

**RESULTS OF THE PALERMO GEOCHEMICAL SURVEY, NEW YORK**  
Final Report

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## ABSTRACT AND KEY WORDS

The Palermo Surface Geochemical Survey was carried out over gas-charged and barren Trenton Limestone reservoirs in Oswego County New York. The objective of the survey was to determine if cost-effective, surface geochemical methods are applicable to gas exploration for Trenton Limestone reservoirs in New York.

A total of 167 shallow (1.5-foot) and deep (8-foot) soil samples were collected at 200-meter intervals along public roads for both hydrocarbon and major/trace element analysis. The main conclusion drawn from the survey is that hydrocarbon-based geochemical methods using both shallow and deep soils effectively distinguish seepage over gas-charged and barren Trenton Limestone reservoirs. These methods can therefore be used where free soil gas is unobtainable because of water-saturated soils. Future geochemical surveys in New York should include the collection of shallow (1.5-foot) soils at short intervals (<200 meters) for C1-C8 hydrocarbon analysis. The most important hydrocarbon ratio in soils for distinguishing gas-charged from barren Trenton Limestone reservoirs is  $C3/nC4+C1+nC7$ . Although dry gas ratios ( $C1/C2$ ) in deep soils effectively detect seepage related to Trenton gas reservoirs, the cost to collect these samples is considerably higher than the shallow soils.

## ACKNOWLEDGEMENTS

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## SUMMARY

A multi-component geochemical soil survey was carried out along public roads near Palermo in Oswego County, New York to determine if unique surface geochemical methods could effectively discriminate between thermogenic gas-charged and barren Trenton Limestone reservoirs. A total of 167 shallow (1.5 foot) and deep (8-foot) soils were collected at 200-m intervals along public roads that follow 2D seismic lines. The deep samples were analyzed by both low (90<sup>0</sup> C) and high (260<sup>0</sup> C) temperature thermal desorption gas chromatography methods for alkane and alkene hydrocarbons in the C1-C8 range. Shallow soils were analyzed for C1-C8 hydrocarbons by the high temperature method only. In addition, both the shallow and deep soils were analyzed for 23 acid-extractable major and trace elements by Inductively Coupled Plasma Emission Spectroscopy, and for organic carbon by a Loss On Ignition method. Absolute concentrations and multivariate ratios of the organic and inorganic variables were plotted on a surficial geology background for interpretation.

The main conclusion of the study is that soil-based hydrocarbon geochemical methods are effective for discriminating between gas-charged and barren Trenton Limestone reservoirs. When using low temperature desorption methods on deep soils, the biogenic methane (C1/C2>100) produced through bacterial degradation of organic matter in swamps, must be removed from the data before interpretation. Plots of biogenic-free methane concentration and dry gas ratios (C1/C2 and %C1) reveal anomalies that are spatially associated with fractured gas-charged areas. When using high temperature desorption methods on shallow and deep soils, it is best to evaluate hydrocarbon ratios rather than absolute concentrations to realize wider dispersed anomalies. For instance, the percent propane ratio (C3/C1+\*100) is anomalous locally within the gas-charged area, and propane is the most important coefficient for distinguishing gas-charged from barren areas based on discriminant analysis of the data. Alkali (potassium) and alkaline earth metals (barium) are anomalous over the fractured, gas-charged area, but the origin of these anomalies remains unclear. They could be related to mobilization of these elements from feldspars and illitic clays in a reduced-acidic environment produced by hydrocarbon microseepage or, alternatively, they could be derived from clay-rich soils developed on glaciolacustrine sediments that cover the gas-charged area.

The most cost effective approach to future geochemical exploration for these types of reservoirs would involve the collection of shallow (1.5-foot) soil samples (~\$20 per sample) at short intervals (<200 meters) for high (260<sup>0</sup>C) temperature desorption and C1-C8 hydrocarbon analysis (~\$70 per sample). The data would then be scanned for those samples having anomalous C3/nC4+C1+nC7 ratios and percent propane (C3/C1+). Low temperature (90<sup>0</sup>C) desorption dry gas ratio (C1/C2 and %C1) and methane anomalies in deep (8-foot) samples are spatially correlated with gas-charged Trenton Limestone reservoirs, but the cost of obtaining these samples with a Geoprobe is substantially higher (~\$80 per sample).



The benefit of this study to future geochemical exploration for Trenton gas reservoirs in New York is that soil-based hydrocarbon methods can be used for the detection of microseepage over these reservoirs where free gas is unobtainable because of water-saturated soils.

## 1.0 INTRODUCTION

Gas has been produced from Trenton Limestone in northern New York (Figure 1) for almost 120 years from depths of less than 2,500 feet (Nyahay et al. 2006). Typically the wells have initial pressure spikes that decrease rapidly within a few hours or days. Based on analysis of cores, the gas is probably sourced from bedding plane partings in over pressured limestones and shales, and it is proposed that wells with more sustained gas production tapped vertical fractures that connect larger pore volumes (Nyahay et al. 2006). The Huntley-1 well drilled to a vertical depth of 2,690 feet by Seneca Resources is thought to have tapped a vertical fracture (Figure 2).

The objective of this survey in the vicinity of the Huntley well is to determine which, if any, surface geochemical methods are capable of detecting fractured, gas-charged Trenton Limestone in the Palermo area of Oswego County (Figure 1). If an inexpensive, surface-based for finding gas-charged fractures is found, this could result in testing large areas of northern New York to help focus more expensive seismic and drilling campaigns.

Other workers have found light hydrocarbon soil gas and spectral anomalies over faults and fractures elsewhere in the Appalachian Basin (Harbert et al. 2006; Seneshen and Viellenave, 2004; Nelson et al. 2001). Hydrocarbon-induced alteration of soils and vegetation along prominent fracture zones in the Appalachian Basin is also apparent on satellite imagery (Everett et al. 2003). The solubility of certain major and trace elements in soils can be affected by reducing acidic conditions caused by biological and chemical oxidation of hydrocarbon microseepage over time (Schumacher, 1996). This may lead to the breakdown of feldspars to clays and transformation of illite to kaolinite. Saunders et al. (1999) suggest that potassium will actually be leached from illite through cation exchange and removed by groundwater leaving a potassium halo around the reservoir (Figure 3).

Since there is potential for both organic and inorganic anomalies in soils over gas-charged Trenton Limestone, it was decided to test both methods in the Palermo Geochemical Survey. The following sections of the report summarize the (2.0) general geology of the Palermo area, (3.0) methods used for sample collection, analysis and interpretation, (4.0) results, and (5.0) discussion and conclusions.



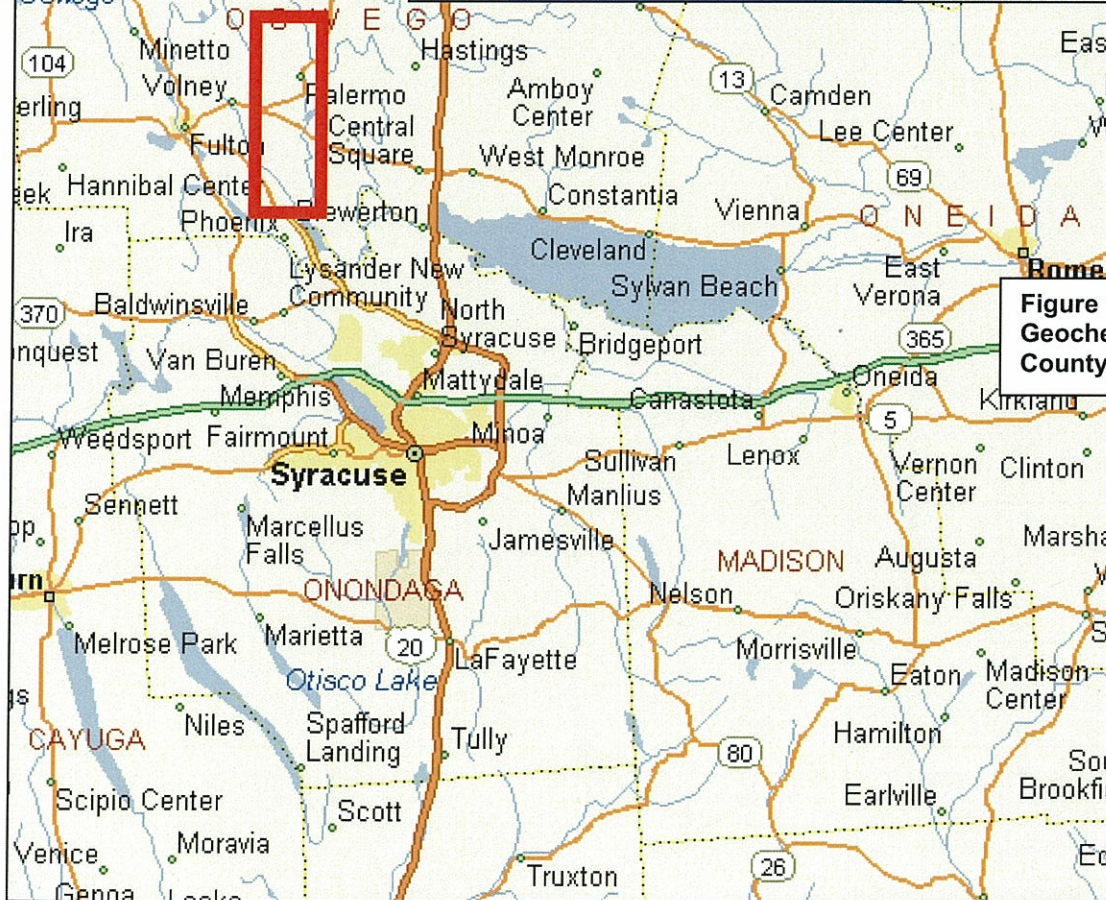
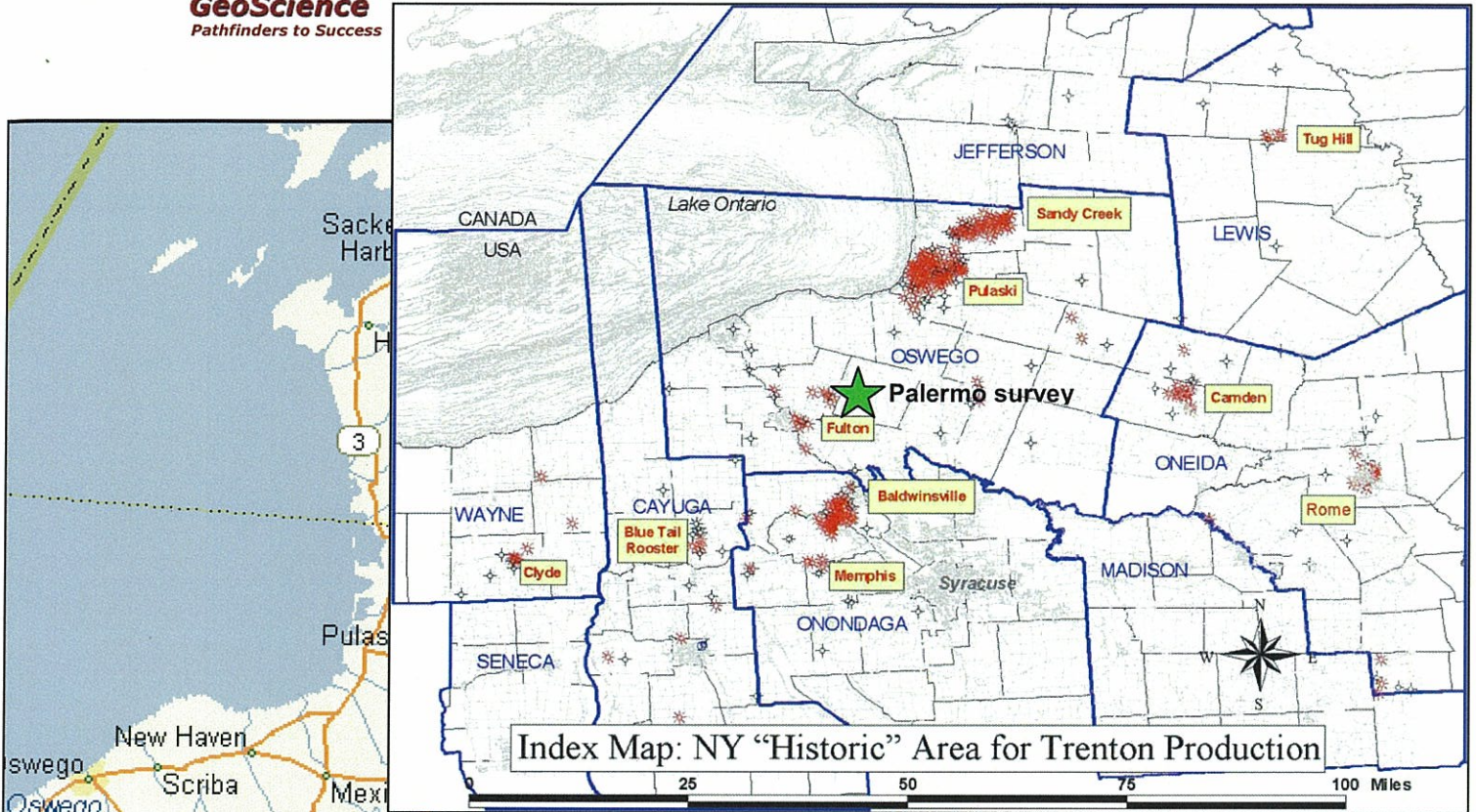
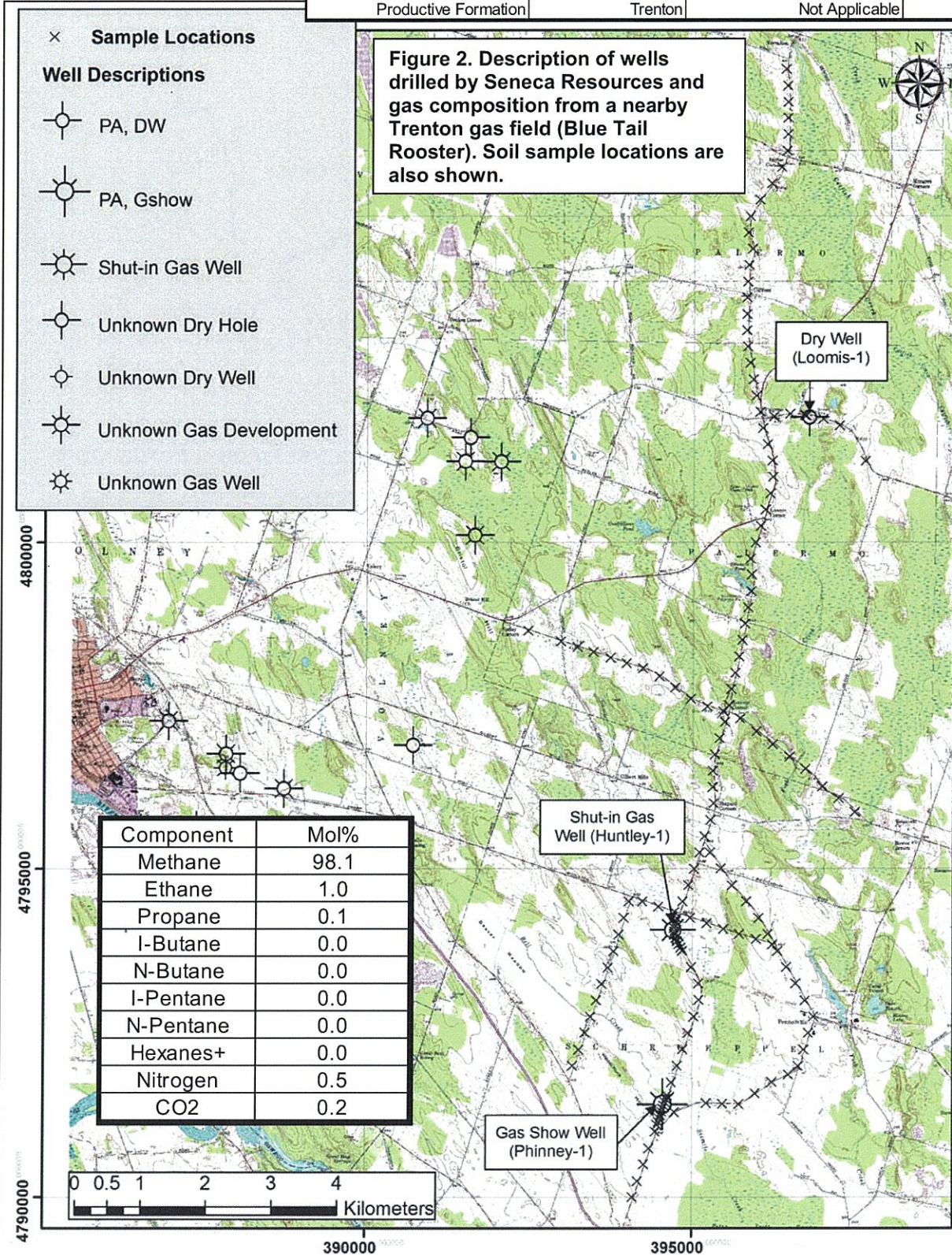


Figure 1. Location of the Palermo Geochemical Survey in Oswego County, New York.



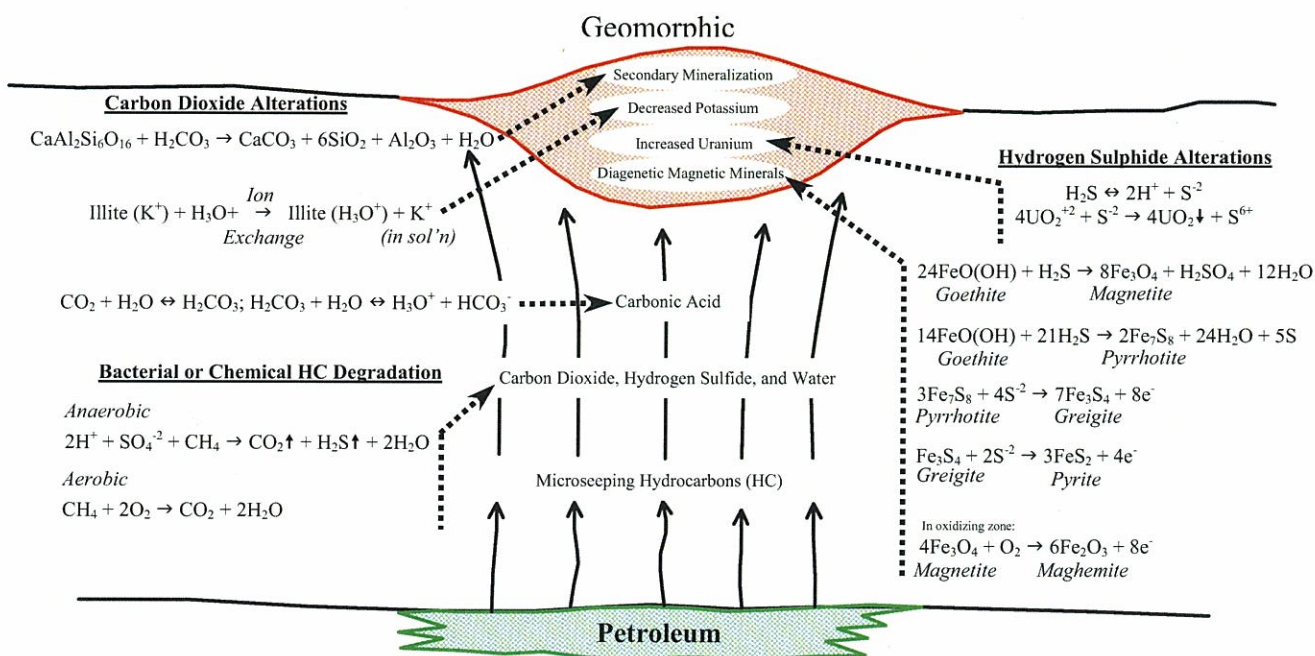
Summary of wells drilled by Seneca Resources Corporation in the area			
Well Name	Huntley-1 37627	Phinney-1 37626	Loomis-1 37628
Status	Shut-In	Plugged and Abandoned	Plugged and Abandoned
Type	GW	Gas Show	Dry Well
Drill Total Depth	2690	2278	2460
Productive Formation	Trenton	Not Applicable	Not Applicable





## 2.0 GENERAL GEOLOGY

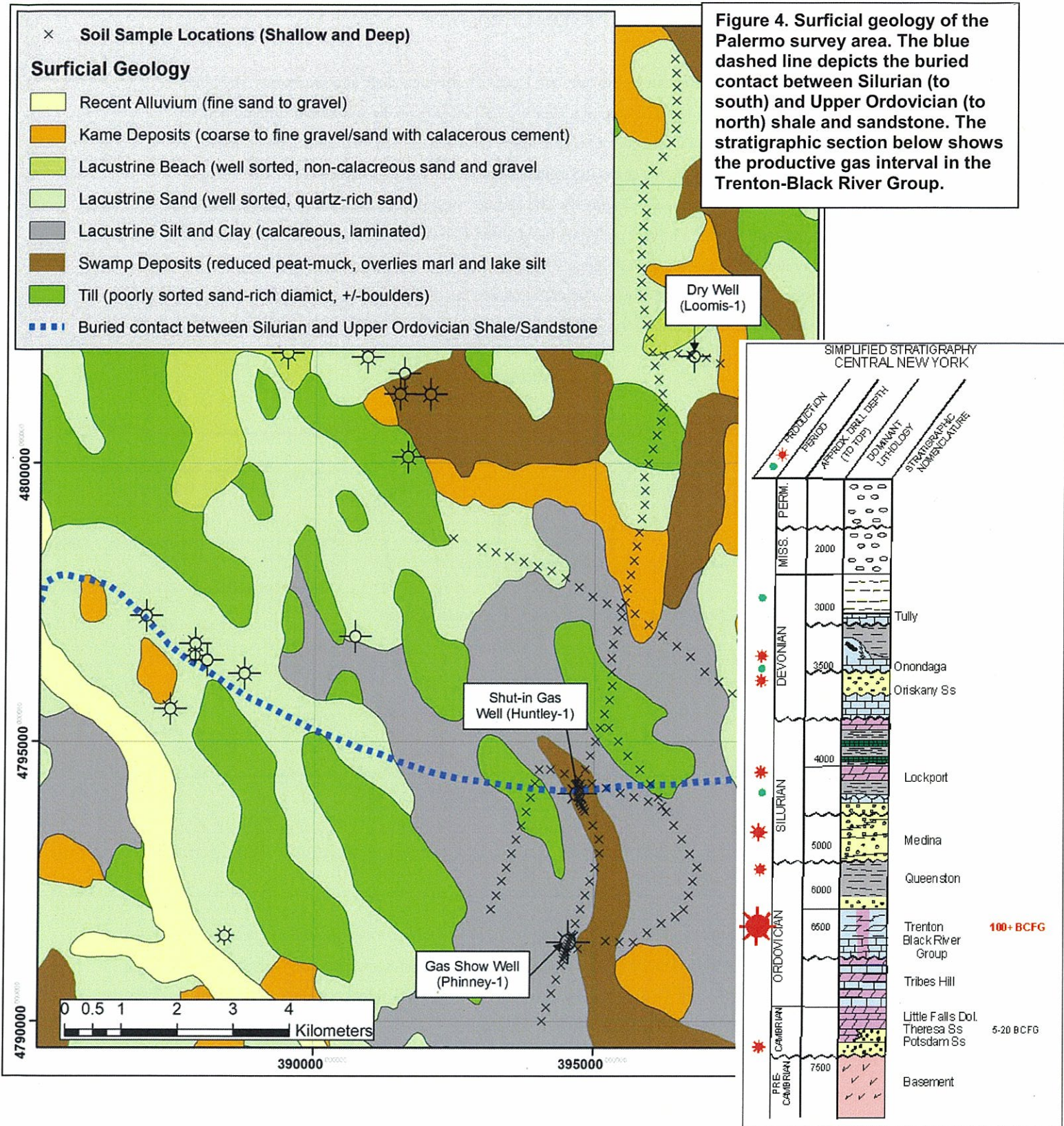
The Palermo survey area is underlain by Silurian and Upper Ordovician shale and sandstone. The blue dashed line on Figure 4 that extends through the Huntley well location is the southward-dipping contact between Silurian shale and sandstone (to south) and Upper Ordovician shale and sandstone (to north). Seneca Resources drilled through this shale and sandstone to reach reservoir objectives in the Trenton Limestone (see stratigraphic section on Figure 4). The Huntley well encountered commercial gas flows in the Trenton Limestone, but the Phinney well only has gas shows based on mud log data. Gas composition data were not available for Huntley and Phinney wells, but the gas is reportedly similar to that of the Trenton Limestone hosted Blue Tail Rooster field 25 miles to the southwest (Figures 1 and 2). It is suggested that the methane in these reservoirs has a thermogenic origin (Laughrey and Kostelnik, 2006).



**Figure 3.** Possible model of hydrocarbon microseepage-related alteration over petroleum deposits (modified after Saunders et al., 1999).

Surficial deposits in the area are highly variable ranging from glaciolacustrine clay/silt and peat-muck and local till lenses (Figures 4 and 5) in the southern part to coarser-grained Kame deposits and glaciolacustrine beach sands in the north (Figure 4). Soil composition reflects the glacial parent material on which they developed beginning after the last ice retreat 10,000 years ago.







### 3.0 METHODOLOGY

The methods employed in the Palermo Geochemical Survey are described under three subsections including (2.1) Sample Collection, (2.2) Sample Analysis, and (3) Interpretation and Mapping.

#### 3.1 SAMPLE COLLECTION

A total of 167 shallow (1.5 foot) and deep (8-foot) soil samples were collected at 200-meter intervals along public roads where Seneca Resources acquired their 2-D seismic data (Figure 2). The shallow samples were collected with a hand-auger and the deep soil cores were taken with an ATV-mounted Geoprobe drill (Figure 6). The initial intention was to collect free gas samples from 8-foot depth, but water-saturated soil was encountered at less than 3 feet, and thus free gas was not obtainable. Samples for high temperature desorption were collected in 4-ounce teflon-sealed glass jars filled to capacity (Figure 3). Soil samples for low temperature desorption (90 °C) were collected in 4-ounce glass jars with 50% soil and 50% Zephiran Chloride to prevent bacterial consumption of loosely held light hydrocarbons (Figure 6). Soils for high temperature desorption (260 °C) and metals analyses were collected in 4-ounce glass jars without Zephiran Chloride.

#### 3.2 SAMPLE ANALYSIS

The headspace gas in soil samples preserved with Zephiran Chloride was analyzed under ambient conditions for C1-C8 hydrocarbons by Flame Ionization Detection – Gas Chromatography (GC-FID see Table 1). Approximately 20 CC of the Zephiran Chloride was then displaced by nitrogen and the Teflon septum of the jar was sealed with silicone gel to cover the puncture from the syringe needle. The silicone was allowed to dry for two days and then the jar was shaken on a mechanical shaker for 20 minutes prior to heating in a water bath at 90 °C for 1 hour. The silicone seal on the Teflon septum was then punctured with a syringe needle and 5 cc of headspace gas was withdrawn and injected into a GC-FID for analysis (Table 1).

Soils without Zephiran Chloride were oven-dried at 50 °C for 48 hours, pulverized with a mortar and pestle, and sieved to <63 microns in stainless steel sieves. One-gram splits of the sieved soil were weighed into glass vials and then aluminum-teflon caps were crimped onto the vials to prevent leakage during heating at 260 °C for one hour to desorb tightly held hydrocarbons. After heating, 5 cc of headspace gas was withdrawn through the teflon septum on vials and injected into a GC-FID for the analysis of C1-C8 hydrocarbons. Hydrocarbon concentrations are reported in part per billion (ppb) levels with a detection limit of about 10 ppb.





Figure 5. Poorly sorted, glacial till was sampled at some sites in the survey area.



Figure 6. An ATV-mounted Geoprobe was used to collect soil cores from 8-foot depth and soils were stored in 4-ounce glass jars with Teflon septa plastic lids for transport to the laboratory in Golden, Colorado.



For the elemental analysis, 0.5 gram splits of the sieved soil was digested in concentrated nitric acid and the supernatant was then filtered and analyzed for 23 major and trace elements by Inductively Coupled Plasma Emission Spectroscopy (ICP-ES). Organic carbon contents (%) in soils were estimated using the gravimetric “Loss On Ignition” technique.

Internal standards, duplicates and blanks were analyzed within batches as quality control checks. The precision of the hydrocarbon and major/trace element analyses is better than +/-10% at the 95% confidence level based on the analysis of duplicates at 10% frequency.

**Table 1. List of analytes reported for the Palermo Geochemical Survey Soil Analyses.**

C1-C8 Hydrocarbons by GC-FID	23 major and trace elements by ICP-ES	Organic Carbon Estimate
methane, ethane, ethene, propane, propene, i-butane, n-butane, butene, i-pentane, n-pentane, pentene, i-hexane, n-hexane, hexene, i-heptane, n-heptane, heptene, i-octane, n-octane	Ag, Al, As, Ba, Ca, Co, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, K, Pb, Sb, Se, Sr, Ti, Tl, V, Zn	Loss on Ignition (%LOI) is a gravimetric method for organic carbon estimation

### 3.3 INTERPRETATION AND MAPPING

The hydrocarbon, major/trace element and organic carbon data were compiled in an Excel spreadsheet prior to statistical interpretation in Statistica 7.0.

The absolute concentration of individual or groups (e.g. C<sub>4</sub>+C<sub>5</sub>+C<sub>6</sub>) of thermally desorbed hydrocarbons are plotted to evaluate the distribution of microseepage intensity which, in some cases can reflect fracture density in underlying bedrock and overburden. Hydrocarbons ratios, on the other hand, provide information about the compositional character of sources. “Gas Wetness” ratios are represented by a heavier (higher molecular weight) hydrocarbon divided by a lighter (lower molecular weight) hydrocarbon. Anomalous heavy to light hydrocarbons (e.g. %Propane or C<sub>3</sub>/C<sub>1</sub> ratio) soils reflects a wet gas or liquid hydrocarbon source. “Percent Propane” would be propane divided by the sum of all the other hydrocarbons (often referred to as C<sub>1</sub>+, the sum of C<sub>1</sub> through C<sub>8</sub>) and would be represented by the formula (C<sub>3</sub>/C<sub>1</sub>+) \* 100. Gas Dryness ratios compare lighter to heavier hydrocarbons. The most common used is

percent methane, which is methane divided by the sum methane through octane (C1+) expressed as a percentage. Samples with 100% methane or C1/C2 ratios >100 are classified as biogenic, which is methane produced by bacterial processes at surface (e.g. swamp gas). These should be removed from the data prior to interpretation and plotting of methane associated with thermogenic components (i.e. C2+ hydrocarbons).

Multivariate statistical techniques were applied to attempt to discriminate between productive (gas-charged) and non-productive (dry wells) areas using several hydrocarbon variables simultaneously. Thermally desorbed C1-C8 hydrocarbons from soils collected the Huntley gas well (n=10) and Loomis dry well (n=10) were used as training sets for discriminant analysis. These techniques measure the covariance of several variables in multidimensional space simultaneously. For example, several hydrocarbons may correlate over productive areas as opposed to dry areas allowing for the distinction between favorable and unfavorable exploration targets. Development of a discriminant model allows the classification of samples from an unknown area into “productive or non-productive” categories based on the probability of a sample belonging to either category. The results of discriminant analysis are plotted as “discriminant probabilities” (i.e. discriminant scores) or, in other words, the likelihood that a particular sample falls into a known category. The higher the probability the more confidence that that sample belongs in that category.

The hydrocarbon and major/trace element results, which include absolute concentrations, bivariate and multivariate ratios and discriminant scores. Breakpoints and thresholds between populations were selected from frequency distributions of the data (i.e. probability plots). The data were plotted as colored proportional symbols on a surficial geology base to look for spatial correlations between anomalies and overburden lithologies. False anomalies related changes in overburden composition must be screened out prior to attributing hydrocarbon and metal anomalies to underlying reservoirs and source rocks.

## 4.0 RESULTS

The results are presented under three subsections, which highlight low and high temperature desorbed hydrocarbons and elements that show a spatial correlation with gas-charged Trenton Limestone in the survey area. The light hydrocarbons (C<sub>1</sub> to C<sub>3</sub>) were the focus of the interpretation and mapping because these compounds are present in detectable concentrations in the Trenton reservoir gas (see gas composition on table in Figure 2).

### 4.1 LOW TEMPERATURE (90 °C) HYDROCARBON DESORPTION RESULTS (DEEP SOILS)

A low temperature desorption was done on bactericide-preserved soil to liberate loosely held hydrocarbons for analysis. The rationale behind this method is that concentration and composition of loosely held light hydrocarbons emulate that which would be found in free gas samples, if these were obtainable.

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A plot of the C1/C2 ratio and percent methane (dry gas ratios) reveals anomalies near the Huntley and Phinney wells and over the central part of the survey area (Figure 7). Samples with C1/C2 ratios greater than 100 are thought to represent biogenic gas (Jones and Drozd, 1983), and the spatial correlation of most anomalies with swamp deposits further supports this assumption (Figure 7). When samples with biogenic gas (C1/C2>100) are removed and the data are re-plotted, dry gas ratio (C1/C2 and %C1) anomalies are evident mainly in the southern and central parts of the survey area (Figure 8). Several anomalies are found around the Huntley and Phinney wells, and there is an isolated anomaly 600 meters southwest of the dry Loomis well (Figure 8). A plot of methane concentration with biogenic outliers removed (C1/C2>100) reveals isolated, high contrast anomalies mainly in the southern and central parts of the survey area (Figure 9). Two methane anomalies are found in glacial till just north of the Huntley well.

#### **4.2 HIGH TEMPERATURE (260 °C) HYDROCARBON DESORPTION RESULTS (SHALLOW AND DEEP SOILS)**

High temperature thermal desorption of soils liberates tightly bound hydrocarbons adsorbed to clays and organic matter. The compositional character of these hydrocarbons generally reflects progressive alteration of soils from long-term microseepage. It therefore represents a “unique” hydrocarbon composition imparted to soils over time, and it does not emulate what would be in free soil gas as does the low temperature desorption.

Methane concentration anomalies (with C1/C2>100 removed) are evident in shallow soils near the Huntley and Phinney wells and at the northern end of the survey area (Figure 10). Intense methane anomalies in deep soils are found around the Phinney well and weaker anomalies occur in the central and northern parts of the survey area. Dry gas ratios (C1/C2 and %C1) show no spatial correlation with the gas-charged Trenton Limestone in the southern part of the survey area.

Discriminant analysis was performed on the C1-C8 hydrocarbon data from shallow soils to develop a linear combination of variables that would distinguish microseepage in soils between the Huntley gas well and dry Loomis well. A plot of the discriminant function (C3/nC4+C1+nC7) and the discriminant scores (gas probability) derived from the function are shown on Figure 11. Samples over and to the east and west of the Huntley gas well show anomalous gas probability, and several anomalous samples over and adjacent to the Phinney gas well are correctly predicted as “gas prone”. Two isolated samples in the central part of the survey area also predict as “gas prone” (Figure 11).

Propane relative to nButane, methane and nHeptane are the most important discriminant coefficients for distinguishing microseepage over “gas prone (Huntley)” and “barren (Loomis)” areas. A plot of percent

propane (C3/C1+\*100) reveals anomalies over and adjacent to the Huntley and Phinney wells in both the shallow and deep soils (Figure 12).

#### **4.3 ACID-EXTRACTABLE MAJOR AND TRACE ELEMENT RESULTS (SHALLOW AND DEEP SOILS)**

The soils were analyzed for 23 major and trace elements by nitric acid extraction (Table 1), which liberates elements from organic matter, clay minerals, sulfides and poorly crystalline iron and manganese oxides. Of the 23 elements, only barium and potassium show any spatial correlation with the gas-charged Trenton Limestone.

Barium anomalies are found in glaciolacustrine clay and silt, till, peat-muck and Kame sand deposits mainly in the southern part of the survey area (Figure 14). Although there is not a “one to one” correlation of barium in shallow and deep soils, anomalies in both media are confined largely to the southern part of the survey area. Several samples around the Huntley and Phinney wells are anomalous in barium (Figure 14).

Potassium is also anomalous in shallow and deep soils in the southern part of the survey area (Figure 15). Most anomalies occur over glaciolacustrine clay and silt and peat-muck, but some are also found over sandy glacial till. Again, there is little “sample to sample” correlation between the shallow and deep soils, but the anomalies occur in the same southern part of the survey area.

#### **5.0 DISCUSSION AND CONCLUSIONS**

Any discussion of the results of the Palermo Geochemical Survey must take into account the following observations:

Low temperature (90 °C) thermally desorbed dry gas ratio (C1/C2 and %C1) and methane anomalies are spatially correlated with gas-charged Trenton Limestone in the southern part of the survey area. Anomalies in the central part of the survey area may point to additional gas potential there. Samples with biogenic methane anomalies (C1/C2>100) that are spatially associated with swamps must be removed from the data to reveal a more meaningful distribution of dry gas ratio and methane anomalies.

High temperature (260 °C) thermally desorbed methane is anomalous in shallow and deep soils near the Phinney and Huntley wells and in the central part of the survey area.



Microseepage over Trenton gas-charged areas contains more propane relative to nButane, methane and nHeptane compared with barren areas. Samples with “gas-prone” microseepage compositional character (i.e. anomalous gas probability) are found over and adjacent to the Huntley and Phinney wells and the central part of the survey area. The Phinney gas show well is correctly predicted by the discriminant model. A plot of the percent propane gas wetness ratio also reveals anomalies around the Phinney and Huntley wells.

Barium and potassium are anomalous in both shallow and deep soils in the southern part of the survey area. The bulk of the anomalies are found over glaciolacustrine clay and silt.

The dry gas ratio (C1/C2 and %C1) and methane anomalies (without biogenic methane) in the southern part of the survey area could reflect microseepage of thermogenic methane from Trenton Limestone reservoir gas, which contain greater than 98% methane. Low temperature (90 °C) desorption of deep soils produces higher contrast and more widely dispersed dry gas ratio and methane anomalies compared with high (260 °C) temperature desorption. Carbon and deuterium isotopic analysis should be performed on low temperature desorbed methane to distinguish between strictly biogenic and mixed biogenic/thermogenic sources. Such analyses were beyond the budgetary constraints of this project.

For the high temperature data, ratios rather than absolute concentrations are more effective for distinguishing between “gas-prone” and “barren” areas. The genetic meaning of the discriminant function ratio (C3/nC4+C1+nC7) and percent propane anomalies that are spatially associated with gas-charged areas is unclear, but it is important to note that percent propane anomalies are also anomalous in soils over 9,000-foot deep Trenton Black River gas reservoirs in the Finger Lakes area (Seneshen and Viellenave, 2004). For now, all that can be concluded is that these are diagnostic wet gas ratios that have been imparted to soils as a result of prolonged microseepage.

Barium and potassium anomalies are prevalent in both shallow and deep soils in the southern “gas-charged” part of the survey area. These elements substitute for one another in potassium feldspars. Microbial oxidation of hydrocarbon microseepage can produce reducing acidic conditions, which promote the alteration of feldspars and illitic clays to more stable kaolinite (Schumacher, 1996). This process would make the potassium and barium more available to nitric acid extraction. Alternatively, the higher concentrations of barium and potassium in the southern part of the survey area could reflect the glaciolacustrine clay and silt substrate on which the soils developed. More detailed mineralogical studies are necessary to determine if the clay minerals in soils are formed through the alteration of feldspars and illitic clays in a reduced acidic environment or through deposition from suspension in a glacial lake.

The main conclusion of the Palermo Geochemical Survey is that soil-based hydrocarbon geochemical methods effectively detect hydrocarbon microseepage over gas-charged, fractured Trenton Limestone in northern New York. The most cost effective approach to future geochemical exploration for these types of reservoirs would involve the collection of shallow (1.5-foot) soil samples (~\$20 per sample) at short intervals (<200 meters) for high (260 °C) temperature desorption and C1-C8 hydrocarbon analysis (~\$70 per sample). The data would then be scanned for those samples having anomalous C3/nC4+C1+nC7 ratios and percent propane (C3/C1+). Low temperature (90 °C) desorption dry gas ratio (C1/C2 and %C1) and methane anomalies in deep (8-foot) samples are spatially correlated with gas-charged Trenton Limestone reservoirs, but the cost of obtaining these samples with a Geoprobe is substantially higher (~\$80 per sample).

### APPLICATION OF RESULTS TO EXPLORATION IN NORTHERN NEW YORK

Previous studies have detected free gas and spectral anomalies over fractured, gas-charged, Devonian shales and Ordovician carbonates in New York ((Harbert et al. 2006; Nelson et al. 2001), but free gas cannot be collected in the saturated soils of the Palermo area. This study, however, reveals that soil-based hydrocarbon geochemical methods can detect light hydrocarbon microseepage that is probably linked to dry gas reservoirs in fractured Trenton Limestones. The Palermo survey has therefore demonstrated the effectiveness of a soil-based hydrocarbon detection technique that can work in saturated soils, which cover a large portion of northern New York. As indicated above, the collection of shallow soils at short intervals (<200 meters) for high (260 °C) temperature desorption of C1-C8 hydrocarbons is recommended from a cost standpoint for future geochemical surveys.

### TECHNOLOGY TRANSFER

The results of this geochemical study in New York have been disseminated to the public through both oral, poster and trade booth presentations at the following meetings:

#### Oral Presentation and trade booth display at:

*Eastern Section-AAPG meeting in Morgantown, WV (September 18-20, 2005).*

**“Geochemical Exploration For Trenton-Black River Gas Reservoirs in New York and Ohio”.**

*Southwest Section-AAPG meeting in Wichita Falls, TX (April 21-24, 2007).*

**“Innovative surface geochemical exploration for conventional and unconventional reservoirs”.**



**Poster Presentation and trade booth display at:**

*AAPG Annual Meeting in Houston, TX (April 9-12, 2006).*

**“The Surface Geochemical Expression of Carbonate-Hosted Hydrocarbon Reservoirs and Faults in New York, Ohio, Nevada and Utah”.**

*Eastern Section-AAPG meeting in Buffalo, NY (October 8-11, 2006).*

**“Surface Geochemical Expression of Hydrocarbon Seepage Over a Utica-Trenton Play Area, New York”.**

*OPI/IOGA Oil and Gas Conference in Niagara Falls, Ontario (November 1-3, 2006).*

**“Surface Geochemical Expression of Hydrocarbon Seepage Over a Utica-Trenton Play Area, New York”.**

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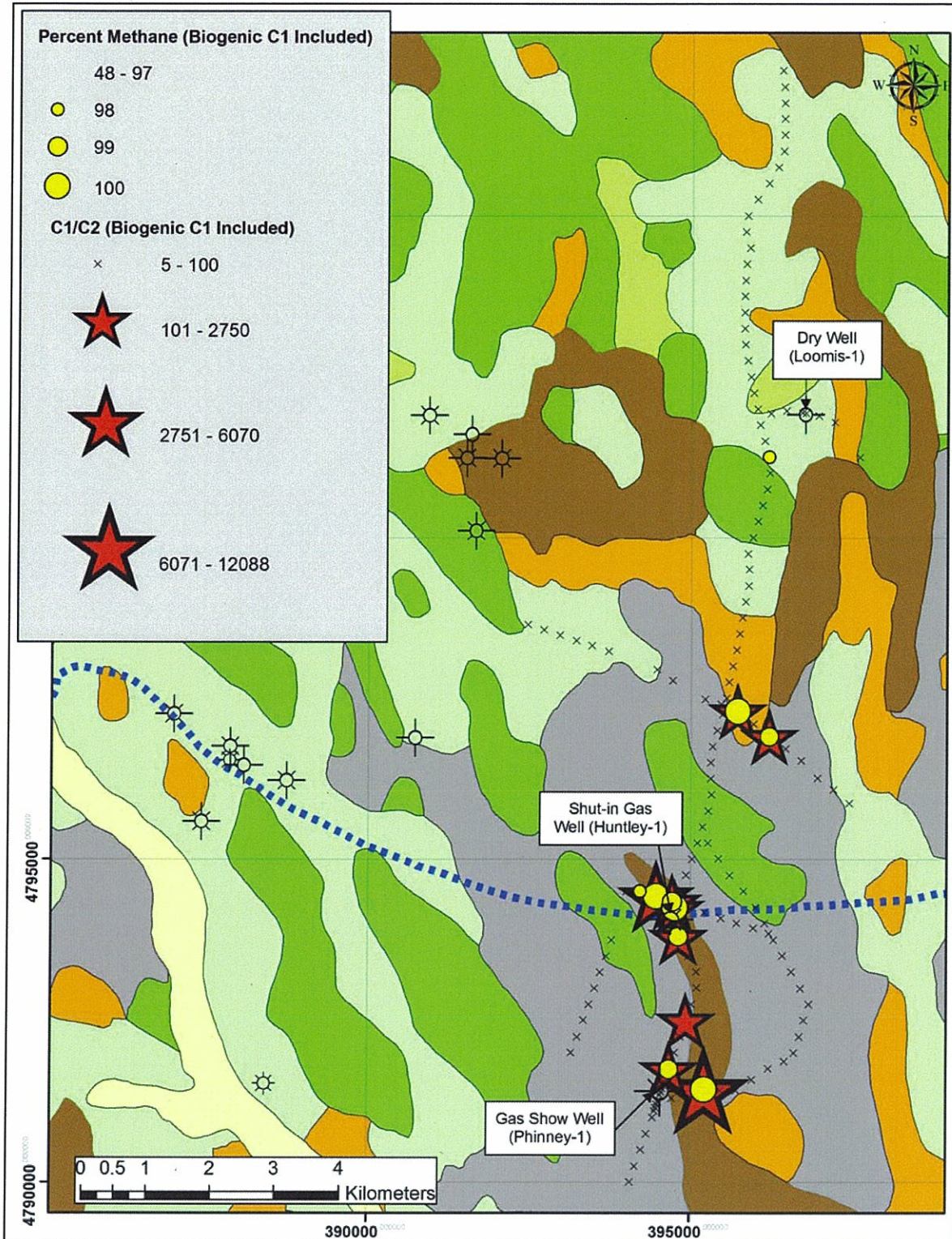


Figure 7. Distribution of percent methane ( $C1/C1+*100$ ) and  $C1/C2$  ratio in 8-foot deep soils ( $90^{\circ}C$  thermal desorption). Samples that have  $C1/C2 >100$  contain mainly biogenic methane, and this fits with their location in peat-muck swamps in the southern part of the survey area.



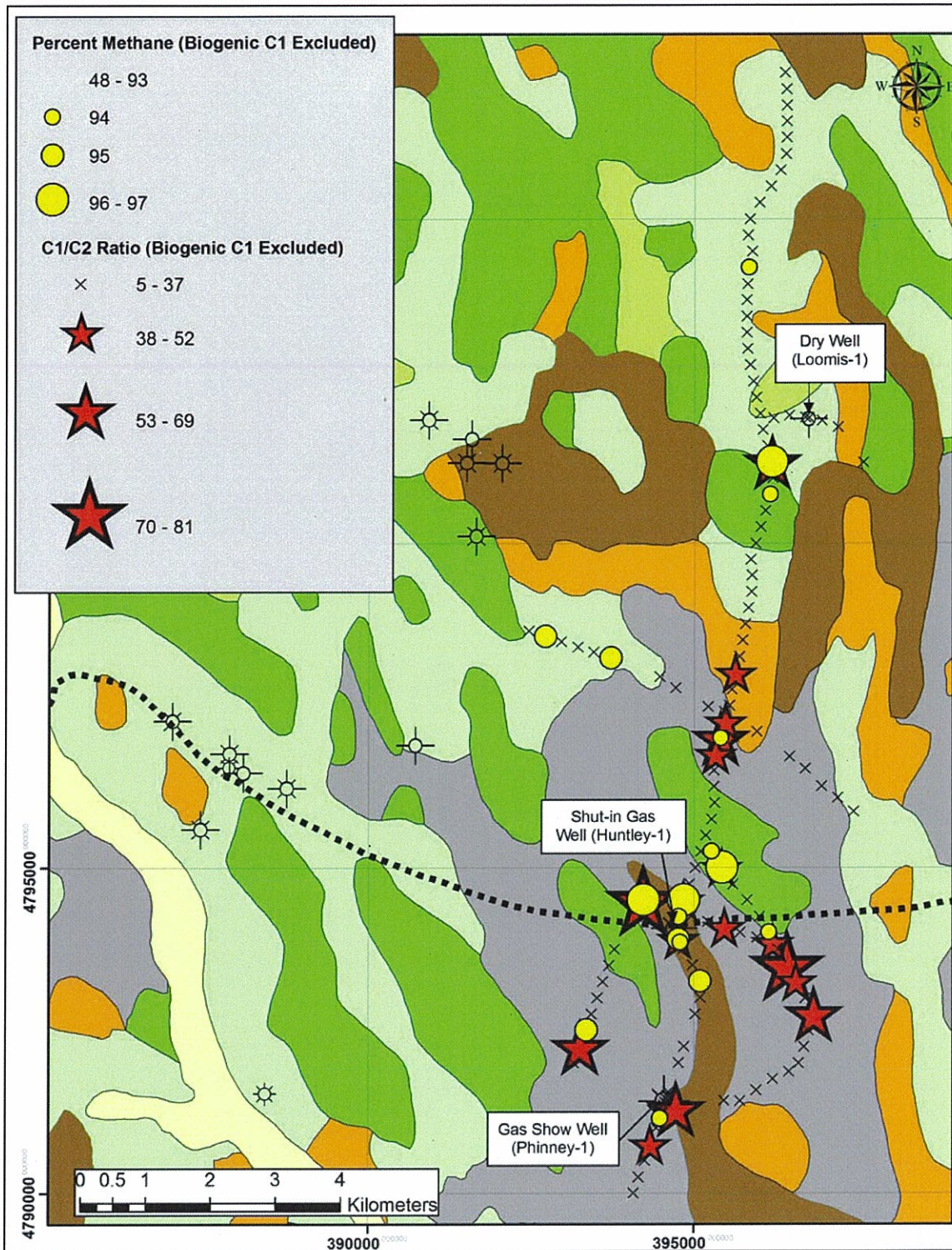


Figure 8. Distribution of percent methane ( $C1/C1+*100$ ) and  $C1/C2$  ratio in 8-foot deep soils ( $90^{\circ}C$  thermal desorption). Samples with suspected biogenic methane ( $C1/C2 > 100$ ) were removed and the data were re-plotted. The %C1 and  $C1/C2$  anomalies are found mainly in the southern and central parts of the survey area. Note the anomaly clusters near the Phinney and Huntley wells.



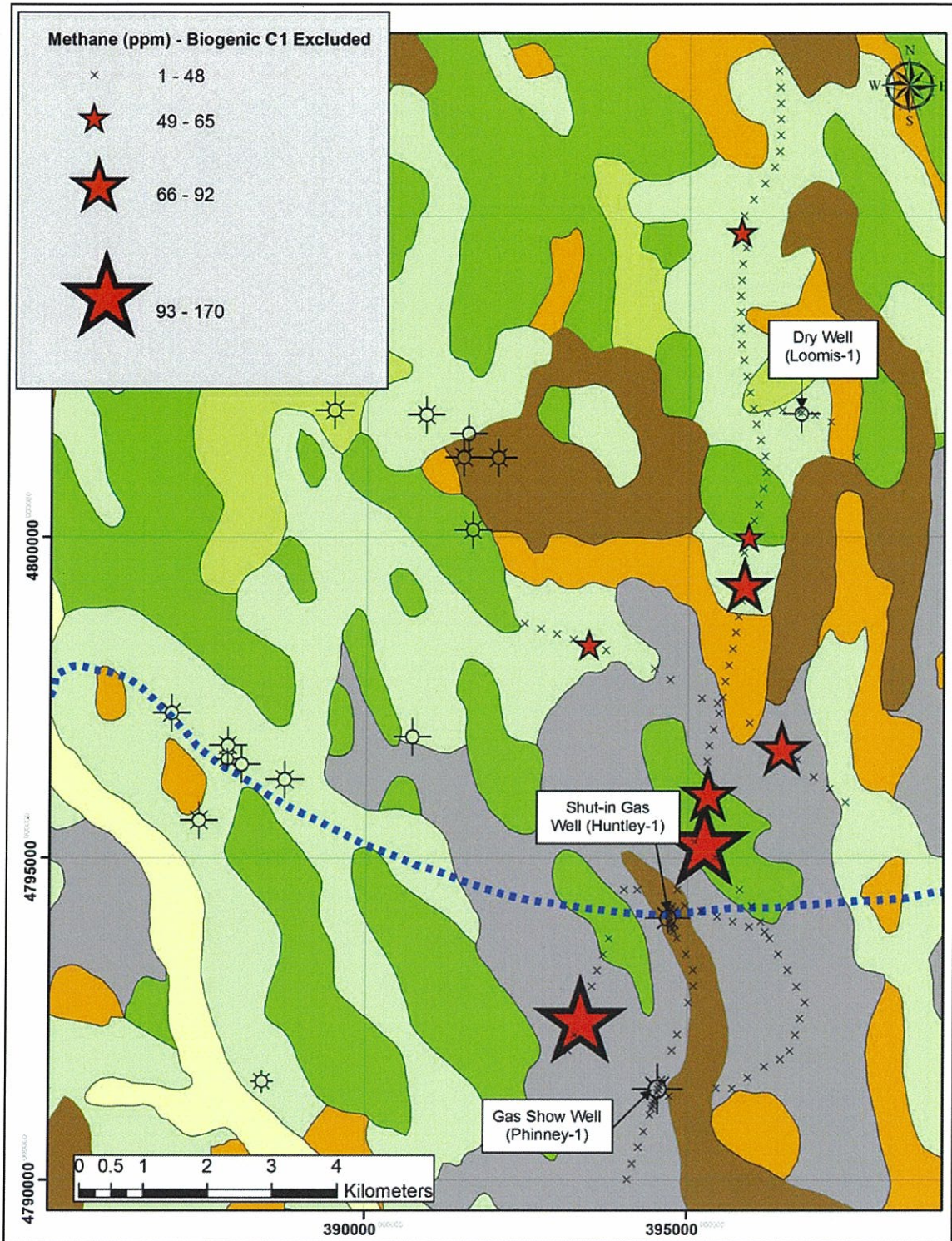


Figure 9. Distribution of methane (ppm) in 8-foot deep soils with biogenic methane (C1/C2>100) removed (90°C thermal desorption). Samples with the highest (thermogenic?) methane concentrations occur in proximity to the Phinney and Huntley wells in the southern and central parts of the survey area.



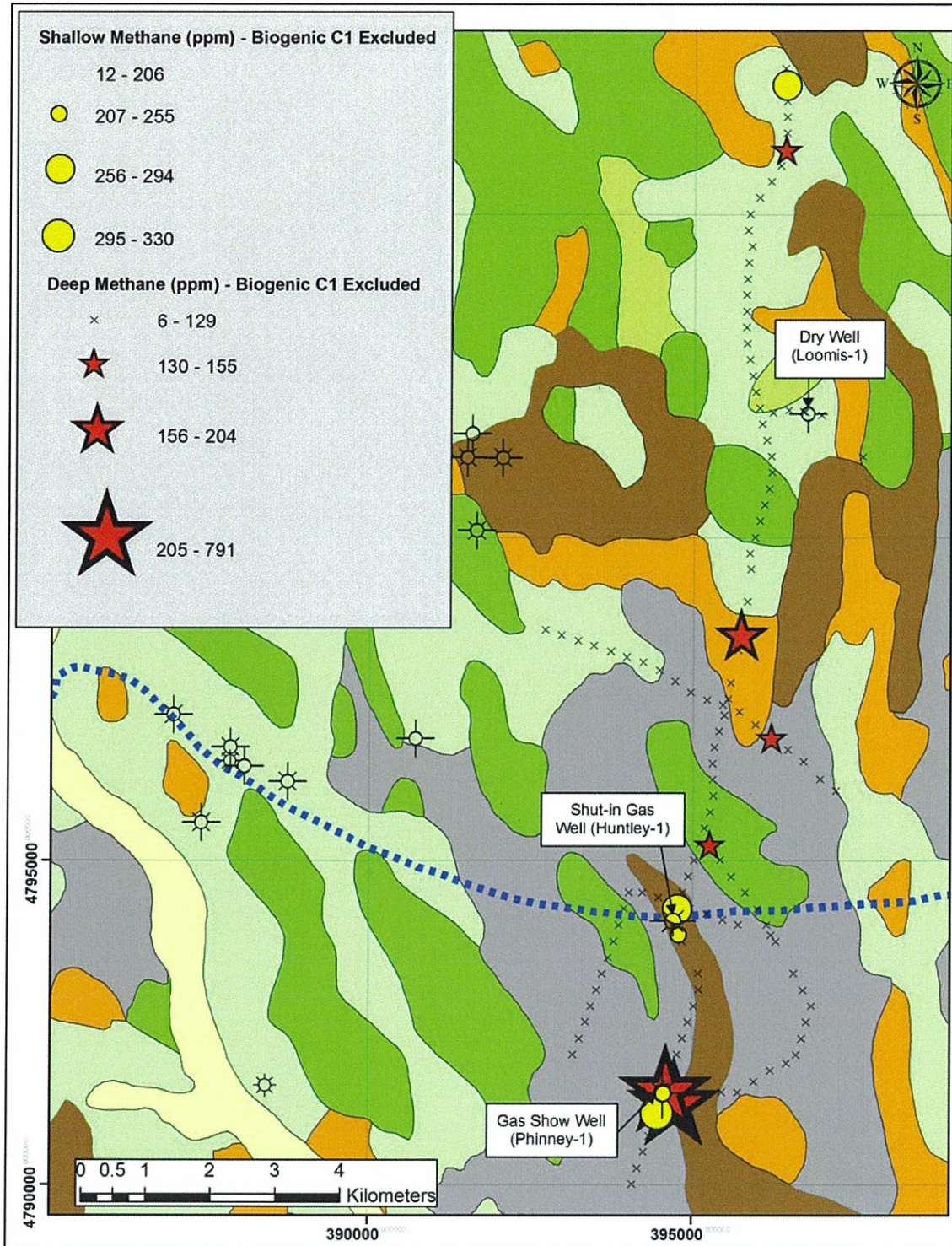


Figure 10. Distribution of methane (ppm) in shallow (1.5-foot) and deep (8-foot) soils with biogenic methane (C1/C2>100) removed (260°C thermal desorption). Methane anomalies are evident in both shallow and deep soils near the Phinney and Huntley wells and also in the central part of the survey area.



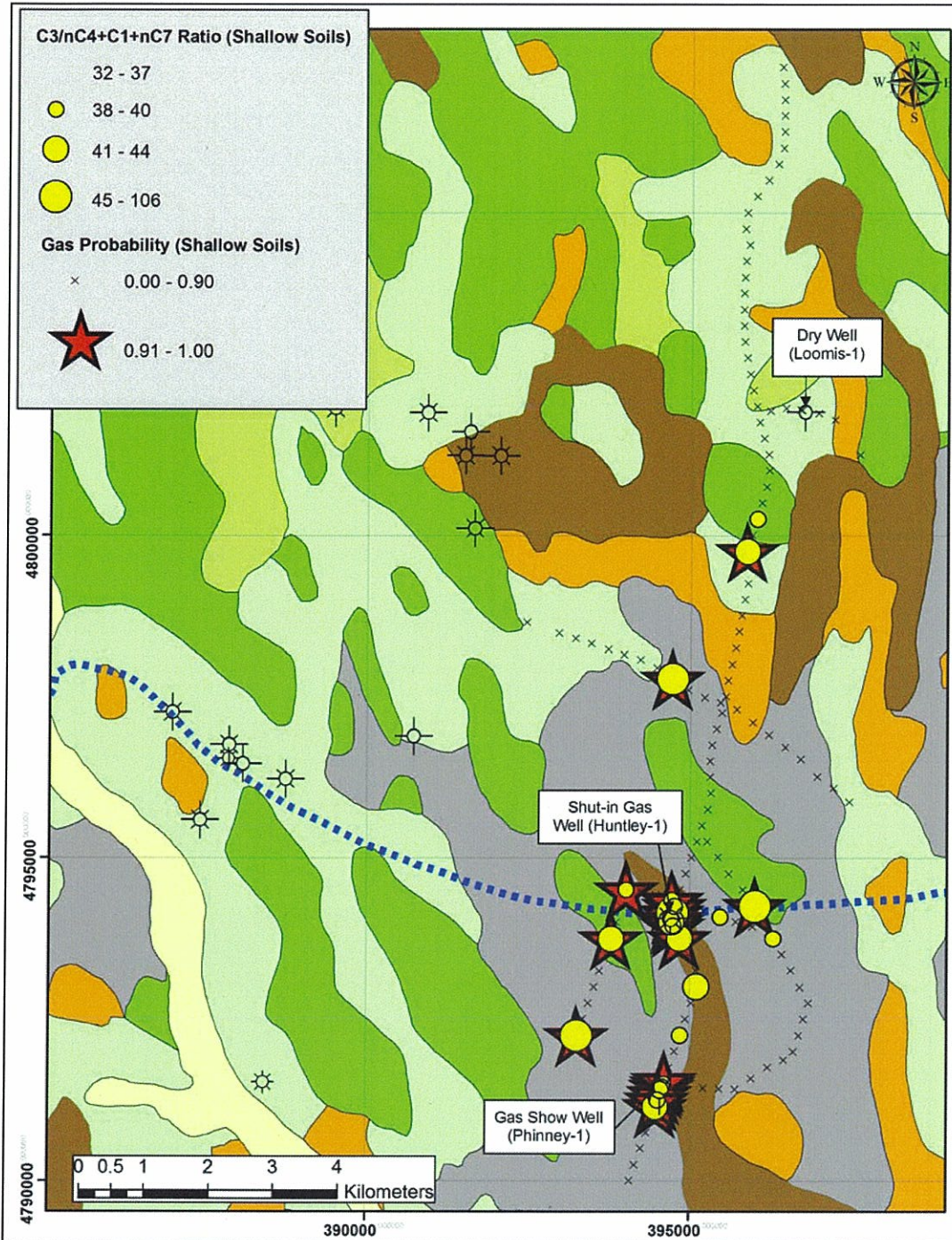


Figure 11. Distribution of gas probability and gas discriminant coefficient ratio in shallow (1.5-foot) soils (260°C thermal desorption). Hydrocarbon data from samples around the Huntley gas well and Loomis dry well were used as training sets in discriminant analysis. Samples with high C3 relative to nC4+C1+nC1 are classified as “gas-prone” and therefore have high discriminant scores or “probabilities”. This discriminant model correctly predicts samples around the Phinney gas show well as “gas-prone”. Other samples that predict as gas-prone are found around the Huntley well, northwest of the Phinney well and in the central part of the survey area.



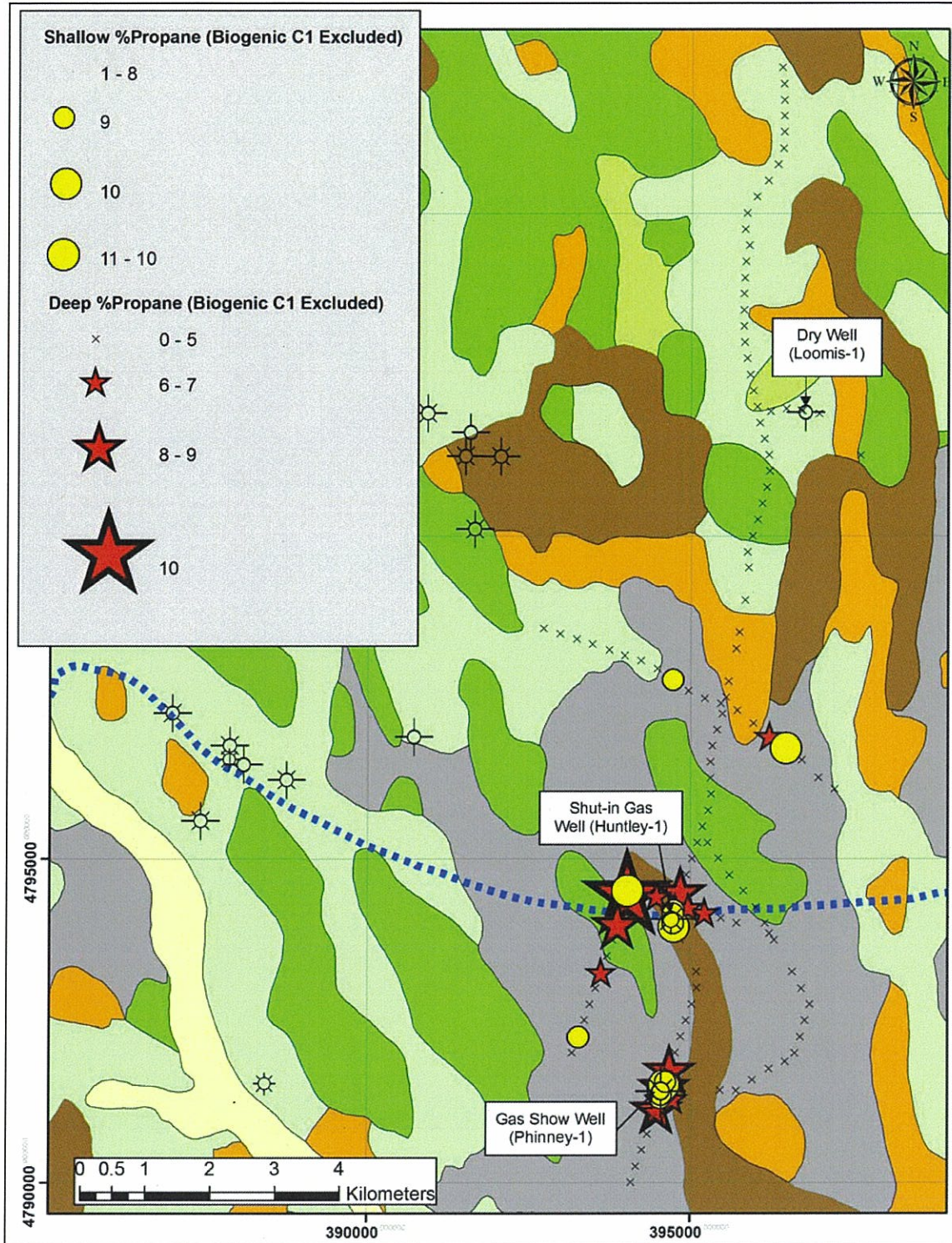


Figure 12. Distribution of percent propane (C3/C1\*100) in shallow (1.5-foot) and deep (8-foot) soils (260°C thermal desorption). Percent propane anomalies are clustered around the Phinney and Huntley wells and also in the central part of the survey area.



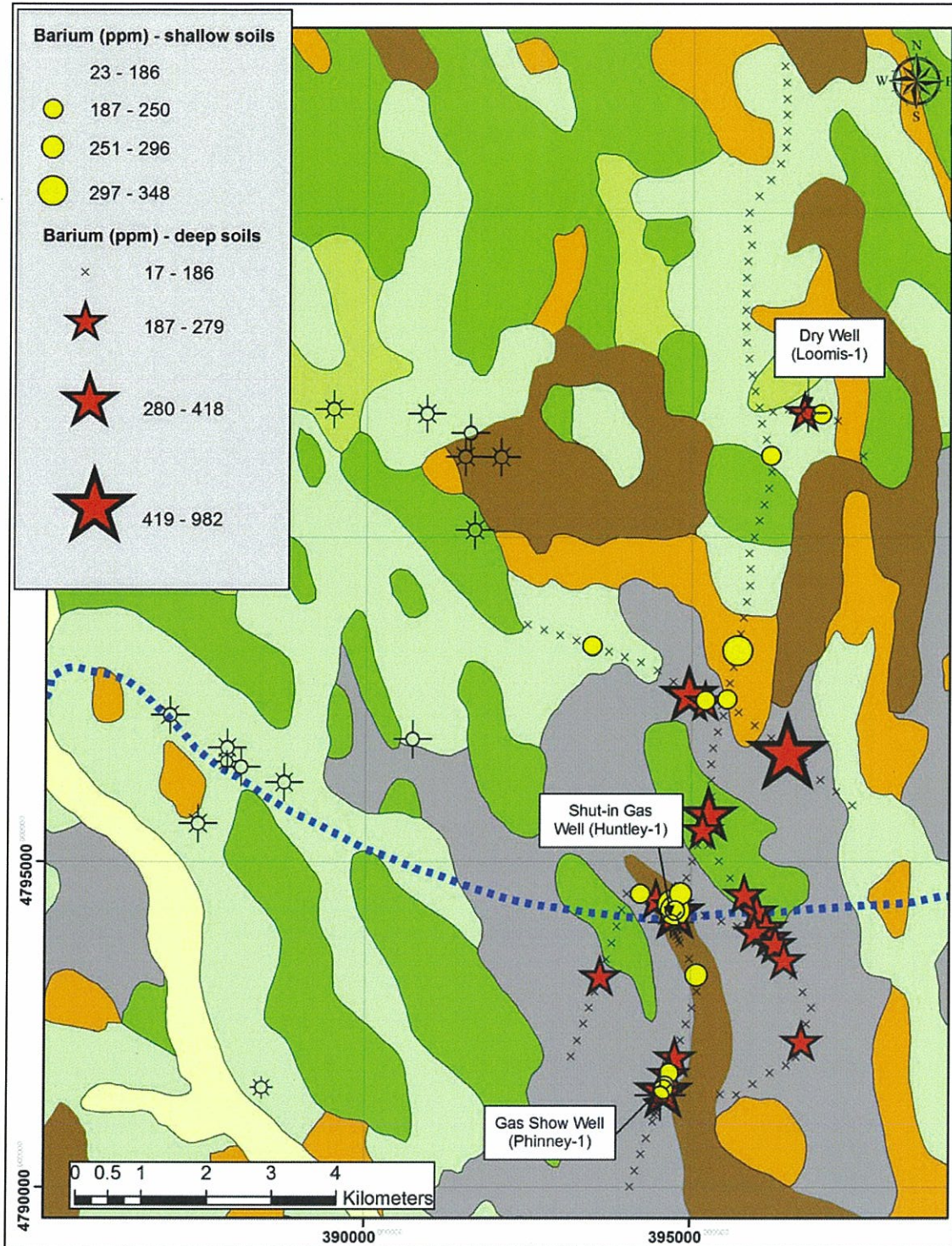


Figure 13. Distribution of aqua regia acid-extractable barium (ppm) in shallow (1.5-foot) and deep (8-foot) soils. Anomalies are clustered around and to the north and east the Phinney and Huntley wells, and in the central part of the survey area. The anomalies are prevalent in the southern part of the survey area where soils are developed on glaciolacustrine clay and silt and peat bogs. Some anomalies, however, are found over sandy till and kame deposits.



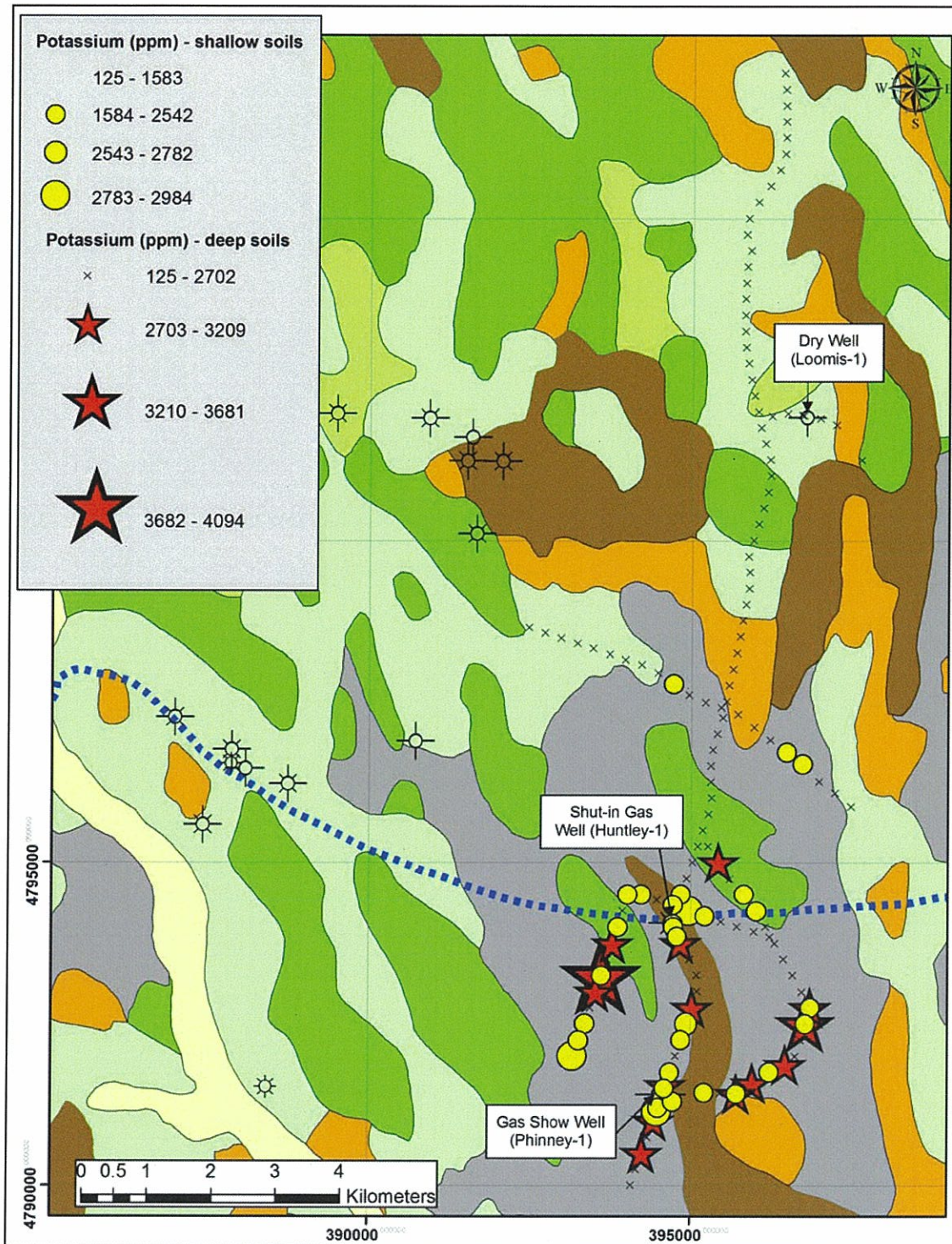


Figure 14. Distribution of aqua regia acid-extractable potassium (ppm) in shallow (1.5-foot) and deep (8-foot) soils. The anomalies are prevalent in the southernmost part of the survey area where soils are developed on glaciolacustrine clay and silt, and peat-muck. Some anomalies, however, are found over sandy till deposits.