Stratigraphic and Lateral Distribution of Hydrogen Sulphide within the Triassic Montney Formation, Northern Regional Play Area, Northeastern British Columbia and Northwestern Alberta

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Introduction

The Triassic Montney Formation is the most significant gas deposit in British Columbia (BC) and accounts for 59% of the province's total gas-in-place resource estimation (BC Oil and Gas Commission, 2015). The Montney Formation is a tight liquids-rich gas reservoir in northeastern BC with a gas-in-place estimate of 55 642 billion cubic metres (1965 tcf; BC Oil and Gas Commission, 2015). The Montney Formation contains nonhydrocarbon gases such as hydrogen sulphide (H_2S) and carbon dioxide (CO_2), which create both an economic and health and safety impact when developing the hydrocarbon play. Hydrogen sulphide in produced gas, even in trace amounts (i.e., ppm), impacts the economics of drilling, production, treatment, and marketing of gas and associated liquids. The occurrence of H_2S in produced fluids is one of the most important environmental hazards and risks to resource development. The stratigraphic and lateral variation in H_2S varies across Montney gas play areas in BC and the distribution, in some areas, can be inexplicable and there are multiple reasons why H_2S is present in some Montney Formation producing wells. Hydrogen sulphide comes from mixed sources, which include it being a product of 1) bacterial sulphate reduction; 2) thermal sulphate reduction; 3) kerogen cracking; and 4) sulphide oxidation and/or decomposition of surfactants used for well completions. Understanding H_2S distribution is further complicated by the fact that H_2S can be produced in situ within the Montney reservoir or may have migrated up-dip through more permeable parasequences within the formation or fracture networks.

To reduce the uncertainty of producing H_2S from the Montney reservoir, the source and processes that generate H_2S need to be understood, which will require: a) mapping lateral and stratigraphic distributions of H_2S; b) determining the sulphur isotopic composition of H_2S gas as well as the potential sulphur sources (kerogen, pyrite, anhydrite); and c) determining the timing of souring (i.e., did H_2S initially spike then decrease or gradually increase over time?), which will provide additional information on likely sources of the H_2S.

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Preliminary Results

This research, initiated in summer 2018, began by mapping the H_2S distributions within the northern regional Montney play area of BC (Figure 1). Using geoLOGIC systems ltd.'s geoSCOUT version 8.8 GIS software, well search criteria was set to identify Montney producers that have tested or produced sour gas (presence of H_2S). The Montney Formation is over 200 m thick within the study area and the authors have informally subdivided the formation into the upper, middle and lower Montney Formation (Figure 2). These subdivisions are based on the sequence-stratigraphic–based boundaries of Davies et al. (2018).

Hydrogen Sulphide Distribution within the Montney Formation

A total of 153 wells have been identified that either tested or produced sour gas within the study area (Figure 3). The H_2S concentrations vary widely across the study area and range from 24 000 ppm (2.4%) to <10 ppm. The presence of H_2S also varies stratigraphically with the majority of sour horizontal wells being drilled in the upper and middle Montney Formation (Figures 2, 4). Wells that have no H_2S present are referred to as sweet gas wells (green symbol, Figure 4). Preliminary data indicate that wells that are drilled within the top 100 m of the formation (upper Montney Formation, upper portion of the middle Montney Formation) have a higher risk of producing sour gas than the wells that are drilled in the lower Montney Formation (i.e., >150 m below the top of the formation). Migration of H_2S gas may be the reason for this observation but other processes cannot be ruled out until further analyses have been completed to identify the isotopic composition of sulphur and its poten-

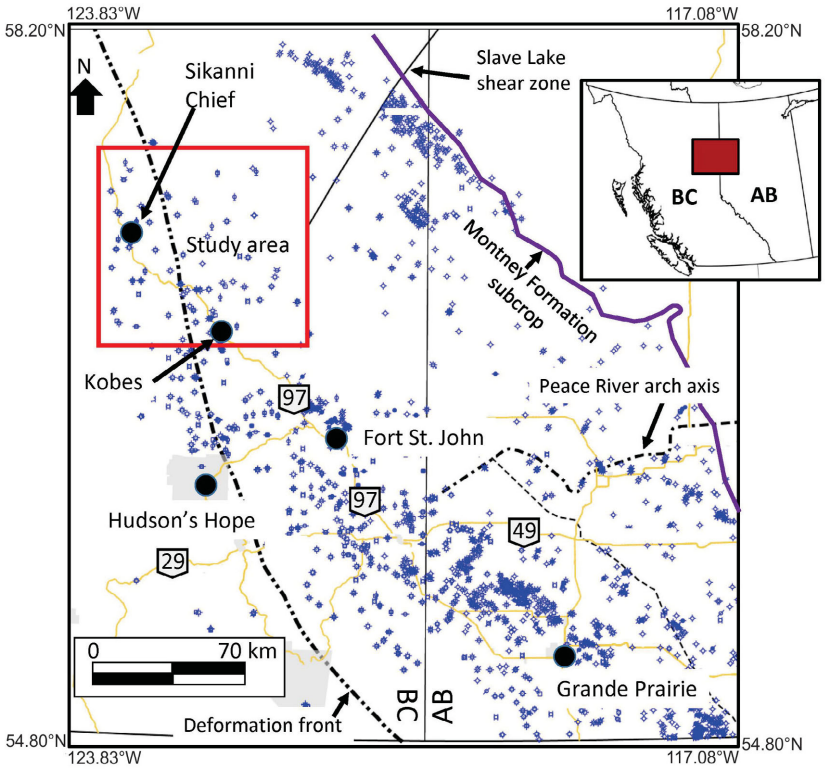

Figure 1. Location of the study area (red box) within northeastern British Columbia. Cored Montney Formation wells are shown as blue well symbols. Data sourced from geoLOGIC systems ltd. (2018).

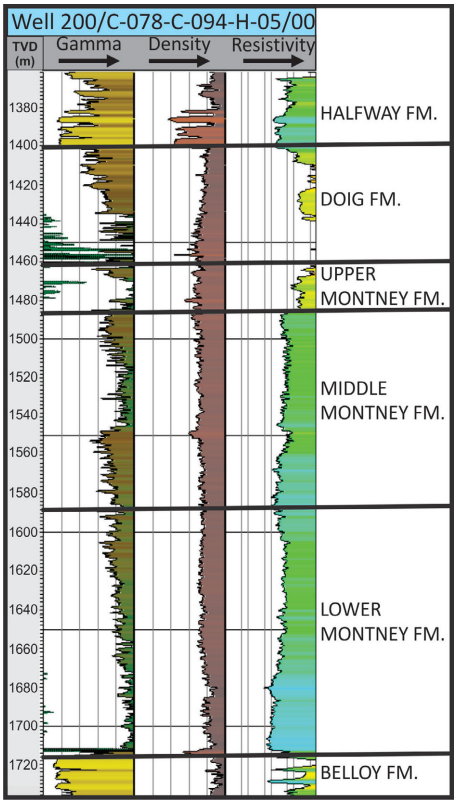

Figure 2. Stratigraphy and log response of the Halfway, Doig, Montney and Belloy formations in well 200/C-078-C-094-H-05/00 (geoLOGIC systems ltd., 2018). The Montney Formation is informally subdivided into the upper, middle and lower Montney Formation based on sequence stratigraphic model of Davies et al. (2018). Abbreviation: TVD, total vertical depth.

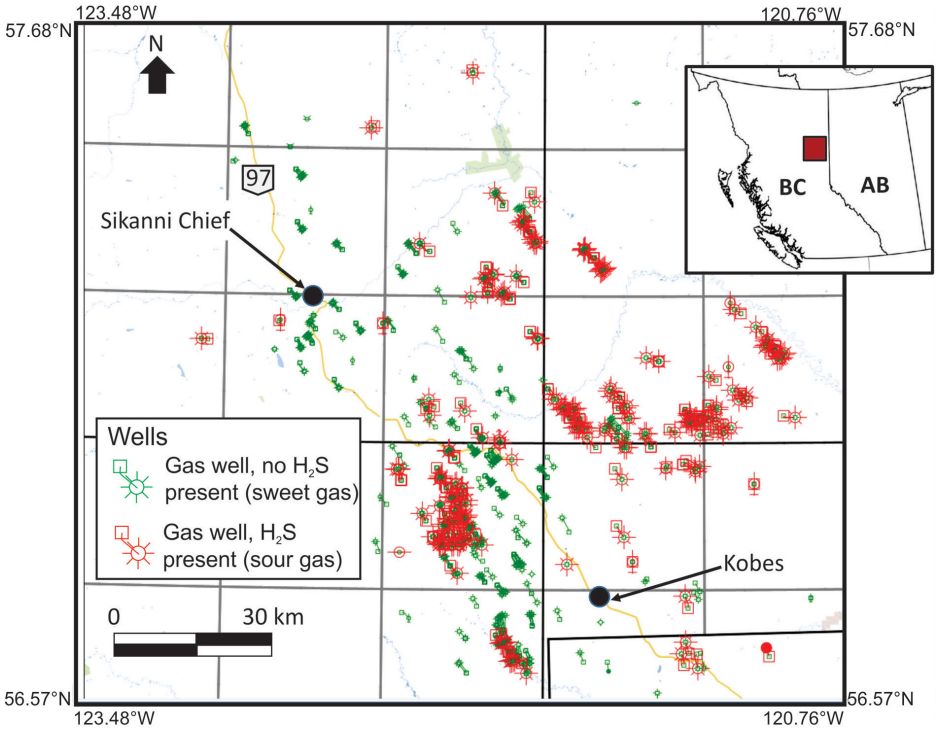

Figure 3. Location map of wells (only the red boxed area in Figure 1) that penetrate the Doig and Montney formations that have H_2S present within the tested or producing hydrocarbons, northeastern British Columbia. Hydrogen sulphide concentrations vary from 24 000 ppm (2.4%) to <10 ppm. Data sourced from geoLOGIC systems ltd. (2018).

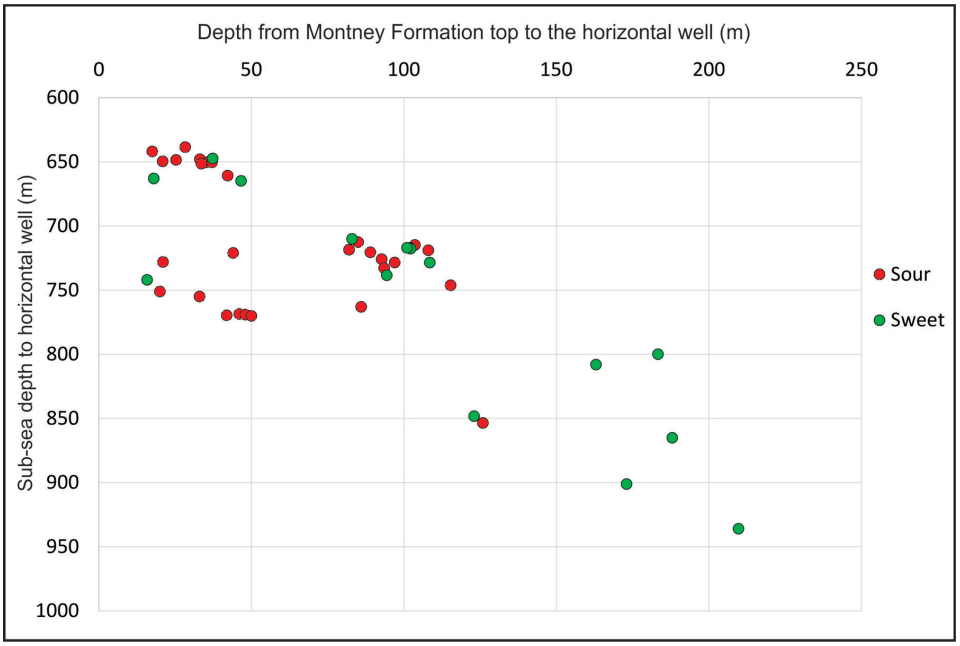

Figure 4. Cross-plot of selected sour (red circles) and sweet (green circles) Montney Formation horizontal wells with respect to their subsea total vertical depth (SSTVD) and their location within the Montney Formation (depth from the top of the Montney Formation). There is a higher risk of Montney Formation wells souring if the horizontal well is placed in the upper Montney Formation or the upper portion of the middle Montney Formation compared to wells that are drilled into the lower Montney Formation (see Figure 2 for stratigraphy).

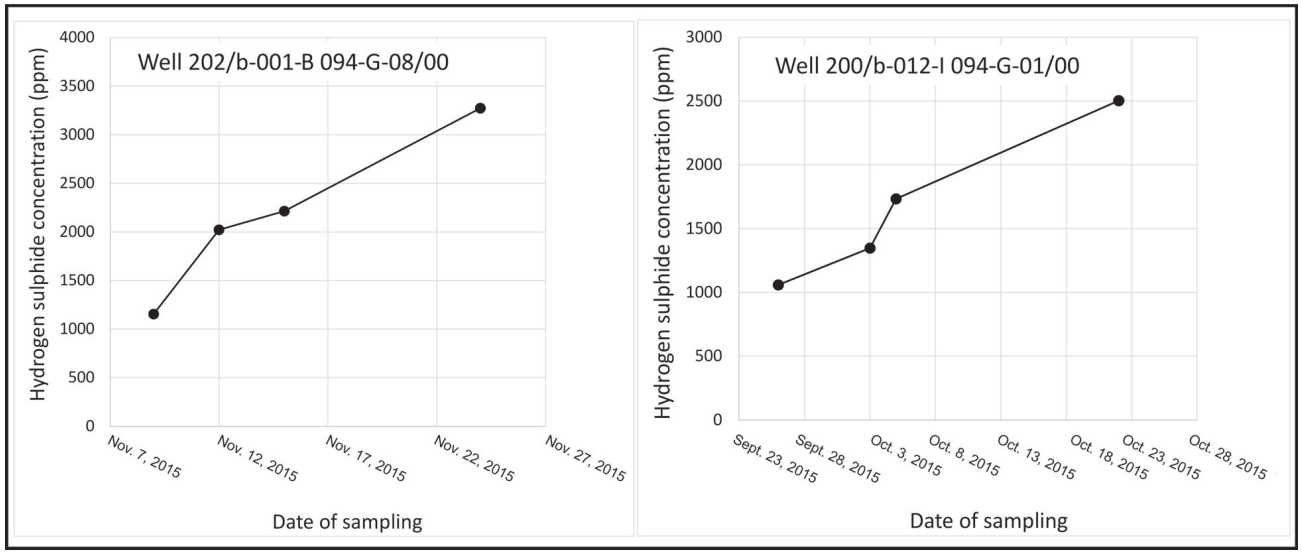

Figure 5. Two examples of changing hydrogen sulphide (H_2S) concentration through time. Preliminary investigation shows wells (202/B-001-B-094-G-08/00 and 200/B-012-I-094-G-01; geoLOGIC systems ltd., 2018) with multiple sampling of H_2S over time have increasing H_2S concentration over time or show no change in concentration.

tial sources (i.e., kerogen, fracturing fluid, pyrite, anhydrite).

Time Series Analysis of H_2S Concentrations

A preliminary investigation into the change in H_2S concentration over time has shown that for wells that have multiple sample points through time, there is a general trend of increasing H_2S concentration (Figure 5) or no change in concentration. A more detailed investigation is being performed to understand why the H_2S concentration changes over time.

Future Work

Inline samples from flowing Montney Formation wells are being analyzed to determine the isotopic composition of the sulphur from the H_2S gas. Rock samples will also be obtained from these wells to determine the sulphur isotopic composition of kerogen, pyrite and anhydrite grains. Currently, a search for a suitable laboratory to perform these measurements is being undertaken. Comparison of the range of sulphur isotopic compositions will help determine the sources of H_2S and build a geological model for the Montney play. This geological model will provide the information companies need to incorporate into their development plans to reduce economic, health and environmental risks.

Conclusions

The study into the lateral and stratigraphic H_2S distribution within the Montney Formation in British Columbia began in the summer of 2018. Preliminary results indicate that wells that target the upper portions of the Montney Formation in the northern region of the Montney play are at a higher risk of souring compared to wells that are placed in the lower portions (i.e., lower Montney Formation).

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