AAPG HEDBERG CONFERENCE
"Near-Surface Hydrocarbon Migration: Mechanisms and Seepage Rates"
SEPTEMBER 16-19, 2001, VANCOUVER, BC, CANADA

Geochemical and Hydrogeological Correlation of Active Gas Macro-seeps in Alberta

J. LETOURNEAU (University of Alberta)
B. ROSTRON (University of Alberta)
K. MUEHLENBACHS (University of Alberta)

Recent advancements in stable isotope geochemistry techniques have been used to create geochemical fingerprints of subsurface gases in Alberta. These isotopic fingerprints have been used to identify the source of vertically migrating gases in the vicinity of oil and gas wells (Rowe and Muehlenbachs, 1997). Isotopic fingerprinting techniques were subsequently applied to four well known, natural gas seeps and gas occurrences across Alberta to determine the origin of the hydrocarbons (Figure 1). Samples were collected at the surface and from shallow boreholes near the seeps, and were analyzed for carbon isotopes of methane, ethane, propane and butane and compared with nearby samples from producing gas wells. The field samples were compared to gas samples from downdip producing wells. Results indicate that the isotopic "fingerprint" of these shallow gases is often very similar to adjacent production gas samples.

The first example is from one of the oldest producing areas in Alberta – the Turner Valley Field (Link, 1953). Gas seepages were reported here during early exploration of the area (Dowling, 1914) and the Dingman No. 1 discovery well was located within 10m of one. Samples of the seep were analyzed and compared to nearby Mississippian and Lower Cretaceous production samples. Isotopic signatures of the produced gas and the surface seep were nearly identical except for the presence of isotopically lighter methane in the surface seepage samples. Overall, the source of the seeps is attributed to vertical gas migration from the producing zones with a minor contribution of isotpically lighter methane from upper Upper Cretaceous horizons.

The second example is from an active natural macro-seep that occurs in the middle of the Peace River approximately 40 km north of the Town of Peace River on the northern flank of the Peace River arch. This seep is on trend with the subcrop edge of the Mississippian Debolt Formation. Geological and geochemical evidence indicate that these seeps are likely connected to the nearby Mississippian aged Cadotte Debolt A gas pool.

In the third example, a ~30 m deep gas occurrence was accidentally discovered during the drilling of a foundation test well in the parking lot of a pulp mill located 20 km north of the Town of Peace River (Figure 2). In addition, there are orphan wells on the mill property that were drilled from 1916-1918 that currently leak gas to surface. The isotopic signatures of the surface gas samples in the vicinity of orphan wells is similar to those from the Cretaceous Bluesky Formation in the Dunvegan region 150 km to the SW (Muehlenbachs et al, 2000).

The gravels encountered in the 30 m test hole directly overly the Cretaceous Peace River Formation and the isotopic signature of the shallow gas is similar to that of Peace River Formation gas in the Deep Basin region (Muehlenbachs et al, 2000). Petroleum hydrogeology of the Lower Cretaceous Peace River and Spirit River Formations indicates that they host a regionally extensive, underpressured basin centered gas accumulation. Formation pressures decline uniformly towards outcrop along the Peace River. Geological, geochemical and hydrogeological evidence indicate the potential for long distance gas migration to outcrop.

In the final example, there is a historical record of natural gas seepages 80 km north of High Level, which is reportedly maintained in a flaming condition (Mussueix and Nelson, 1998). Isotopic fingerprinting of the natural gas seep known as "The Hot Pot" (Figure 3) supports lateral migration of gas from Cretaceous and Tertiary aquifers. This rules out the proposed vertical migration of gas up the Hay River Fault Zone. Thus, the combination of regional hydrogeology and isotope geochemistry enabled the outlining of lateral migration pathways for gas seepages at the Hot Pot. These seepages are inferred to represent the discharge of regional gas migration systems of 10's to 100's of kilometers in length.

Isotopic gas signatures were combined with an evaluation of the regional petroleum hydrogeology to outline prospective gas migration routes. Results showed that isotopic fingerprinting was a simple, cost effective method that increased the accuracy of geological interpretations on the source and migration pathways of natural gas present at surface seepages. Long distance gas migration pathways in basin centered gas accumulations can be more accurately determined from source areas to seepage regions using this tool.

FIGURES

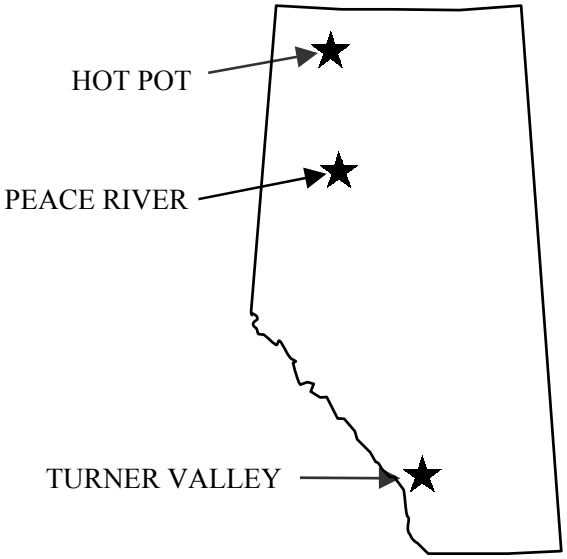

FIGURE 1 – Map of the Province of Alberta showing gas seep locations.

FIGURE 2 - Gas flaring from a 30m test hole in pulp mill parking lot 20km north of the Town of Peace River.

FIGURE 3 – The Hot Pot natural gas seep. The seep is sometimes extinguished after a heavy snowfall but local aboriginals and forestry officials keep it burning. Aboriginals in the region call it "kudadekune" which translates to English as "burning fire".

REFERENCES

Dowling D.B., 1914, Geological Notes to Accompany Map of Sheep River Gas and Oil Field, Alberta, Geological Survey of Canada, Memoir 52.

Link, T., 1953, History of geological interpretation of the Turner Valley structure and Alberta Foothills, Canada, in Alberta Society of Petroleum Geologists 3rd Annual Field Conference and Symposium, p. 117-133.

Muehlenbachs, K., Szatkowski, B., and R. Miller, 2000, Carbon isotope ratios in natural gas: A detailed depth profile in the Grande Prairie Region of Alberta. GeoCanada 2000: the millennium geoscience summit Conference Proceedings CD, May 29-June 2, 2000, Calgary, Alberta.

Mussieux, R. and Nelson, M., 1998, A traveller's guide to geological wonders in Alberta Edmonton, Alta. : Provincial Museum of Alberta, p. 39.

Rowe, D. and Muehlenbachs, K., 1999, Isotopic fingerprints of shallow gases in the Western Canadian sedimentary basin; tools for remediation of leaking heavy oil wells, *in* B. S. Lollar and T. A. Abrajano, Jr., eds., Compound-specific isotope analysis; tracing organic contaminant sources and processes in geochemical systems: Organic Geochemistry v. 30, no. 8A, Pergamon, Oxford-New York, p. 861-871.