GEOCHEMICAL SOIL GAS SURVEY
A Site Investigation of SW30-5-13-W2M
Weyburn Field, SASKATCHEWAN
Monitoring Project Number 2

Submitted to: Cameron and Jane Kerr

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1. Summary

Major Findings:

1. **Soil gas surveys were found to be feasible in the winter but the hydrocarbon and CO2 concentrations in frozen soils were severely attenuated in comparison with a survey of the same property in August 2010.**
2. **Notwithstanding the effects of the frozen soils three major anomalies for each of CO2, methane and C2+ were found, particularly in the vicinity of the Kerr residence (now abandoned) and near the producing and abandoned oil wells in the SW corner of the property.**
3. **The provenance of the CO2 in the soil gases found on the Kerr property is clearly the anthropogenic CO2 injected into the reservoir. Results clearly confirm the findings of an August 2010 soil gas survey conducted by Petro-Find. Stable carbon isotopes of the CO2 and methane/ethane ratios were the determinative factors.**
4. **A major soil gas anomaly of CO2 with a DeltaCCO2 of -23.5 in the immediate vicinity of an oil well and a nearby abandoned oil well in the SW corner of the Kerr property clearly shows that at least one of the wells is leaking and that the CO2 is anthropogenic.**
5. **An almost exact correlation of methane to thermogenic ethane concentrations fingerprints essentially all the CO2 found in the soil gas as anthropogenic.**
6. **Additional evidence, both empirical and interpretative, also links the CO2 found in soil gas with the anthropogenic CO2 injected into the Weyburn reservoir.**
7. **The CO2 and light hydrocarbons found in soils on the Kerr property are attributable to leaky wells, vertical/ lateral escape by fast flow paths along fracture/fault systems, and leakage in the form of plumes migrating to the surface by micro-fractures.**

Cam and Jane Kerr initiated this second study mainly because they felt that a winter investigation would contribute to a better year-round picture of CO2 leakage and its effects this could have on the health and safety of people living in the Weyburn field area. A previous soil gas survey by Petro-Find of the same property was conducted in August 2010, which was provided to ***Cenovus*** and the ***Saskatchewan Ministry of Energy and Resources*** in

October 2010 and released to the press January 11, 2011. The Kerrs have remained concerned about the lack of surface monitoring for CO_2 seepage over the Weyburn Pool since 2005.

A 30-sample soil gas survey on the Kerr property during the winter found anomalous concentrations as high as 10,668 ppm for CO_2 and 30 ppm for methane. However, the concentrations of both CO_2 and the light hydrocarbons except for methane and ethane were severely attenuated in frozen soils when compared to the results of a soil gas survey conducted August 2010 when concentrations of CO_2 in soil gas reached as high as 110,000 ppm. To the author's knowledge, this is the first time a soil gas survey has been conducted under winter conditions to assess CO_2 in soils over a reservoir undergoing EOR.

The surface of the property was sampled by a proprietary probe using a cordless drill. Winter conditions made drilling somewhat more difficult than in the summer because of the frozen soils and snow up to two feet deep. The snow was cleared away and a pre-drill 24 inches long was used to penetrate the icy ground surface. The probe was then inserted into the hole and drilled to the normal 3-foot depth, well below the A-and B-zones of the soil profile to avoid contamination by biogenic CO_2 and methane.

In frozen soils CO_2 concentrations in soil gas were drastically attenuated because of various impermeable barriers, which impeded the migration from the deeper subsurface. The reduced concentrations in soils at three-foot depth were mainly due to barriers caused by the loss of porosity/ permeability and ice lenses.

The provenance of the CO_2 in the soil gases found on the Kerr property is clearly the Synfuels anthropogenic CO_2, which is being injected into the reservoir. Results confirm the findings of the August 2010 soil gas survey conducted by Petro-Find. The source of the CO_2 in soil gas is firmly established by:

- An average Delta 13CCO2 that compares with the last previously known value (2001) for the CO_2 in reservoir fluids. The analysis in 2001 of CO_2 from produced fluids would be the same as the CO_2 in the reservoir as well as for the soil gas CO_2, which would have migrated from the reservoir along fast-flow paths.
- A major shift from baseline values of Delta 13C of the CO_2 in produced fluids from -12 to -14 established in 2000 before CO_2

injection began to an average value of -23.1 found in this soil gas survey. The analysis in 2000 of CO_2 from produced fluids would be the same as the CO_2 in the reservoir as well as for the soil gas CO_2, which would have migrated from the reservoir along fast-flow paths.

- A much heavier carbon isotope ratio (i.e. less negative) than for biogenic CO_2.
- A major soil gas anomaly of CO_2 (Figure 8) with a Delta 13CCO2 of -23.5 in the immediate vicinity of an oil well and a nearby abandoned oil well in the SW corner of the Kerr property clearly shows that at least one of the wells is leaking and that the CO_2 is anthropogenic.
- An almost exact correlation of methane to thermogenic ethane concentrations fingerprints essentially all the CO_2 found in the soil gas as anthropogenic.

The following additional evidence, both empirical and interpretative, links the CO_2 found in soil gas with the anthropogenic CO_2 injected into the Weyburn reservoir:

- A very high level of CO_2 concentrations over normal baseline values in soils at 3-foot depth is a prime indicator of leakage from the Weyburn reservoir. Average CO_2 concentrations over background values were up to 50 times in the August 2010 survey and up to 20 times in the winter survey when concentrations were attenuated.
- A major advantage of a winter survey is that biological activity and CO_2 respiration is so low that anomalous values (i.e. in excess of background values) can be linked to CO_2 migrating from a non-biogenic source.
- A slightly higher Delta13CCO2 since the August 2010 soil gas survey (-23.1 versus -22.0) shows that the ratio of the anthropogenic CO_2 from the Synfuels plant to recycled CO_2 being injected into the reservoir is increasing. However, the Delta13CCO2 is still well below the range of -27 to -28 for biogenic CO_2 found in soils for this area (University of Saskatchewan Thesis: "Storage of Organic and Inorganic Carbon of Biogenic Origin in the Soil of the Parkland-Prairie Ecosystem"; Dunling Wang; 1997).
- A weak anomaly of CO_2 and methane in the vicinity of another abandoned oil well in the SE corner of the Kerr property is indicative of minor leakage.
- The anthropogenic CO_2 leakage from one or both of the SW wells is likely to have come from one or more of the three CO_2 and nine

WAG (water alternating CO_2) injection wells just to the north, northeast and east of the Kerr property. To reach the SW well the CO_2 flooding and associated oil would have made its way in the oil reservoir under the Kerr property where it would have the opportunity to migrate to the surface in the form of either plumes or along fast flow paths such as fractures/faults. The reservoir in this area would have been depleted years ago were it not for CO_2 flooding. Some wells date from 1958.

- CO_2 from three CO_2 injection wells with horizontal legs oriented parallel to the predominant NE-SW fracture/faults can move easily both vertically and laterally onto the Kerr property. The toe of one of the horizontal wells is about 2000 meters from the Kerr property.
- Empirical data shows that CO_2 can move laterally at great speeds along faults (as much as 500 meters in 30 days).
- Deep-seated and open fractures/faults interpreted from lineaments traversing the Kerr property in NE-SW and NW-SE directions can provide the means for CO_2 and hydrocarbons to escape both vertically and laterally to the surface.
- A portion of the anomalous CO_2 and light hydrocarbons found in soils over the entire property is the result of upward migration in the form of plumes through the subsurface from the reservoir without the benefit of fast flow paths such as faults. Accordingly, the current surface patterns could be an exact replica (given some time lag) of the concentration patterns at the reservoir level.
- The molecular size of CO_2 presents no barrier to upward migration as heavier pentane is able to migrate from the reservoir to the surface.
- Soil gas sampling at a three-foot depth, well below the A- and B-zones of the soil profile where biogenic CO_2 is mainly produced, assures that almost all the CO_2 measured comes from another source, i.e. from the reservoir.
- Sloughs and humic areas on the down thrown side of faults where anaerobic conditions favor production of biogenic CO_2 are simply avoided. Petro-Find proprietary passive probes can sample sloughs but these were not used in either the winter or summer soil gas surveys.
- Macroseeps provides direct evidence of the existence of open faults, which can provide easy access to the surface for CO_2 as well. Leakages of oil or macroseeps observed in the gravel pits (August

2010 report) can only have found their way to the surface by one or more open faults that have intersected the Weyburn oil reservoir.

The Weyburn-Midale EOR project reportedly injects into the Weyburn and Midale reservoirs about 8,000 tonnes a day of anthropogenic CO2 pipelined in liquid form from the Great Plains Synfuels Plant in North Dakota. Enhanced oil recovery as practiced at the Weyburn field has two main objectives: to enhance oil recovery and to sequester CO2 permanently in the subsurface.

The CO2 in a supercritical state is directed to injection wells strategically placed within a pattern of wells to optimize the areal sweep of the reservoir. The injected CO2 becomes miscible with residual oil forming a concentrated oil bank. Water (brine) injection sweeps the oil from the injection sites to the producing wells. Also used are WAG (water alternating gas) wells, which inject alternatively CO2 and brine from the same well to mitigate the tendency for the lower viscosity CO2 to channel its way ahead of the displaced oil.

The higher-grade anomalies of CO2, methane and C2+ were found in the northeast section of the property where the Kerr residence is located. CO2 anomalies were also found in the northwest and southwest and both methane and C2+ anomalies were located in the northeast and southwest. As noted in the August 2010 Survey the contours of CO2, methane and C2+ concentrations can exhibit different patterns from time to time because of the dynamic nature of EOR operations with alternating water and CO2 injections.

High coincident anomalies of CO2, methane and C2+ in the vicinity of an operating oil well and an abandoned well in the SW corner of the Kerr property and stable carbon isotopes strongly indicates that at least one of these wells is leaking and that the source is anthropogenic. No leakage was detected in the August 2010 survey because sampling points were not as close to the wells. A minor leakage of CO2 and methane was noted in the vicinity of an abandoned oil well in the SE corner of the Kerr property.

Two major lineaments that intersect just north of the Kerr residence are interpreted as faults (Figure 4A). The coincidence of the high anomalies of CO2, methane and C2+ with their intersection indicates that the faults are open. Moreover, the faults are interpreted to be high angle because of their linearity and deep seated because of their length. The north side of the NE-SW fault appears to have been downthrown as well as the east side of the NW-SE fault because of the location of the ponds and naturally occurring sloughs.

The interpretation of lineaments as deep-seated faults demonstrates that the overlying thick cap rock of anhydrite and shale aquitards have been breached and may not be as an impermeable barrier to the upward mobility of reservoir gases as is generally thought. Some of the faults are interpreted to be of the open kind, which can act as conduits for light hydrocarbons and CO2 as well as the heavier hydrocarbons in the form of oil to reach the surface. The fact that oil in the form of blue sheen was found in the gravel pits near the intersection of the faults last summer (August 2010 Report) provides further evidence that the faults are open rather than closed.

The provenance of the CO2 found in soil gas is clearly the injected anthropogenic CO2 from the Synfuels plant, North Dakota. Analysis of six samples of CO2 in soil gas shows Delta 13C values in the -22.2 to -23.6 range with an average of -23.1, which compares with a previously known value of -20.4 established in 2001, a year after EOR operations began (Table 2). In 2001 the Delta 13C of the CO2 from produced fluids would be the same for the CO2 in the reservoir as well as for the CO2 in soil gas because the CO2 migrates from the reservoir to the surface along fast-flow paths. The average Delta 13C of -23.1 shows a major shift from the baseline values of -12 to -14 for the produced fluids determined prior to the beginning of EOR operations. The increase over last year (as well as over the previously known value) is attributed to a higher proportion of new CO2 from the Synfuels plant to recycled CO2. However, the average Delta C13 is still much less than those for biogenic CO2 with a range in value between -27 to -28 (University of Saskatchewan Thesis: "Storage of Organic and Inorganic Carbon of Biogenic Origin in the Soil of the Parkland-Prairie Ecosystem"; Dunling Wang; 1997).

The Petro-Find soil gas method assures that the data is highly accurate and repeatable. Other methods, such as the closed chamber and probe/infra-red, do not always produce as good a result. A closed chamber unit, which is placed essentially on top of the ground, is not that useful because it measures concentrations and fluxes of both biogenic and anthropogenic CO2. Some units can measure CO2 concentrations only up to 5,000 ppm. The probe/infra-red method usually requires frequent calibration in the field and can only measure CO_2 and methane, not the other light hydrocarbons. Subsequent sampling using the same probe for measurement of other analytes can result in dilution with ambient air.

The survey clearly shows the usefulness of geochemical soil gas surveys in assessing EOR projects for leakage of CO2 and light hydrocarbons. Soil gas surveys may also be able to determine the extent and patterns of CO2 flooding operations at depth. It can be concluded that the CO2 and the light hydrocarbons have penetrated the supposedly impermeable anhydrite cap rock and have found their way to the surface by micro fractures in the form of plumes and by fast-flow conduits such as faults and fractures.

In the author's opinion a mathematical simulation, conducted in the context of the IEA study("IEA GHG Weyburn CO2 Monitoring & Storage Project), cannot predict with any accuracy the containment of CO2 over a period of 5,000 years based on data obtained over only a short monitoring period (2001-2004) and sampling of only 5% of the Weyburn/Midale reservoir area.

Near the abandoned Kerr home the CO2 concentration is about 2,700 ppm, but at about 350 meters to the NW of the house it is 10,000 ppm (at the epicenter of a major anomaly). The Recommended Exposure Limit (REL) for the workplace, based on a time-weighted average (TWA) is 5,000 ppm over a 10-hour workday during a 40-hour week (Table 1). For someone remaining in the home for 24 hours per day, which can happen in winter, the limiting threshold is half the workday value, or 2,500 ppm.

Had the Kerrs still lived in their home (now abandoned because of health concerns), CO2 could have entered in dangerous concentrations through the crawl space due to negative pressures caused by a natural gas heating furnace. Further soil gas could be drawn into the home from warmer air rising and other mechanical exhausts such as bath fans, clothes dryers, range hoods and water heaters. It should be noted that the concentration of CO2 in soils near the Kerr residence could change rapidly on a daily basis because of the dynamic movement of CO2 in the EOR operations. There is no danger for persons in open air where CO2 from the soil quickly dissipates.

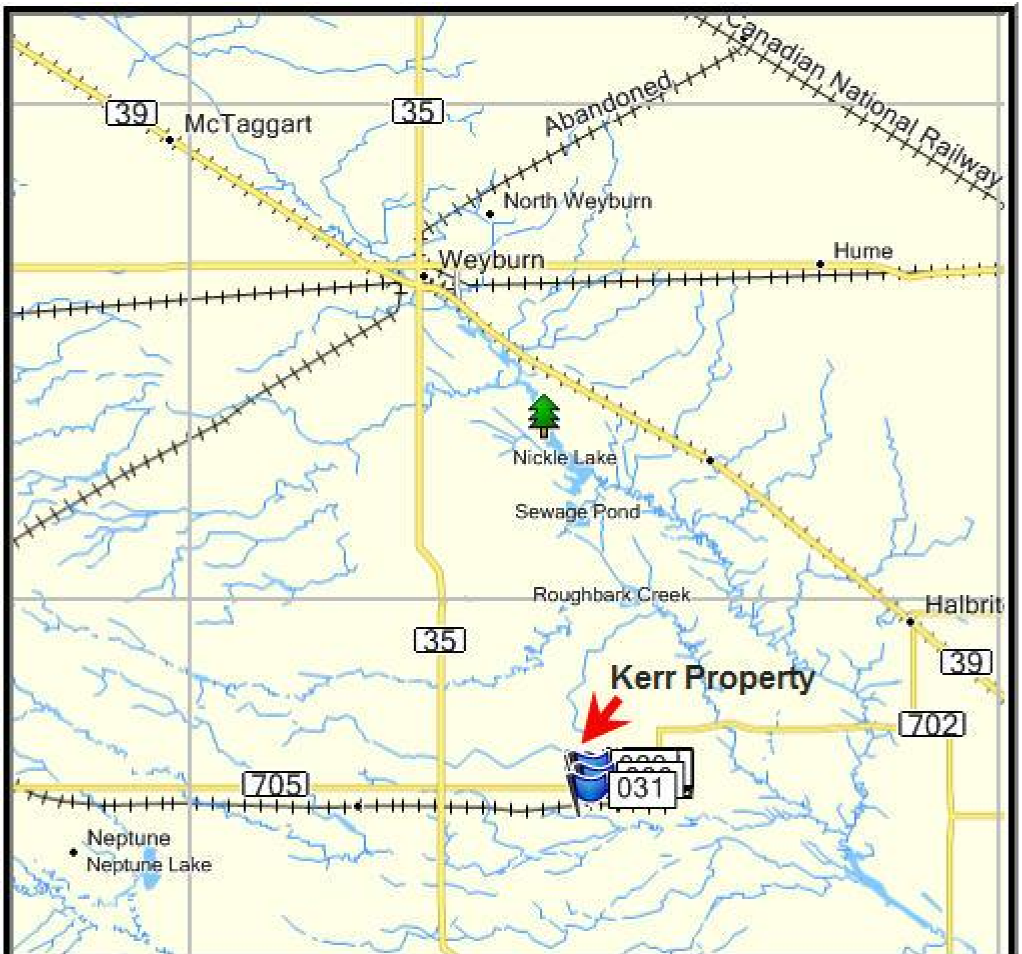


Figure 1. Location Kerr Property

It is well known from numerous landfill studies that a cap of any kind including compacted snow or ice, such as observed during this survey, can divert normally upward migrating CO2 and methane laterally. A lateral migration of CO2 in winter could increase the potential hazard in homes that have either a crawl space or a cracked concrete basement.

2. Introduction

On January 27, Petro-Find Geochem Ltd submitted a proposal to Cameron and Jane Kerr at their request to conduct a second geochemical soil gas survey on their property (SW 1/4 30-5-13-W2M) near Weyburn, Saskatchewan (Figure 1). The Kerr property is within the confines of the huge Weyburn oil field that is undergoing Enhanced Oil Recovery (EOR) by

Cenovus Energy (Figures 2 and 5C). The proposal was accepted by the Kerrs on January 28.

Cam and Jane Kerr initiated this second study mainly because they felt that a winter investigation would contribute to a better year-round picture of CO2 leakage and its effects on the health and safety of people living in the Weyburn field area. A previous soil gas survey by Petro-Find of the same property was conducted in August 2010, which was provided to ***Cenovus*** and the ***Saskatchewan Ministry of Energy and Resources*** in October 2010 and released to the press January 11, 2011. The Kerrs have remained concerned about the lack of surface monitoring for CO2 seepage over the Weyburn Pool since 2005.

Discovered in 1954, the Weyburn Field underwent primary production until 1964 when it was water flooded to enhance oil recovery. Multi-leg horizontal drilling beginning in 1991 further increased oil recovery. Starting in 2000, oil production was again enhanced by a massive Enhanced Oil Recovery (EOR) project. The CO2 produced by lignite gasification in North Dakota (Synfuels) is pipelined in liquid form and injected into the Weyburn reservoir. Injection into the reservoir is at a reported rate of 8,000 tons a day (total for Weyburn and adjacent Midale fields) to reduce the oil viscosity. Water also injected into the oil reservoir sweeps the low-viscosity oil to horizontal and vertical production wells. Both CO2 and water are separated from the produced oil and re-injected. The EOR project is currently operated by ***Cenovus*** (formerly ***Encana***); the adjacent EOR project at Midale is operated by ***Apache Canada***.

Prior to CO2 injection, baseline studies of the reservoir were conducted in 2000. Under this program, sampling of produced fluids and gases was supervised by the field staff of ***Pan Canadian Resources*** (now called ***Cenovus***) in cooperation with researchers from the University of Calgary. Analysis of the samples was undertaken primarily by the University of Calgary. The analytical results were then transferred to other research teams within the IEA GHG Weyburn CO2 Monitoring and Storage Project that required this data.

As part of the IEA, a consortium of companies and organizations under the management of the Petroleum Technology Research Center (PTRC) conducted four soil gas surveys in successive years from 2001 to 2004 of a six-Section area some 2 miles north of the Kerr property (IEA GHG Weyburn CO2 Monitoring &Storage Project Summary Report 2000-2004).

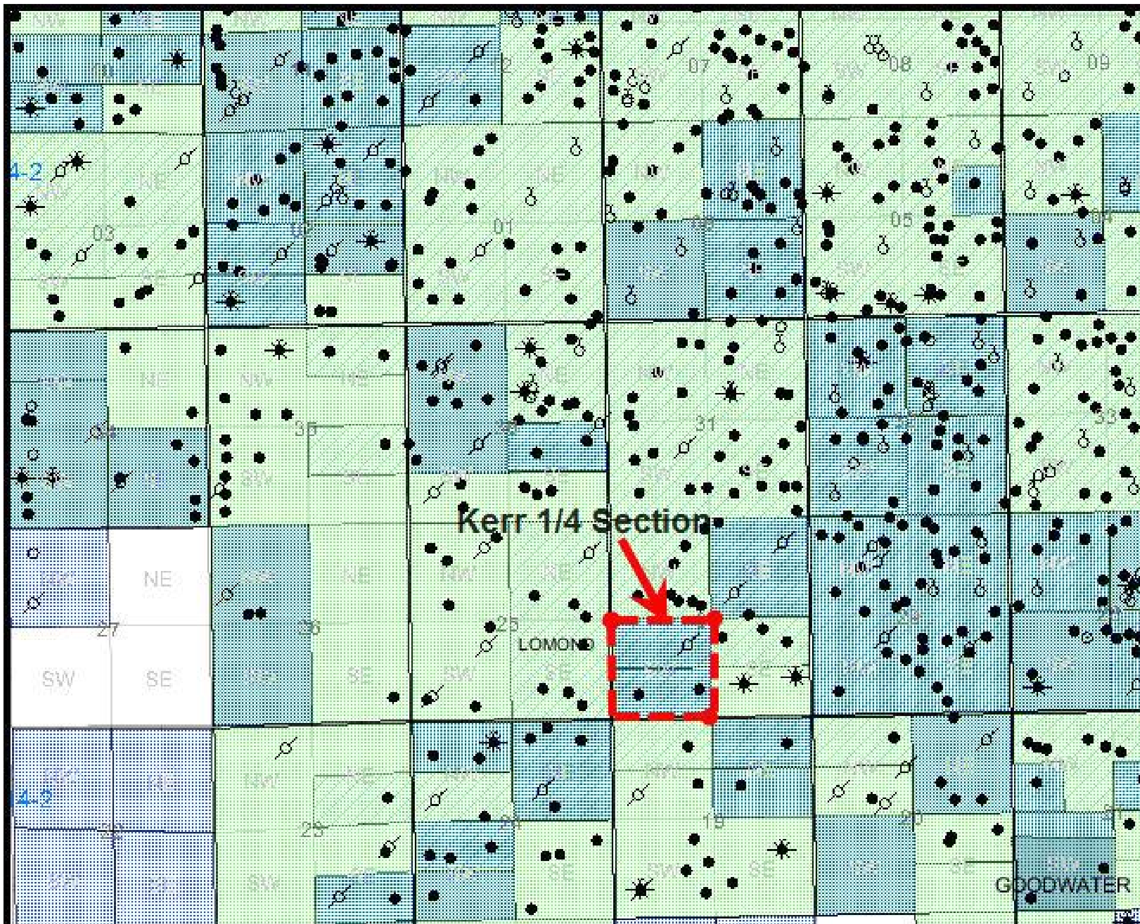


Figure 2. Kerr Property in Midst of Weyburn Field

The monitored area comprises only about 8% of the total field size of 70 square miles and only 5% of the total Weyburn and Midale fields.

The results of the major study conducted as part of the extensive IEA study of the Weyburn Pool from 2001 to 2004 (IEA report) can be used as a template for current conditions at the Kerr Property because it has similar geologic structures and similar water and CO2 injection patterns.

The EOR project has been vastly expanded in a SE direction and with the startup of Phase 2 (reportedly in 2004), the area injected became adjacent to the Kerr property (Figures 5A, 5B, 5C). To the author's knowledge, no monitoring has been conducted over the Weyburn oil reservoir since 2005 nor over the adjacent ***Apache*** Midale reservoir currently undergoing EOR.

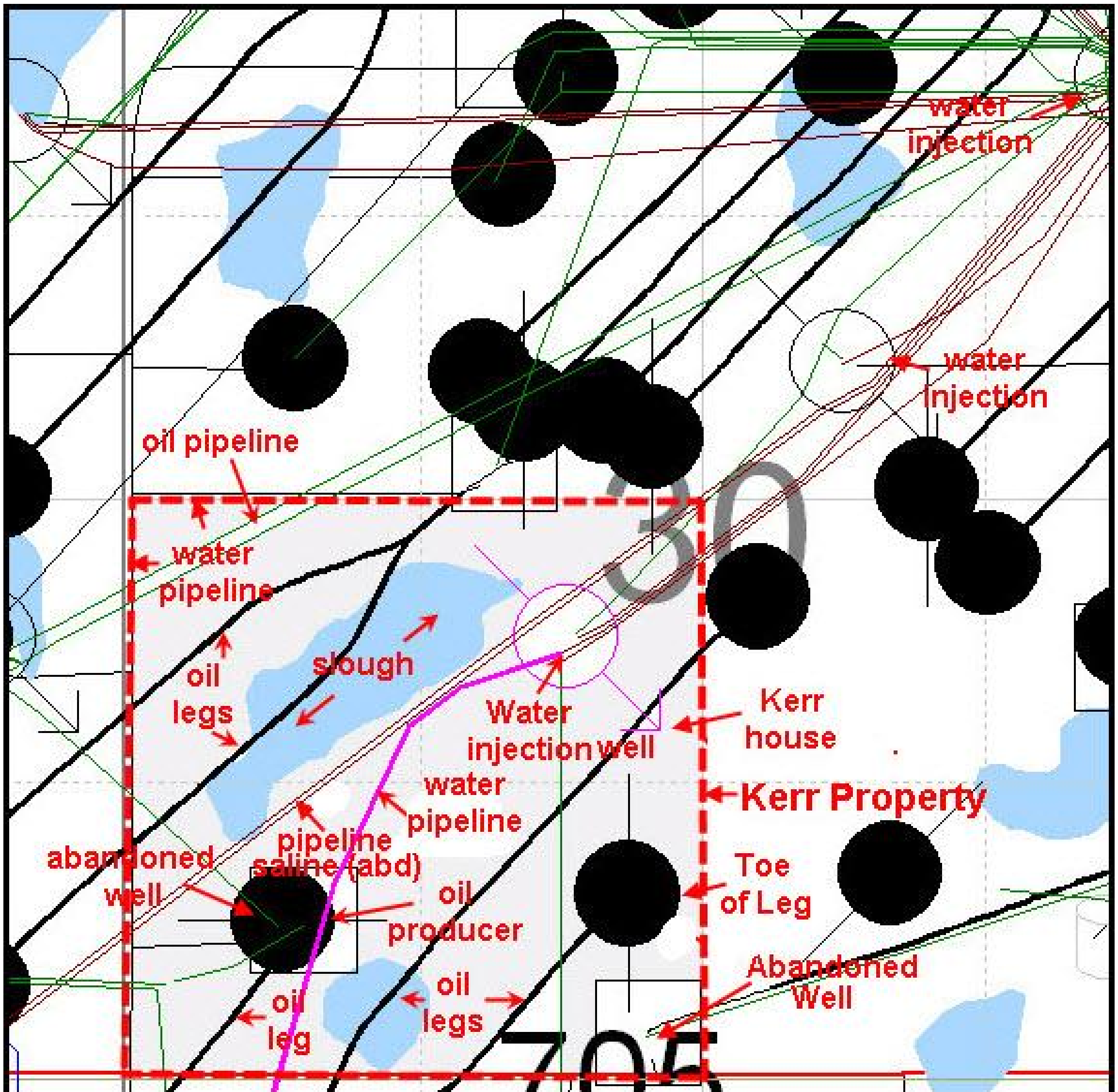


Figure 2A. Kerr Quarter Section- Infrastructure

The field work was conducted by Paul Lafleur and Rudy Willick on February 10. All soil gas analysis for hydrocarbons and CO2 was performed in Petro-Find's laboratory by Rudy Willick (Chemical Technologist and Manager) and completed on February 17. Rudy Willick is a graduate of the Saskatchewan Institute of Applied Science and Technology in Chemical Technology. Stable carbon isotope analysis of CO2 by the ***University of Saskatchewan*** was completed on March 12. This report, including the contouring of data and interpretation, was drafted by Paul Lafleur PEng, President of Petro-Find Geochem Ltd.

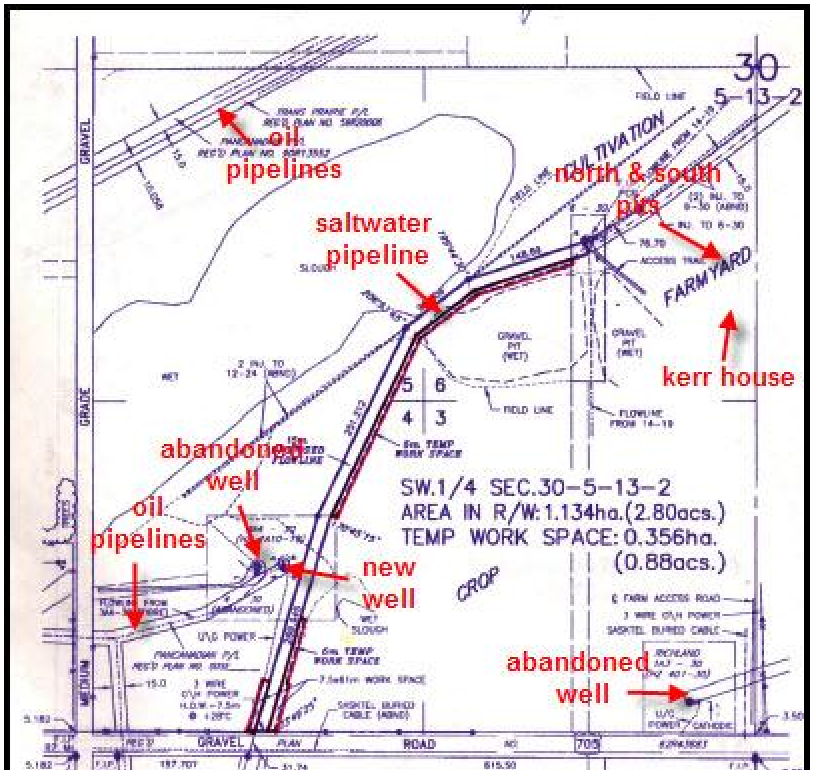


Figure 2B. Kerr Quarter Section-Infrastructure

3. Property Description and Location

The property (SW 30-5-13-W2M) is located some 22 miles S-SE of the City of Weyburn in south Saskatchewan (Figure 1). It is enclosed on two sides – south and west - by gravel roads (Figures 2A, 2B). The property is essentially a flat till plain with an outwash of sand and gravel covering some 40 acres in the NE portion of the property. Fields were covered in snow up to 1.5 feet in depth at the time of the survey. A hard crust made walking difficult (Figures 4C, 4D).

The Kerr property is in the midst of the Weyburn oil field surrounded by numerous active or abandoned: oil wells, oil/water/CO_2 pipelines and water /CO_2/WAG injection wells (Figures 2A, 5F, TAB 4). In active operation on the Kerr property are: one producing oil well with horizontal leg and two oil connecting lines in the SW corner; one salt water injection well (converted oil producer) just to the NW of the Kerr residence; one major saline

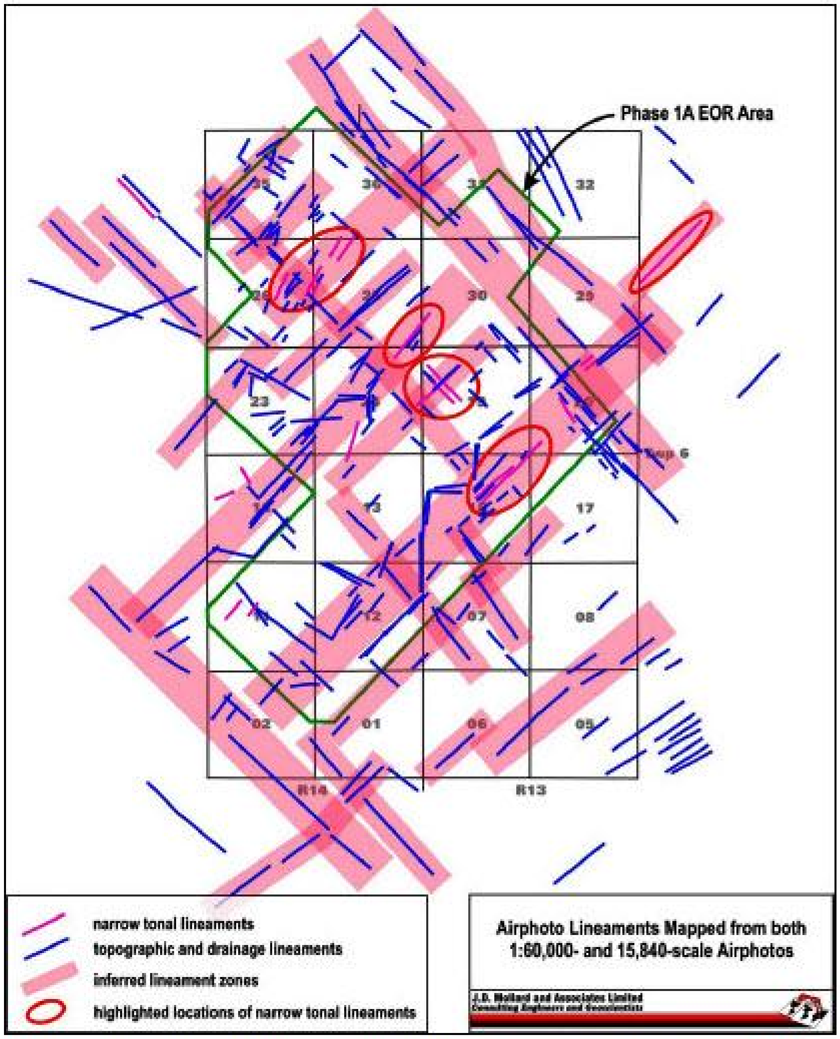


Figure 2C. Surface lineament distribution in the Weyburn Field as determined from remotely sensed data. Lineaments are interpreted to occur in two characteristic trends (NE-SW and NW-SE) that intersect obliquely. Source: Contribution of Mollard & Associates to the IEA Weyburn Field study)

water pipeline traversing the property from the NE to the SW; a major oil pipeline traversing the NW corner; and a saline water line on the west and part of the north boundaries. Other infrastructure that are or appear to be inactive include two abandoned oil wells in the SW and SE corners; four legs from oil wells outside the Kerr property boundary; an emulsion oil line going due south from the water injection well; and an abandoned saline water pipeline that traverses the property from the NE to the SW. All pipelines are reported to be at 4-5 feet below the surface.

Over the years, production has been maximized by conversion of oil wells to either saline or WAG wells. For example, the saline injection well on the Kerr property was formerly an oil well from 1960 to 1965. The so-called "abandoned" oil well next to the currently operating oil well in the SW corner was drilled in 1962 and "suspended" in 1995 (Kerr communication). The current well was drilled in 1999 and has been operational since.

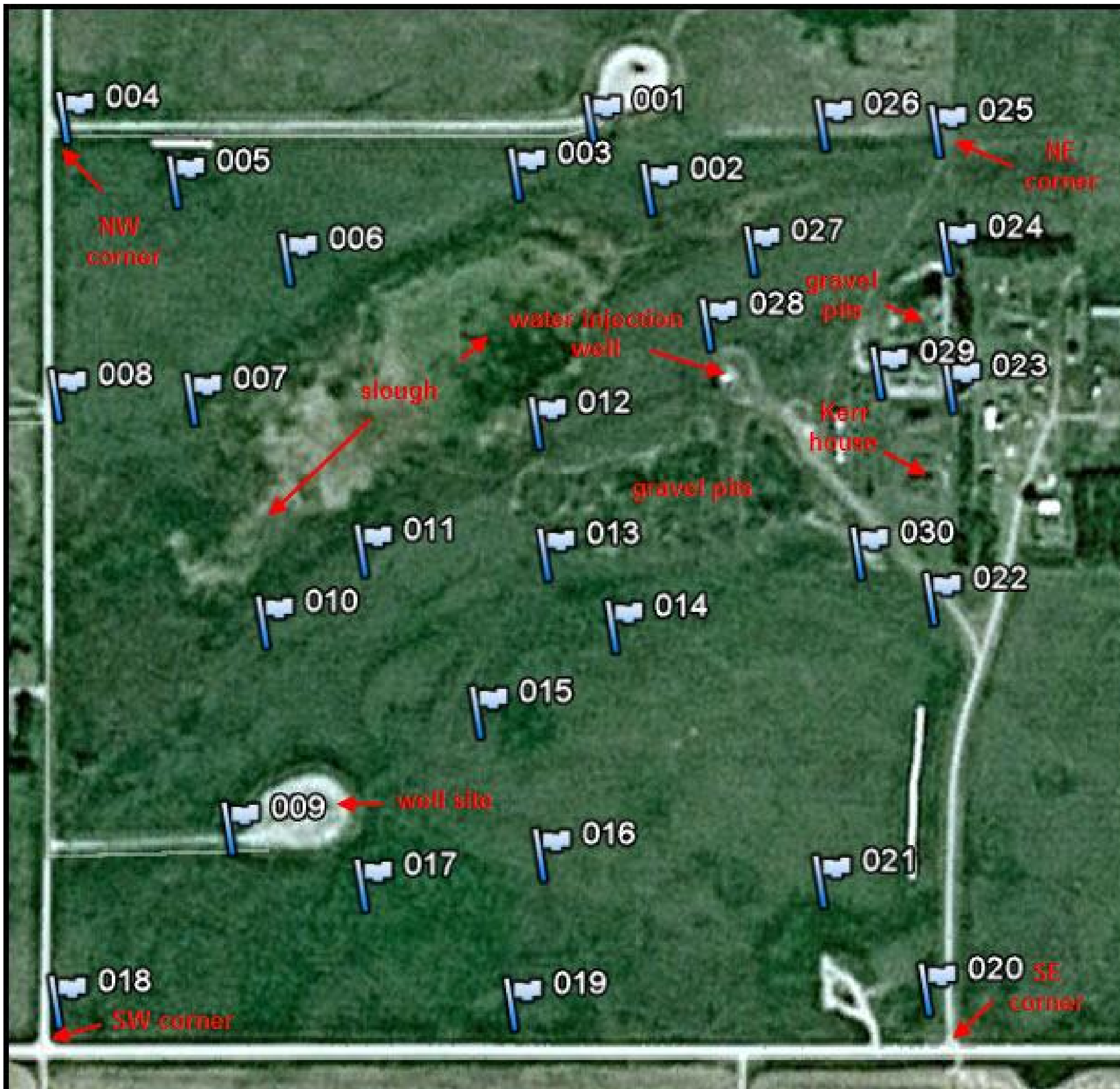


Figure 3. Soil Survey Locations

In 1975, the Kerrs moved to a double-wide mobile home on a half basement/half crawl space. The original potable water well was hand dug in the basement but went dry and the existing well was dug in 1981. Gas heating replaced oil heating about 25 years ago. Gas bubbles were observed in the well and sinks in the house, but SaskEnergy was unable to find any leaks (of natural gas). A multiple gas monitor was unsuccessful in identifying the gas bubbles in the well or sinks. No CO2 or CO detectors were ever used; only one for radon.

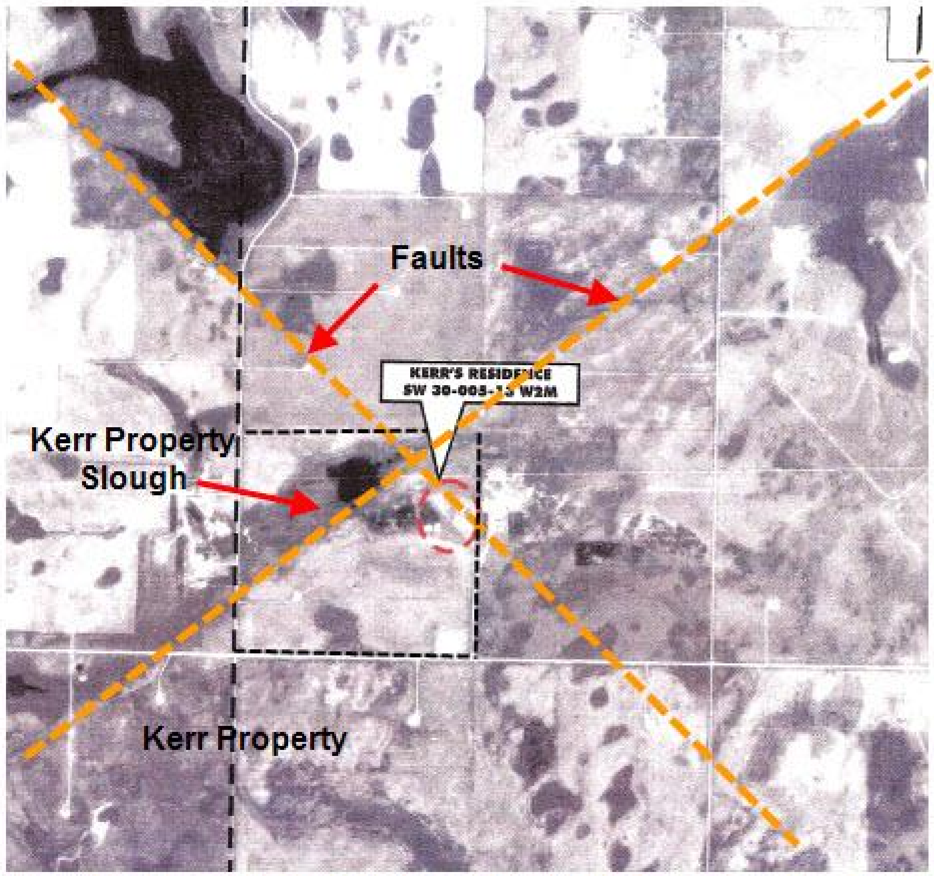


Figure 4A. Lineaments Interpreted as High-Angle Faults - Traces Imposed on 1997 Air Photo

4. Lineaments, Fractures/Faults Weyburn Reservoir

To trace the sources of CO2 and hydrocarbon leakages it is important to develop a knowledge base of fractures/faults and their patterns on and in the vicinity of the Kerr property.

In general, lineament studies from air photos and satellite imagery have been used extensively in the exploration for oil and gas reservoirs because lineaments give major clues to the existence of oil or gas in the subsurface (Bibliography, Tab 3). Fracture/fault systems cutting or intersecting reservoirs can provide major conduits for hydrocarbons and CO_2 to migrate or escape to the surface. Macroseeps (such as those found in the Kerr gravel pits - see August 2010 report) are associated with open faults. All oil and gas reservoirs leak to a certain extent, especially along fractures/faults. How does the geologist recognize surface lineaments?

A paper entitled "Application of Satellite and Airphoto Remote Sensing to Map Fracture Zone and Faults in the International Energy Agency (IEA) Weyburn CO_2 Monitoring and Storage Project Canada" (Penner, Cosford and Mollard) states that "The 200x200km IEA Weyburn regional study area is characterized by systematic NE-SW and NW-SE oriented remotely sensed lineaments and lineament zones and minor N-S and E-W trends. Viewed in satellite and air photo imagery, surface lineaments in this young glaciated landscape appear as discontinuously aligned linear escarpments, valleys and smaller surface drainage depressions that vary in length and relief. In some locations, subtle linear tonal features can be identified in the soil and natural vegetation. Clusters of co-linear individual lineaments that are aligned in the same direction within narrow tracts define longer lineament zones."

Figure 2c (Source: Mollard and Associates) depicts the surface lineament distribution as determined from remotely sensed data of a portion of the Weyburn Field some 2 miles north of the Kerr property. The existence and the same orientation of lineaments in the Kerr property area can be easily picked from air photos (4A).

The Weyburn Reservoir has always been characterized in literature as a fractured reservoir. "Weyburn oil reserves lay within a thin zone of fractured carbonates in the Midale beds of the Mississippian Charles Formation…The dominant fracture set within the reservoir strikes NE-SW sub parallel to the regional trajectories of maximum horizontal stress. Horizontal wells within the ***EnCana*** **(**now **Cenovus -** author's note**)** Weyburn Field are oriented parallel to the predominant fracture direction." (***The Leading Edge*** July 2009). Methods of investigating fault and fracture distribution have involved **surface lineament** studies using remote sensing data and air photos as well as 2D seismic data and high resolution aeromagnetic data.

Petro-find has found in the course of its hydrocarbon exploration activities that elongated low lying areas or lineaments are prime targets for exploration of oil and gas. That is because low lying areas with associated high concentrations of CO2 and light hydrocarbons indicate that they are surface representations of open fractures/faults that have allowed these gases to escape from a reservoir to the surface. Conversely, very low concentrations of gases in linear and elongated low lying areas indicate closed faults.

All reservoirs also naturally leak to a certain extent through micro fractures not seen by seismic. Micro fractures allow microseeps to migrate from the

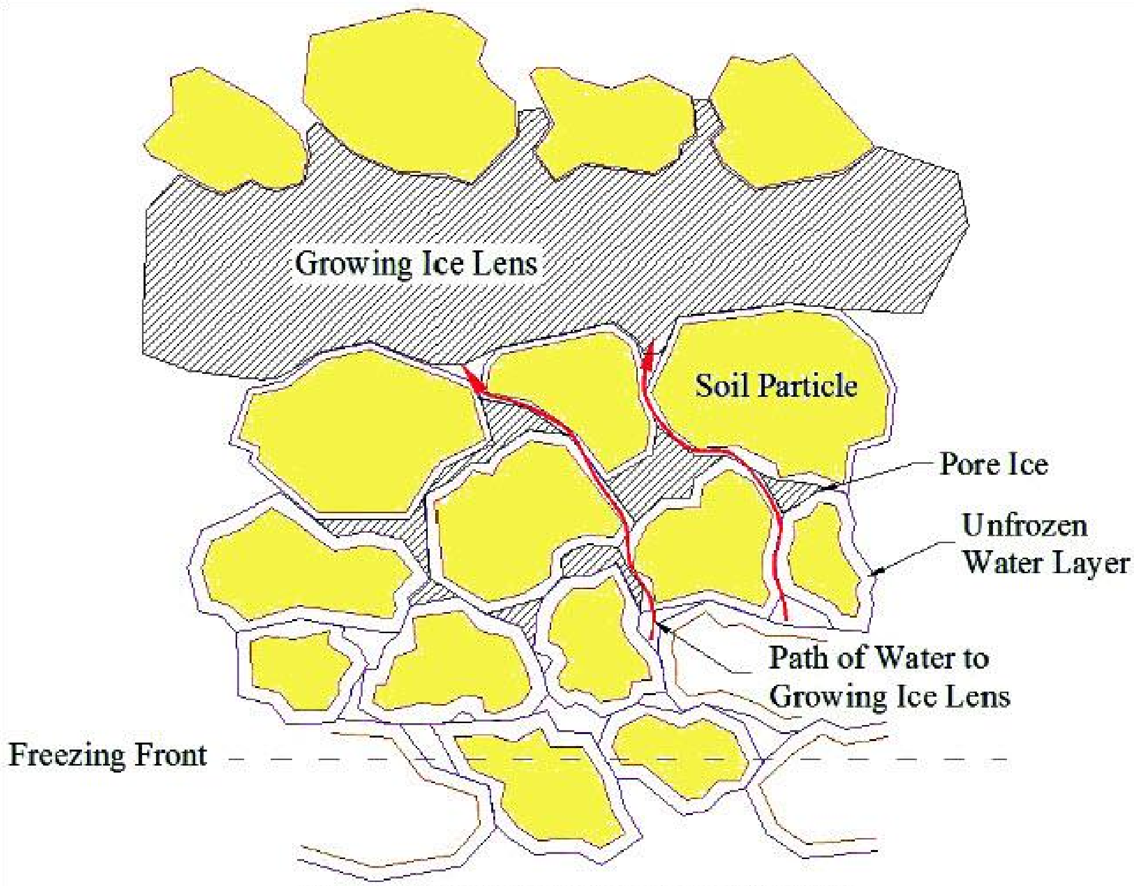


Figure 4B. Schematic of Growing Ice Lens
(Source: Development of a Frost Heave Test.....; MSc Thesis;RussellLay)

reservoir in the form of plumes to the surface where they can be qualified and quantified by geochemical soil gas methods.

The elongated low lying areas may have resulted from the erosion of weak and fractured areas by the gouging and bulldozing action of the last continental glacier. The ice loading from an estimated 10,000 foot thick glacier lasting 2 million years and its retreat causing isostatic rebound 12,000 years ago has left a major imprint on the Canadian landscape. New fractures/faults could have been created as a result and old fractures/faults re-activated. The elongated areas may have developed in tills since the retreat of the glacier and it is possible that some faults may be still active. This factor alone should have given any geologist pause to think that leakage of injected CO_2 is highly possible from EOR operations in obviously faulted areas.

Two lineaments interpreted as faults cross just NE of the Kerr house (Figure 4A). The elongated slough running NE-SW at the north end of the Kerr property is interpreted to be the surface expression of a major fracture/fault system beneath the glacial till. This lineament lines up with a row of water injection and WAG wells as well as one CO_2 injection well both on an off the Kerr property to the NE (Figure 5C). Lakes and sloughs along these two lineaments are interpreted to be on the down thrown side of normal faults. Care was taken not to sample the sloughs themselves (although this can be done with passive samplers) because they are likely to yield a mix of biogenic and anthropogenic CO_2. Soil gas sampling is not done in wet sediments because the soil gas probe has a tendency to plug up.

5. Geochemical Soil Gas Surveys in Frozen Soils

An understanding of how and why soils freeze is important to the interpretation of soil gas data obtained in winter soil gas surveys. Much of the following is based on Petro-Find's experience in conducting soil gas surveys for exploration of oil/gas in winter when soils are normally frozen at one-meter depth or more.

Several factors are responsible for the attenuation of CO_2 and the light alkanes/alkenes in soil gas when soils are frozen. The main effect of freezing of pore water in soils is the reduction of soil porosity and permeability, which negatively affects the concentration levels of any hydrocarbons and CO_2 in soil gas emanating from a deep source. A major advantage of a winter survey is that the biological activity and CO_2 respiration is so low that anomalous values (i.e. in excess of background values) can be linked to CO_2 migrating from a non-biogenic source.

Other factors that can contribute to the attenuation of hydrocarbons and CO_2 concentrations in frozen soils include:

a. Reduced advection (i.e. mass flow from pressure differences) due to a cap of snow pack and ice cover;

b. Restricted upward migration of gases by ice lenses;

c. Increased water content of winter soils that hinder both upward advection and diffusion (i.e. flow due to concentration differences) of gases; and

d. Possibly increased dissolution of CO2 with increased water saturation.

Figure 4C. Sampling Frozen Soils

Literature is replete with studies on soil freezing and resultant frost heaving because it can affect the stability of highways, structures, pipelines, etc. Much of the following text is taken from an excellent thesis –"Development of a Frost Heave Test Apparatus"; Russell Lay; Brigham Young University; December 2005.

With the onset of freezing air temperatures, increasing amounts of heat are removed from the soil and the freezing front begins to progress downward through the soil strata. Because air temperatures can drop much faster than soil temperatures, a large temperature gradient is created at the air-soil interface. Large temperature differences cause the frost front to move rapidly downward through the soil nearest the surface. An **increase in volume by 9 percent** as water changes phases from liquid to ice results in reduced porosity and permeability, which negatively affects an upward gas migration.

Steady-state conditions occur when the energy extracted from the soil in the vicinity of the freezing front is equal to the energy provided by the underlying soil in the form of latent heat of crystallization released by water as it freezes. At this time, further frost penetration ceases, and **ice lensing** occurs. The ability of the soil to supply water to the ice lens diminishes as the water in the region below the freezing front is exhausted. When the water supply to the growing ice lens becomes limited, the latent heat of crystallization may not equal the heat being removed from the soil, causing the frost front to continue downward until the conditions need to form an ice lens are again met. In this way, a series of lenses form perpendicular to the direction of heat flow, separated by layers of frozen soil. "**An ice lens will effectively block any vertical movement of water or solutes through the soil"** (Source: "What's Happening to Your Soil Under the Snow?"; ***Better Farming***; Pat Lynch)

The ability of water to move through the soil matrix ultimately controls the growth of ices lenses. The transport of water from the warmer underlying soil towards the frost front is the result of three main mechanisms: vapor differences, osmosis and capillary rise, the latter being the most important factor. Before the soil begins to freeze, water on the surfaces of the soil particles and in the pore spaces between soil particles form a network of channels through which water and gases are able to flow. As the freezing front passes through the soil, ice crystals nucleate in the pore water between the particles. The formation of ice in the pores cause unfrozen water films on the surface of the particles to become thinner so that the effective radius of the capillaries forming the unfrozen water network within the freezing soil decreases. Although the reduced water content causes a dramatic increase in capillary suction, **the permeability of the soil rapidly diminishes** as the channels become increasingly **tortuous and narrow** as the freezing progresses. A schematic depicting features of freezing soil is shown in Figure 4B.

Ground water in frost susceptible soils is sucked up from the water table by capillary action (Guidance Note; Terram Ltd; Tony Jay; September 2002). It is drawn into the soil above what is known as the capillary zone. This soil is moist but not saturated i.e. there is a mixture of soil, water and air. When the moisture in the capillary zone freezes and is held by solid ice as lenses, the capillary forces are no longer in balance and more water is drawn up from the water table. This extra water, in its turn, becomes frozen and the process of capillary rise and freezing of groundwater becomes continuous one throughout the duration of the freeze period. **The amount of water held in a frozen condition in the capillary zone can be many times more than the non-frozen saturation level for the soil.** CO_2 is attenuated under these conditions.

It is well known that the artificial freezing of soils finds application in controlling groundwater and isolation of subsurface contamination of gases and fluids.

Figure 4D. Sampling Equipment

6. Methodology

The surface of the property was sampled by a proprietary probe using a cordless drill. Winter conditions made drilling somewhat more difficult than in the summer because of the frozen soils and snow up to two feet deep (Figures 4C, 4D). The snow was cleared away and a pre-drill 24 inches long was used to penetrate the icy ground surface. The probe was then inserted into the hole and drilled to the normal 3-foot depth, well below the A-and B-zones to avoid contamination by biogenic CO2 and methane.

A syringe was used to purge the probe of ambient air and extract a 24 cc sample, which was injected into a previously evacuated vial (to 1/5 torr or 0.0003 bar). The evacuation system is of Petro-Find's own design. To avoid any breakage in transit to Petro-Find's laboratory in Saskatoon, the vials were inserted into holes cut into Styrofoam and placed in firm boxes.

A GPS (Garmin CSX) was used to record the coordinates of each sampling point. The GPS was loaded with a Garmin Topo Canada map for additional guidance in the field. All coordinates were recorded in a field notebook to provide backup.

All analysis of light hydrocarbons and CO2 was performed in Petro-Find's state-of-the-art lab at Innovation Place, Saskatoon. In the lab the septum was pierced with a syringe and 3cc was withdrawn for injection into a gas chromatograph equipped with FID and TCD detectors. The analytes were the C1-C5 alkanes, C2-C4 Alkenes and the fixed gas, CO2. A major peak between butane and pentane has remained unidentified. Analysis was performed by a qualified chemical analyst using a high-end gas chromatograph. To obtain a high linear dynamic the gas chromatograph was calibrated each day with all the individual gases expected to be measured.

The coordinates and analytical data were downloaded to a computer and saved as an EXCEL file. Petro-Find's state-of-the-art software program was used to produce contour maps of CO2, methane and C2+ (sum total of all the C2-C5 analytes) concentrations (Figures 8, 9, 9A, and Exhibits 1 and 2). The scattered data points were contoured by a triangular, non-gridded computer program. Contours were printed on clear film for overlay on a previously prepared georeferenced base map. All printing was done in-house.

After analysis for hydrocarbons and CO2 in Petro-find's laboratory six vials were sent to the University of Saskatchewan for analysis of stable carbon isotopes C12 and C13 in CO2 and determination of Delta13CCO2.

Petro-Find uses the soil gas probe exclusively for sampling of soil gas. Other sampling methods exist for monitoring of CO2 leakages at the surface and near-surface. ***In situ*** methods using a probe and infra-red analyzer can measure CO2 directly in soil gas. However, after two years of experience using the ***in situ*** method, Petro-Find abandoned this approach because results were found to be unreliable. Calibration in the field of the various instruments used was always a problem. The sampling of tight clay soils by the infra-red ***in situ*** method usually drains the soil gas available around the probe end and a second extraction from the same probe for analysis of other analytes, such as radon and the sulphur species, can result in errors. This is because the high vacuum created by a hand or internal pump pulls ambient air down from around the annulus of the probe thus diluting the sample.

Other monitoring techniques used elsewhere include the accumulation chamber method, which measure the total CO2 concentration and flux at the soil-atmosphere interface. As these essentially sit on top of the ground they measure both upward migrating CO2 from the subsurface as well as biogenic CO2 produced in the A- and B-horizons by respiration and microbial activity. They cannot be used in winter when the soil is frozen and the surface soil is icy. Some chamber methods cannot measure CO2 concentrations above 5,000 ppm and therefore are not suitable for measuring any substantial breakthroughs of CO2 from EOR operations.

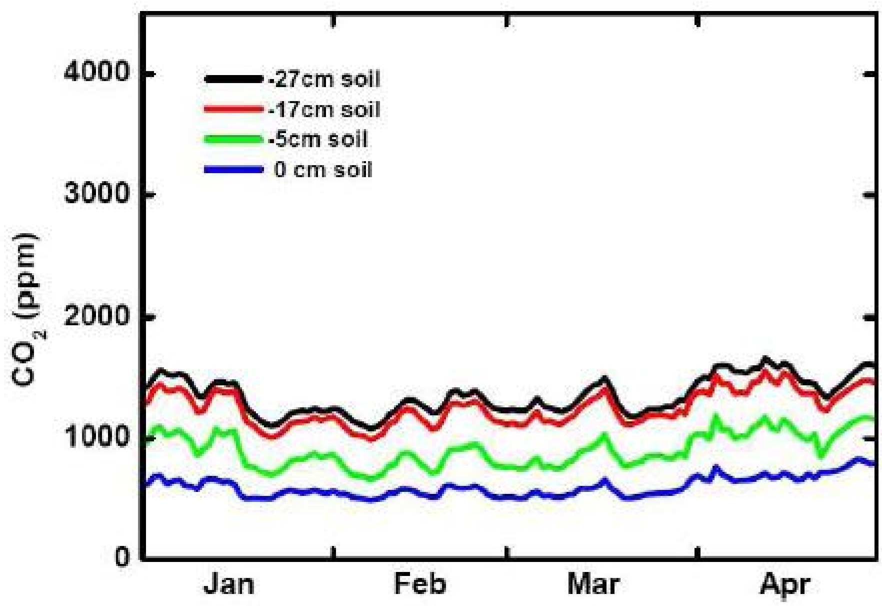
7. Geochemical Soil Gas Survey for Hydrocarbons

Modern geochemical methods, such as Petro-Find soil gas surveys, are important tools for finding hydrocarbon reservoirs because they are direct indicators of hydrocarbons as well as carbon dioxide (http://www.gasoilgeochem.com). Light hydrocarbons and CO2 (about the same molecular weight as propane) naturally escape as **microseeps** from reservoirs and travel vertically to the surface where they can be detected and analyzed by gas chromatograph. Concentration patterns or surface anomalies of these microseeps can be reliably related to petroleum/gas accumulations at depth. Open and closed fractures/faults in such surveys can be detected at the surface by linear high or low concentrations in soils, respectively.

The fact that the relative amount of light alkanes and alkenes in soil gas has about the same relative composition as the gas in the underlying reservoir provides a reliable indicator of the type of reservoir the anomaly represents. Some principal indicators of reservoir content are: percentage of methane

(C1) in total light hydrocarbons (C1-C5); ratio of methane to ethane; and ethane+ or the sum of the ethane to pentane concentrations. In general, the near-surface anomaly or surface expression of a hydrocarbon reservoir decreases in intensity once the reservoir undergoes production because of declines in pressure. These pressures are renewed after either water or CO2 flooding but the surface patterns may be different.

From previous experience with soil gas surveys in frozen soils, the concentrations of C3-C5 hydrocarbons and CO2 are seriously attenuated (see Section 5 of this Report). Of particular significance are the drastically reduced concentrations in soil gas of the higher molecular hydrocarbons such as butanes, butenes and pentanes. The butanes and butenes are liquid at



Daily average of CO_2 concentration in soil and snow during a period of January 2005-April 2006 measured with probes buried in the soil.

Figure 4E. CO2 Concentrations in Soils

the freezing point of water and report to soil gas in only reduced amounts. Pentane, already in liquid form at room temperature, becomes less volatile in frozen soils. CO2, which has a slightly higher molecular weight than propane, is also highly attenuated in frozen soils.

8. Geochemical Soil Gas Survey for CO2

CO2 concentrations in soil gas are drastically attenuated in frozen soils because of various barriers, which impede migration from the deeper subsurface. The reduced concentrations are mainly due to barriers caused by the loss of porosity/permeability due to freezing of water and the formation of ice lenses in the subsurface (see Section 5).

Petro-Find believes that its geochemical soil gas method is the most cost-effective tool for the surface monitoring of CO2 leakages from EOR and other sequestration sites in winter. Its proprietary probe can penetrate frozen soils that have hard ice lens formation. The depth of sampling is three feet, which is well below the biologically active A-and B-horizons of the soil profile, even though respiration and microbial activity is only a fraction of that in non-frozen soils. Compacted snow and ice at the surface minimizes barometric pumping, which causes wide swings in CO2 concentrations at up to 18 inches in depth due to an exchange of CO2 with the atmosphere.

The changing patterns of CO2 and light hydrocarbon concentrations are best depicted by contours, which are printed on clear substrate for overlay on base maps so that they may be correlated with actual ground locations. A triangular, non-gridded computer program provides accurate contouring of concentrations

The Weyburn-Midale EOR project currently injects into the Weyburn and Midale reservoirs about 8,000 tonnes a day of anthropogenic CO2 pipelined in liquid form from the Great Plains Synfuels Plant in North Dakota. The CO2 supply is reported to be comprised of 96% CO2, 2.3% C2+ hydrocarbons, 0.9% hydrogen sulphide, 0.7% methane, 0.1% carbon monoxide, and minor amounts of nitrogen, oxygen and water (Source: The IEA Weyburn CO2 Monitoring and Storage Project; Final Report of the European Research Team; British Geological Survey; 2005).

Enhanced oil recovery as practiced at the Weyburn field has two main objectives: to enhance oil recovery and to sequester CO2 permanently in the subsurface. While the enhanced oil recovery process is contributing in a major way to oil recovery, it can be shown that CO2 has escaped from the Weyburn reservoir. CO2 plumes can take some time to reach the surface but leakage can quickly reach the surface in high concentrations by means of improperly plugged wells, open fractures/faults and other fast-flow paths. A reliable and effective monitoring system using geochemical soil gas surveys can ensure that sequestration is a safe and acceptable method for the permanent disposal of CO2. Repetitive surveys over a long period of time give assurances that there is no leakage at the surface.

The fractured nature of some reservoirs mitigates their use for EOR sequestration. If CO2 reaches the shallow subsurface or migrates out of the ground into the ambient air, health and environmental risks can arise. A study by Mollard and Associates as part of the Weyburn study showed considerable faulting and fracturing in the area of the Weyburn reservoir (The IEA Weyburn CO2 Monitoring and Storage Project). A lineament study of the Kerr property two miles to the south of the Mollard study shows two major lineaments traversing the Kerr property that are interpreted to be fractures and faults (Figure 4A).

Petro-Find has found in the course of geochemical soil gas surveys for oil/gas throughout the year in Saskatchewan that the average background CO2 concentration in soils at a 3-foot depth is about 1400 ppm during the summer and only about 600 ppm during the winter when the ground is frozen. About the same daily average of CO2 concentrations has been reported by others (Figure 4E. Source: “Equilibrium Sampling in Soil, Snow and Aquatic Ecosystem Measurements”; ***Vaisala***).

The lower background levels for CO2 in winter are attributed to freezing of soils and a concomitant decrease in root respiration and microbial degradation of organic matter. Anomalous concentrations of up to 3,000 ppm in soils have been obtained during the summer/early fall season above newly-discovered oil reservoirs, especially in the comparatively shallow heavy oil district of western Saskatchewan. The anomalous CO2 is attributed to the severe microbial degradation of the natural hydrocarbons at the reservoir level. However, the strength of the CO2 signal is much attenuated once these reservoirs are in production or have become depleted.

Sub-surface monitoring of CO2 in soils for EOR projects in winter can still produce good results notwithstanding the attenuation of concentrations in frozen soils and ice lenses. Monitoring of CO2 in the summer/fall is complicated by the fact that the detection of any leakages can be masked by the relatively high concentrations in the near-surface environment. The major contributors of CO2 in soils are microbial activity and root respiration, which fluctuate widely depending on such factors as temperature and moisture. Compacted snow with icy layers results in less effective barometric pumping, which in summer can cause wide variations in CO2 concentrations at the near-surface (maximum 1.5 foot depth) due to an exchange of CO2 with the atmosphere. The groundwater degassing of CO2 still contributes to background values. Some off-gassing of CO2 from organic carbon such as coal or lignite in the subsurface can also make a contribution.

High concentrations of biogenic CO2 are usually observed in humic soils in sloughs and wet areas during most of the year due to anaerobic conditions. On a practical level, soil gas sampling of sloughs at any time of the year is avoided because probes become plugged in water-saturated sediments (although passive samplers have been developed for this purpose). It can be expected that some of the biogenic CO2 is converted to methane in sloughs and humic soils. A linear plot of methane versus ethane average concentrations in a soil gas survey can show whether the methane is thermogenic or biogenic and whether the CO2 is anthropogenic or biogenic.

Table 4.7 U.S. Occupational Exposure Standards (National Institute for Occupational Safety and Health, 1997).

	CO_2 concentration (ppm; %)	Circumstances
REL*	5,000 ppm (0.5%)	TWA*; 10-hour day, 40-hour week
STEL*	30,000 ppm (3%)	15-minute TWA
IDLH*	40,000 ppm (4%)	Immediately dangerous to life/health

NOTE: REL = recommended exposure limits; STEL = short-term exposure limit; IDLH = immediately dangerous to life and health. TWA = time-weighted average. See text for additional discussion.

Table 1. U.S. Occupational Exposure Standards for CO2
Source: IEA GHG Weyburn CO2 Monitoring and Storage Project

It is important to assess the CO2 concentrations in soils because of the possible harm to humans, flora and fauna. It is well known that human health can be impacted at very low levels. Humans can die of asphyxiation if the concentration of CO2 in air is as little as 50,000 ppm (5%) (Source: The IEA Weyburn CO2 Monitoring and Storage Project, Final Report of the European Research Team, 2005). This can be a major problem for homes situated over high leakage areas because of the negative pressures caused by winter heating and other utilities.

In the first report of the IEA GHG Weyburn CO2 Monitoring and Storage Project in 2004 the Recommended Exposure Limit (REL) for the workplace, based on a time-weighted average (TWA), was 5,000 ppm over a 10-hour workday during a 40-hour week (Table 1). The Short-Term Exposure Limit, a 15-minute time-weighted average of 30,000 ppm, "should not be exceeded at any time." A 40,000 ppm concentration is regarded as "Immediately Dangerous to Life or Health". The report further noted that more restrictive requirements might be expected for a domestic building, where people may spend a longer time indoors. For someone remaining in the home for 24 hours per day the limiting threshold is half the workday value, or 2,500 ppm.

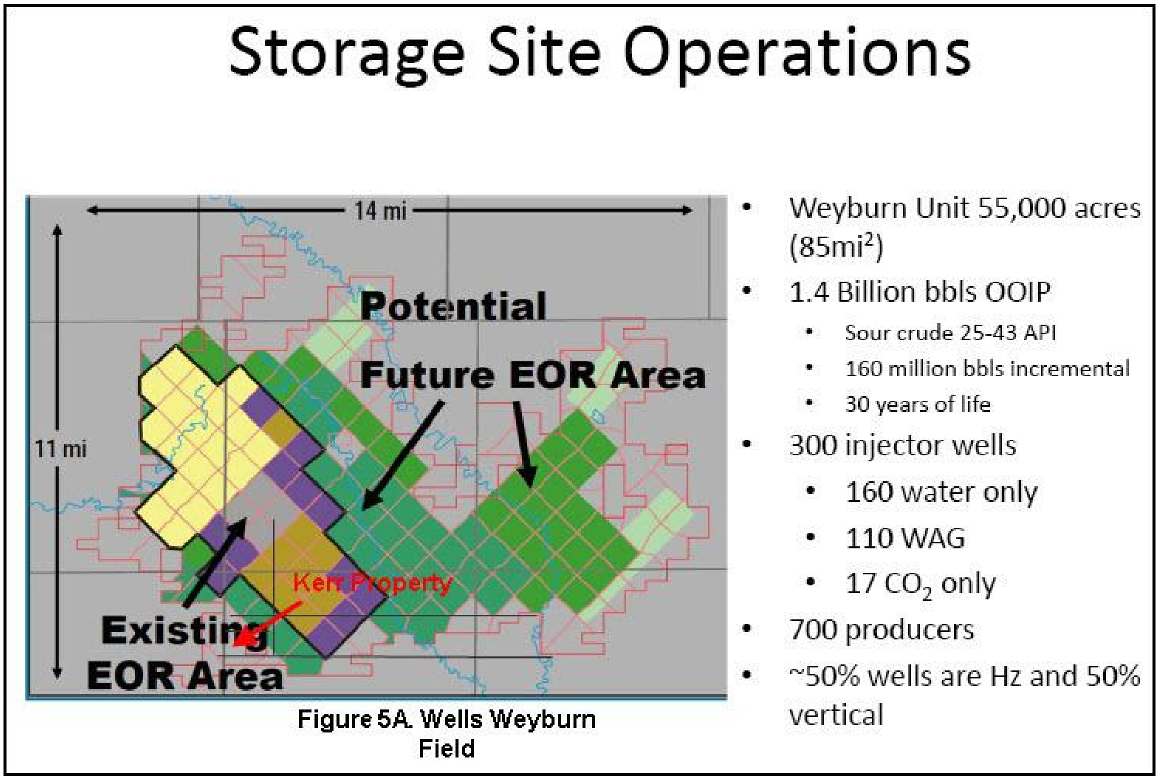


Figure 5A. Wells Weyburn Field

The Minnesota Department of Health "has set workplace safety standards of 10,000 ppm for an 8-hour period and 30,000 ppm for a 15 minute period. This means the average concentration over an 8-hour period should not exceed 10,000 ppm and the average concentration over a 15 minute period should not exceed 30,000 ppm." According to the report, carbon dioxide can cause headache, dizziness, nausea and other symptoms at high levels. This could occur when exposed to levels above 5,000 ppm for many hours. At even higher levels, CO_2 can cause asphyxiation as it replaces oxygen in the blood and exposure to concentrations of around 40,000 ppm is immediately dangerous to life and health.

It is well known from numerous landfill studies that an impermeable cap of any kind including compacted snow or ice can divert normally upward migrating CO2 and methane laterally. Lateral migration of CO2 in winter could increase the potential hazard in homes that have either a crawl space or a cracked concrete basement. "When an impermeable or nearly impermeable cover exists or when a permeable cover is overlain with snow or it is nearly saturated with moisture, horizontal lateral subsurface migration may be the path of least resistance"(Source: "Evaluating Landfill Gas Emissions from Closed or Abandoned Facilities"; USA Environmental Protection Agency).

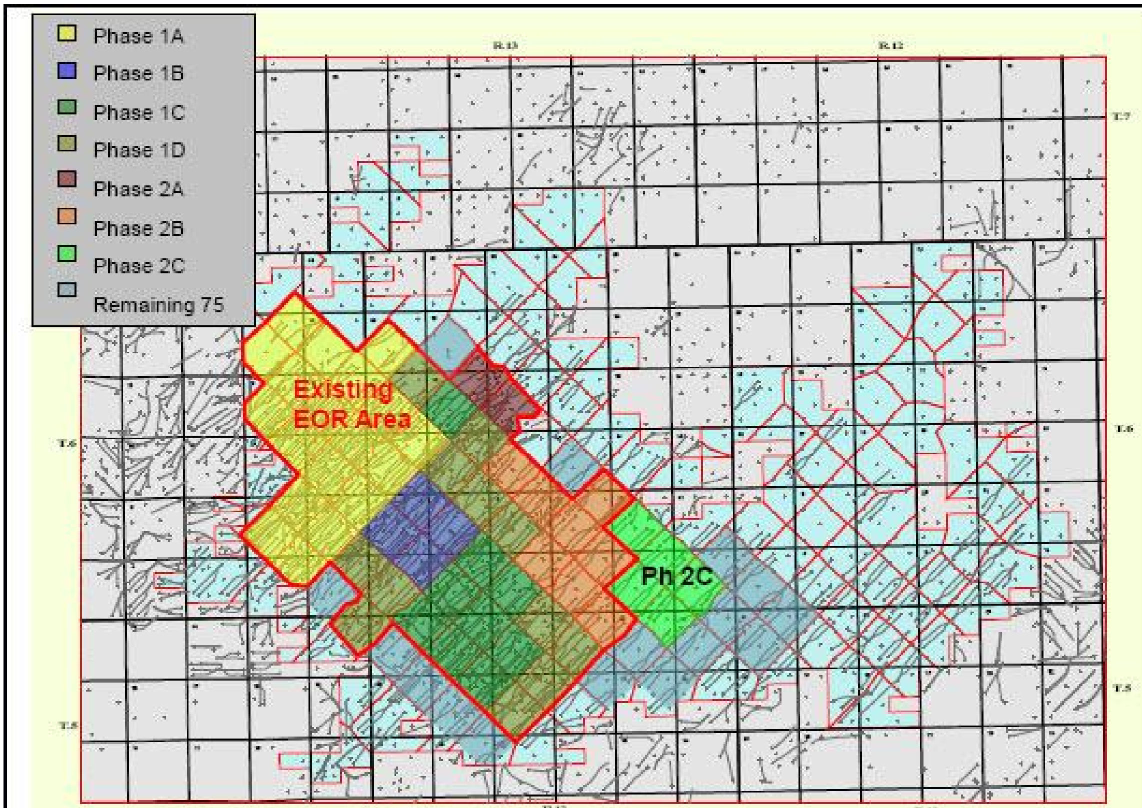


Figure 5B. CO2 Flooding Program (as of December 2010)

9. Well Patterns – Oil Producers, CO2 Injectors and Water Injectors

To trace the sources of any leakages of CO2 and hydrocarbons it is important to develop a knowledge base of types, locations and patterns of wells and pipelines in the vicinity of the Kerr property. A study of surface facilities that separate and recycle the fluids and gases completes the picture.

Figure 5C. Wells in Vicinity of Kerr Property

The Weyburn-Midale EOR project reportedly injects into the Weyburn and Midale reservoirs about 8,000 tonnes a day of anthropogenic CO2 pipelined in liquid form from the Great Plains Synfuels Plant in North Dakota. Enhanced oil recovery as practiced at the Weyburn field has two main objectives: to enhance oil recovery and to sequester CO2 permanently in the subsurface.

The well and pipeline locations and patterns of the ***Cenovus*** EOR operations are depicted in Figures 5A, 5B and 5C (Sources: **a.** "Regional Carbon Sequestration Partnerships Annual Review"; PTRC; October, 2010; **b.** "An Update on the Saskatchewan CO2 Floods [Weyburn +Midale] and Storage Monitoring Activities"; PTRC; December 2010; and **c.** Saskatchewan Department of Industry and Energy.

The Weyburn unitized field consists of 55,000 acres (85 square miles) with about 300 injector wells including 160 water only, 110 WAG (water and CO_2) and 17 CO_2 only(Figure 5A). Of the 700 producing wells, about 50% are horizontal and 50% are vertical. The pattern of the injectors and producers, which can change over time, will typically be determined based on computer simulations that model the reservoir's behavior based on different design scenarios. For example, some oil wells have been converted to water and to WAG injectors.

Figure 5D. Saline Water Injection Well, Kerr Property

Based on information obtained from the Saskatchewan Department of Industry and Energy three CO_2 injection wells exist to the NE and east of the Kerr property (Figure 5F). All of these wells have horizontal legs. The toe (at the end) of one of the horizontal wells (92/10-29-005-13W2) is an estimated 2030 meters (i.e. about 2 kilometers) from the NE corner of the Kerr property.

Also existing in the north, NE and East of the Kerr property are seven water and nine WAG (water alternating CO_2) injection wells (Figure 5F). One saline injection well and one oil producing well occur on the Kerr property (Figure 2A). The saline injection well was originally an oil producer from 1960 to 1965. It should be noted that this water injection well is on line

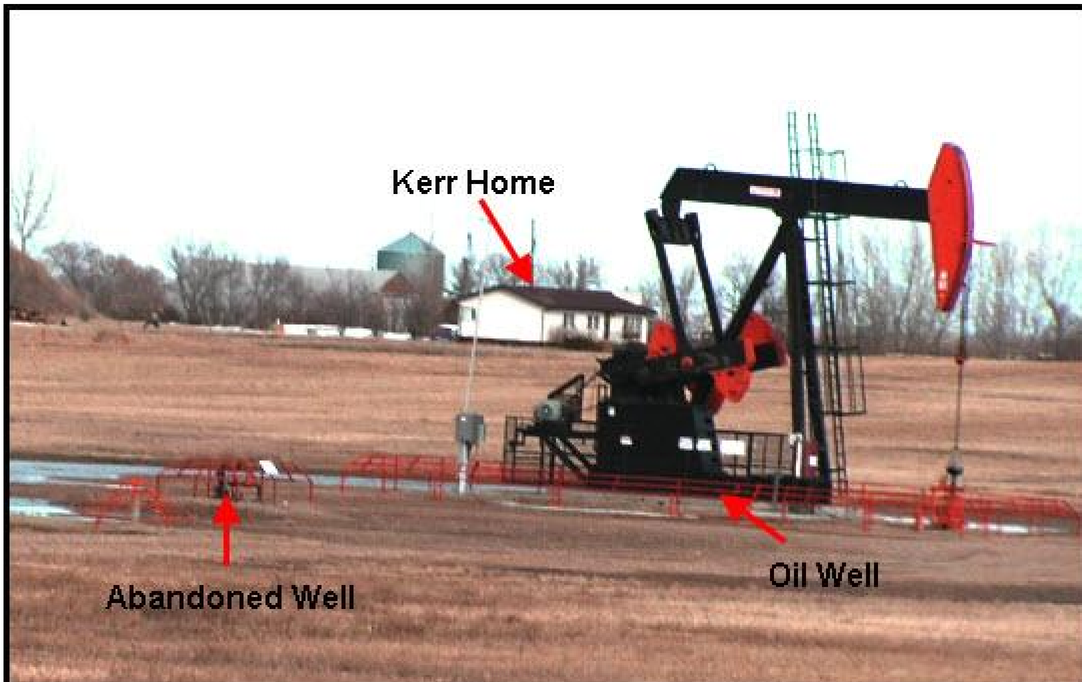


Figure 5E. Wells in SW Corner of Kerr Property

oriented in the NE direction with two water, three WAG and one CO_2 injection wells. This orientation is parallel with the predominant NE-SW fracture direction (***The Leading Edge*** July 2009).

In general, the CO_2 pipelined from the Synfuels plant in a supercritical state is directed to injection wells strategically placed within a pattern of wells to optimize the areal sweep of the reservoir. The injected CO_2 in the reservoir becomes miscible with residual oil forming a concentrated oil bank. Water (brine) injection sweeps the oil from the injection sites to the producing wells. Also used are WAG (water alternating CO_2) wells, which inject CO_2 and brine in alternating fashion from the same well to mitigate the tendency for the lower viscosity CO_2 to channel its way ahead of the displaced oil. If the CO_2 breaks through to a producing well, any CO_2 injected afterwards will follow that path, thereby reducing the overall efficiency of the injected fluids to sweep the oil from the reservoir rock.

At a producing well, a mix of oil, water (brine), CO_2 (in gaseous form) and natural gas is pumped to the surface where it flows to a centralized collection facility. Here, the produced fluids and gases are separated into their various components. First, the CO_2 is separated out from the mixture, recompressed and re-injected along with makeup CO_2 (from the Synfuels plant) into the reservoir. Water is removed from the oil, treated and re-injected into the reservoir. Oil is also treated before being pipelined to market. It is not known whether the hydrocarbon gases are flared, re-injected or marketed.

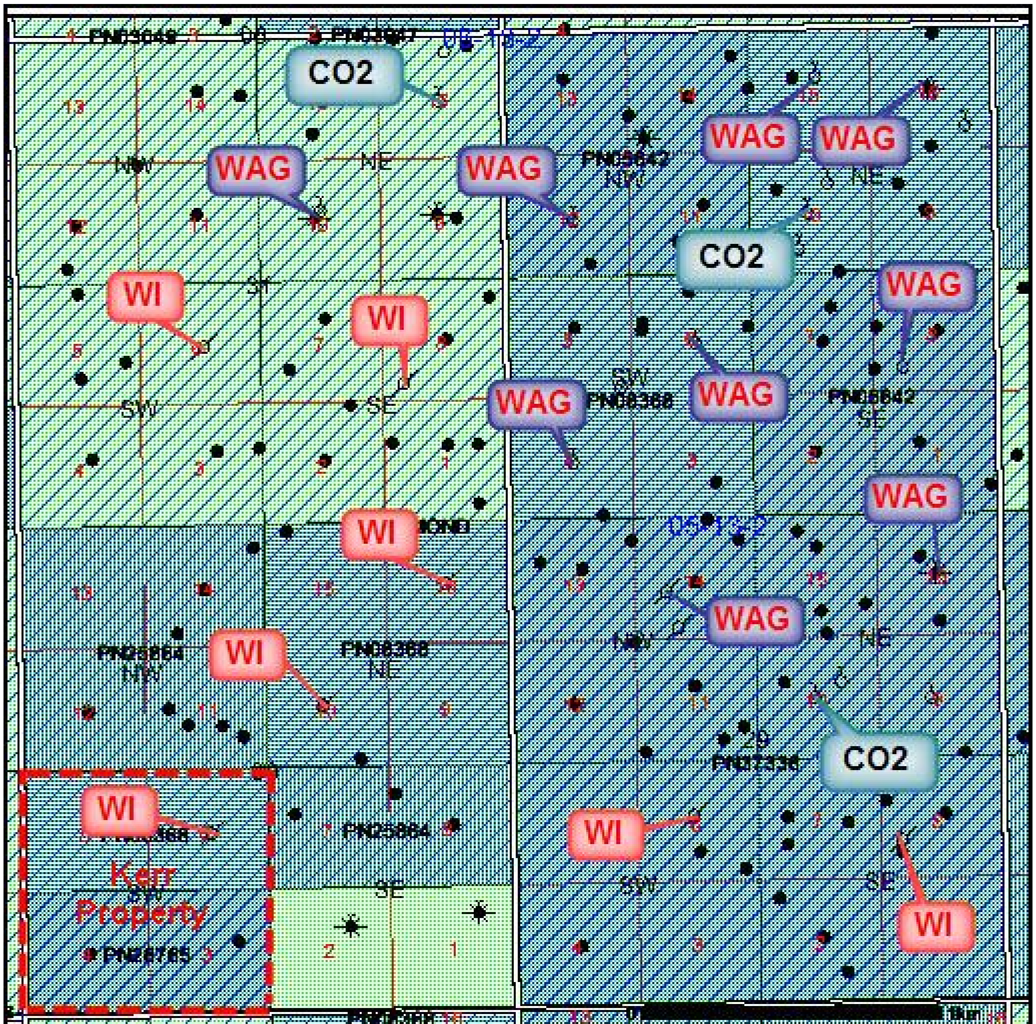


Figure 5F. Kerr Property Relative to Water Injection (WI), Water Alternating CO2 (WAG) and CO2 Injection Wells

10. Carbon Isotope Analysis of CO2

The stable carbon isotope analysis of CO2 conducted as part of the extensive IEA study of the Weyburn Pool from 2000 to 2004 (IEA Summary Report) as well as scientific reports since then can be used in this report to establish baseline values. The Kerr Property has similar geologic structures, soil types and water/CO2 injection patterns as the six-square-mile area monitored in 2000-2004 (IEA Summary Report).

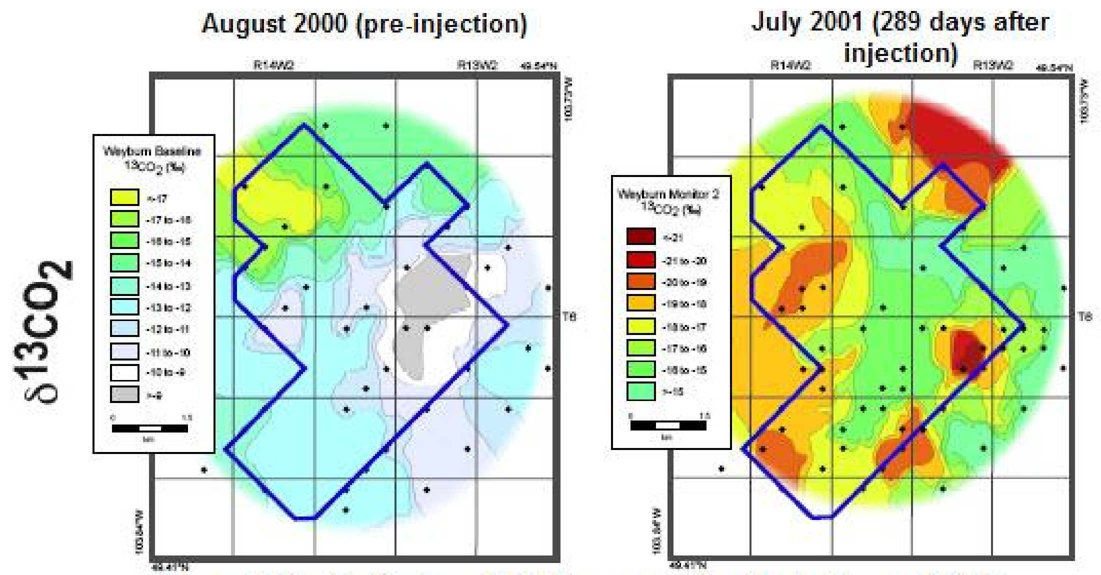


Figure 6. Delta CarbonCO2 Pre- and Post-Injection of CO2, IEA Weyburn Project

This increase in negative values due to injection of anthropogenic lighter CO2 is depicted in Figures 6 and 7 (Source: Summary Report IEA GHG Weyburn CO2 Monitoring and Storage Project 2000-2004). Researchers have also shown that injected CO2 can move rapidly up and transversely along faults (for a discussion see Section - Results and Interpretation).

Increased CO2 concentration over baseline values in soils over a sequestration site is of course the primary indicator of leakage from a reservoir that undergoes EOR. The usefulness of C12 and C13 stable isotopes in determining the provenance of CO2 (i.e. whether biogenic or anthropogenic) depends largely if the isotopic ratio C12/C13 (Delta C13 or the fractional difference between a sample and a standard) of the injected CO2 is significantly different than that of the baseline CO2. Leakage would be indicated by a shift in this ratio.

A paper – “Tracing the Fate of Injected CO2 in the Subsurface Using Chemical and Isotopic Techniques”; Climate Change: Global Risks, Challenges and Decisions, Earth and Environmental Science 6; 2009 - is summarized as follows: “Stable isotope data can assist in successful monitoring of the fate of injected CO2 in enhanced oil recovery and geological storage projects. This is demonstrated for the International Energy Agency Greenhouse Gas Weyburn-Midale CO2 Monitoring and

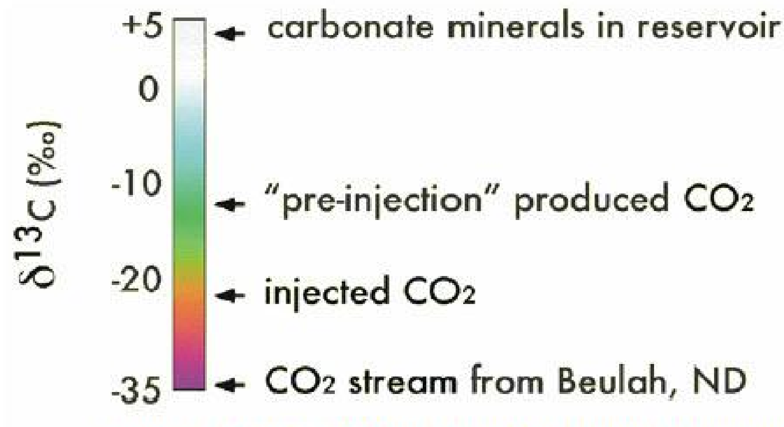


Figure 7. **DeltaC13(%)for Reservoir Rock, Pre-Injection Produced CO2, Injected CO2 and CO2 Sourced from Gasification Plant, North Dakota**

Storage Project (Saskatchewan) and the Pembina Cardium CO2 Monitoring Project (Alberta) where **fluid** and **gas** samples from multiple wells were collected and analyzed for geochemical and isotopic compositions. In both projects, C and O isotope values of injected CO2 were sufficiently distinct from those of background CO2 in the reservoir. Consequently C and O isotope ratios constitute a suitable 'fingerprint' for tracing the fate of injected CO2 in the respective reservoirs. The objective of this paper is to demonstrate the usefulness of isotopic tracers for geochemical monitoring of injected CO2."

The above referenced study went on to say: "At Weyburn baseline delta13C values of CO2 gas (Delta 13CCO2) were between -12‰ and -14‰ ….. The injected CO2 at Weyburn comes from a coal gasification plant in North Dakota and has a delta 13CCO2 value of -20.4 ‰. After CO2 injection commenced, geochemical data revealed that CO2 contents increased to reach 70-90 mole % at one observation well (Weyburn Well 1) after over a year of injection whilst delta 13CCO2 values steadily decreased to values near -20 ‰. In contrast, geochemical data for a second well (Weyburn Well 2) displayed only a minor increase in CO2 concentration with time while the delta 13CCO2 values trended towards values near -20 ‰ circa one year after CO2 injection began."

The results at Weyburn were compared with those at the Pembina EOR project in Alberta. "At Pembina baseline delta 13C values for CO2 gas were between -16 and -18 ‰ …... CO2 injected at Pembina is trucked in daily and has a mean delta 13C value of -4.5 ± 2 ‰ depending on the source of the

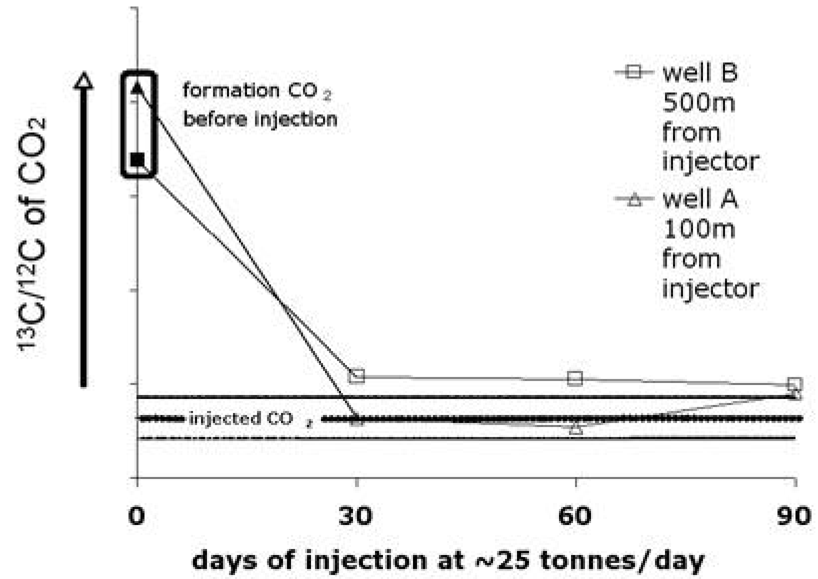


Figure 1: Detection of small volumes of injected CO2

Figure 7A. Detection of Anthropogenic CO2 Horizontally Along Faults Using Stable Carbon Isotopes

CO2. Geochemical data for one observation well (Pembina Well 1) revealed that CO2 concentrations increased rapidly as CO2 injection began to maximum values around 90% within 6 months of injection. At the same time delta13CCO2 values increased rapidly towards values of -5 ‰. Geochemical data for a second observation well (Pembina Well 2) showed negligible changes in CO2 concentration with time while delta13C values trended towards -8 ‰ over a period of 6 months after injection began."

The study concluded: "Regulatory and safety issues dictate that successful CCS projects will require the ability to trace the fate of CO2 in the reservoir… Carbon isotope ratios are an effective tool to trace the movement and reaction of injected CO2 in mature oil fields, provided that the injection CO2 is isotopically distinct."

The concentration patterns of CO2 in soils near the Kerr residence could change rapidly on a daily basis because of the dynamic movement of CO2 in the EOR operations. Empirical data shows that CO2 moves horizontally very quickly (Figure 7A). Following an injection of around 750 tonnes of CO_2 over one month, the CO_2 was detected at two producing wells 100 meters

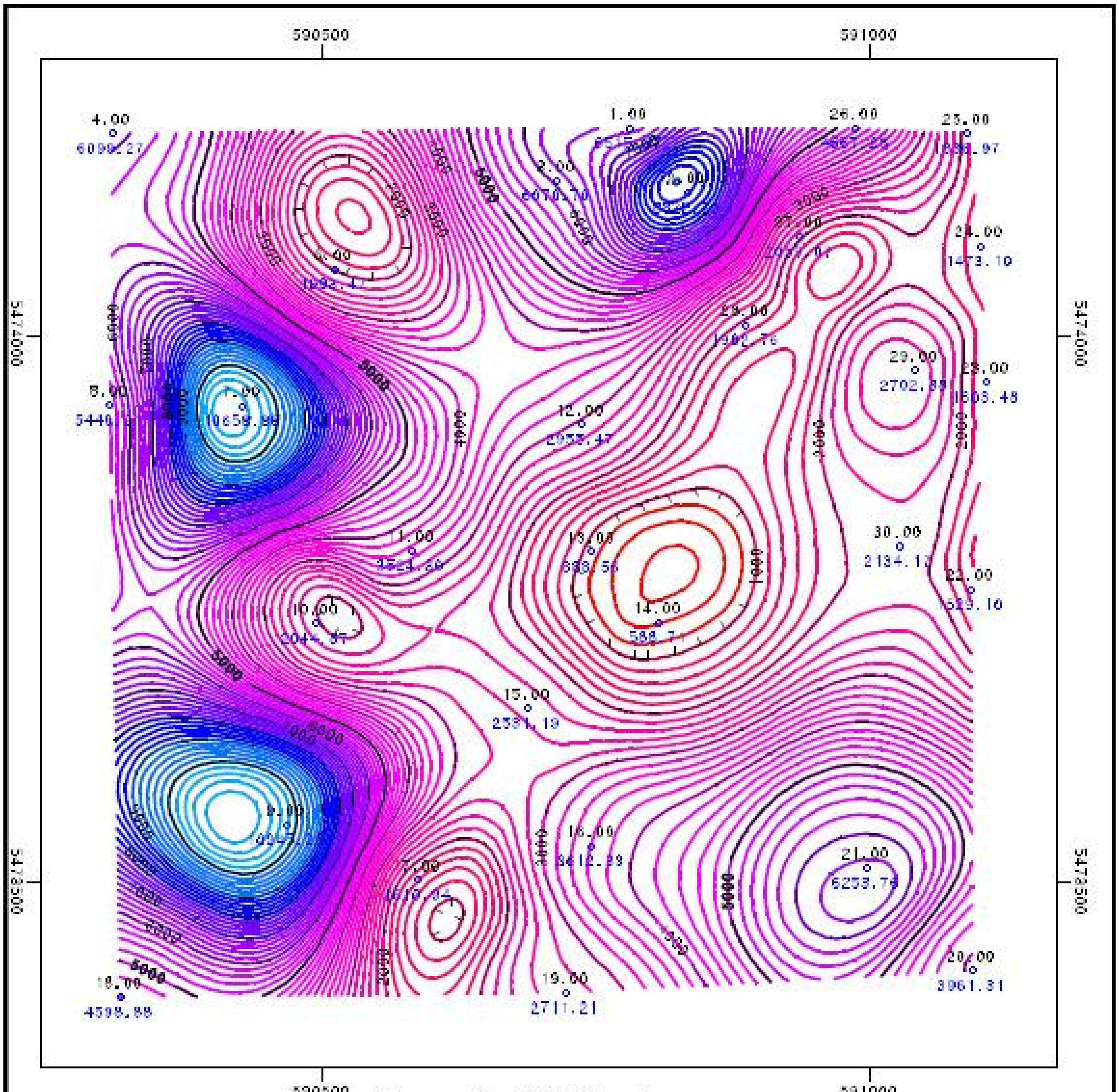


Figure 8. CO_2 Contours

and 500 meters from the injection well (Source: "Monitoring CO_2 During Enhanced Hydrocarbon Recovery and Geological Storage"; UK Department of Trade and Industry; Issue 13, February 2007).

11. Results and Interpretation

A 30-sample soil gas survey on the Kerr property during the winter found anomalous concentrations as high as 10,668 ppm for CO_2 and 30 ppm for methane (Tab 1, Figures 8, 9 and 9A). Notwithstanding these high anomalous values, the concentrations of both CO_2 and the light hydrocarbons except for methane were severely attenuated in frozen soils when compared to the results of a survey in August 2010 when concentrations of CO_2 in soil gas reached as high as 110,000 ppm. To the author's knowledge, this is the first time a soil gas survey has been conducted under winter conditions to assess CO_2 in soils over a reservoir undergoing EOR.

The provenance of the CO_2 in the soil gases found on the Kerr property is clearly the Synfuels anthropogenic CO_2, which is being injected into the reservoir. Results confirm the findings of the August 2010 soil gas survey conducted by Petro-Find. The source of the CO_2 in soil gas is firmly established by:

- An average Delta $^{13}CCO_2$ that compares with the last previously known value (2001) for the CO_2 in reservoir fluids. The analysis in 2001 of CO_2 from produced fluids would be the same as the CO_2 in the reservoir as well as for the soil gas CO_2, which would have migrated from the reservoir along fast-flow paths.

- A major shift from baseline values of Delta ^{13}C of the CO_2 in produced fluids from -12 to -14 established in 2000 before CO_2 injection began to an average value of -23.1 found in the soil gas. The analysis in 2000 of CO_2 from produced fluids would be the same as for the CO_2 in the reservoir as well as for the soil gas CO_2, which would have migrated from the reservoir along fast-flow paths.
- A much heavier carbon isotope ratio (i.e. less negative) than for biogenic CO_2.
- A major soil gas anomaly of CO_2 (Figure 8) with a Delta $^{13}CCO_2$ of -23.5 in the immediate vicinity of the oil well and a nearby abandoned oil well in the SW corner of the Kerr property clearly shows that at least one of the wells is leaking and that the CO_2 is anthropogenic.
- An almost exact correlation of methane to thermogenic ethane concentrations fingerprints almost all the CO_2 found in the soil gas as anthropogenic.

The following additional evidence, both empirical and interpretative, links the CO_2 found in soil gas with the anthropogenic CO_2 injected into the Weyburn reservoir:

- A very high level of CO_2 concentrations over normal baseline values in soils at 3-foot depth is a prime indicator of leakage from the Weyburn reservoir. Average CO_2 concentrations over background values were up to 50 times in the August 2010 survey and up to 20 times in the winter survey when concentrations were attenuated.
- A major advantage of a winter survey is that biological activity and CO_2 respiration is so low that anomalous values (i.e. in excess of background values) can be linked to CO_2 migrating from a non-biogenic source.
- A slightly higher Delta13CCO2 since the August 2010 soil gas survey (-23.1 versus -22.0) shows that the ratio of the anthropogenic CO_2 from the Synfuels plant to recycled CO_2 being injected into the reservoir is increasing. However, the Delta13C is still well below the range of -27 to -28 for biogenic CO_2 found in soils for this area (University of Saskatchewan Thesis: "Storage of Organic and Inorganic Carbon of Biogenic Origin in the Soil of the Parkland-Prairie Ecosystem"; Dunling Wang; 1997).
- A weak anomaly of CO_2 and methane in the vicinity of another abandoned oil well in the SE corner of the Kerr property is indicative of minor leakage.
- The anthropogenic CO_2 leakage from one or both of the SW wells is likely to have come from one or more of the three CO_2 and nine WAG (water alternating CO_2) injection wells just to the north, northeast and east of the Kerr property. To reach the SW well the CO_2 flooding and associated oil would have made its way in the oil reservoir under the Kerr property where it would have the opportunity to migrate to the surface in the form of either plumes or along fast flow paths such as fractures/faults. The reservoir in this area would have been depleted years ago were it not for CO_2 flooding. Some wells in this area date from 1958.
- CO_2 from three CO_2 injection wells with horizontal legs oriented parallel to the predominant NE-SW fracture/faults can move easily both vertically and laterally onto the Kerr property. The toe of one of the horizontal wells is about 2000 meters from the Kerr property.
- Empirical data shows that CO_2 can move laterally at great speeds along faults (as much as 500 meters in 30 days).
- Deep-seated and open fractures/faults interpreted from lineaments traversing the Kerr property in NE-SW and NW-SE directions can

provide the means for CO_2 and hydrocarbons to escape both vertically and laterally to the surface.

- A portion of the anomalous CO_2 and light hydrocarbons found in soils over the entire property is the result of upward migration in the form of plumes through the subsurface from the reservoir without the benefit of fast flow paths such as faults. Accordingly, the current surface patterns could be an exact replica (given some time lag) of the concentration patterns at the reservoir level.
- The molecular size of CO_2 presents no barrier to upward migration as heavier pentane is able to migrate from the reservoir to the surface.
- Soil gas sampling at a three-foot depth, well below the A- and B-zones of the soil profile where biogenic CO_2 is mainly produced, assures that almost all the CO_2 measured is from another source, i.e. from the reservoir.
- Sloughs and humic areas on the down thrown side of faults where anaerobic conditions favor production of biogenic CO_2 are simply avoided. Petro-Find proprietary passive probes can sample sloughs but these were not used in either the winter or summer soil gas surveys.
- Macroseeps provides direct evidence of the existence of open faults, which can provide easy access to the surface for CO_2 as well. Leakages of oil or macroseeps observed in the gravel pits (August 2010 report) can only have found their way to the surface by one or more open faults that have intersected the Weyburn oil reservoir.

The surface of the property was sampled by a proprietary probe using a cordless drill. Winter conditions made drilling somewhat more difficult than in the summer because of the frozen soils and snow up to two feet deep (Figures 4C, 4D). The snow was cleared away and a pre-drill 24 inches long was used to penetrate the icy ground surface. The probe was then inserted into the hole and drilled to the normal 3-foot depth, well below the A-and B-zones to avoid contamination by biogenic CO_2 and methane.

The attenuation was most severe for CO_2 (average concentration was 1/6 that obtained in the August 2010 survey) and for C2+ (1/3.36), which comprises all the alkanes from C2 to C5 and alkenes from C2 to C4. Controlling factors for the reduced but still significant concentrations are attributed mainly to the freezing of some of the higher alkanes/alkenes (such as butane), molecular size, loss of soil porosity/permeability due to a phase

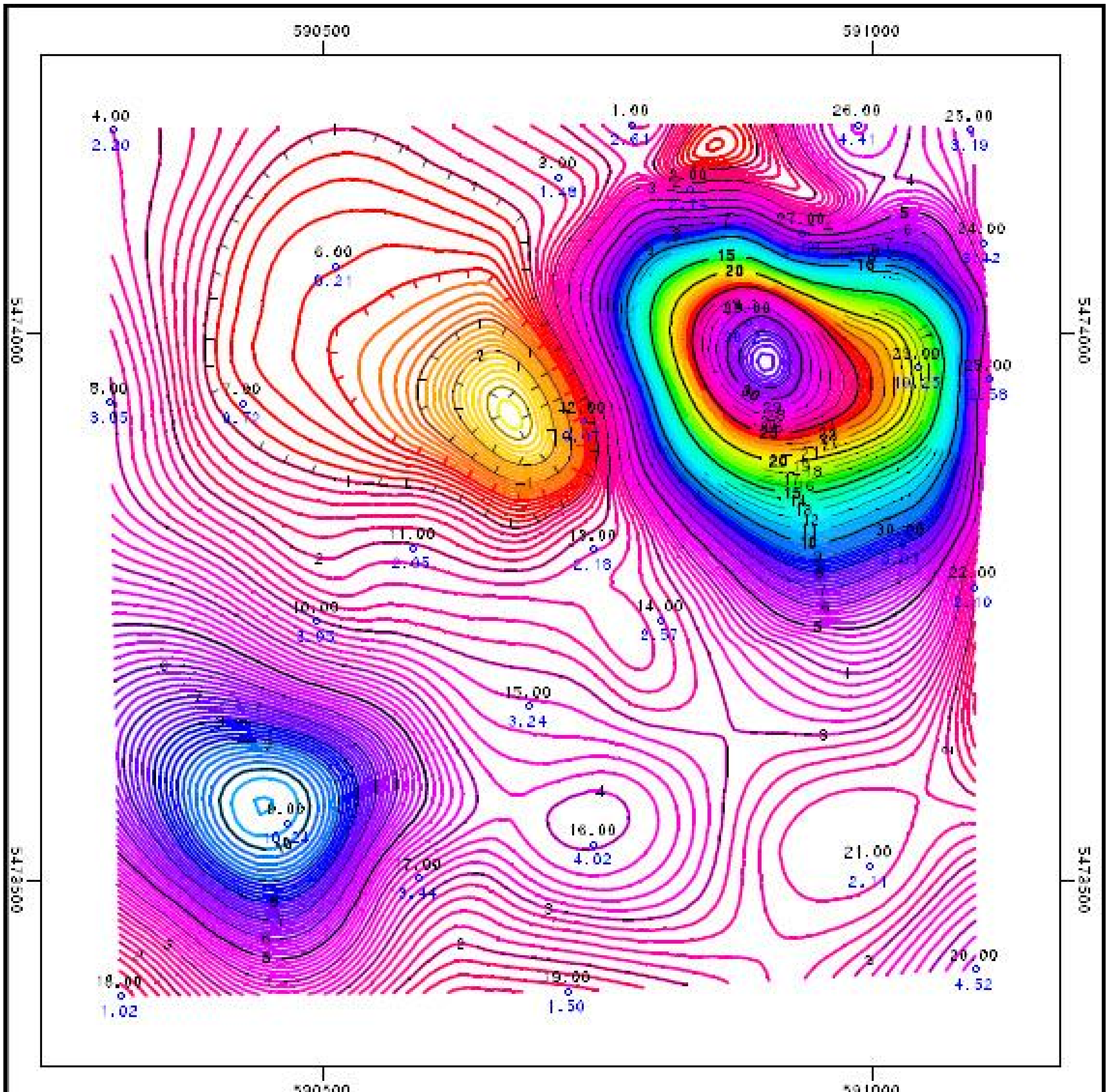


Figure 9. Methane Contours

change from water to ice (i.e. water expands by 9% upon freezing), ice lens formation, and compact snow/crust/ice on the surface (for a discussion of these parameters see Section 5 - Geochemical Soil Gas Surveys in Frozen Soils).

The butane and pentane concentrations were found to be very low or non-existent because of the zero or near-zero temperatures at the 3-foot sampling level. Concentrations of butane were severely attenuated because it exists in liquid form at zero degrees. A range of 0.02-0.48 ppm pentane was obtained in three samples compared with a range of 0.01-5.58 ppm pentane in seven samples obtained in the previous survey conducted on the same property during the hot weather month of August 2010. Pentane, already in liquid form at room temperature, becomes less volatile in frozen soils. Concentrations of methane and ethane were affected only marginally.

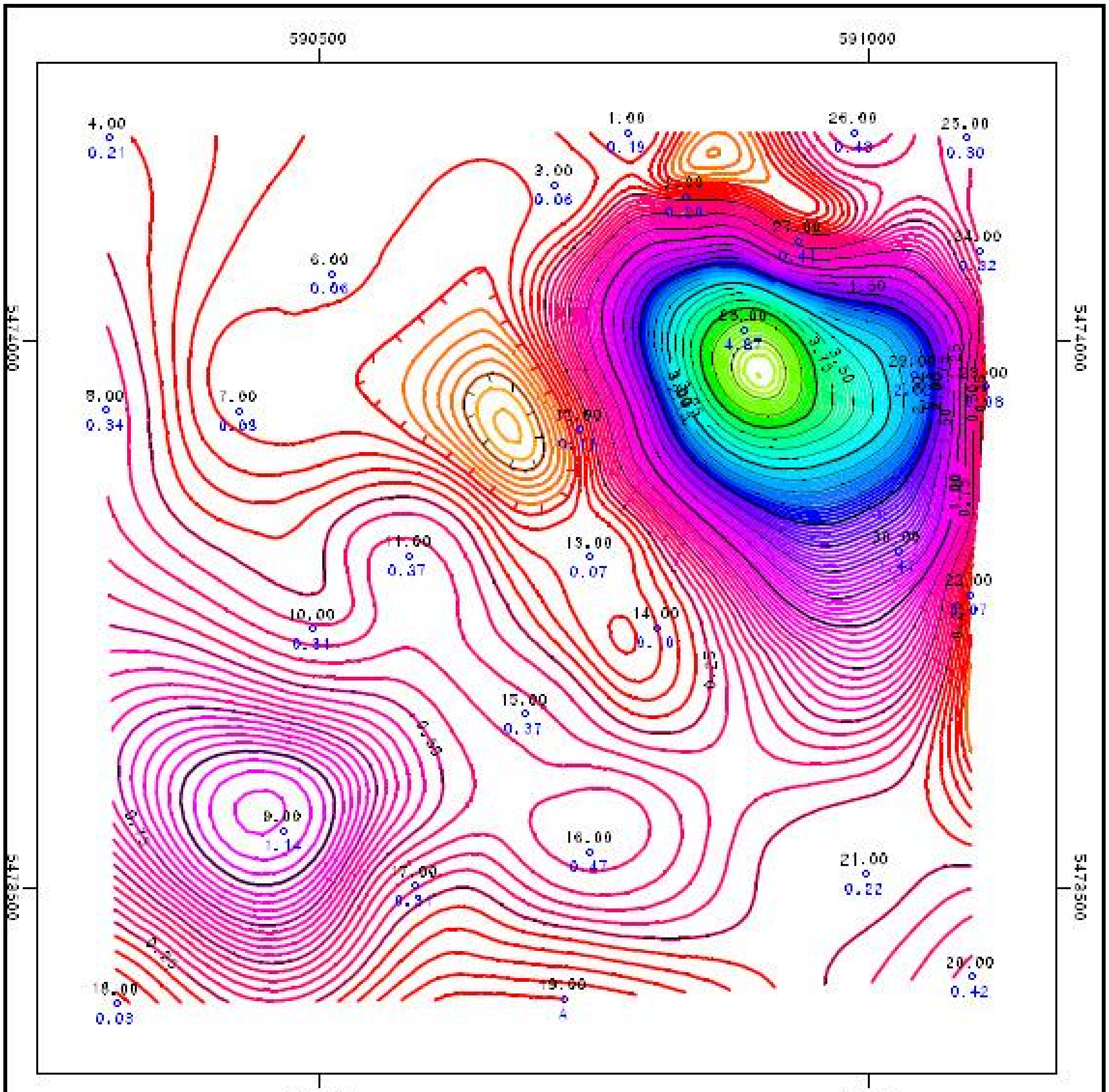


Figure 9A. C2+ Contours

The higher-grade anomalies of CO_2, methane and C2+ were found in the northeast section of the property where the Kerr residence is located (Figures 8, 9, 9A) as well as in the NW and SW corners. The two coincident high anomalies of methane and C2+ were found in the NE and SW. As noted in the August 2010 Survey the contours of CO_2, methane and C2+ concentrations can exhibit different patterns from time to time because of the dynamic nature of EOR operations with alternating water and CO2 injections.

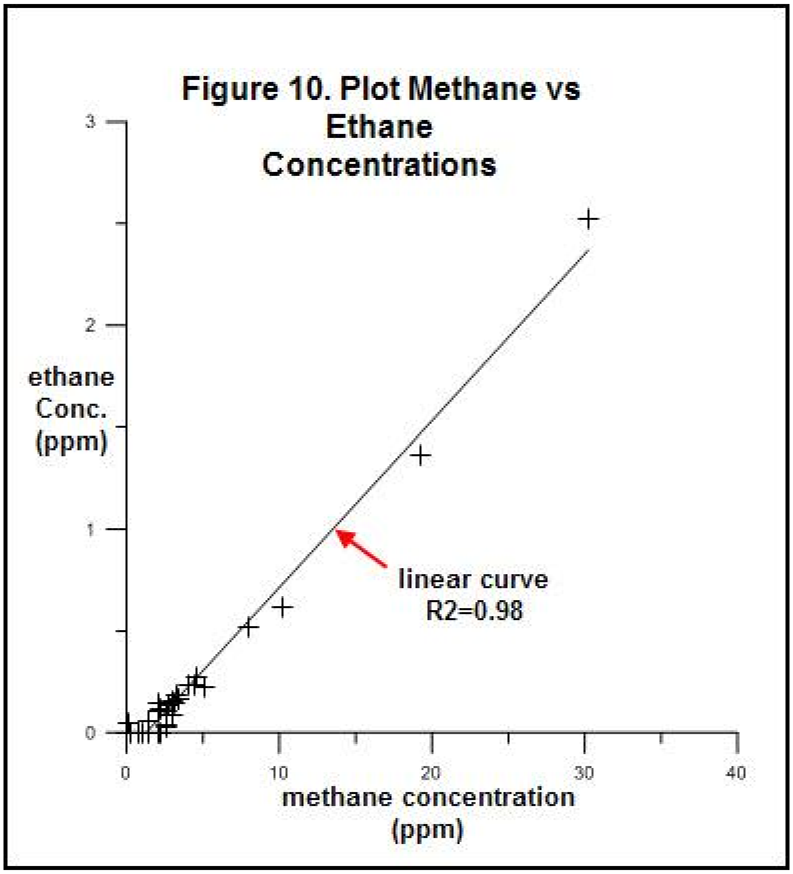


Figure 10. Plot Methane vs Ethane Concentrations

The ratio of methane to ethane concentrations gives an important clue as to whether the soil environment is aerobic or anaerobic and accordingly, whether the anomalous CO2 found in soils is anthropogenic or biogenic (Figure 10). In normal soils at three-foot depths where oxidation or aerobic conditions normally prevail very little CO2 is converted to methane. A conversion of CO2 to methane occurs mainly under anaerobic conditions existing in wet and humic soils during the spring and in areas such as sloughs. The linear relationship between methane and thermogenic ethane concentrations with an R2 of 0.98 shows that almost all the methane is of thermogenic origin i.e. emanating from the reservoir through upward migration. Thus, it can be conclude that anaerobic conditions favourable for the production of biogenic CO2 from methane did not exist and almost all the CO2 found in the soil gas samples from this survey was from an anthropogenic source.

On a practical level, soil gas sampling of sloughs or wet areas is avoided to prevent plugging up of the probe. Petro-Find has developed passive samplers that can be used for sampling watery sediments but these were not used.

Table 2
Comparison Delta13C Values for CO2 Gas between Weyburn and Pembina EOR Operations and Kerr Property Surveys

	Baseline*	Injected CO2****	After Injection
Weyburn SK	-12 and -14	-20.4	-20.4 (after one year)
Pembina Alta	-16 and -18	-4.5	-5, -8 (after 6 months)
Kerr Property August 2010	-12 and -14**	-20.4	-22.0 ***
Kerr Property February 2011	-12 and -14**	-20.4	-23.1***

Source for Weyburn and Pembina EOR data: "Tracing the Fate of Injected CO2 in the Subsurface Using Chemical and Isotopic Techniques; Climate Change: Global Risks, Challenges and Decisions"; Earth and Environmental Science 6, 2009.
*Delta13CO2 range of original reservoir; ** Same as baseline values for Weyburn EOR study; *** Average analysis of six CO2 samples from soil gas survey of Kerr property (Source: Stable Isotope Facilities, University of Saskatchewan); ****Mix of recycled CO2 and new anthropogenic CO2 from Beulah.

The provenance of the CO2 found in soil gas is clearly the injected anthropogenic CO2 from the Synfuels plant in North Dakota. Analysis of six samples of CO2 shows Delta 13C values in the -22.2 to -23.6 range with an average of -23.1, which compares with a previously known value of -20.4 established in 2001, a year after EOR operations began (Table 2). The average Delta 13C for CO2 of -23.1 shows a major shift from the baseline values of -12 to -14 determined prior to the beginning of EOR operations. The increase over last year (as well as over the previously known value) is attributed to a higher proportion of new CO2 from the Synfuels plant to recycled CO2. However, the average Delta C13 is still much less than those for biogenic CO2 with a value in the -27 to -28 range (University of Saskatchewan Thesis: "Storage of Organic and Inorganic Carbon of Biogenic Origin in the Soil of the Parkland-Prairie Ecosystem"; Dunling Wang; 1997).

The Petro-Find soil gas method assures that the data is highly accurate and repeatable. Other methods do not always produce as good a result. A closed chamber unit, which is placed essentially on top of the ground, is not that useful because it measures concentrations and fluxes of both biogenic and anthropogenic CO2. Some units can measure CO2 concentrations only up to 5,000 ppm. The probe/infra-red method usually requires frequent calibration in the field and can only measure CO2 and methane, not the other light hydrocarbons. Subsequent sampling using the same probe for measurement of other analytes can result in dilution with ambient air.

The Weyburn reservoir has been known since its discovery as a typically fractured carbonate reservoir. A high concentration of light hydrocarbons in soil gas is indicative that the light hydrocarbons and CO2 (about the same molecular weight as propane) naturally escape as microseeps in the form of plumes that travel vertically in micro-fractures to the surface where they can be detected and analyzed by gas chromatograph. Concentration patterns or surface anomalies of these microseeps can be correlated with petroleum/gas accumulations at depth. Open and closed fractures/faults in such surveys can be detected at the surface by linear patterns of high or low concentrations in soils, respectively.

Two major lineaments that intersect just north of the Kerr residence are interpreted as faults (Figure 4A). The coincidence of the high anomalies of CO2, methane and C2+ with their intersection indicates that the faults are open. Moreover, the faults are interpreted to be high angle because of their linearity and deep seated because of their length. The north side of the NE-SW fault appears to have been downthrown as well as the east side of the NW-SE fault because of the location of the ponds and naturally occurring sloughs.

The interpretation of lineaments as deep-seated faults demonstrates that the overlying thick cap rock of anhydrite and shale aquitards have been breached and may not be as an impermeable barrier to the upward mobility of reservoir gases as is generally thought. Some of the faults are interpreted to be of the open kind, which can act as conduits for light hydrocarbons and CO2 as well as the heavier hydrocarbons in the form of oil to reach the surface. The fact that oil in the form of blue sheen was found in the gravel pits near the intersection of the faults last summer (August 2010 Report) provides further evidence that the faults are open rather than closed.

To trace the sources of any leakages of CO_2 and hydrocarbons it was important to develop a knowledge base of types, locations and patterns of wells and pipelines in the vicinity of the Kerr property. A study of surface facilities that separate and recycle the fluids and gases completed the picture.

Based on information obtained from the Saskatchewan Department of Industry and Energy three CO2 injection wells exist to the NE and east of the Kerr property (Figure 5F). All these wells have horizontal legs. The toe (at the end) of one of the horizontal wells (92/10-29-005-13W2) is an estimated 2030 meters (i.e. about 2 kilometers) from the NE corner of the Kerr property (Figure 5F). The horizontal legs of CO2 injection wells are parallel to the predominant fracture direction, which is NE-SW (***The Leading Edge*** July 2009). Empirical data shows that CO2 can move laterally at great speeds along faults (as much as 500 meters in 30 days).

Near the abandoned Kerr home the CO2 concentration is about 2,700 ppm, but at about 350 meters to the NW of the house it is 10,000 ppm (at the epicenter of a major anomaly). The Recommended Exposure Limit (REL) for the workplace, based on a time-weighted average (TWA) is 5,000 ppm over a 10-hour workday during a 40-hour week (Table 1). For someone remaining in the home for 24 hours per day, which can happen in winter, the limiting threshold is half the workday value, or 2,500 ppm.

Had the Kerrs still lived in their home (now abandoned because of health concerns) CO2 could have entered in dangerous concentrations through the crawl space due to negative pressures caused by a natural gas heating furnace. Further soil gas could be drawn into the home from warmer air rising and other mechanical exhausts such as bath fans, clothes dryers, range hoods and water heaters. It should be noted that the concentration of CO2 in soils near the Kerr residence could change rapidly on a daily basis because of the dynamic movement of CO2 in the EOR operations. There is no danger for persons in open air where CO2 from the soil quickly dissipates.

It is well known from numerous landfill studies that a cap of any kind including compacted snow or ice, such as observed during this survey, can divert normally upward migrating CO2 and methane laterally. Lateral migration of CO2 in winter could increase the potential hazard in homes that have either a crawl space or a cracked concrete basement.

It should be noted that the concentration of CO_2 in soils near the Kerr residence could change rapidly on a daily basis because of the dynamic movement of CO_2 in the Weyburn EOR operations. Empirical data shows that CO_2 moves horizontally very quickly. Following injection of around 750 tonnes of CO_2 over one month, the injected CO_2 was detected at two producing wells 100 meters and 500 meters from the injection well (Source: Monitoring CO_2 During Enhanced Hydrocarbon Recovery and Geological Storage; UK Department of Trade and Industry; Issue 13, February 2007).

The survey clearly shows the usefulness of geochemical soil gas surveys in assessing EOR projects for leakage of CO_2 and light hydrocarbons. Soil gas surveys may also be able to determine the extent and patterns of CO_2 flooding operations at depth. It can be concluded that the CO_2 and the light hydrocarbons have penetrated the supposedly impermeable anhydrite cap rock and have found their way to the surface by micro fractures in the form of plumes and by fast-flow conduits such as faults and fractures.

It is possible that given the high average concentration of CO_2 in the soil gas the groundwater on the Kerr property may be contaminated. CO_2 dissolves in water both as CO_2 and as carbonic acid which is a reversible chemical reaction. Metals can be leached out of the subsoil by carbonic acid and contaminate potable groundwater. H_2S and other sulphur compounds such mercaptans, which are known to occur in the injected CO_2 sourced from North Dakota, are other possible contaminants. Water analysis of ground waters over and around the Weyburn oil pool would need to be assessed to prove this hypothesis, but any analysis of this sort is outside the area of Petro-Find's expertise.

In the author's opinion a mathematical simulation, conducted in the context of the IEA study("IEA GHG Weyburn CO_2 Monitoring & Storage Project), cannot predict with any accuracy the containment of CO_2 over a period of 5,000 years based on data obtained over only a short monitoring period (2001-2004) and sampling of only 5% of the Weyburn/Midale reservoir.

12. Statement of Qualifications –Paul Lafleur

I, Paul Lafleur of 215 Mallin Crescent, Saskatoon, Saskatchewan, S7K7X3, phone number 306-931-3156 do hereby certify that:

I am a graduate Geological Engineer from the Colorado School of Mines and a graduate of the University of Western Ontario. I have had years of experience practicing my Profession as a geologist, engineer and mineral economist. During the last eight years I have been engaged as a Geological Engineer to conduct geochemical soil gas surveys for oil and gas. I am currently the President of Petro-Find Geochem Ltd of Saskatoon SK. Paul and Ruth Lafleur are the sole owners of the company.

I am a registered Professional Engineer with the:

Association of Professional Engineers & Geoscientists of Saskatchewan (APEGS).

Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA).

I have been granted permission by The Association of Professional Engineers &Geoscientists of Saskatchewan to offer my services in Saskatchewan as a Consulting Engineer/Geoscientist in the following fields:

Geological Engineering: mineral and energy economics; application of trace hydrocarbon and fixed gas analysis of soil gas to identify and characterize the presence of hydrocarbons and minerals.

The APEGS ***Certificate of Authorization*** for Petro-Find Geochem Ltd is ***C1406***.

Appendices

Tab 1. Data - Hydrocarbon and CO_2 Analysis of Soil Gas
Tab 2. Data - Analysis of Stable Carbon Isotopes in CO_2
Tab 3. Examples of Lineament Studies
Tab 4. Complexity of Enhanced Oil Recovery Operations in the Vicinity of the Kerr Property; Individual Ownership Plan
Tab 5. Contour Maps of CO_2, Methane and C2+

Tab 1. Data - Hydrocarbon and CO2 Analysis of Soil Gas

c*	Sample # < ID >	Northing < Y >	Easting < X >	CO2 < Z1 >	Methane < Z2 >	C2+ < Z3 >	Ethane < Z4 >	Ethylene < Z5 >
	1.00	5474189	590780	6515.87	2.61	0.19	0.11	0.01
	2.00	5474130	590833	8822.75	2.74	0.20	0.13	A
	3.00	5474141	590714	6070.70	1.48	0.06	0.06	A
	4.00	5474184	590308	6099.27	2.20	0.21	0.12	A
	6.00	5474060	590511	1983.47	0.21	0.06	A	A
	7.00	5473935	590427	10658.88	0.72	0.03	A	A
	8.00	5473936	590306	5440.21	3.05	0.34	0.15	0.06
	9.00	5473553	590467	10245.29	10.24	1.14	0.61	0.14
	10.00	5473737	590494	2044.87	3.05	0.31	0.09	A
	11.00	5473803	590581	3524.30	2.05	0.37	0.15	0.06
	12.00	5473919	590736	2955.47	0.07	0.11	0.05	A
	13.00	5473802	590746	888.56	2.18	0.07	A	A
	14.00	5473738	590807	588.71	2.57	0.10	0.04	A
	15.00	5473660	590687	2531.19	3.24	0.37	0.19	A
	16.00	5473534	590746	3612.33	4.02	0.47	0.24	A
	17.00	5473503	590587	1610.94	3.44	0.31	0.16	0.05
	18.00	5473396	590315	4598.88	1.02	0.03	A	A
	19.00	5473400	590722	2711.21	1.50	A	A	A
	20.00	5473420	591093	3961.31	4.52	0.42	0.27	A
	21.00	5473514	590997	6253.76	2.11	0.22	0.10	A
	22.00	5473768	591092	1529.10	2.10	0.07	A	A
	23.00	5473957	591106	1603.48	2.58	0.08	0.02	A
	24.00	5474081	591100	1473.10	3.42	0.32	0.16	A
	25.00	5474184	591089	1836.97	3.19	0.30	0.14	A
	26.00	5474189	590987	4667.28	4.41	0.48	0.23	0.05
	27.00	5474090	590936	2059.07	5.08	0.41	0.22	A
	28.00	5474009	590887	1902.76	30.21	4.37	2.52	0.36
	29.00	5473968	591041	2702.88	19.25	2.52	1.36	0.24
	30.00	5473807	591026	2134.17	8.03	1.47	0.52	0.08

Propane	Propylene	iso-Butane	n-Butane	1-Butene	trans-2-Butene	cis-2-Butene	n-Pentane
< Z6 >	< Z7 >	< Z8 >	< Z9 >	< Z10 >	< Z11 >	< Z12 >	< Z13 >
0.07	A	A	A	A	A	A	A
0.06	A	A	A	A	A	A	A
A	A	A	A	A	A	A	A
0.09	A	A	A	A	A	A	A
A	A	A	A	A	0.06	A	A
A	A	A	A	A	0.03	A	A
0.07	0.03	A	A	A	0.02	A	A
0.22	0.07	0.02	0.05	A	0.03	A	A
0.04	A	A	A	A	A	A	0.18
0.08	0.05	A	A	A	0.03	A	A
0.06	A	A	A	A	A	A	A
A	A	A	A	A	0.07	A	A
A	A	A	A	A	0.05	A	0.02
0.12	A	A	0.03	A	0.03	A	A
0.16	A	A	0.03	A	0.04	A	A
0.07	A	A	A	A	0.03	A	A
A	A	A	A	A	0.03	A	A
A	A	A	A	A	A	A	A
0.11	A	A	A	A	0.04	A	A
0.05	A	A	A	A	0.06	A	A
A	A	A	A	A	0.07	A	A
A	A	A	A	A	0.05	A	A
0.09	A	A	A	A	0.07	A	A
0.08	A	A	A	A	0.08	A	A
0.12	A	A	0.03	A	0.05	A	A
0.13	A	A	A	A	0.06	A	A
0.88	0.20	0.12	0.20	0.02	0.06	A	A
0.51	0.15	0.09	0.10	A	0.07	A	A
0.20	0.04	0.04	0.05	A	0.05	A	0.49

Tab 2. Data - Analysis of Stable Carbon Isotopes in CO2

Stable Isotope Facilities

The following 13C/12C stable isotope analysis measurement results (of CO2 samples in N2) were obtained for Petrofind Geochem:

Sample 07	-22.8
Sample 08	-23.5
Sample 09	-24.4
Sample 015	-22.2
Sample 016	-22.5
Sample 018	-23.6

The above results are expressed in units of 'per mil' relative to the 13C/12C isotope ratio of International Standard PDB (PeeDee Belemnite) which as defined as 'zero per mil'.

This analysis was performed by Myles Stocki using a mass spectrometer and associated instrumentation at the University of Saskatchewan Stable Isotope Facilities.

Myles Stocki

Myles Stocki
Lab Manager/Technician

DEPARTMENT OF SOIL SCIENCE UNIVERSITY OF SASKATCHEWAN SASKATOON SASKATCHEWAN CANADA S7N 5A8 TEL.306-966-6832/2703 FAX.306-966-6881

Tab 3 Examples of Lineament Studies

1. "Both stratigraphic and structural traps in Osage County, Oklahoma were found to remarkably follow the trends and positions of the surface lineaments. The strike orientations of the subsurface structures mapped from the Mississippian Chat Formation were very consistent with those of the **surface lineaments** and fracture traces. New exploration leads were developed in Osage County, Oklahoma." (AAPG Search and Discovery Article #91021©1997 AAPG Annual Convention, Dallas, Texas).

2. "It was also observed that many producing oil and gas reservoirs in Colorado and northwestern New Mexico, and almost all in the state of Arizona are positioned along and/or at the intersections of the surface major fracture zones. A subtle association appears to exist between oil shows and surface fracture zones and/or basement fault systems within northeastern Arizona. As a result, this study suggests that the areas along or adjacent to the surface fracture zones and/or basement fault systems in northeastern Arizona be considered priority locations for exploratory drilling and/or geophysical and geochemical surveys."(AAPG Search and Discovery Article #91021©1997 AAPG Annual Convention, Dallas, Texas)

3. "Generally, where productive, lineaments define dominantly northeast and northwest-trending fault systems and other structural features. Together with thickness variations, stratigraphic changes and overpressuring (up to 0.7 psi/ft.), Bakken reservoirs have been created. Two recent major oil discoveries, Elm Coulee and Parshall fields, have caused a renewal of the cyclic exploration effort of the Bakken." (AAPG Search and Discovery Article #90092©2009 AAPG Rocky Mountain Section, July 9-11, 2008, Denver, Colorado)

4. "Many of the fields within the Powder River Basin are structurally controlled by large-scale basement ***lineaments*** running along NE-SW and SE-NW trends. In the case of Fiddler Creek Field, the major control was a NE-SW trending lineament known as the Fiddler Creek Trend. This fault downthrows to the SE, and provided shallow topographic drainage to funnel sediment through to the deeper basin. The westernmost part of the field overlies the SE-NW trending Weston/Hat Creek Trend, which downthrows to the SW and offsets the Newcastle Sandstone by ~300' in the study area." (AAPG Search and Discovery Article #90090©2009 AAPG Annual Convention and Exhibition, Denver, Colorado, June 7-10, 2009).

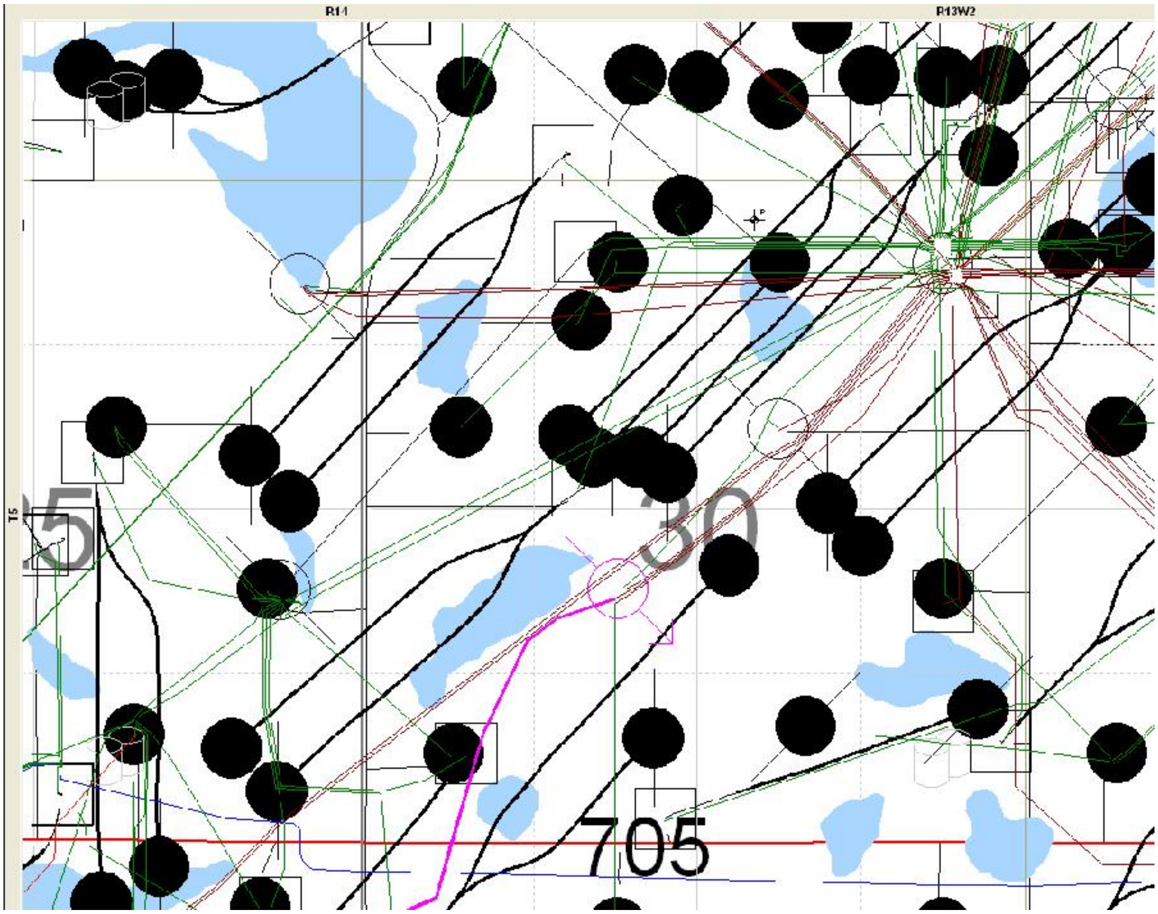
5. “Estimates of Clinton net sand thickness range from 6 to 77 feet. Estimated ultimate reserves show SE to NW trends, parallel to certain lineaments.”(AAPG Search and Discovery Article #90095©2009 AAPG Eastern Section Meeting, Evansville, Indiana, September 20-22, 2009)

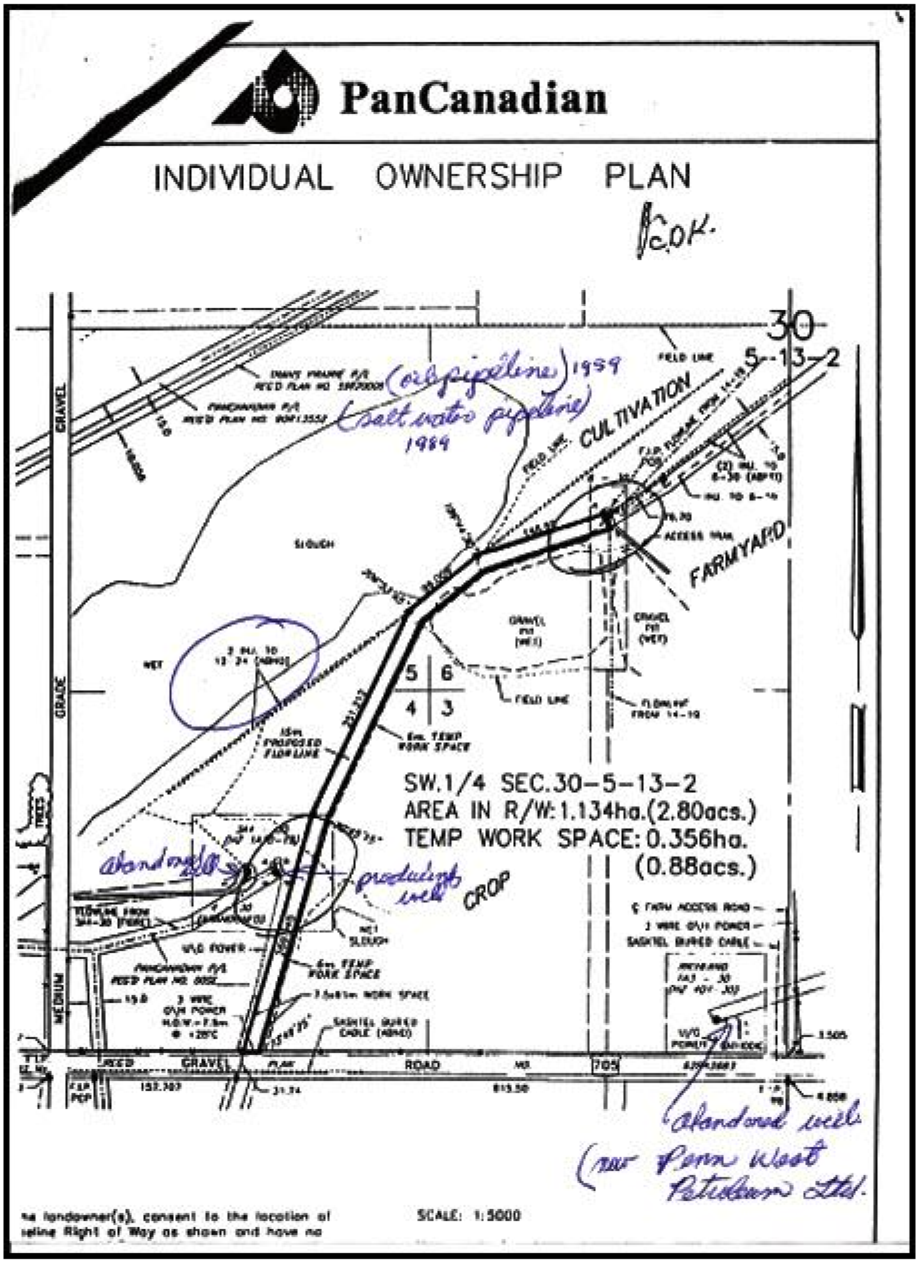
6. “The correlation between surface linear features and subsurface structures were assessed on a GIS platform, where all these thematic maps beside satellite images could be stored, manipulated, overlaid and integrated in the computer. It was observed that the surface linear features were extremely consistent in orientation with the basement linears, and the overlying faults in the basin. The interrelationship of faults, source rock and known hydrocarbon bearing areas have been evaluated and it can be inferred that the possibility of occurrence of hydrocarbons is governed primarily on the availability of source rocks and possible conduits/entrapment in the form of high fault densities and /or structural cross trends. The superimposition of source rock thickness over the oil/gas field map reveals that, in general, the geographic occurrences of oil/gas and source are the same. Wherever they differ they are associated with higher fault densities with preferential alignment along the NE-SW fault density zones. **This indicates that the faults and their intersections have played an important role for enhanced fluid migration.** Taking into consideration the above model and analogy, the technique was applied to the rest of the Cambay Basin to decipher the lead areas for hydrocarbon exploration.”(AAPG Search and Discover Article #90100©2009 AAPG International Conference and Exhibition 15-18 November 2009, Rio de Janeiro, Brazil; Sengupta Siddhartha and Dave Harshvardhan)

7. “Prediction of Exploration Targets. Much of Nebraska’s underlying geology is obscured by the sand dune fields, open rangeland, and agricultural fields with no outcrop expression. In these areas, exploration potential prediction must be based on the subtle surface evidence of subsurface geologic structure (expressed as drainage deviations, tonal anomalies, subtle topographic highs), fault and fracture patterns, and evidence of possible oil seeps…..Surface lineaments: these are generally shorter in length, may consist of many short but aligned segments, and are texturally distinct and well defined…..Commonly displayed as linear stream segments…elongate lakes or topographic depressions; even a series of aligned or elongate tonal and textural anomalies.” (Remote Sensing Geomorphic & Exploration Potential Analysis of Nebraska)

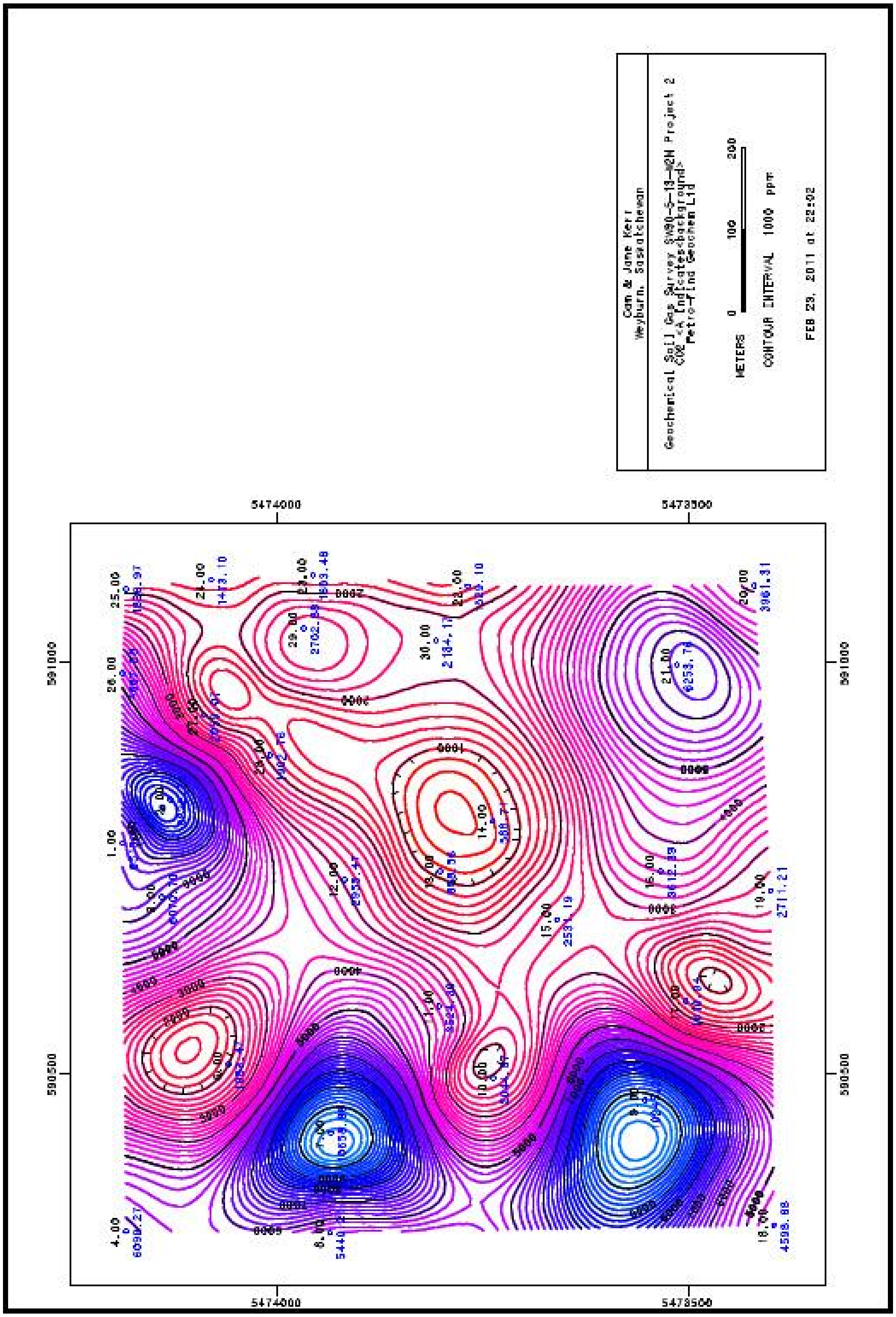
8. “The excellent quality of the TM and radar imagery allowed the mapping of regional and local lineaments over the entire valley, including the large playa in the center of the basin. Combining this data with published information suggested a regional structural framework for the basin and established the geometric relationship of the known producing fields to the lineaments. The regional geochemical survey provided data of sufficient resolution to establish both magnitude and compositional correlations of significant geochemical anomalies with lineaments, lineament intersections, and producing fields. The results of this study were presented at the Fourth Thematic Mapper Conference (Jones et al., 1985).”(Remote Sensing and Soil Gas Geochemical Study, Railroad Valley, Nye County, Nevada; Exploration Technologies, Inc)

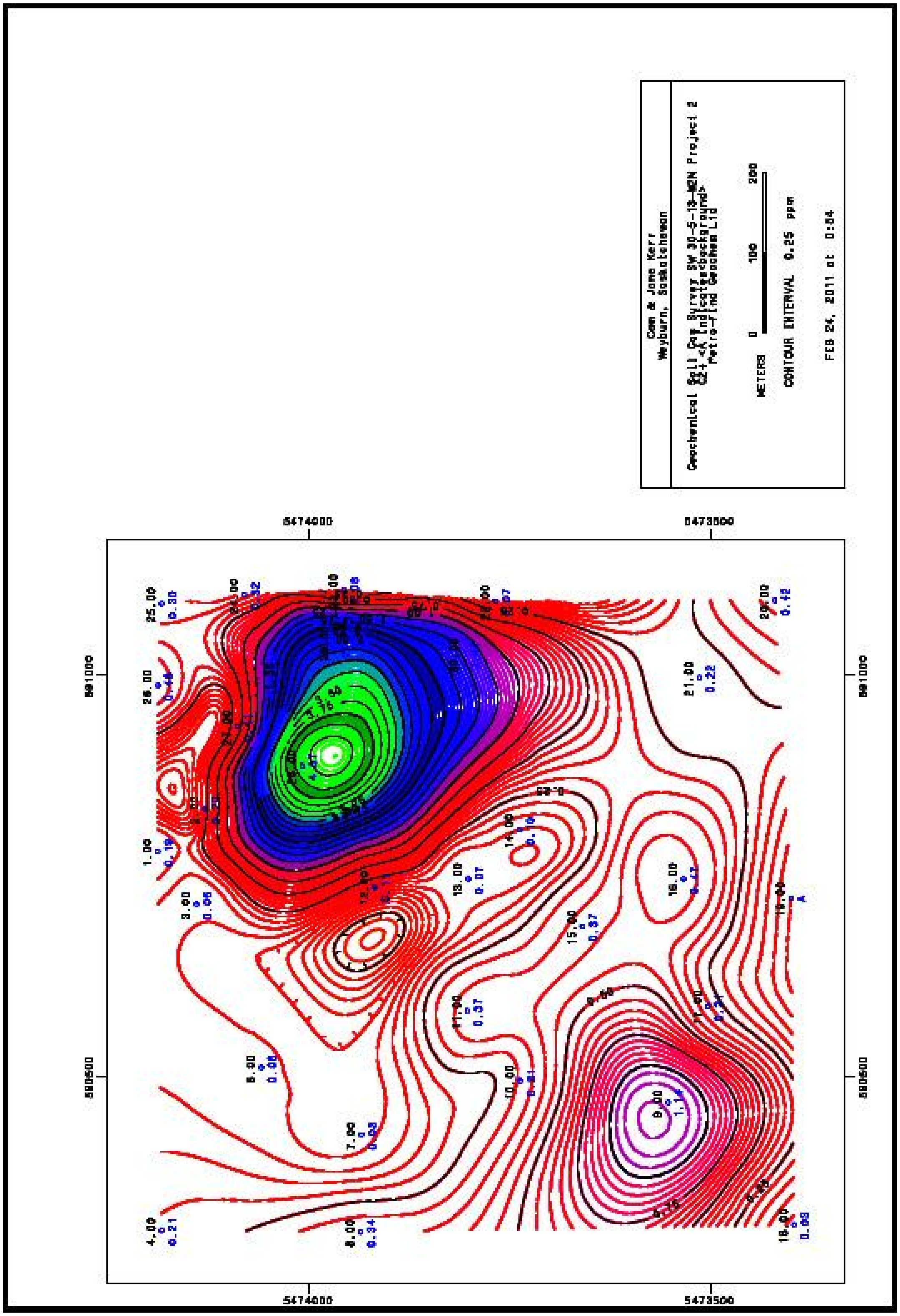
Tab 4. Complexity of Enhanced Oil Recovery Operations in the Vicinity of the Kerr Property; Individual Ownership Plan



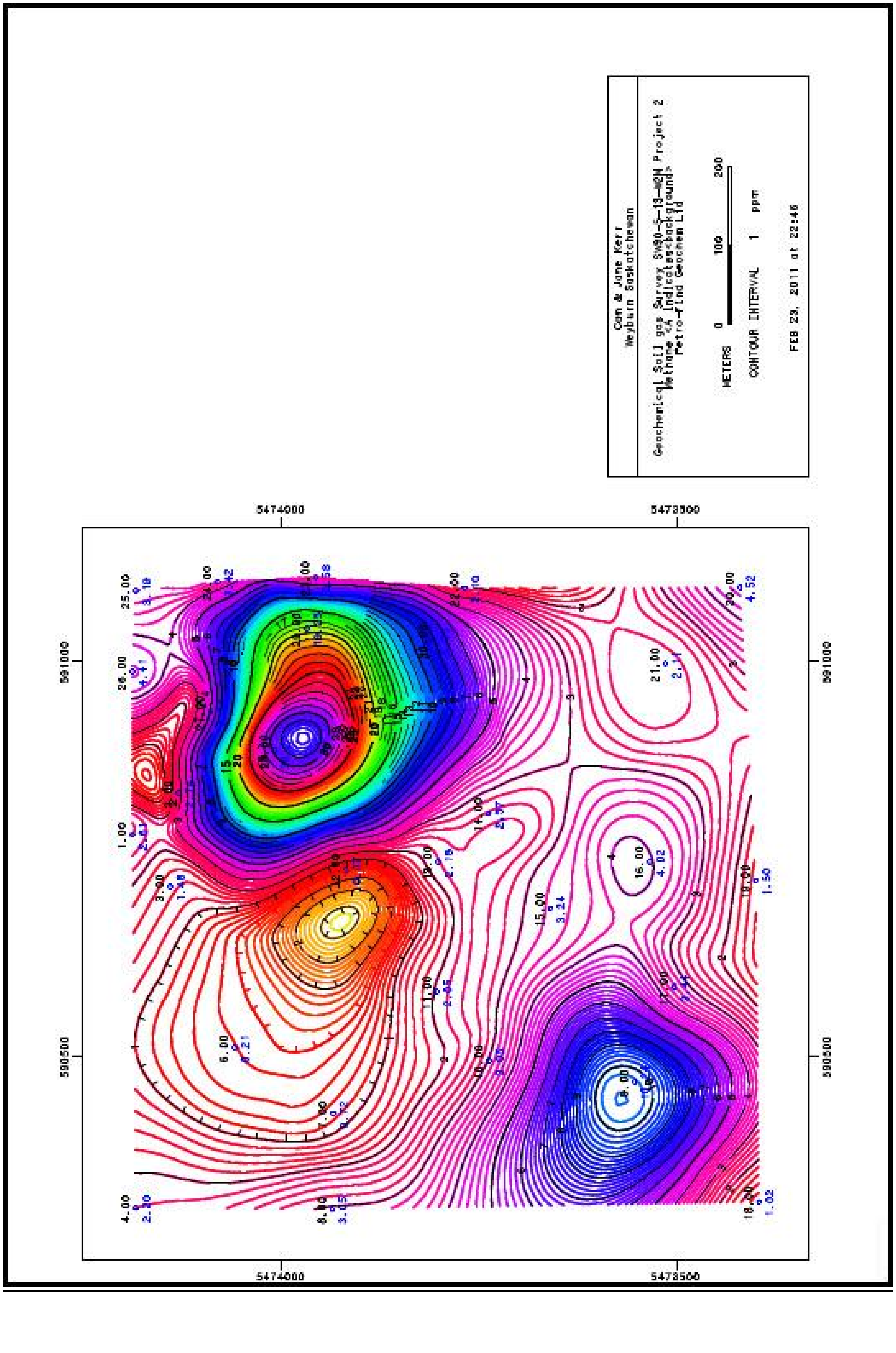

PanCanadian
INDIVIDUAL OWNERSHIP PLAN
30
5-13-2
(oil pipeline) 1959
(salt water pipeline) 1989
CULTIVATION
FIELD LINE
SLOUGH
FARMYARD
ACCESS TRAIL
GRAVEL PIT (WET)
WET
5 6
4 3
FIELD LINE
6m. TEMP WORK SPACE
15m PROPOSED FLOWLINE
SW.1/4 SEC.30-5-13-2
AREA IN R/W:1.134ha.(2.80acs.)
TEMP WORK SPACE: 0.356ha.
(0.88acs.)
abandoned well
producing well
CROP
WET SLOUGH
U/G POWER
3 WIRE O/H POWER
SASKTEL BURIED CABLE
GRAVEL
GRADE
MEDIUM
TREES
GRAVEL
ROAD
705
abandoned well
(now Penn West Petroleum Ltd.
he landowner(s), consent to the location of
eline Right of Way as shown and have no
SCALE: 1:5000

Tab 5. Contour Maps of CO2, Methane and C2+





Cam & Jane Kerr
Weyburn, Saskatchewan
Petro-Find Geochem Ltd
METERS 0 100 200
CONTOUR INTERVAL 0.25 ppm
FEB 24, 2011 at 0:04


Cam & Jane Kerr
Weyburn Saskatchewan
Geochemical Soil gas Survey SW30-5-13-W2M Project 2
Methane <A Indicates background>
Petro-Find Geochem Ltd
METERS 0 100 200
CONTOUR INTERVAL 1 ppm
FEB 23, 2011 at 22:46
5474000
5473500
591000
590500