Advanced Methodologies to Determine Venting Gas Flow Rates & Volumes in Soils (AGM) and Surface Casing Vents (SCVF) - Characterization, Classification and Determining the Origins of Undesired Natural Gas Invasion (Vapour Intrusion) at Resource Wells using Energy Forensics

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Summary

In western Canada, many oil and natural gas wells are leaking gas into surface casing vents and into soils around the well-head. This undesired leakage, or migration of natural gases from deep (thermogenic) sources may pose significant operational, safety and environmental concerns. Fugitive gases may migrate into shallower strata impacting shallow aquifers, soils and, ultimately, may be released to atmosphere contributing to greenhouse gas emissions. Gaseous hydrocarbons may enter a well bore at points of poor cement bonding with wall rock, in small, and possibly gas induced, channels within the cement itself, or in micro-annuli at the contact between casing and cement. When gas is detected in the vent between the production and surface casing, it is considered to be surface casing vent flow (SCVF) and when found in soils outside the casing, it is termed active gas migration (AGM). In addition to thermogenic gas associated with drilling and hydrocarbon exploitation activities, gases may be present in soils from biological activity, contamination, or natural background processes. Correct identification of the origin of the gas found near a wellbore is essential for determining appropriate remediation procedures.

Identifying the geological source or origin from which gases are migrating has proven to be a difficult and challenging task, but is essential for successful intervention and remediation of a leaking well bore. Conventional methods for identifying the source of leaking gases have been variably successful and include noise, temperature, cement bond and cement imaging logs.

Chemical and isotopic chemistry has proven a useful and powerful tool in forensic science for detecting the alteration in alcohols or wines, confirming the origin of ancient artifacts and detecting or tracing the origin of contraband substances. The same principals can be applied to fingerprint and/or characterize natural gas related to surface gas migration (SCVF & AGM) at resource well bores. Stable carbon ($\delta^{13}C$) and hydrogen (δD) isotopic compositions of light-alkane gases change systematically with stratigraphic depth therefore, individual geological formations contain gases with unique or characteristic isotopic compositions. By comparing molecular, $\delta^{13}C$ and δD isotopic compositions of migrating gases collected at or near surface to established fingerprints of subsurface gases, a source for the migrating gases can be identified and repair operations can be focused on the forensically determined geological interval of the leaking gas source. Energy Forensics is particularly effective as it utilizes direct information of natural gas molecules and not indirect or secondary measurements. In areas where definitive subsurface control has been established (i.e. High Resolution-Exsolved Mud Gas-Isotope Logs), repair success rates have increased from 10% to 20% using conventional gas leakage techniques to 87% or greater by incorporating Energy Forensics.

In this presentation, **Energy-Forensics Vapor Intrusion Methodologies and Techniques** are provided to establish baseline control and measure gas flow rates and volumes venting from soils or surface casing vents at well bores. In addition, the geological source of leaking gases is determined using molecular and stable isotopic compositions of carbon and hydrogen in light alkane/ene gases.