Interpretation of Soil Hydrocarbon Gas Data for Assessing Thermogenic Gas Migration over the Eileen and West Sak Fault Zones, North Slope, Northern Alaska

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Hydrocarbons often leak from petroleum reservoirs and faults sometime facilitate the migration of oil and gas from the deeper reservoirs to the shallower surface. The Eileen and West Sak faults in North Slope Alaska are a set of normal faults that structurally separate the Prudhoe Bay and Kuparuk oil fields. It is hypothesized that these normal faults also controlled the surface leakage of hydrocarbons in this region. To test this hypothesis soil hydrocarbon gas samples were collected by USGS from the shallow cores of permafrost along three traverses and across the Eileen fault zone during the summer of 1991 and winter of 1992. The samples were analyzed for light hydrocarbons (alkanes - methane through hexane) and helium.

With this data we tried to – (1) identify seepage anomalies, (2) understand the origin of the gas by studying the compositional and stable isotope values (∂D and ∂^{13}C) of methane and (3) examine whether faults are related to the anomalies. We first log transformed the raw data which made the distributions look less skewed and more amenable to statistical treatments. By plotting the variables in normal probability plot as well as in the quantile plot, we identified the presence of multi-population for methane through pentane except for iso-butane and determined the threshold of anomalous concentrations. With the help of Pixler plot and use of ratios e.g. Bernard ratio (C_1/C_2+C_3), we identified the soil gas samples which migrated from the productive wet gas field, productive oil field and nonproductive dry gas field. By studying the molecular and stable isotope values of methane from a few samples obtained along the Eileen fault in 1992 winter, we understood that biogenic methane is the preferred explanation for most of the data; however, the presence of thermogenic gas can't be ruled out either. Finally we carried out semivariogram analysis for the log transformed variables (Helium and alkanes, methane through pentane). Semivariogram models for most of the species showed high nugget effect which rendered krigging to be unusable. All the fitted semivariograms for the above mentioned species were anisotropic with three preferred directions obtained as major ranges e.g. NE – SW (for helium and methane), N - S (for ethane) and NW - SE (propane, n-butane and pentane). These three directions correlate with the directions for NW-SE trending Eileen fault, NE-SW trending basement faults and the NNE-SSW trending West Sak faults, suggesting that faults could be favorable routes for hydrocarbon migration.