November 18, 2016

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Location ID 414907
Document 2527376

Kris Rowe
HRL Compliance Solutions
2385 F½ Road
Grand Junction, CO 81505

Dear Mr. Rowe,

Enclosed is a copy of the analysis report for the sample identified as "DG Water Well (272793)" collected on 10/26/16. The sample was a dissolved gas sample collected from a monitoring well southeast of Rifle, in Garfield County, Colorado and assigned to Isotech Job 33299. The analytical report includes the compositional analysis of the gas, concentration of dissolved methane, ethane, and propane, as well as the stable isotope analysis of the methane. The question is whether the dissolved gas originated from a microbial or thermogenic source or perhaps from the produced water impoundment facility approximately 500 ft to the south of the monitoring well. The copy of the analytical report is included in the Appendix. To help illustrate the data I have enclosed figures to show how the dissolved gas sample compares with compositions typically observed for different sources of methane, plus published results of other dissolved gas samples and production gas collected from the surrounding area.

The compositional results showed that the gas from the DG Water Well sample contained 43.92 % methane (C_1), 63 ppm of ethane (C_2) and no quantitative detection of heavier hydrocarbons through hexanes. The dissolved methane concentration was determined to be 14 mg/L. The presence of heavier hydrocarbons in a gas sample is often indicative of thermogenic gas; however, some gases produced from microbial sources have been shown to contain small amounts of the heavier hydrocarbons, especially ethane (*Taylor et al., 2000, Envron. Sci. Technol., v 34, p 4727-4732; Bernard et al, 1978, J. Geophys. Res., v. 83, p 4053-4061*). The gases identified to be of primarily microbial in origin by Taylor et al. (2000) contained ethane ranging from below detection limits to approximately 420 ppm.

The carbon and hydrogen isotopic composition ($\delta^{13}C$ and δD) of the methane from the DG Water Well sample plots well within the range of values typically associated with thermogenic gases (Figure 1). Since the DG Water Well sample was collected from Garfield County within the Piceance Basin of Colorado, we compared the isotopic composition to other published dissolved gas samples collected in that same region between 2004 through 2008 (Figure 2). This comparison shows the DG Water Well sample plots in the same area as many other dissolved gas samples in Garfield County.

Another approach is to examine the isotopic composition along with the GC compositional data such as the ratio of methane to ethane plus propane (Figure 3). This diagram, often referred to as a Bernard Plot, shows the DG Water Well sample has a $\delta^{13}C$ value similar to thermogenic gases but a $C_1/(C_2+C_3)$ ratio much greater than expected for thermogenic gases. As shown in Figure 3, the DG Water Well has a greater $C_1/(C_2+C_3)$ ratio than many of the domestic water wells sampled for the surrounding area. Low concentrations of heavier hydrocarbons in gases from thermogenic origin can be a result of vertical migration through thick sediments in the subsurface which tends to strip the heavier hydrocarbons from the gas but does not change the isotopic composition of the methane. Another possibility that could lead to a composition similar to that observed for the DG Water Well

in Figure 3 is microbial oxidation of a primarily biogenic gas with relatively little heavier hydrocarbons present. Microbial oxidation of methane preferentially consumes the isotopically lighter isotopes shifting the isotopic composition of the residual methane to more positive values. When considering Figure 1, and the general trend of microbial oxidation shown by the dashed arrow, if microbial oxidation has effected the isotopic composition of methane in the DG Water Well sample then the original gas would have had to of probably been a mixture of biogenic and thermogenic gas. The characteristics of the DG Water Well sample are similar to other dissolved gas samples observed in Garfield County which appear to range from being predominantly biogenic to predominantly thermogenic gas or a mixture of both. This particular sample may be related to thermogenic gas migration from depth or perhaps oxidation of a mix of biogenic and thermogenic gas. Without data from the production water impoundment facility we cannot determine if it is possible that the methane could have migrated from the base of the impoundment through the subsurface to the monitoring DG Water well. Lateral migration through sediments and groundwater may also have the tendency to strip the heavier hydrocarbons relative to methane.

In summary, based on the chemical and isotopic characteristics of the dissolved gas in the DG Water Well sample the source of the methane could be from the vertical migration of thermogenic gas through the subsurface sediments which has stripped most of the heavier hydrocarbons or perhaps microbial oxidation of a gas that was a mix of significant amounts of biogenic methane with some thermogenic gas. Without data from the production water impoundment facility we cannot determine if it is possible that the methane could have migrated from the base of the impoundment facility through the subsurface to the monitoring DG Water well. Dissolved gas samples from the impoundment facility would help determine the characteristics of the gas dissolved in the production water stored at the impoundment and allow a direct comparison to the dissolved gas observed in the DG Water Well. Chemical analyses of the water from the DG Water well and the impoundment facility should also help determine if there has been impact from the impoundment facility at this monitoring well.

If you have any questions or if there is anything else we can do for you, please do not hesitate to contact us. Thank you for choosing Isotech for your analysis needs, we appreciate your business.

Sincerely,

Keith C. Hackley, Ph.D., PG
Senior Isotope Geochemist
Isotech Laboratories, Inc.
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Enclosures (6)

Table 1. GC Composition, isotope results, and hydrocarbon concentrations for the dissolved gas sample associated with Job 33299.

Isotech Lab No.	Sample Name	Sample Date	Sample Time	Field Name	Location	He %	H_2 %	Ar %	O_2 %	CO_2 %	N_2 %	CO %	C_1 %	C_2 %	C_2H_4 %	C_3 %	C_3H_6 %	iC_4 %	nC_4 %	iC_5 %	nC_5 %	C_6+ %
584996	DG Water Well (272793)	10/26/2016	11:45	Ursa - Wasatch Bench - DG Water Well	Ursa Wasatch Facility	na	nd	0.609	6.38	0.54	48.54	nd	43.92	0.0063	nd	nd	nd	nd	nd	nd	nd	nd

Isotech Lab No.	Sample Name	Sample Date	Sample Time	Field Name	Location	$\delta^{13}C_1$ ‰	δDC_1 ‰	Dissolved CH_4 cc/L	Dissolved CH_4 mg/L	Dissolved C_2H_6 cc/L	Dissolved C_2H_6 mg/L	Dissolved C_3H_8 cc/L	Dissolved C_3H_8 mg/L	Helium dilution factor *
584996	DG Water Well (272793)	10/26/2016	11:45	Ursa - Wasatch Bench - DG Water Well	Ursa Wasatch Facility	-45.62	-178.7	20	14	0.0033	0.0041	< 0.0001	< 0.0002	0.55

nd = not detected, na = not analyzed

* Analysis is of gas extracted from water by headspace equilibration. Analysis has been corrected for helium added to create headspace.

* Addition of helium negates the ability to detect native helium and may negate the ability to detect hydrogen.

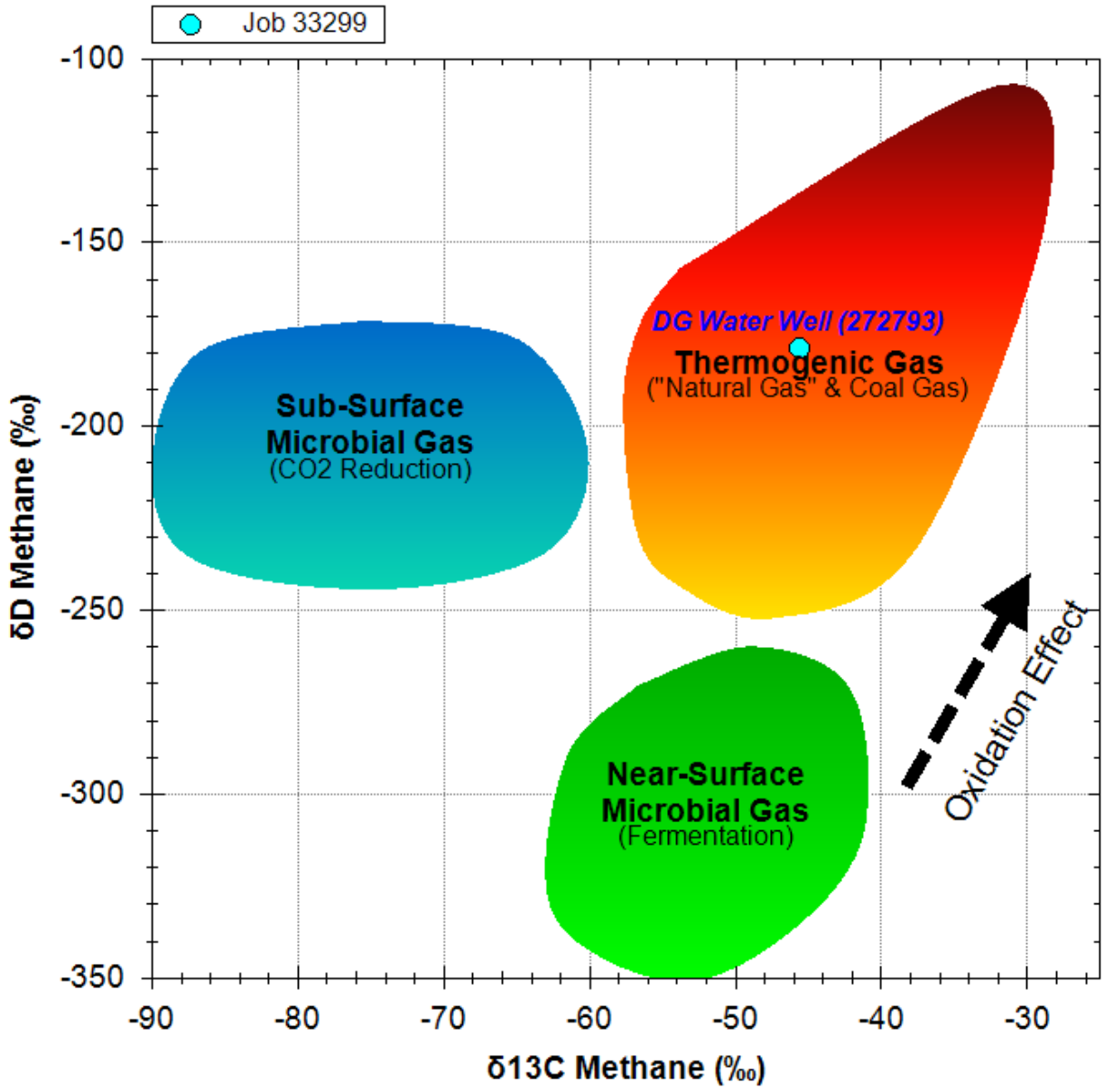

Figure 1. Graph of $\delta^{13}C$ and δD data of methane from the DG Water Well sample (Job 33299) plotted along with typical domains for various sources of methane. (*Diagram modified from Coleman, Liu, Hackley, and Pelphrey, 1995, Environmental Geosciences, v. 2, p. 95-103.*)

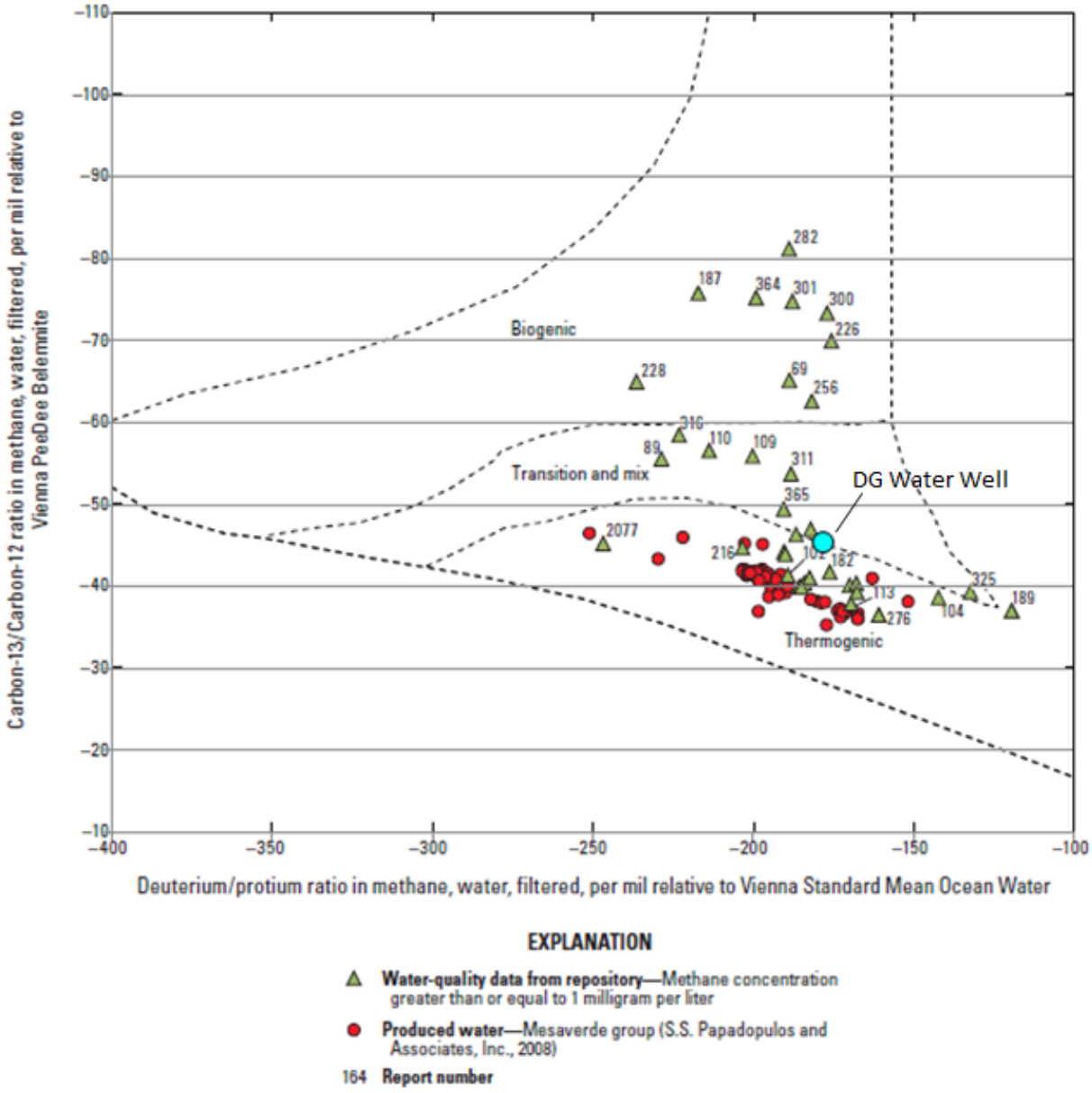

Figure 2. Graph of the $\delta^{13}C$ and δD data of the methane for the DG Water Well sample (light blue filled circle) plotted on a figure with published data from other dissolved gas samples from water wells (small green-filled diamonds) and from production wells (red-filled circles) in Garfield County, Colorado collected from 2004 through 2008 (*Thomas and McMahon, 2012, USGS, Scientific Investigations Report 2012-5198, Figure 24)*.

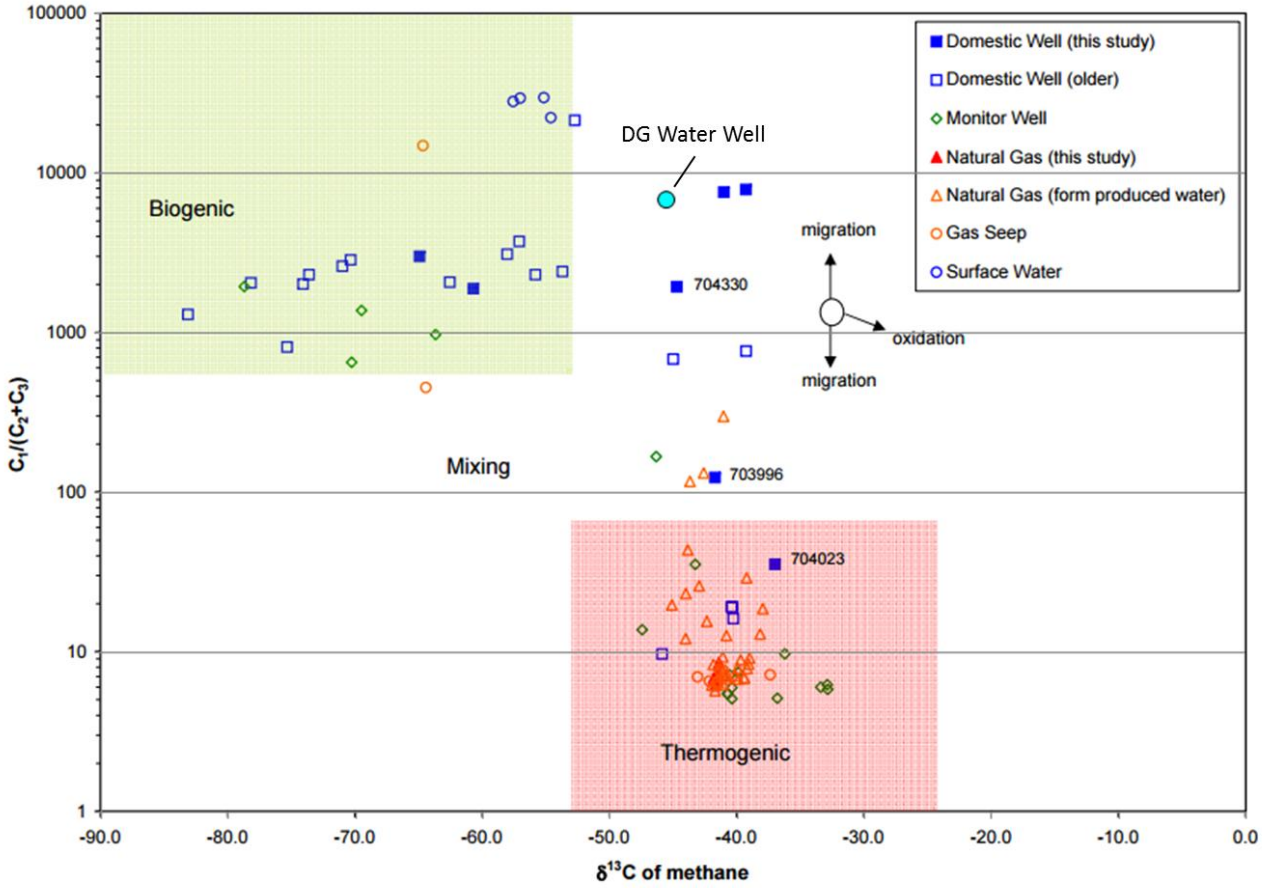

Figure 3. Graph of $\delta^{13}C$ of the methane versus the ratio of methane (C_1) over heavier hydrocarbons ($C_2 + C_3$) for the DG Water Well sample (light blue filled circle) plotted on a figure with published data from other dissolved gas samples from water wells and from production wells in Garfield County, Colorado collected from 2004 through 2008 (*S.S. Papadopulos & Associates, Inc. 2008, Phase II Hydrogeologic Characterization of the Mamm Creek Field Area, Garfield County, Colorado, Figure 4.20)*.

APPENDIX

Analytical Data Reports for Job 33299

Lab #: 584996 Job #: 33299 IS-67955 Co. Job#:
Sample Name: DG Water Well (272793) Co. Lab#:
Company: HRL Compliance Solutions
API/Well:
Container: 1 Liter Plastic Bottle
Field/Site Name: Ursa - Wasatch Bench - DG Water Well
Location: Ursa Wasatch Facility
Formation/Depth:
Sampling Point:
Date Sampled: 10/26/2016 11:45 Date Received: 10/27/2016 Date Reported: 11/14/2016

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	$\delta^{18}O$ ‰	Dissolved gas cc/L	Dissolved gas ppm
Carbon Monoxide	nd					
Helium	na					
Hydrogen	nd					
Argon	0.609					
Oxygen	6.38					
Nitrogen	48.54					
Carbon Dioxide	0.54					
Methane	43.92	-45.62	-178.7		20	14
Ethane	0.0063				0.0033	0.0041
Ethylene	nd					
Propane	nd				< 0.0001	< 0.0002
Propylene	nd					
Iso-butane	nd					
N-butane	nd					
Iso-pentane	nd					
N-pentane	nd					
Hexanes +	nd					

Remarks:
Analysis is of gas extracted from water by headspace equilibration. Analysis has been corrected for helium added to create headspace. Helium dilution factor = 0.55
*Addition of helium negates the ability to detect native helium and may negate the ability to detect hydrogen.

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Isotopic composition of oxygen is relative to VSMOW, except for carbon dioxide which is relative to VPDB. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.