Keenesburg, Weld Co, Colorado

Gas Composition and Isotopic Data Summary
July 24, 2019

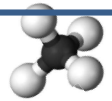
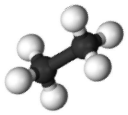
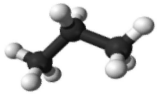
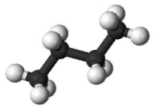
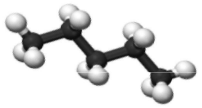
dig
Dolan Integration Group
Geochemistry for Energy™

digforenergy.com

303.531.2030

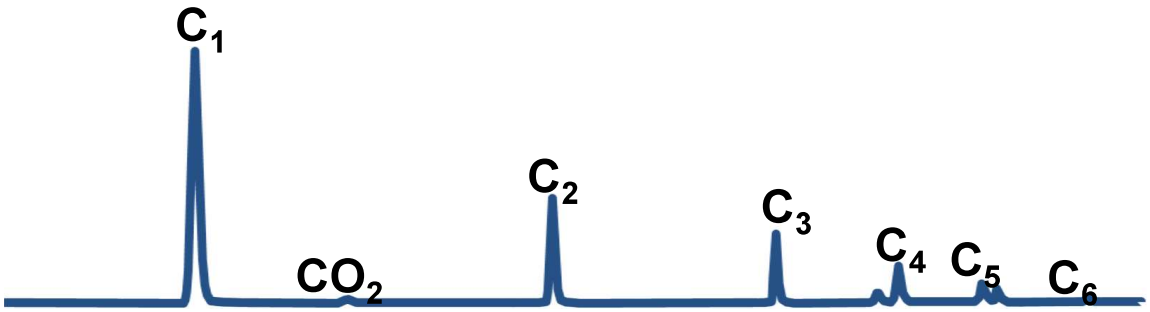
Composition of Natural Gas

Natural and Oil Associated Gases

Methane		CH_4
Ethane		C_2H_6
Propane		C_3H_8
Butane		C_4H_{10}
Pentane		C_5H_{12}
Nitrogen		N_2
Carbon Dioxide		CO_2

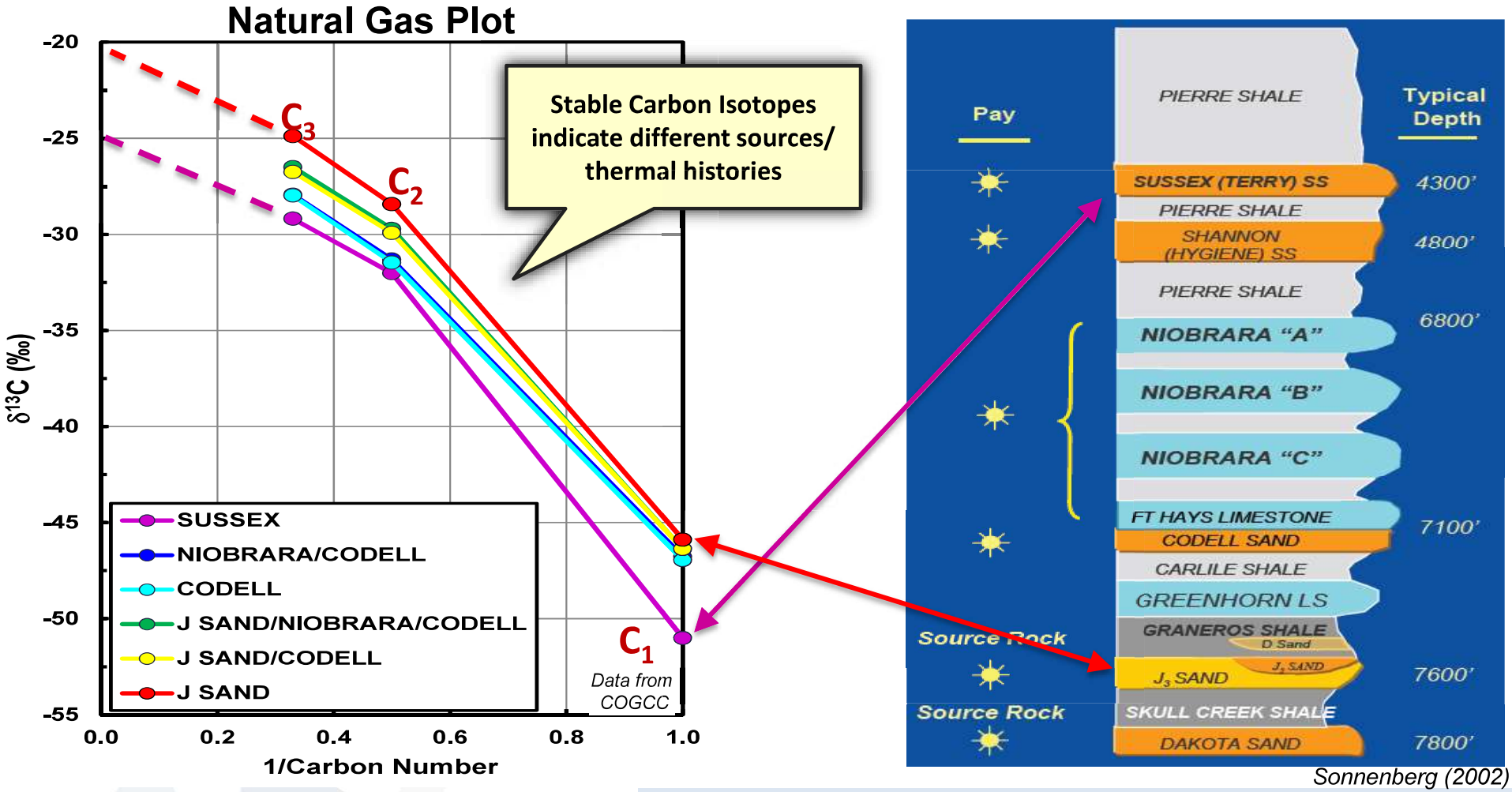
H_2S, He….

Alkanes: C_nH_{2n+2}



Gas chromatograph signature

Wattenberg Field: Production Gas Characterization

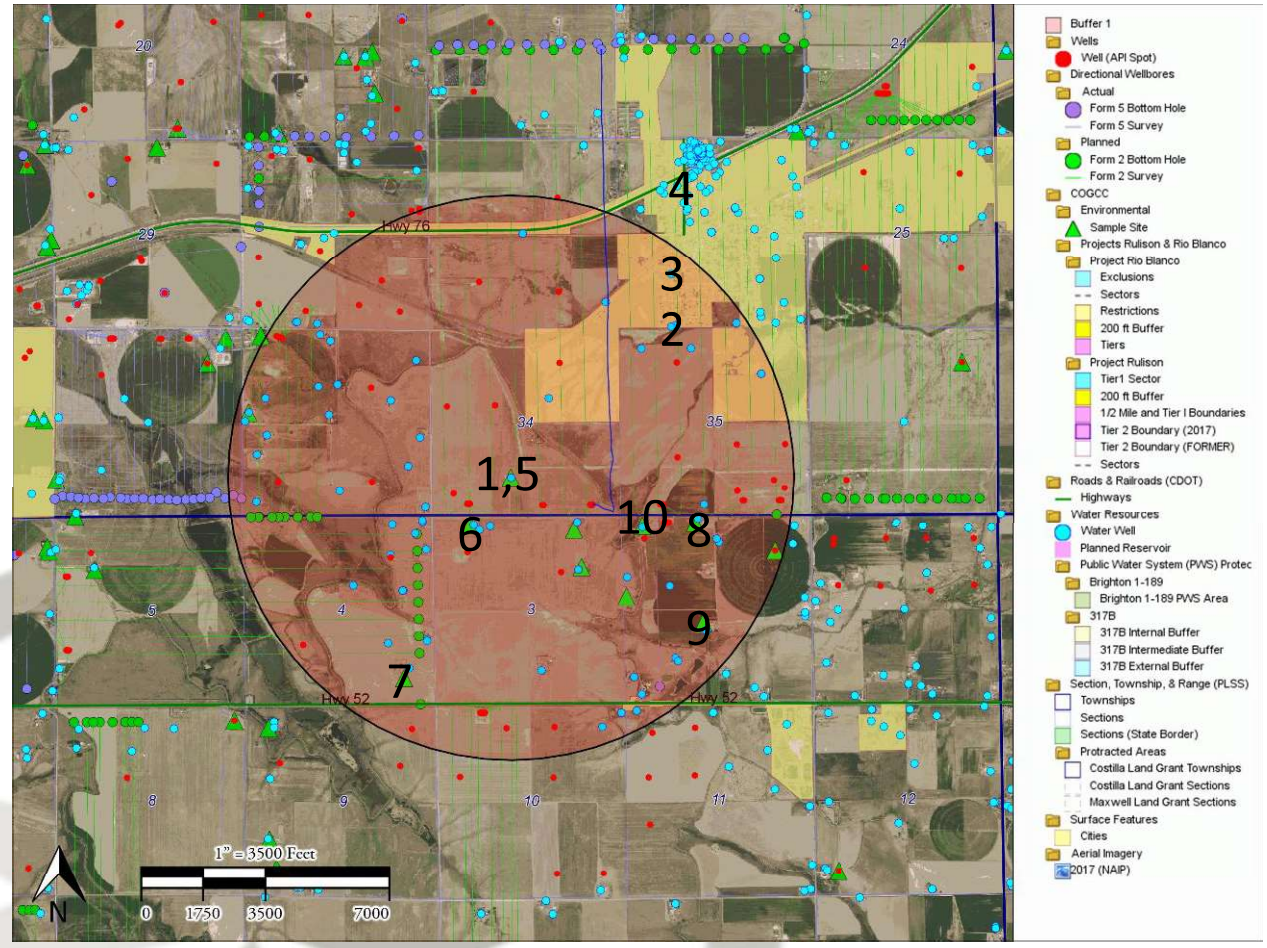


Sonnenberg (2002)

Project Background

- DIG was contacted in June of 2019 regarding the composition and isotopic fingerprint of dissolved gas detected in a water well near Keenesburg, Colorado
- DIG conducted the gas composition and isotopic analysis of 6 water samples collected in that area.
- DIG conducted the gas composition and isotopic analysis of 2 natural gas samples collected from the following oil and gas wells in the area:
  - Shufly Y 34-714 horizontal spud 1/8/2018 NBRR production
  - Fritzler 12-34 vertical spud 5/16/2005 J-CDL production
- DIG compiled gas composition and isotopic data from nearby water well and oil & gas well locations in the COGCC online database, and DIG compared the isotopic signatures between the available gas and water samples.
- This presentation is a summary of those data and the relevant interpretations and conclusions.

Nearby samples from COGCC database (water wells)



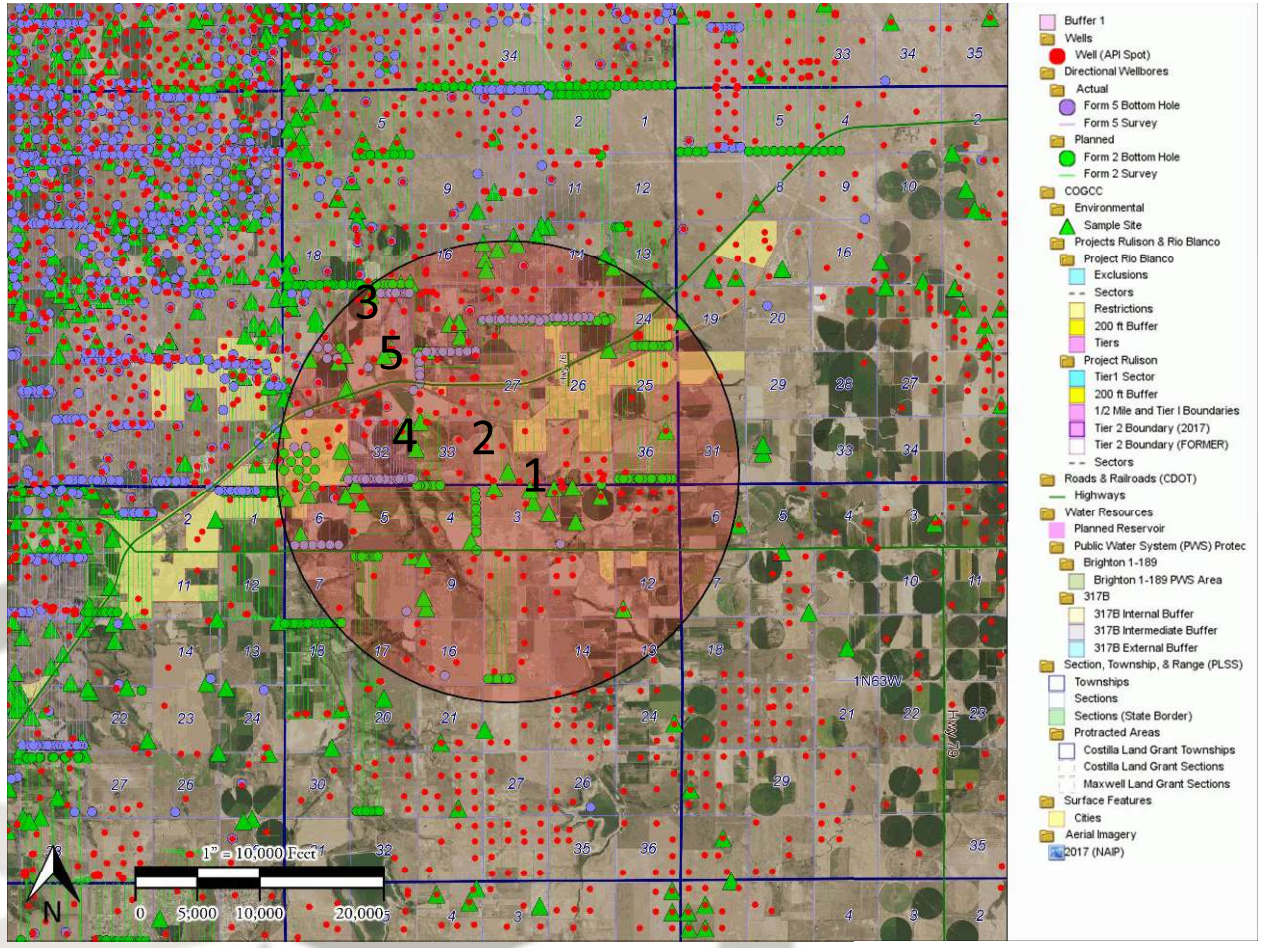
Keenesburg water wells analyzed at DIG:

1) Keenesburg #7 (various dates)
2) Keenesburg #4
3) Keenesburg #5
4) Keenesburg #2

Water samples with COGCC data in 1.5 mile radius from #7 well:

5) Snow 210202
6) Reiter 0515825
7) Farner 278368
8) Pastelak 102625
9) Madsen 246938

Nearby samples from COGCC database (O/G wells)



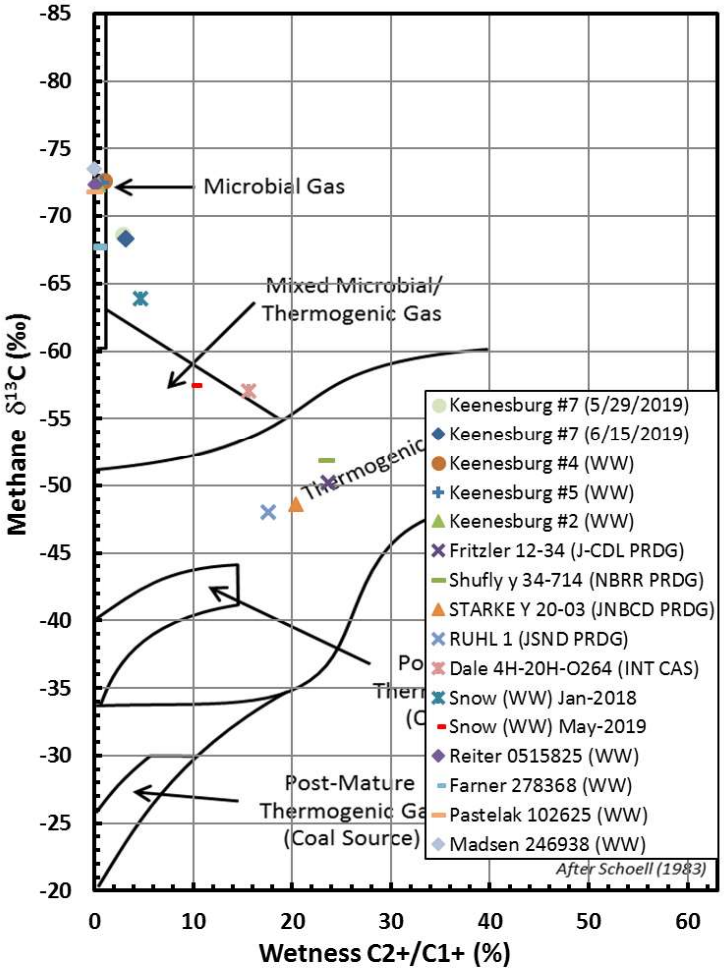
Noble O/G wells analyzed at DIG:

1) Shufly Y 34-714 (NBRR PRDG)
2) Fritzler 12-34 (J-CDL PRDG)

O/G samples with COGCC data in 3.5 mile radius from #7 well:

3) STARKE Y 20-03 (JNBCD PRDG)
4) RUHL 1 (JSND PRDG)
5) Dale 4H-20H-O264 (INT CAS)

Schoell (1983) Genetic Classification Plot



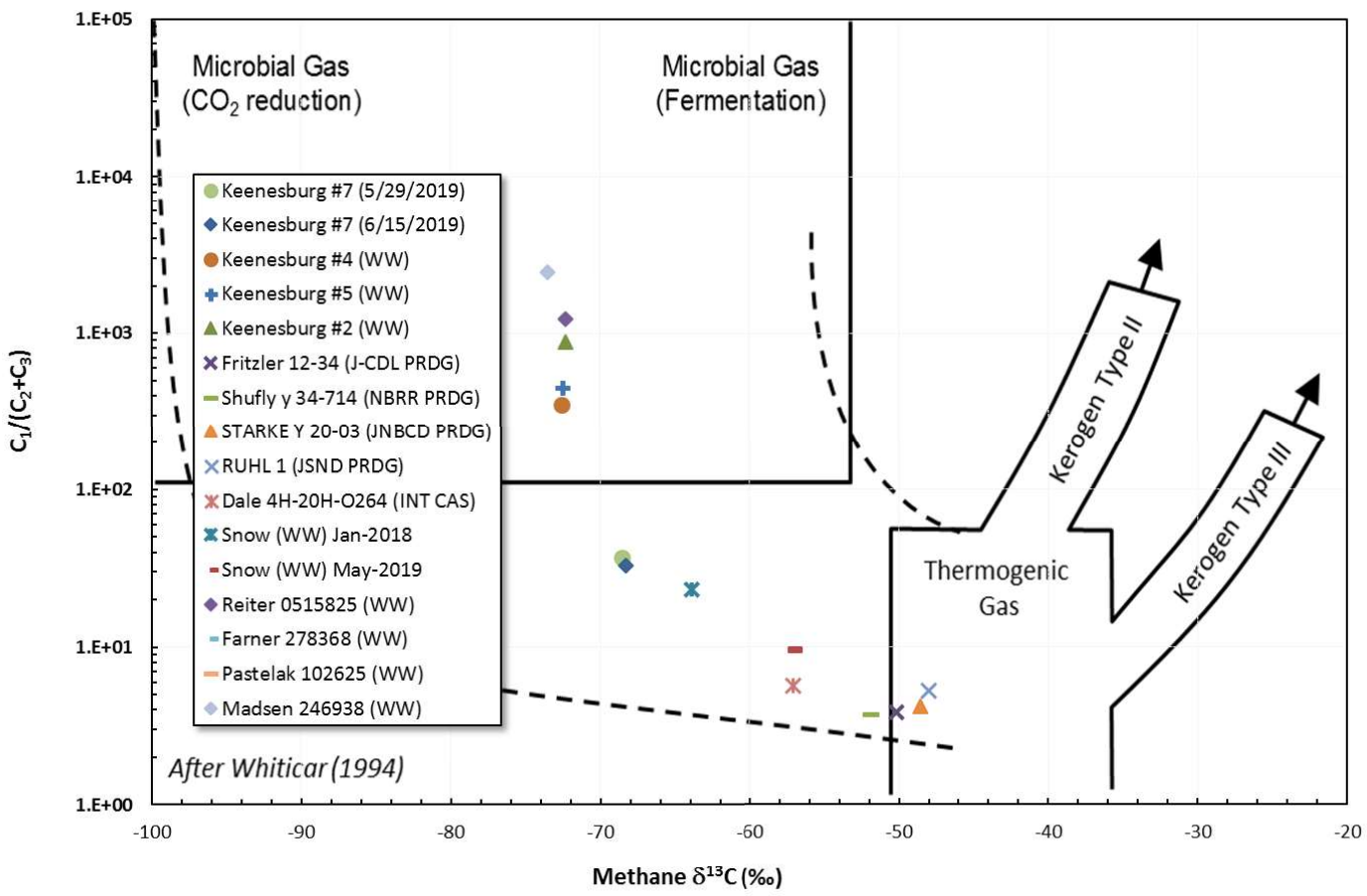
Classification based on methane stable carbon isotope composition and gas wetness (%C_2+).

All water samples contain entirely or predominantly microbially derived C_1 (methane).

In addition to C_1, the Keenesburg # 7(5/29/2019) , Snow and Keenesburg #7(6/15/2019) also contain slightly higher homologue C_2+ compounds that are thermogenic in origin. These samples are classified as mixed microbial-thermogenic gas.

Produced gas samples are classified as thermogenic in origin.

Methane $\delta^{13}C$ vs $C_1/(C_2+C_3)$ Genetic Classification Plot

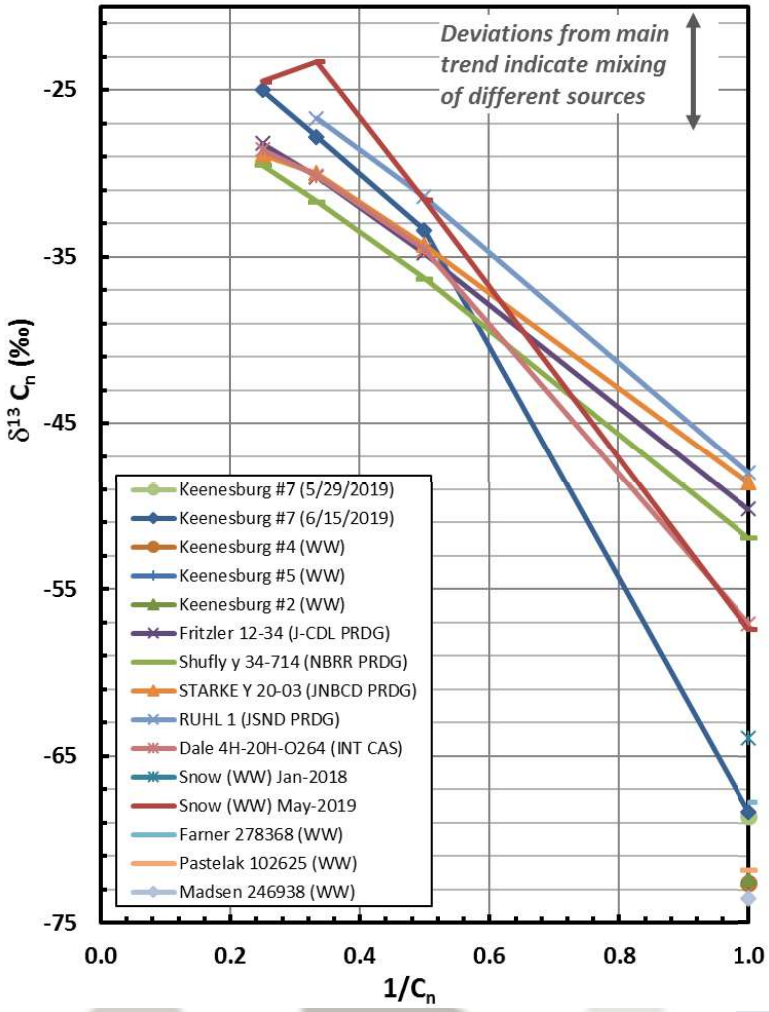


Snow water well results shift towards more thermogenic contribution from Jan 2018 to May 2019.

Though no isotopic data was submitted, the Snow water well contained thermogenic C_2+ dating back to Nov 2017 (pre-Shufly hz):

- C_1 = 10.4 mg/l
- C_2 = 0.954 mg/l
- C_3 = 0.572 mg/l

Natural Gas Plot



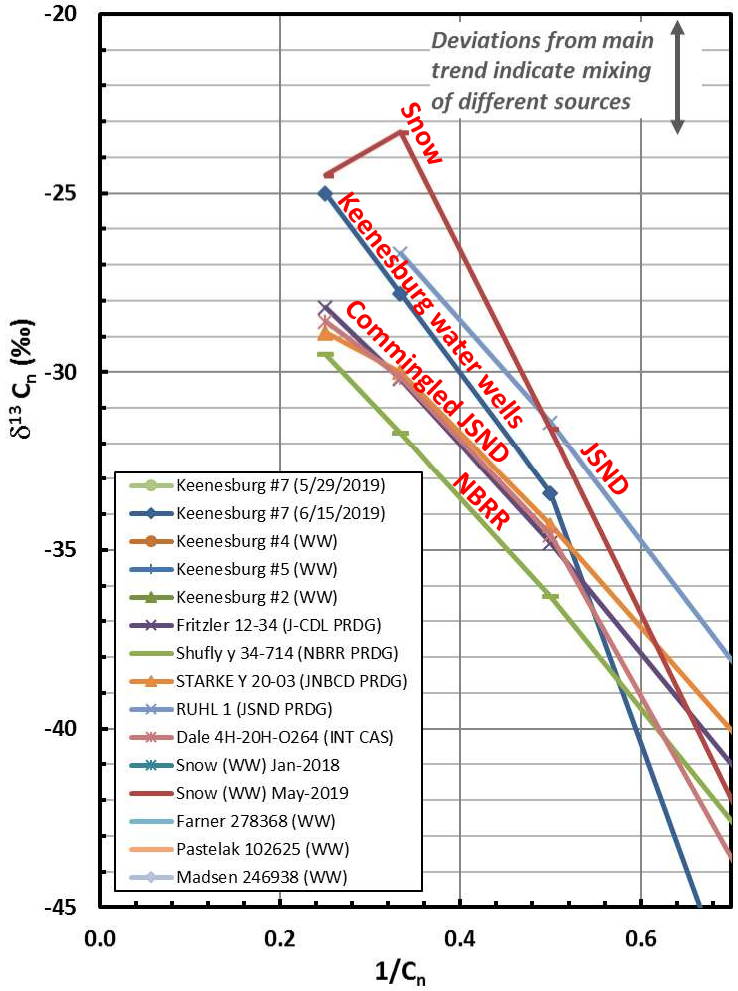
The natural gas plot is an effective tool for evaluating differences in stable carbon isotope composition of gases from multiple sources.

Only methane was analyzed for most of the water samples, hence the lack of C_2+ data.

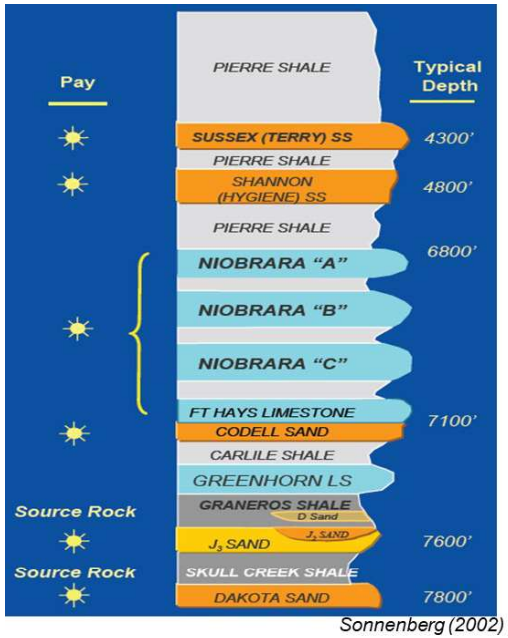
Gases that are unaltered by microbial processes typically plot linearly, as shown by the produced gas samples.

The “kink” exhibited by the Keenesburg, Snow and Dale INT CAS gas, is due to mixing of isotopically light, microbial C_1 with thermogenic C_2+ compounds.

Natural Gas Plot (C_2, C_3 and nC_4)

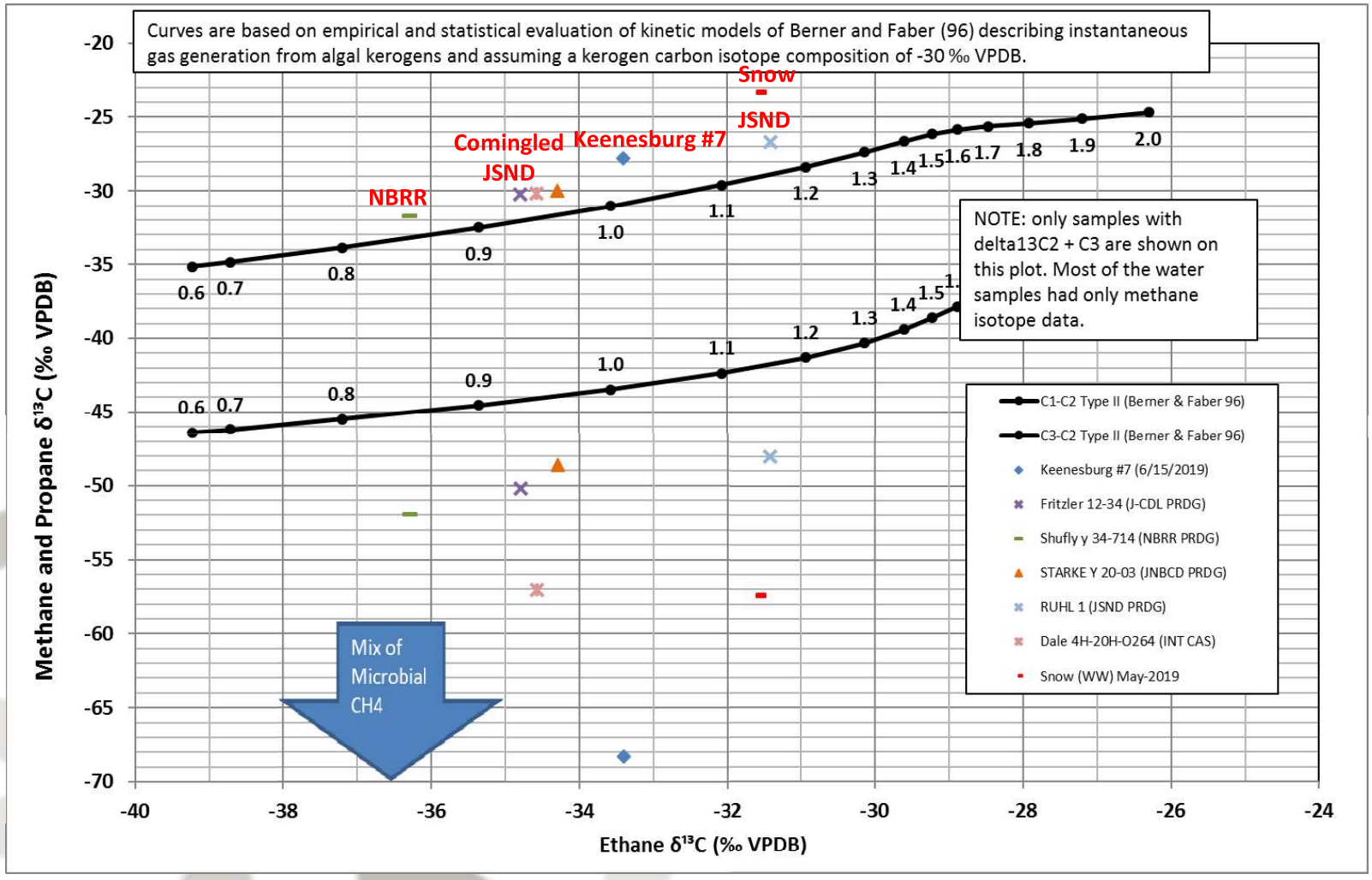


Ignoring C_1, which is readily affected by bacterial processes such as mixing with microbial C_1 or oxidation, the C_2+ (predominantly thermogenic hydrocarbons) stable carbon isotope data effectively distinguishes the samples.



Sonnenberg (2002)

Berner & Faber (96) - Vitrinite Reflectance Equivalent based on Natural Gas Stable Carbon Isotope Composition



Thermal maturity of the source rock at the time of generation can be correlated from the C_1, C_2 and C_3 gas isotope data.

These data show clear differences between wells producing from distinct formations or combinations of formations.

Conclusions

- Microbial methane is present in several water wells in the study area.
- In addition to microbial methane, the Keenesburg # 7(5/29/2019) , Snow and Keenesburg #7(6/15/2019) samples also contain C_2+ compounds that are thermogenic in origin.
- The Snow samples exhibited a shift towards more thermogenic gas from Jan 2018 to May 2019. The initial sample results submitted from Nov 2017 also contained thermogenic gas, though isotopic results were not available in the COGCC database. From the COGCC records, this pre-dates the drilling and completion of the Shufly Y 34-714 horizontal well.
- The stable carbon isotope composition of the C_2+ compounds effectively distinguish gases collected from Niobrara, J-Sand and commingled J-Sand production in the area.
- Produced Niobrara gas from the Shufly Y 34-714 well is isotopically distinct from the gas sampled in the Keenesburg water wells.
- The source of the thermogenic gas in the Keenesburg #7 and Snow samples is likely from either the J-Sand or a commingled J-Sand source.