

# Understanding the Subsurface Helium System in Manitoba and Evaluating the Potential for Economic Concentrations by Analyzing Entrained Volatiles in Legacy Cuttings

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## Summary

Manitoba, especially in the southwestern portion of the province, has many of the same subsurface features that are present in the successful helium plays and areas with high helium gas tests in Saskatchewan. However, there are a lack of gas tests for helium in this part of the province to help understand if a meaningful helium resource might be present and to drive further investigation. This is not to say that there are no data, there are existing helium tests that suggest an exploitable resource may be present and there has been extensive investigation of the subsurface to help facilitate economic activities including oil and gas exploration and development. Utilizing Advanced Hydrocarbon Stratigraphy's (AHS) Rock Volatiles Stratigraphy (RVS) technology, the Manitoba Geological Survey in partnership with AHS has examined cuttings from four wells covering the Precambrian to the Mississippian, three terminating in the Lodgepole Formation and one terminating in the deeper Devonian Dawson Bay Formation. Coverage of these deeper formations is crucial in terms of trying to evaluate the potential for a subsurface helium system in Manitoba as the Cambrian Deadwood Formation in Saskatchewan is an existing target for helium production and is thought to possibly source its helium from the immediately adjacent Precambrian basement. Geographically the four wells are spaced to provide coverage of features like the presence of the Deadwood Formation, the Devonian Prairie Evaporite, among other subsurface features such as potential faulting which may be important as migration conduits for helium.

## Theory / Method / Workflow

In brief RVS is based on novel cryo-trap mass spectrometry instrumentation developed and built in house by AHS. In the case of the work done here with legacy cuttings 0.4 cc of rock sample is loaded into a standardized brass sample canister and crushed by the radial application of 2 tons of force across a  $\frac{1}{4}$  in<sup>2</sup> surface area. Crushing occurs while the sample canister is integrated into the RVS instrumentation and under vacuum to gently (no added heat or solvents) extract the entrained subsurface volatile fluids held within the rock sample. At the back end of the RVS instrumentation is a liquid nitrogen cooled cryo-trap – extracted volatiles are passed to this cryo trap where most species freeze and condense. Some species like helium and methane do not freeze under these conditions and are analyzed by collecting a “head space” sample and passing this directly to the mass spectrometer. The frozen compounds condensed on the cryo-trap are separated and analyzed by slowly warming the cryo-trap and passing the sublimating compounds to the mass spectrometer. 40+ volatile compounds are measured by the RVS instrumentation including noble gases, carbon dioxide, water, sulfides, the C1-10 hydrocarbons, and several other compounds. Extraction occurs across of increasingly strong vacuum conditions on the same rock sample also providing information about the ease of release of these volatile compounds which can be related back to rock properties. Importantly, the analysis of these subsurface fluids are the modern day subsurface volatiles unlike the case with fluid inclusions which are about the

geological past and which the distribution of is very strongly controlled by diagenetic conditions linked to the formation of such inclusions.

## **Results, Observations, Conclusions**

While core offers many advantages and there are some existing RVS methods for interpreting helium data from cores to identify potentially economic concentrations, cuttings provide a much greater opportunity for stratigraphic coverage. Assessing this broad stratigraphic section in relation to these geographically distinct features has provided some key insights; in many cases significant helium responses are observed in the Ordovician Red River Formation before undergoing a baseline shift to lower values in the top of the Ordovician to Silurian – in addition to providing significant insights into other portions of the subsurface that serve as significant controls on the subsurface helium system. Using core has the benefit of being directly applied to assessing potentially economic concentrations of helium, unfortunately this cannot be done with cuttings, however if it is assumed that cuttings would retain less helium than core samples, there is good evidence of potentially economic concentrations of helium being present if the appropriate rock properties are also present. The RVS helium data also show meaningful relationships to the presence of the subsurface features covered in the geographical selections of wells providing additional insights into the controls on the subsurface helium system. These data, and potentially from additional wells, will be discussed and demonstrate that 1) there does appear to be an active subsurface helium system in the southwestern section of Manitoba, 2) it is possible to appreciate where helium is most abundant and what stratigraphic and geographic features serve as controls on the system, and 3) some of these RVS helium data are promising in terms of potentially economic concentrations of helium in the province.

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## **References**

Nicolas, M.P.B., Smith, C.M. and Smith, M.P. 2024: Rock volatiles analysis of drill cuttings to evaluate the helium and hydrocarbon prospectivity of southwestern Manitoba (parts of NTS 62F2, K3); in Report of Activities 2024, Manitoba Economic Development, Investment, Trade and Natural Resources, Manitoba Geological Survey, p. 153–163.

Nicolas, M.P.B., Smith, C.M. and Smith, M.P. 2023: Volatiles analysis of drill cuttings to evaluate the helium prospectivity of southwestern Manitoba (parts of NTS 62F2, K3); in Report of Activities 2023, Manitoba Economic Development, Investment, Trade and Natural Resources, Manitoba Geological Survey, p. 93–104.