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Evaluation of SCVF and GM measurement approaches to detect fugitive gas migration around energy wells.

Neil A. Fleming, Tiago A. Morais, Celia S. Kennedy, and M. Cathryn Ryan
Geoscience, University of Calgary

Summary

Leaky energy wells can exhibit well integrity issues in the form of surface casing vent flows (SCVF; where fugitive gas leaks through the surface casing directly into the atmosphere), and gas migration (GM; where gases migrate from gas-charged production or intermediate zones to the surface outside of the well casing (Figure 1).

Although GM measurements have been conducted since the 1980s, research documenting significant spatial variability in GM has only recently been published (Forde et al. 2018). There is also anecdotal evidence, both within the industry, and in the scientific literature (Gorody, 2012; Jackson and Dusseault 2014), that SCVF's and GM can be episodic or variable in nature, and affected by external factors including seasonal changes, such as soil temperature and the presence of frost, and barometric pressure changes induced from weather patterns. These phenomena are well documented in related industries involving leaking gases, such as above landfills (Börjesson and Svensson 1997). All of these factors can lead to spatial and temporal variations in the presence and detection of GM, and differing rates of SCVF. This variability in the physical occurrence of SCVF and GM is also accompanied by differing testing procedures used by oilfield service companies, thereby potentially influencing the detection of these well integrity issues.

Common procedures currently used in the industry for the detection of GM were observed and compared over the 2018 field season. Several energy wells with known integrity issues were used for comparison of current practices. A detailed spatial and temporal analysis of the occurrence of GM was also completed around selected wells, including the collection and analysis of gas samples for compositional variations in the soil gas.

Introduction

A common current industry practice to determine if a well has SCVF uses a recommended procedure known as the bubble test, described in Appendix 3 of the Alberta Energy Regulator (AER) Directive 020, and involving (at a minimum) a ten-minute visual observation of the presence of gas flow through a hose attached to the SCV, and bubbling up through water. The AER's Directive 20 also includes a recommended gas migration survey format, involving the measurement of soil gases at distances of 0.3, 2, 4 and 6 meters in a cross pattern through well centre. Although both recommended procedures acknowledge other equivalent testing procedures may be used, there has been no published comparison.

Methods

Several energy wells (either suspended or abandoned), with a known history of GM, were selected for this study. Background research included a review of past GM test results, the well history, and the local geology. Through the field season of 2018, several collaborating companies independently performed gas migration tests at these selected wells. The results of these tests were compared. This comparison of methods was enhanced by direct side-by-side replication of some of these methods by U of C researchers at several sites, at the same location and time.

Intensive gas migration measurements and sampling were also performed around these wells, including closely spaced surface gas concentration measurements, and sampling at multiple depths. Gas samples were collected at discrete depths, at different locations around these wells, and later analysed for composition using a gas chromatograph. This gave a more detailed understanding of the spatial variability, both laterally and with depth. Repeated measurements were also recorded by completing measurements at the same locations multiple times through the day, and on separate days. External factors such as barometric pressure were documented during this time.

Observations and Results

Service companies use at least 4 different methods for performing gas migration tests. While effective, these differ from the AER's recommended procedures. Side-by-side comparison of three of these methods compared poorly, indicating that the testing method may have an influence on the detection of GM. Analysis of the gas samples revealed that fugitive gas concentrations increased with depth of sampling in soil in spatially discrete zones, and showed significant lateral spatial variability, with concentrations sometimes varying by orders of magnitude within meters. This variability in the occurrence and detection methods of GM may influence the detection of leaking wells in some instances. This work is presented as part of the initial findings of a multi-stage research initiative involving multiple partners within the energy industry, with the intent of developing a better understanding of the movement and attenuation of leaking gases within the subsurface.

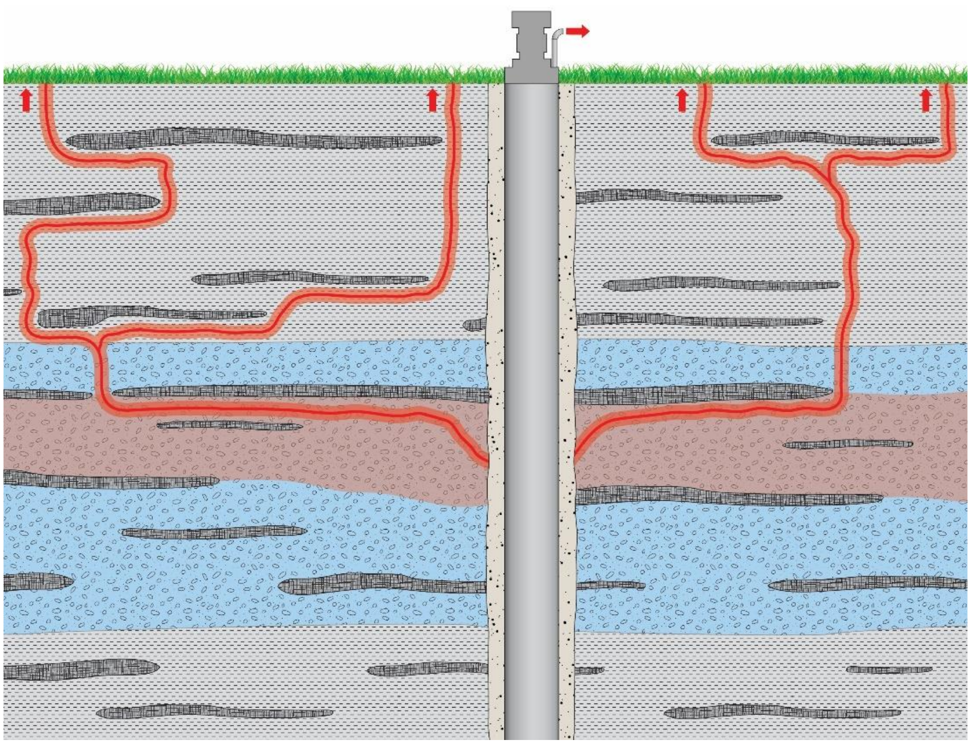

Figure 1: A conceptual diagram of gas migration (GM) and surface casing vent flow (SCVF). Leakage pathways are indicated in red, and exhibit significant variability due to subsurface heterogeneity.

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