A Field Investigation on Transport and Fate of Fugitive Gas in Glacial-derived Deposits

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Summary

Globally expanding petroleum resource development has generated concerns regarding the release of fugitive gas (comprised primarily of CH_4) from integrity-compromised wellbores into the shallow subsurface. Free-phase fugitive gas can move vertically to the ground surface by buoyancy and pressure gradients and therefore contribute to greenhouse gas emissions (Fig. 1), or accumulate in confined spaces of adjacent structures and potentially create an asphyxiation and explosive hazard. When the free-phase fugitive gas dissolves into groundwater, it can be oxidized via a series of microbially-mediated redox reactions that may affect groundwater quality. There is a critical need to better understand the field behavior of fugitive gas in the shallow subsurface to assess environmental impacts and develop more effective monitoring plans. We injected a synthetic natural gas in a controlled-release experiment to investigate free-phase gas transport, the dissolution of free-phase gas, the resultant distribution of dissolved gas, gas degradation and the potential changes in groundwater quality at a site that is representative of much of the glacial-derived surficial geology of the unconventional gas plays in the Western Canadian Sedimentary Basin (WCSB).

Workflow

This research characterized the potential geological controls of a shallow subsurface on fugitive gas migration at a site consisting of glaciofluvial sediments, typical of the WCSB, in northeastern British Columbia (NE BC), Canada, a region of active petroleum resource development. Then, a total of 84 kg of a synthetic natural gas was intentionally injected at the base of the groundwater zone, 26 m below the surface. The spatiotemporal distribution of the fugitive gas, changes in geochemical, isotopic, and microbiological parameters were monitored before, during, and up to 760 days after the injection using a total of 55 discrete monitoring points.

Results, Observations, Conclusions

The key outcomes of this work are: (1) the demonstration that for regions of glaciogenic sediments, the fugitive gas released from an energy wellbore into the surrounding geological strata will likely be retained in the subsurface by the relatively continuous veneer of low-permeability diamict, a feature common across the WCSB; (2) the demonstration of the significant heterogeneity in fugitive gas distribution and the dynamic gas partitioning in the glaciofluvial groundwater environment, making the assessment of gas origin using carbon isotope ratio alone challenging; (3) the approximation of the longevity of free-phase gas in a heterogeneous system using upscaled methods based on CH_4 data collected from discrete monitoring points; and (4) the demonstration that the geochemical and microbiological potential for anaerobic methane oxidation in shallow groundwater environments of NE BC is limited, illustrating the strong dependency of methane oxidation on biogeochemical conditions. Overall, the results of this work significantly enhance the ability to constrain the migration and distribution of fugitive gas in a heterogeneous glaciofluvial environment and the physical and geochemical processes on its fate.

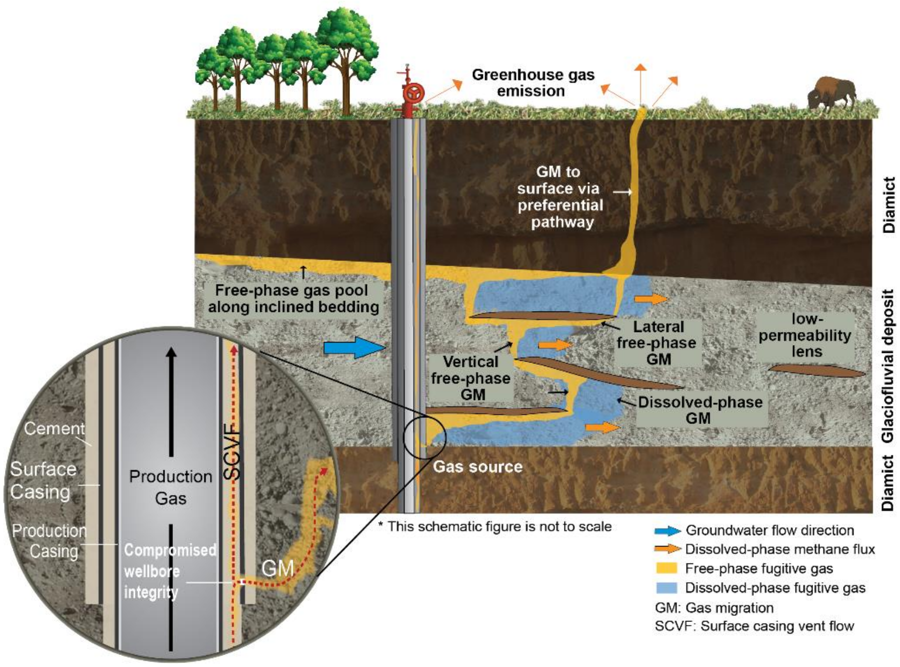

Fig. 1 Conceptual model of the release of fugitive gas into the shallow subsurface in glacial-derived deposits (Chao et al., 2020)

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