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Characteristics of surface casing vent flow methane emissions in Red Deer, Alberta

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Background

The Canadian government has recently affirmed its support for reducing global methane emissions and has announced the goal of a 40-45 % reduction of methane emissions from the oil and gas sector by the year 2025 (The Government of Canada, 2017). Therefore, understanding the current state of emissions and identifying the major sources of emissions within the oil and gas industry are required to realistically achieve this goal.

Fugitive emissions account for nearly half of Alberta's methane gas emissions from oil and gas activities (Abboud et al., 2021). One of the known main contributors to fugitive emissions is surface casing vent flow (SCVF) leaks (Schiffner et al., 2021). SCVF is a phenomenon that refers to an uncontrolled flow of formation gas or fluid through the surface casing vent assembly on a wellhead. SCVFs may be caused by several factors (Figure 1) ranging from an insufficient cement seal or the failure of a downhole component allowing downhole hydrocarbon migration to occur (Sahnoun et al., 2014).

According to Alberta Energy Regulator (AER) Directive 087: Well Integrity Management, all oil and gas wells drilled and cased must be tested for SCVF leaks within 90 days of drilling rig release (AER, 2021). Wells with positive SCVF and a flow rate greater than 300 m^3/day or a stabilized shut-in pressure exceeding 11 kPa/m at the casing setting depth must be repaired within 90 days. However, wells with lower than 300 m^3/day of flow need only be monitored and reported to the AER, leading to large emissions. Figure 2 illustrates the spatial distribution of flow rates in the study area.

Recent studies have shown that the methane emissions from oil and gas activities for specific regions such as Red Deer, Alberta are underestimated and significantly higher than those reported in federal inventories (e.g., Johnson et al., 2017). This study intends to analyze what factors contribute to SCVF leaks, and what role they have in the underestimation of methane emissions in this area.

Methodology

This ongoing study is accomplished by:

1) Locating current and historical SCVF leaks, using available data from the AER daily vent flow and gas migration report
2) Identifying the geological source formation of the methane emissions using isotope analysis
3) Evaluating major wellbore attributes that may correlate with SCVFs, using geoSCOUT
4) Quantifying the current unresolved SCVF leak potential

5) Suggesting opportunities for prioritizing detection and mitigation of SCVFs in the study area
6) Providing insights into possible government and industry mitigation pathways.

To understand which wellbore characteristics are correlated with SCVF occurrences, statistical analyses (e.g., regression, probability density functions, and statistical hypothesis tests) are conducted to understand if the likelihood of a SCVF leak is higher with certain attributes being present in a wellbore. The following data is cross-referenced with SCVF frequency:

Observations

- Isotope data – Isotope analysis data are used from gas samples taken from wellbores that had active SCVFs, enabling an understanding of the depth and formation from which the gas is from. The majority of methane isotope data in the region indicates gas originating from shallow sources.
- Well age – older wells are expected to show a higher rate of gas emissions; however, SCVF have not been reported prior to 1995 which may indicate an underestimation of methane emissions from older wells (Watson et al., 2009). Among the wells with a reported SCVF, occurrences of leakage with a flow rate > 300 m^3/day are higher for wells aged 20 to 40 yrs. compared to other ages.
- Completion formation – completion target and depth will be used in combination with isotope data to understand if there are formations that may be prone to poor cementing or if the SCVF leaks may be occurring from other zones.
- Well type and status - the impact of well type (producer or injector) and status being active, abandoned, or suspended are examined. Abandoned wells account for 53 % of super emitters (flow rates > 300 m^3/day) in the region.
- Well completion style – monobore-style casing design will be compared to telescopic style casing design.
- Wellbore trajectory – vertical, deviated, and horizontal wellbore trajectories are to be examined. Occurrences of SCVF with flow rates > 300 m^3/day of methane are higher for vertical wells than horizontal and deviated wells.
- Hydraulic fracturing operations – in 2012, hydraulic fracturing operations in the Red Deer field affected a nearby producing vertical well and caused an incident of a release of formation fluids (i.e., water, gas, and oil) at the surface due to inter-wellbore communication between the two wells (Energy Resources Conservation Board, 2012). It is therefore required to investigate the potential of surface casing vent flows caused by fracture propagation outside of the hydraulic fracturing zone during hydraulic fracturing operations where there are hundreds of pre-existing abandoned and suspended vertical wells.

The results of isotope analyses combined with understanding any correlations with wellbore attributes will be used to qualitatively evaluate the probability and cause of SCVF methane emissions in Red Deer. This characterization will allow us to propose better policy and mitigation pathways based on local isotope variations in addition to the quantity of emissions. In addition, the quantification of active SCVFs in the target area will provide value for future use in which the social cost of methane emissions can be juxtaposed with the required remediation expenses to fix these leaks.

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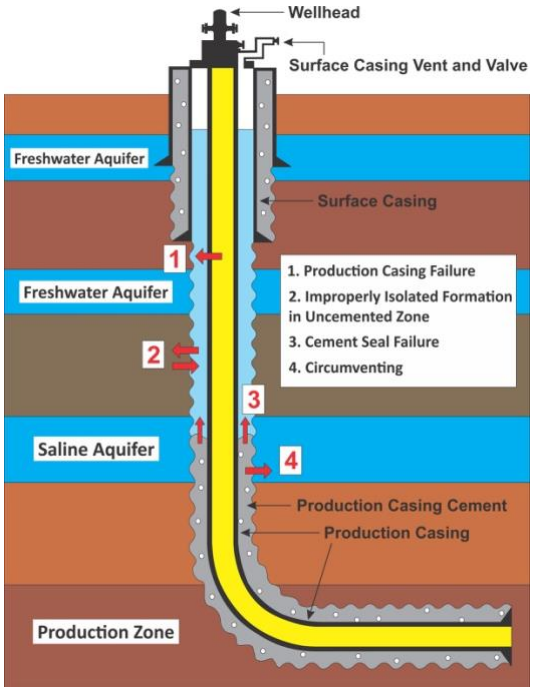

Figure 1. Typical well construction and SCVF causes (modified after Wisen et al., 2020; Lackey and Rajaram, 2019).

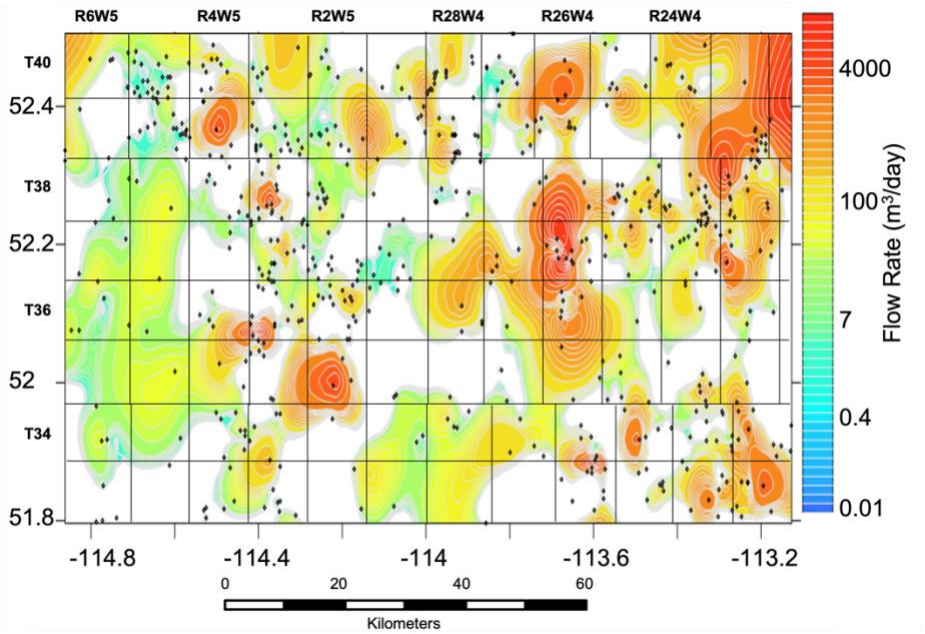

Figure 2. The spatial distribution of flow rates (m^3/day) near the Red Deer region, Alberta. The map shows both Latitude/Longitude and Townships/Ranges of the study area. Black dots represent well locations used for mapping flow rates.