

***Sauer Water Well Dissolved Gas Comparison
Conducted for K.P. Kauffman Company, Inc.***

Brief Report provided by Dolan Integration Group



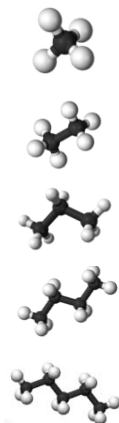
Geochemistry for Energy™

- Use data provided by K.P. Kauffman to compare hydrocarbon fluids sampled for Sauer Water Well Investigation
- Use Compositional and Stable Isotope analyses for comparative purposes. Use results from:
 1. Maul 20-2 Wellhead Gas 05-123-12420 (DIG Analyzed)
 2. Johnston 20-1 Wellhead Gas 05-123-12214 (DIG Analyzed)
 3. BW_Sauer_302734 (APC Isoflask - analyzed at Isotech)

1. Gas Compositions and Isotopes – A brief definition.
2. Gas Composition and Isotope Characterization Plot (Schoell Plot)
3. Gas Isotope Characterization Plot (aka Chung or Mixing Plot)
4. Gas Isotope Characterization Plot (Ethane/Propane Maturity Plot)

Organic components of thermogenic natural gas:

- Methane (CH_4)
- Ethane (C_2H_6)
- Propane (C_3H_8)
- Butanes (nC_4H_{10} and iC_4H_{10})
- Pentanes (nC_5H_{12} and iC_5H_{12})



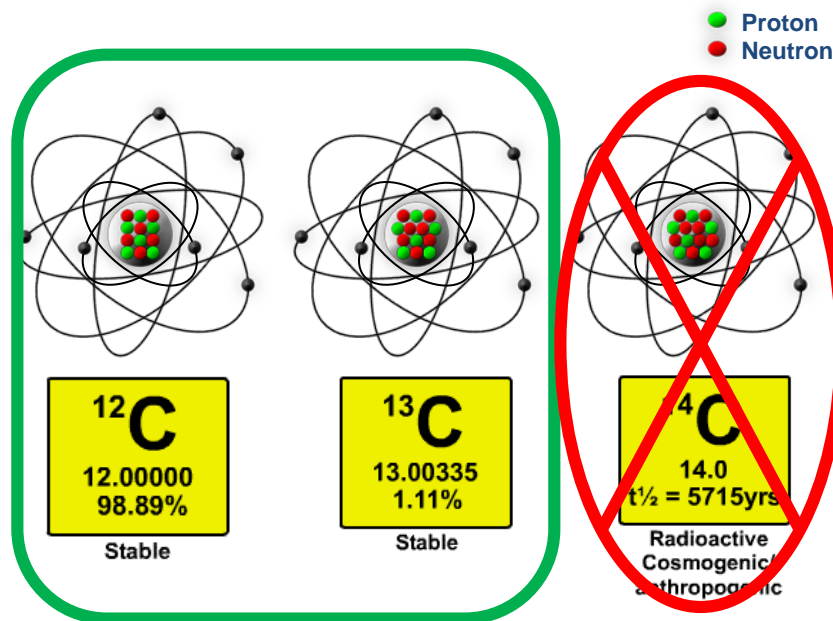
Inorganic components of some natural gases:

- Hydrogen sulfide (H_2S)
- Carbon dioxide (CO_2)
- Nitrogen (N_2)
- Hydrogen (H_2)
- Helium (He)

STABLE



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Three common isotopes of carbon:

^{12}C and ^{13}C are **stable** isotopes. Do not decay.

^{14}C – **Radioactive**, decay rate useful for dating recent geologic, historic, or anthropologic materials.

“Schoell” Plot

Schoell, M., 1983, *Genetic characterization of natural gases*: American Association of Petroleum Geologists Bulletin, v. 67, p. 2225-2238.

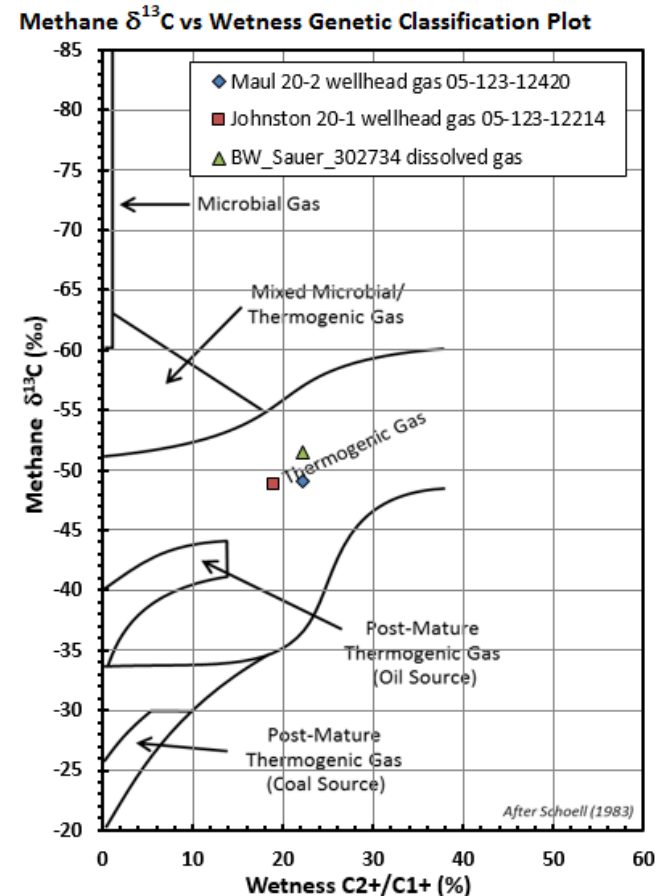
- This plot was developed by Martin Schoell in the 1980s from empirical relationships and provides an excellent screening criteria for gases when composition (x-axis) is compared to the Methane Stable Carbon Isotope (y-axis).

Results

- All three samples interpreted show that they fall into the thermogenic gas zone on the published Schoell plot. The methane isotopes are showing isotopically heavier (more ^{13}C) values that clearly characterize them as derived from a thermogenic source.

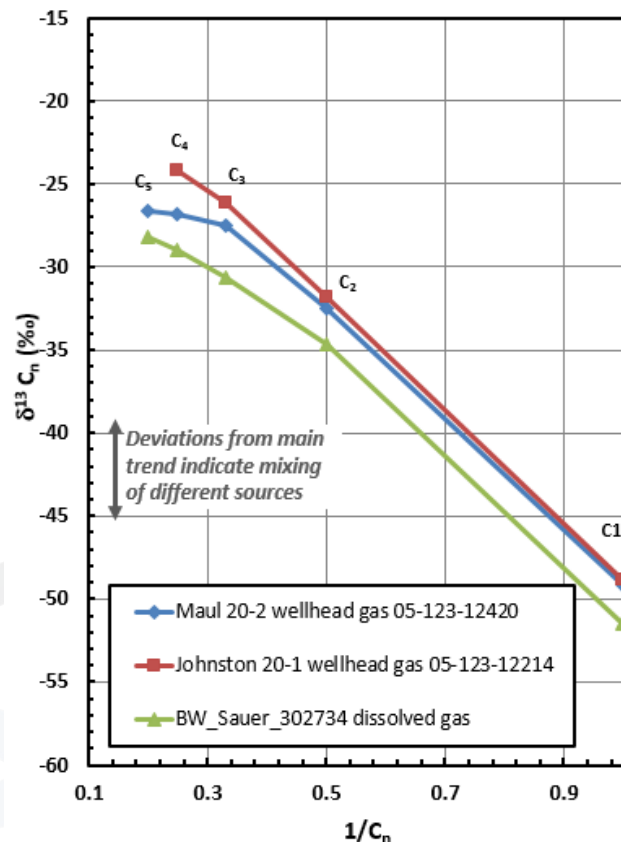
Discussion

- This merely characterizes the gas, further interpretation is needed to determine the distinction of the gas.
- The conclusion is that all three samples are thermogenic in origin.



Gas Characterization – Mixing Plot

Mixing Plot



Chung, H.M., Gormly, J.R., and Squires, R.M., 1988, *Origin of gaseous hydrocarbons in subsurface environments: theoretical considerations of carbon isotope distribution: Chemical Geology*, v. 71, p. 97-103.

- This plot was developed by Moses Chung et. al. to characterize the natural gas compound isotopes according to potential source rock genetics. The inverse of the number of carbons in the molecule is plotted on the x-axis. The isotopic value of each molecule is plotted on the y-axis. It is implied that one can derive the isotopic value to the kerogen in the source rock that may have been responsible for generating the gas.

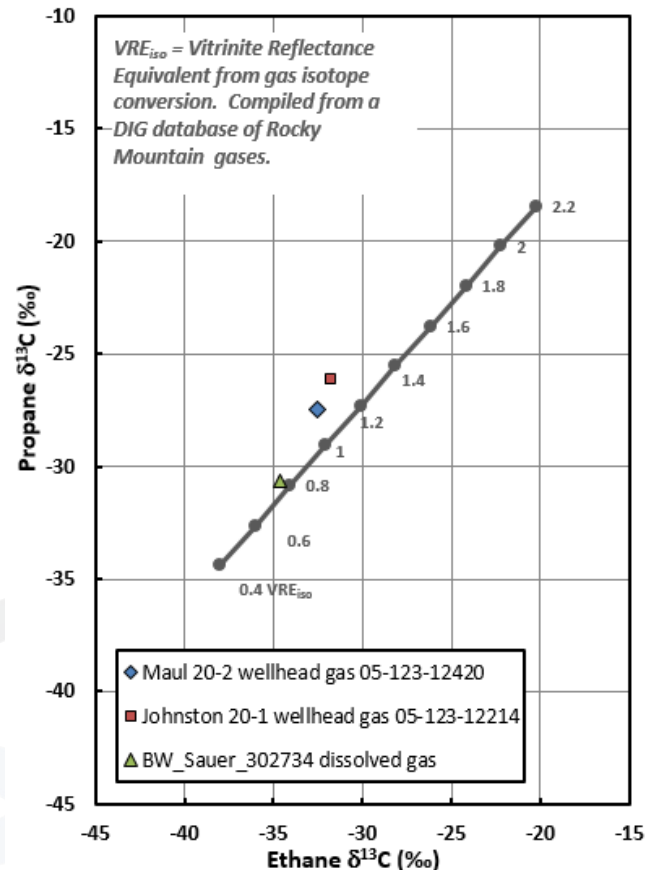
Results

- The gas that was dissolved in the Sauer water sample is significantly different and does not share a common source with the Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214.
- There is some deviation as the gases are analyzed in the C4 (Butane) and C5 (Pentane) molecules for the Johnston 20-1 wellhead gas 05-123-12214 and Maul 20-2 wellhead gas 05-123-12420.
- Standard error for these isotope analyses is less than the size of data point (0.5 ‰)

Discussion

- The butane/pentane deviation effect is commonly seen if accumulated hydrocarbons exhibit different compartments, commingled gas mixtures or reservoir mixtures of the gas.
- The conclusion is that the BW_Sauer water dissolved gas sample is distinct from the Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214.

Ethane - Propane Maturity Plot



Berner, U., and Faber, E., 1996, Empirical carbon isotope/maturity relationships for gases from algal kerogens and terrigenous organic matter, based on dry, open-system pyrolysis: *Organic Geochemistry*, v. 24, p. 947-955.

- This plot was modified from Berner & Faber who developed the technique to characterize the natural gas compound isotopes according to maturity. Ethane stable carbon isotope value is plotted on the x-axis. Propane stable carbon isotope value is plotted on the y-axis. The kinetic isotope fractionation effect is explained for the changes in value and the relationship to maturity. The correlation is made on the Vitrinite Reflectance Equivalence scale (VRE_{iso}).

Results

- The Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214 samples ethane/propane values exhibit a higher maturity than the Sauer water dissolved gas sample.

Discussion

- The maturity relationship of these gases is very well established in the Wattenberg Field and the Denver Basin in general. The maturity values for the Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214 are typical for J Sand gas production in this area. The gas dissolved in the Sauer water sample is derived from a gas that is less mature. This implies a shallower thermogenic source for this gas.
- No attempt is made to establish a source for the gas in the Sauer. The conclusion is that the Sauer gas dissolved in the water is distinct from the Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214.

1. Gas Compositions and Isotopes – A brief definition.
 - a) Gas Compositions and Stable Carbon Isotopes are forensic tools used in this brief report.
2. Gas Composition and Isotope Characterization Plot (Schoell Plot)
 - a) All gases have thermogenic characterization according to methane and compositional results.
 - b) This merely characterizes the gas, further interpretation is needed to determine the distinction of the gas.
3. Gas Isotope Characterization Plot (aka Chung or Mixing Plot)
 - a) The Maul 20-2 wellhead gas 05-123-12420 and Johnston production gases share a genetic source. The gas that was dissolved in the Sauer water sample is significantly different and does not share a common source with the Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214.
4. Gas Isotope Characterization Plot (Ethane/Propane Maturity Plot)
 - a) The maturity relationship of these gases is very well established in the Wattenberg Field and the Denver Basin in general. The maturity values for the Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214 are typical for J Sand gas production in this area. The gas dissolved in the Sauer water sample is derived from a gas that is less mature. This implies a shallower thermogenic source for this gas.
 - b) No attempt is made to establish a source for the gas in the Sauer. A clear conclusion is that the Sauer gas dissolved in the water is distinct from the Maul 20-2 wellhead gas 05-123-12420 and Johnston 20-1 wellhead gas 05-123-12214.