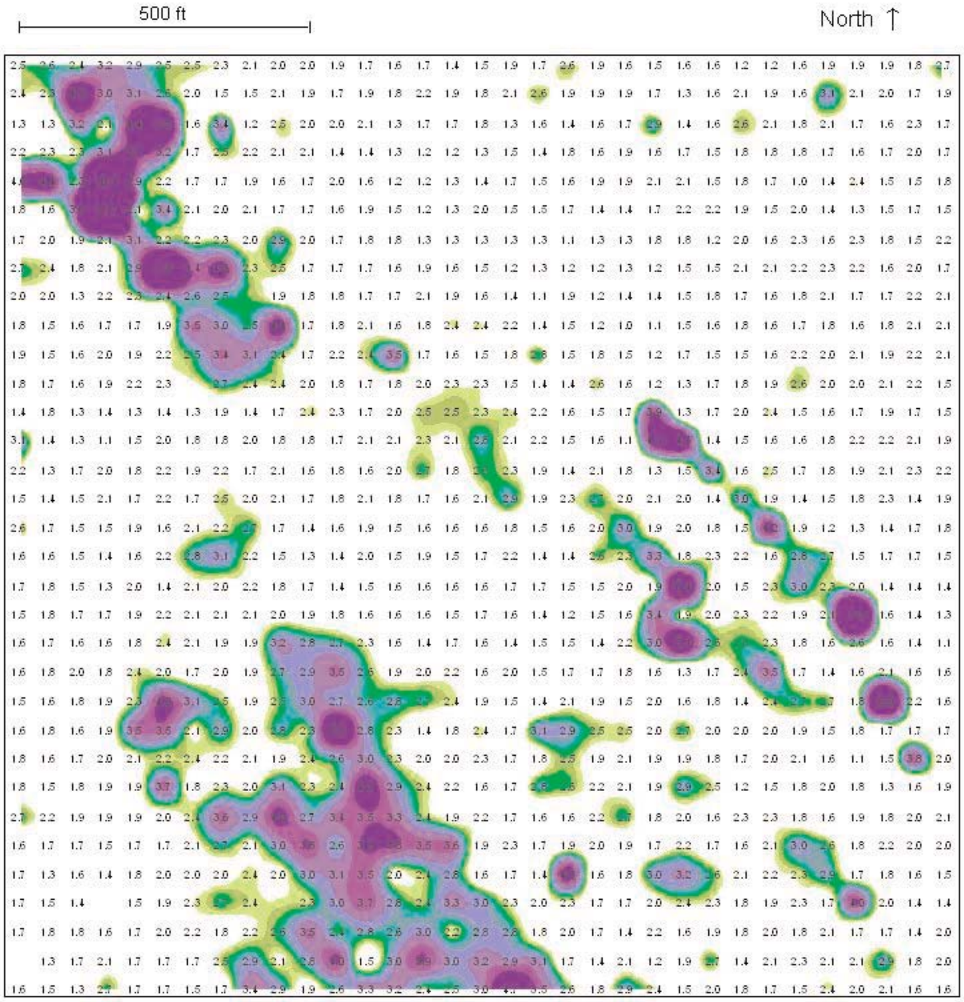

Figure 3

client remain anonymous. **Figure 3** displays 1084 samples taken on 50 ft. centers. This sampling program is nearly 50 times the density of a typical hydrocarbon geochemical survey. The primary objective of the survey was to find potential fault zones. The iodine survey not only found iodine highs suggestive of fault breccia, but it also appeared to have identified linear features between 50 and 100 feet wide extending almost 800 feet which are likely faults.

TEN TO ONE DENSITY

The **Figure 3** survey identifies an anomaly to the southwest (SW), a smaller one to the northwest (NW) and two potential faults to the east. Understanding that most hydrocarbon targets are larger than the 500 by 600 ft. SW anomaly, I will use this area to evaluate the sample density necessary to reliably identify this anomaly and attempt to propose a general principle to apply to geochemical sample densities. The sample density of **Figure 3** is "ten to one." The smallest dimension of the SW anomaly is 500 ft. and ten samples spaced 50 ft. apart span this distance.

ONE TO ONE DENSITY

The survey, depicted in **Figure 3**, can be separated into 100 unique subsets with samples 500 ft. apart. Limited space, in this paper, precludes showing all 100 maps but each map can be evaluated using the following three criteria: does the survey identify the SW anomaly, does the survey identify the SW anomaly, but the anomaly is exaggerated, or is the SW anomaly missed entirely?

Eighty of the 100 500-ft. surveys, found the SW anomaly. However, sixty of these surveys exaggerated the anomaly and twenty of the 100 surveys failed to find the SW anomaly. Combining this 20% with the 60% of exaggerated anomalies, this sample density fails eight of ten times to effectively map the geochemical pattern. Nearly half of the surveys identify the faults and other small anomalies as significant, often linking them with the SW anomaly. These linked areas, in a few examples, span multiple samples as chance connects isolated high points giving the appearance of huge anomalies that, in fact, do not exist.

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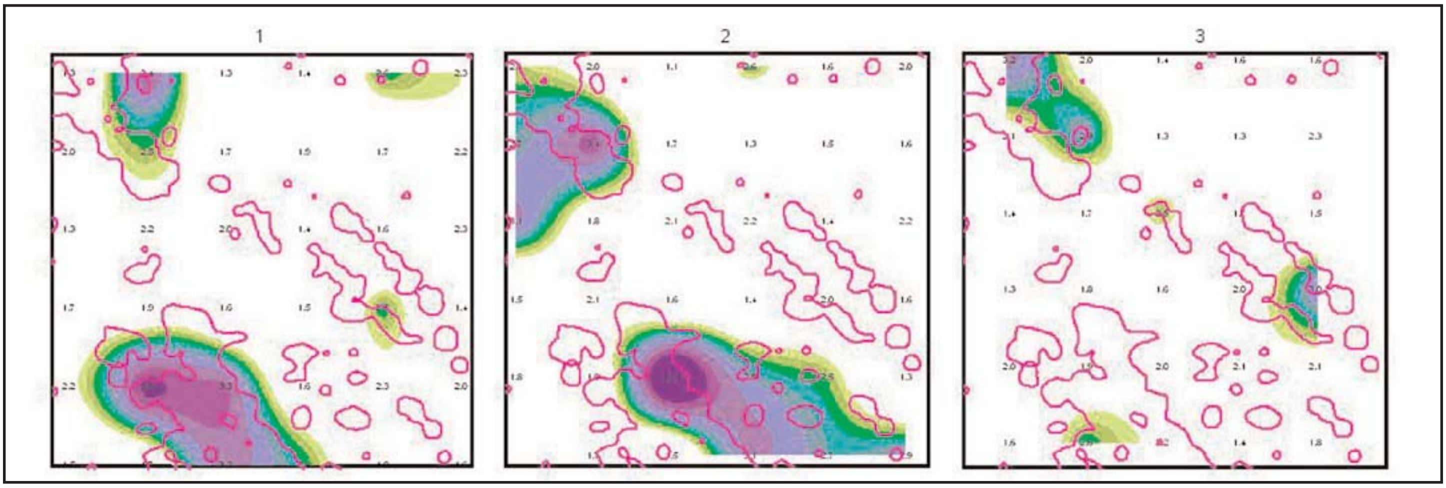

Figure 4

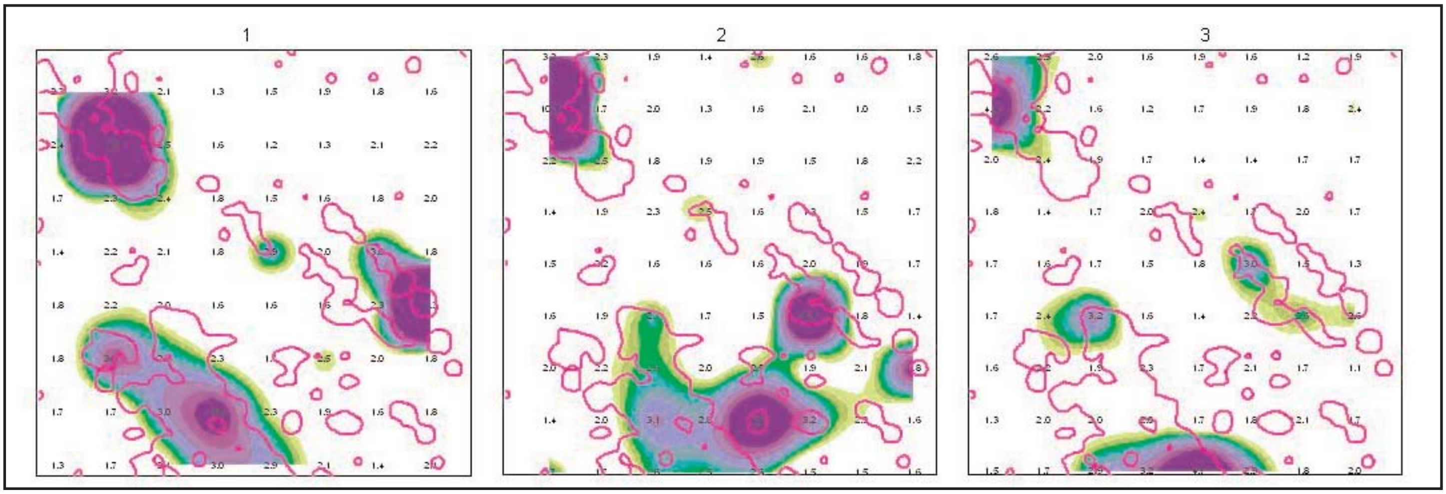

Figure 5

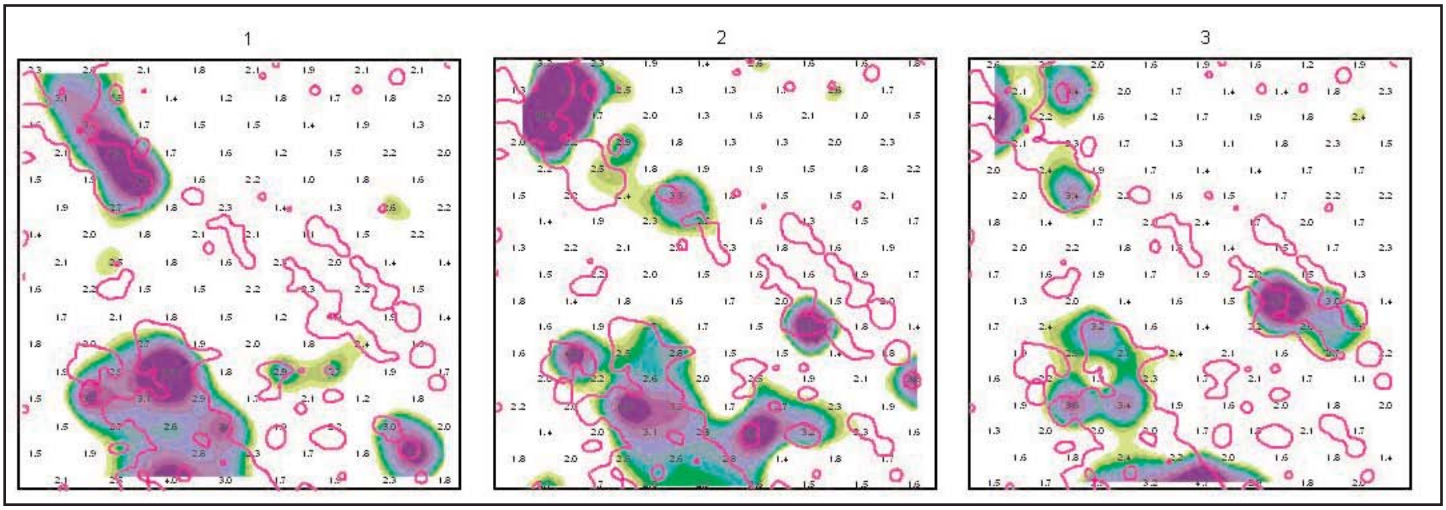

Figure 6

TWO TO ONE DENSITY

With samples spaced 300 feet apart, there are 36 unique sub surveys available from the data of **Figure 3**. The SW anomaly is found more than 90% of the time and approximates the actual anomaly nearly 60% of the time, but in a quarter of the surveys the SW anomaly is exaggerated. Additionally, the faults and isolated highs appear as significant anomalies in some of the surveys.

Figure 4 displays three of the 36 sub surveys with samples spaced 300 ft. apart. Each map shows the geochemical pattern produced by the survey along with a line overlay of the **Figure 3** anomalies. The first survey is part of the 60% that finds and defines the geochemical pattern in the SW. The second example is part of the 25% that exaggerates and misplaces the SW anomaly and the last map is one of the three that almost misses the SW anomaly. From a technical standpoint there is no difference, qualitatively, between these three surveys, or between any of the 36 surveys, other than the placement of the grid.

THREE TO ONE DENSITY

With samples spaced 200 ft. apart there are 16 unique sub surveys. Fifteen of sixteen find the SW anomaly with 11 of 16 (69%) correctly mapping the anomaly, however 5 of 16 (31%) either slightly exaggerates and misplaces or in one case nearly misses the anomaly.

The three surveys in **Figure 5** are three of the sixteen 200 ft. surveys generated from the data of **Figure 3**. The first one, part of the 69% that correctly maps the SW anomaly, matches the higher density map as well as can be expected. The second shows the survey that most exaggerates the SW anomaly and the third is the survey that misses the middle section of the SW anomaly.

FOUR TO ONE DENSITY

Doubling the 200-ft. density by shrinking spacing to 133 ft. between samples produces eight unique surveys, all of which detect the SW anomaly.

Figure 6 shows three of the eight surveys. The first survey defines the SW anomaly almost exactly, the NW anomaly is also well defined, but neither fault is detected. The second survey is the most exaggerated mapping of the SW anomaly and the third is the least definitive of the SW anomaly.

FIVE TO ONE DENSITY

Finally, 100 foot spacing yields four separate surveys, all of which are displayed in **Figure 7**. This density yields

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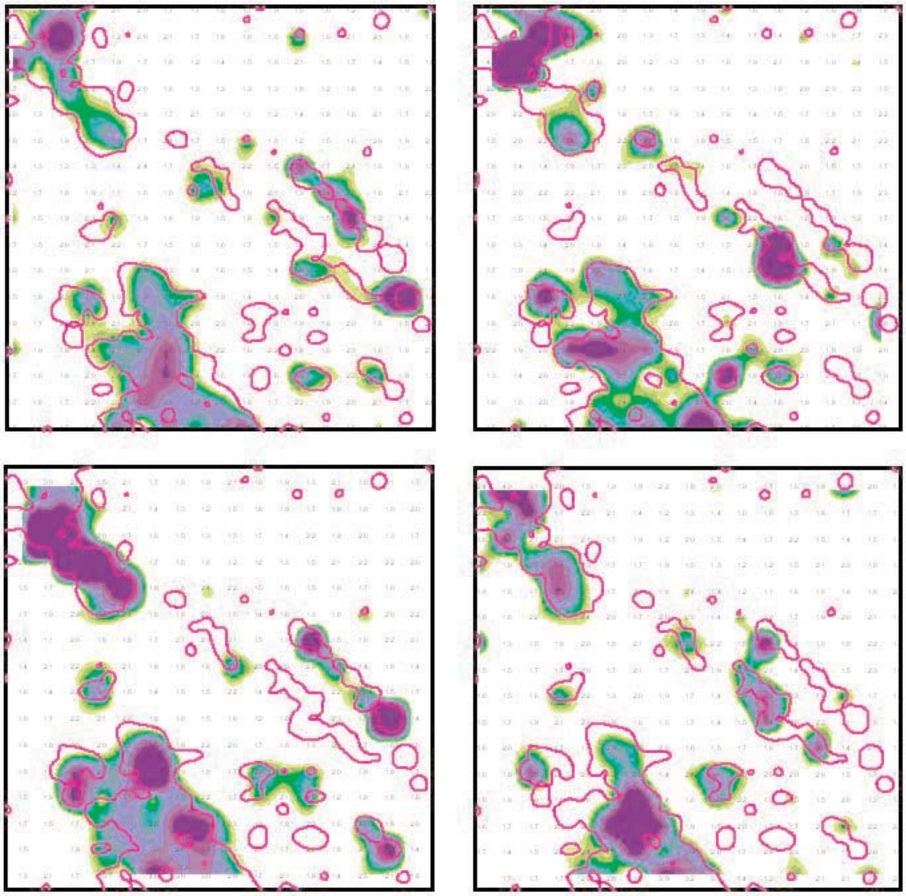

Figure 7

maps which all identify the SW anomaly, with all four matching the high density outline effectively. All four also map the NW anomaly, and all pick up parts of the two faults to the east and the strong NW trend is clear in all four surveys.

CONCLUSIONS

Geochemistry can be a very valuable tool, but the value is largely dependent on the sample density of a survey. Low density surveys may both miss targets and exaggerate small and disconnected anomalies. Low density, one to one or two to one, surveys should only be considered as a part of a program that follows leads with higher density surveys and with the expectation that some targets may be missed.

Geochemical surveys with sample spacing one third to one quarter of the prospective targets smallest dimension can produce good results a high percentage of the time. At these densities almost all targets are detected, however, exaggerated targets will still be encountered.

Increasing sample density by reducing sample spacing to between one fifth to one tenth the target's smallest dimension produces geochemical results, at least based on this example, that reliably maps the target's seepage pattern.

BIOGRAPHY

Chuck K. Goudge is the founder and president of GrayStone Exploration Labs, Inc. of Golden, Colorado. He attended the University of Colorado from 1971 to 1975, majoring in chemistry. He has been investigating and providing near surface geochemical petroleum exploration services, focusing on soils and soil properties for almost thirty years. He was a charter member and officer of the Association of Petroleum Geochemical Explorationists, and is a member of RMAG. He can be contacted at 303-278-3252 or graystonelabs@yahoo.com.

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