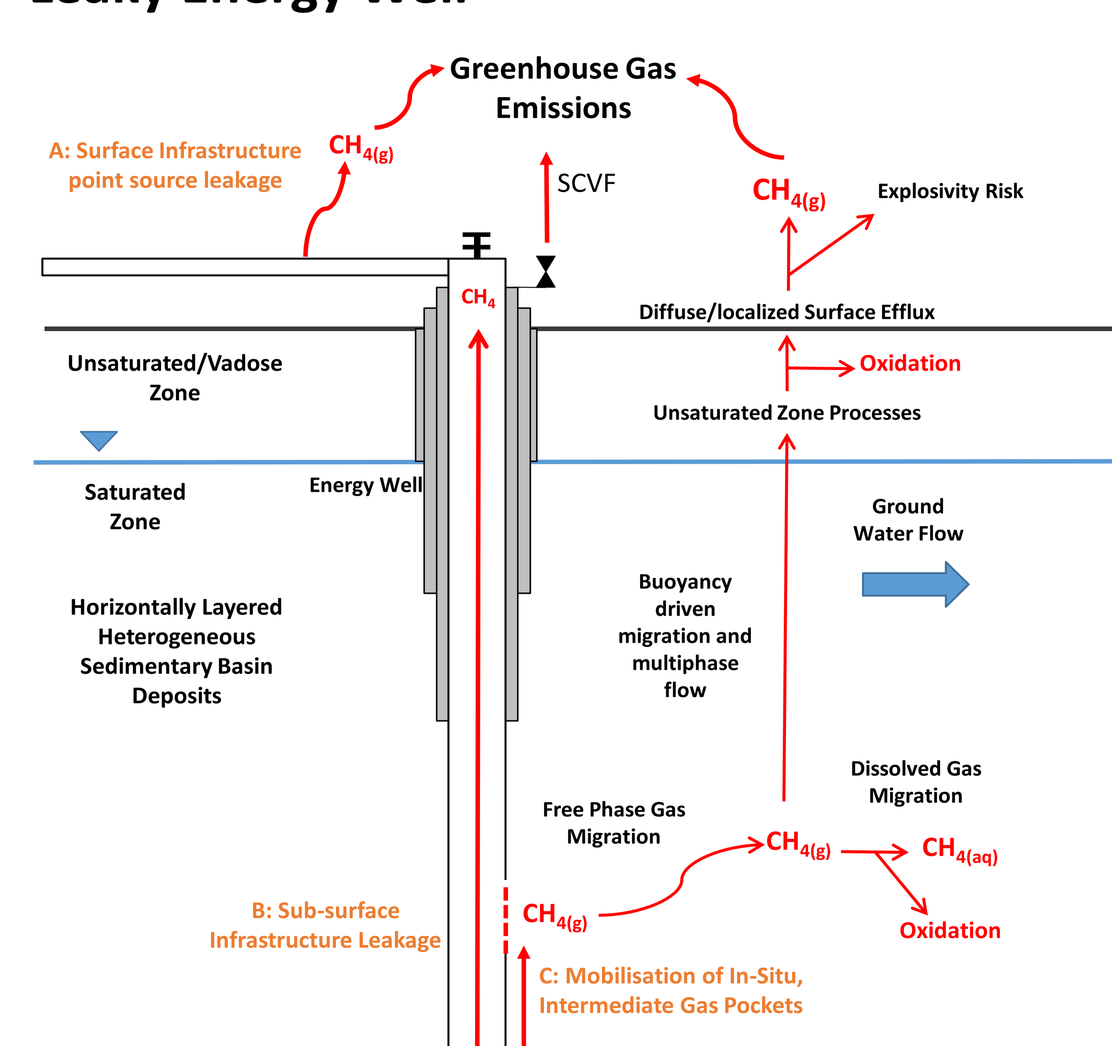
ADVANCING KNOWLEDGE ON FUGITIVE NATURAL GAS FROM ENERGY RESOURCE DEVELOPMENT AT A CONTROLLED RELEASE FIELD OBSERVATORY

A. G. Cahill[a*], J. Chao[a], O. Forde[a], E. Prystupa[a], B.Ladd[a], I. Hawthorne[a], K. U. Mayer[a], D. Tannant[a], A. Black[a], S. Crowe[a], S. J. Hallam[a], B. Mayer[b], R. Lauer[b], C. van Geloven[c], L. Welch[d], C. Salas[e], V. Levson[a], and R. D. Beckie[a]

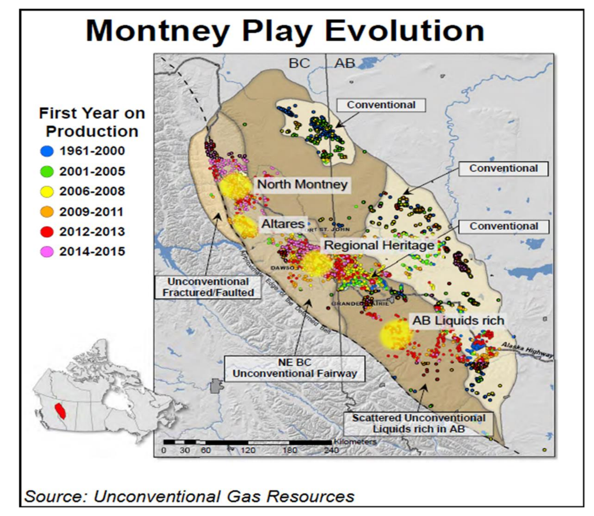
[a]Energy and Environment Research Initiative, Earth, Ocean and Atmospheric Sciences, University of British Columbia (*email: acahill@eoas.ubc.ca); [b]Applied Geochemistry Group, Department of Geosciences, University of Calgary, Alberta; [c]Ministry of Forests, Lands and Natural Resource Operations, Prince George, British Columbia; [d]British Columbia Oil and Gas Commission, Kelowna, BC; [e]Geoscience BC, Vancouver, Canada

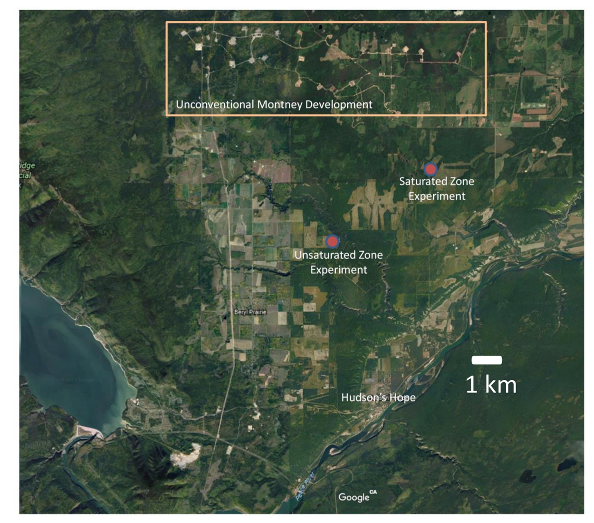
Introduction: Fugitive gas, comprised primarily methane, can be unintentionally released from upstream oil and gas development either at surface from leaky infrastructure or in the subsurface through failure in energy well bore integrity. Concerns associated with fugitive gas release at surface and in the subsurface include contributions to greenhouse gas emissions, subsurface migration leading to accumulation in nearby infrastructure and impacts to groundwater quality[1]. Current knowledge of fugitive gas including how to best detect and monitor over time, and particularly migration and fate in the subsurface at the individual event scale, is incomplete. In order to advance understanding an experimental field observatory for evaluating fugitive gas leakage has been established. Natural gas has and will be intentionally released at surface and up to 25 m below surface at various rates and durations. Resulting migration patterns and environmental impacts of the released natural gas are being evaluated through examination of the geology, hydrogeology, hydro-geochemistry, isotope geochemistry, hydro-geophysics, vadose zone and soil gas processes, microbiology, and atmospheric conditions.

Leaky Energy Well



Hudson's Hope Field Research Station is situated within the Peace Region of NE British Columbia, Canada which is a part of the greater Montney Resource play; an area representative of the Western Canadian Sedimentary Basin which hosts historic and ongoing petroleum resource development. The Montney play encompasses approximately 2.9 million hectares from the south Peace region near the city of Dawson Creek extending up to the northwest of the city of Pink Mountain. It is estimated that the production of natural gas in the region has increased by 44% over the past 10 years[2]. Approximately 90% of all oil and gas wells drilled in BC are in the Montney play, and over half of those wells are distributed in the Peace region[3]. The field station is formed by two closely located but separate field sites, both comprised of a Quaternary glacial geology typical of the region[4]. Consequently the area constitutes a highly relevant setting in which to advance knowledge on surface and subsurface fugitive gas leakage.

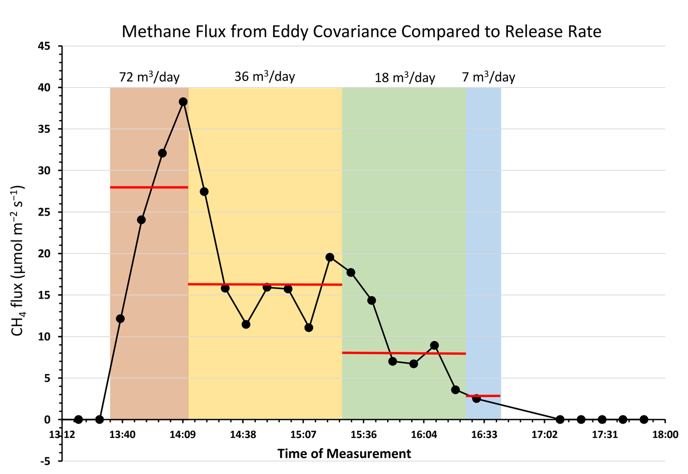




Activities at the site aim to:

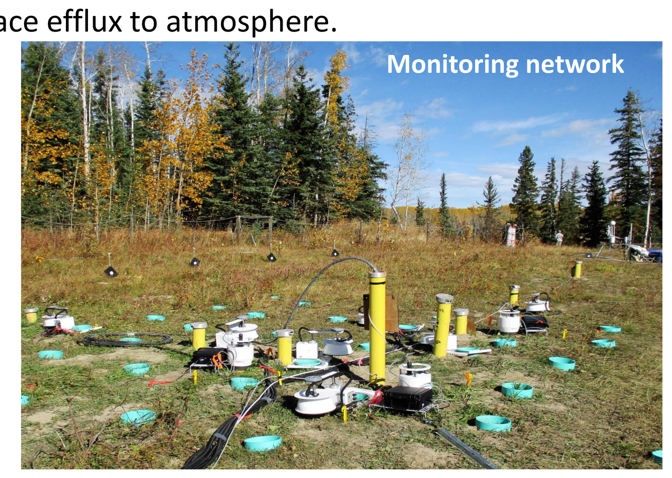
- **Advance understanding on migration and fate of fugitive gas at surface and in the subsurface**
- **Develop improved monitoring technologies**
- **Provide scientific data to develop risk management strategies and inform regulations**
- **Train highly qualified personnel**
- **Foster public engagement and understanding**

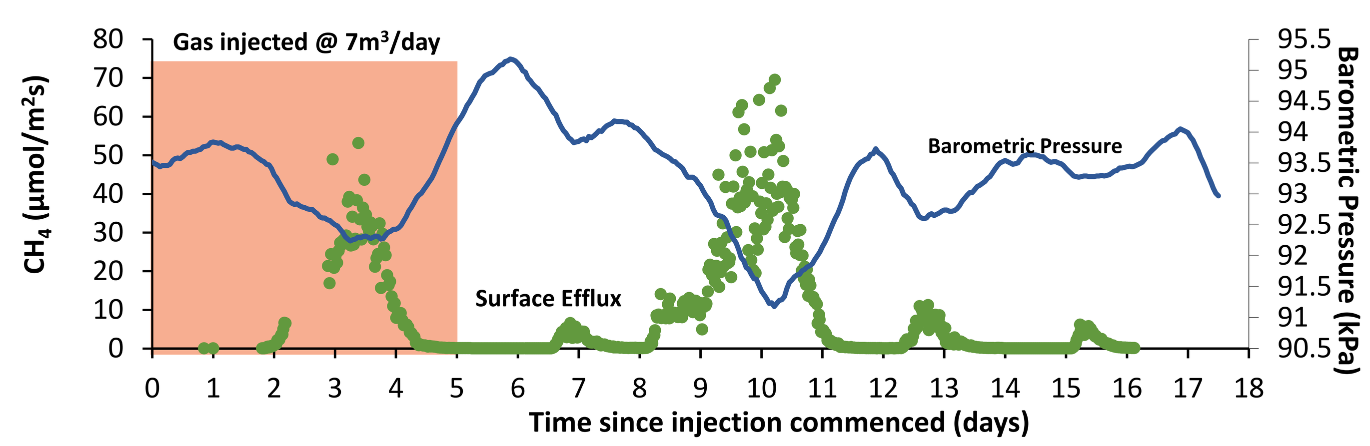
Surface Leakage Experiments: A series of controlled surface natural gas releases have been undertaken at varying rates (7 – 72m^3/day) and under varying meteorological conditions. Surface release rates are controlled precisely with a computer controlled mass flow valve while eddy covariance and drone mounted laser methane sensing technologies have been tested as potential tools for monitoring and characterizing fugitive gas leakage. Initial results suggest both methods have potential to detect and characterize fugitive gas with eddy covariance being particularly sensitive.



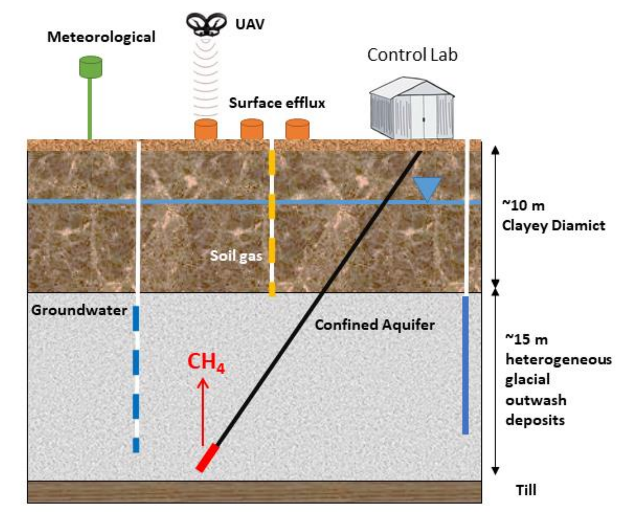
Subsurface Leakage Experiments

Unsaturated Site: Located on grazing land on the west side of Lynx Creek (a tributary of the Peace River) NE BC, the unsaturated zone site is comprised of dry bedded silts and clays with rare pebbles; underlain by interbedded silty and fine to medium sands. A total of 29 m^3 of natural gas was injected at 12 m depth over 5 days in fall 2017 and resultant gas migration and fate monitored comprehensively with multi-level soil gas sampling systems, surface efflux chambers, eddy covariance and drone mounted methane laser. Initial results show that gas migrates through the bedded silts and clays to surface and that barometric pressure exerts significant influence on surface efflux to atmosphere.



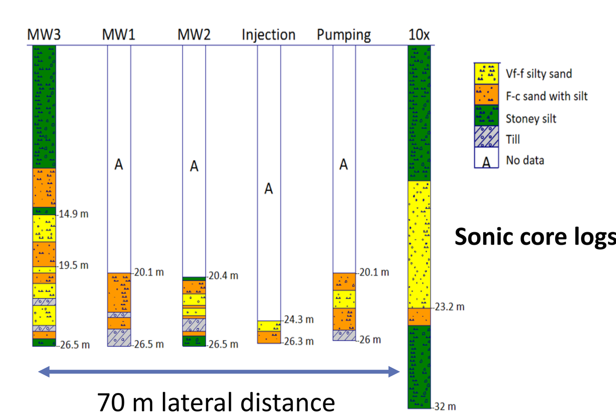


Saturated Site: Located on grazing land near Farrell Creek, NE BC the saturated zone site consists of a confined aquifer formed by complex interbedded sequences of very fine to fine sands, silts and pebbly silts overlain by ~12m of a clayey glacial diamict. Initial site characterization shows that the site is highly heterogeneous with little apparent lateral lithological continuity. The aquifer is formed by beds of varying permeability (10^{-4} – 10^{-6} m/sec) where injected gas migration patterns and impacts are expected to be highly dynamic and complex. Initial investigations indicate various electron accepters are present in the aquifer system with which dissolved hydrocarbons can be oxidized. An inclined injection well has been installed through which approximately 120 m^3 of natural gas will be delivered over summer 2018 in concert with a multi-disciplinary monitoring investigation to track gas migration through the critical zone; while impacts to groundwater and greenhouse gas emissions are assessed and quantified.



Electron accepting species

O_2 (mg/L)	NO_3 (mg/L)	Fe (mg/kg)	Mn (mg/kg)	SO_4 (mg/L)
4.4	0.04	808	94.4	173.8



Acknowledgements: Funding provided by Natural Resources Canada, Geoscience BC and the BC Oil and Gas Commission. Special thanks to Venator Ranches and Hudson's Hope Municipality for supporting and hosting the field research stations.

References:

1: Council of Canadian Academies, 2014. Environmental Impacts of Shale Gas Extraction in Canada. Ottawa (ON)

2: Rivard et al. An overview of Canadian shale gas production and environmental concerns, International Journal of Coal Geology, Volume 126, 2014, P 64-76,

3: Adams et al. Summary of shale gas activity in Northeast British Columbia 2013; Oil and Gas Reports 2016, British Columbia Ministry of Natural Gas Development, p 1–39.

4: Hickin et al. Coalescence of late Wisconsinan Cordilleran and Laurentide ice sheets east of the Rocky Mountain Foothills in the Dawson Creek region, northeast British Columbia, Canada, Quaternary Research, Volume 85, Issue 3, 2016, Pages 409-429,

For more information check out our website: **eeri.ubc.ca**

Summary: Fugitive gas released during energy resource development poses risk to the environment and is a potentially large contributor to greenhouse gas emissions. Fugitive gas can be released at surface or in the subsurface and is an issue which involves the whole of the critical zone (i.e. groundwater through to the boundary layer) requiring a multi-disciplinary approach to advance understanding. The University of British Columbia, Energy and Environment Research Initiative has established a multidisciplinary field research station within the Montney resource play in NE BC, Canada. Our ongoing research, centered on controlled gas releases experiments, is creating evidence-based knowledge to inform surface and subsurface monitoring approaches with respect to fugitive gas. It is envisaged our research will guide changes to associated regulatory and technical guidance policies as well as aid in quantifying and ultimately reduce fugitive gas emissions.