



dig
Dolan Integration Group

Geochemistry for Energy

2520 55th St, Suite 101
Boulder, CO 80301
p: 303.531.2030

Hydrocarbon Gas Composition and Stable Isotopes Data and Interpretation

Job #: 16080688
Lab #: DIG-009669-009673
Client: PDC Energy
Well Name: Chestnut 21Q-321
Chestnut 21T-201
Chestnut 21Y-401
Chestnut 21Y-341
Jacobucci 32K-443
09/27/2016 Updated with Carbon Isotope Data

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Client/Well Name: PDC Energy / Production Gases
Job #: 16080688
Lab #: DIG-009669-009673

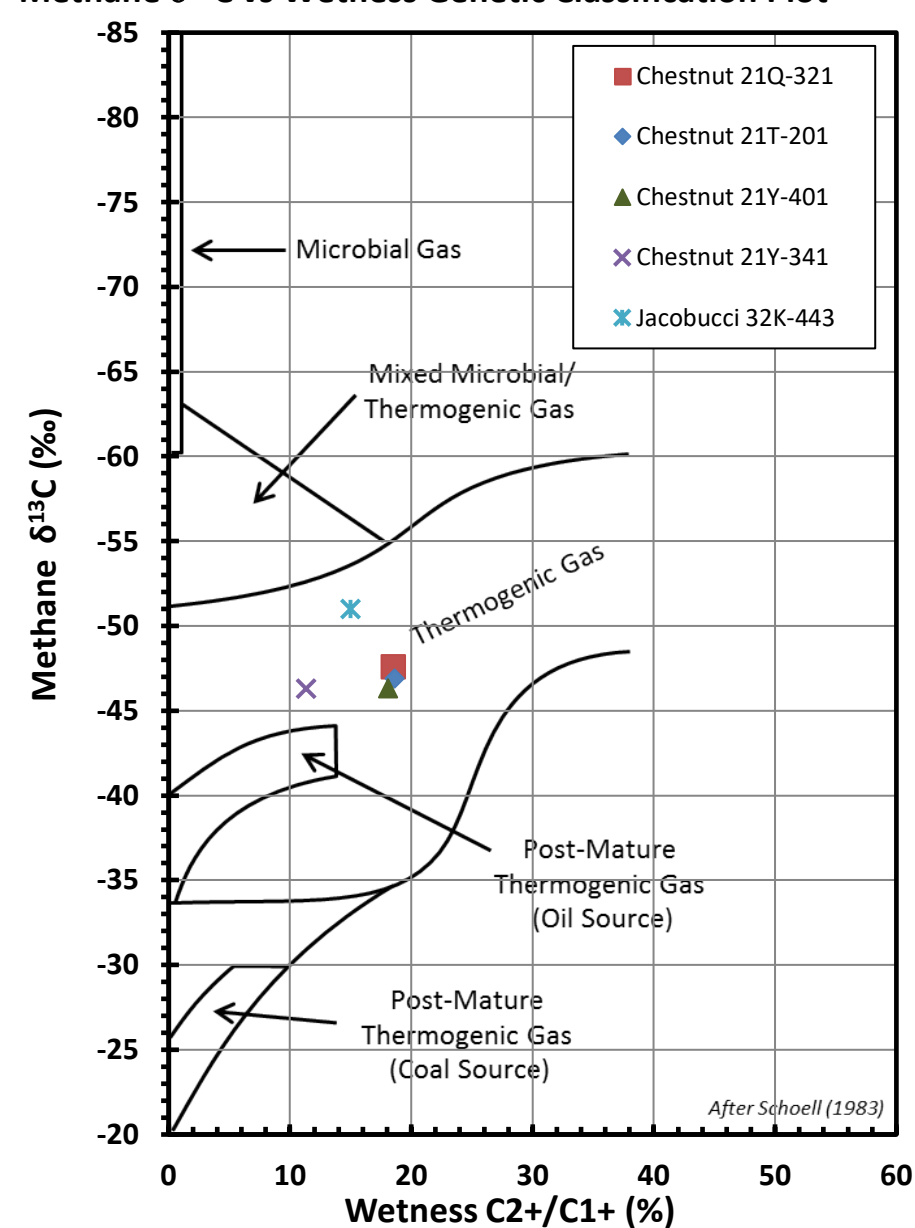
SAMPLE INFORMATION				COMPLETE GAS ANALYSIS														HYDROCARBON GAS ANALYSIS (normalized to total HC content)							
Job Number	Lab Number	Well Name	Sample Date	GC Date	N ₂ ppm	O ₂ + Ar ppm	CO ₂ ppm	C ₁ ppm	C ₂ ppm	C ₃ ppm	iC ₄ ppm	nC ₄ ppm	iC ₅ ppm	nC ₅ ppm	C ₆ + ppm	He ppm	H ₂ ppm	C ₁ mol%	C ₂ mol%	C ₃ mol%	iC ₄ mol%	nC ₄ mol%	iC ₅ mol%	nC ₅ mol%	C ₆ + mol%
16080688	DIG-9669	Chestnut 21Q-321	8/26/2016	8/30/2016	9133	700	24	805520	115856	45449	5809	11541	2183	2066	810	116	67	81.4	11.7	4.6	0.6	1.2	0.2	0.2	0.1
16080688	DIG-9670	Chestnut 21T-201	8/26/2016	8/30/2016	8864	378	nd	800586	121325	44460	5119	9819	1444	1262	353	87	9847	81.3	12.3	4.5	0.5	1.0	0.1	0.1	0.0
16080688	DIG-9671	Chestnut 21Y-401	8/26/2016	8/30/2016	7532	757	nd	812298	125412	39187	4363	7864	1509	1272	783	75	1319	81.8	12.6	3.9	0.4	0.8	0.2	0.1	0.1
16080688	DIG-9672	Chestnut 21Y-341	8/26/2016	8/30/2016	8467	877	4	877049	88565	18101	1507	2631	464	491	815	93	416	88.6	8.9	1.8	0.2	0.3	0.0	0.0	0.1
16080688	DIG-9673	Jacobucci 32K-443	8/26/2016	8/30/2016	17926	792	nd	834347	101485	32263	3062	7240	1519	1540	1172	261	214	84.9	10.3	3.3	0.3	0.7	0.2	0.2	0.1

SAMPLE INFORMATION				COMPLETE GAS ANALYSIS (Mol %)													
Job Number	Lab Number	Well Name	Sample Date	GC Date	N ₂ ppm	O ₂ + Ar ppm	CO ₂ ppm	C ₁ ppm	C ₂ ppm	C ₃ ppm	iC ₄ ppm	nC ₄ ppm	iC ₅ ppm	nC ₅ ppm	C ₆ + ppm	He ppm	H ₂ ppm
16080688	DIG-9669	Chestnut 21Q-321	8/26/2016	8/30/2016	0.914	0.070	0.002	80.625	11.596	4.549	0.581	1.155	0.219	0.207	0.081	0.012	0.007
16080688	DIG-9670	Chestnut 21T-201	8/26/2016	8/30/2016	0.892	0.038	nd	80.574	12.211	4.475	0.515	0.988	0.145	0.127	0.035	0.009	0.991
16080688	DIG-9671	Chestnut 21Y-401	8/26/2016	8/30/2016	0.752	0.076	nd	81.150	12.529	3.915	0.436	0.786	0.151	0.127	0.078	0.008	0.132
16080688	DIG-9672	Chestnut 21Y-341	8/26/2016	8/30/2016	0.848	0.088	0.000	87.795	8.866	1.812	0.151	0.263	0.046	0.049	0.082	0.009	0.042
16080688	DIG-9673	Jacobucci 32K-443	8/26/2016	8/30/2016	1.790	0.079	nd	83.323	10.135	3.222	0.306	0.723	0.152	0.154	0.117	0.026	0.021

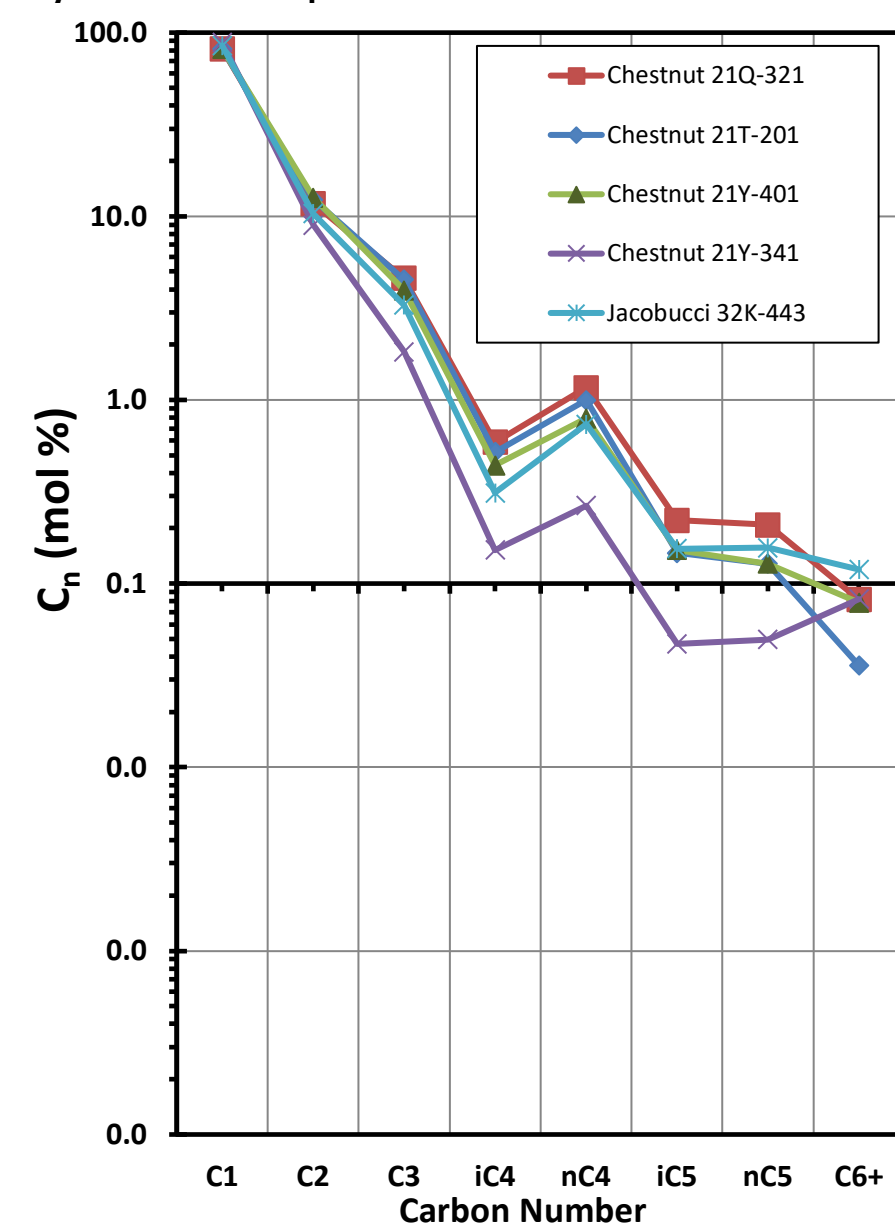
SAMPLE INFORMATION				HYDROCARBON RATIOS					STABLE ISOTOPE ANALYSIS									
Job Number	Lab Number	Well Name	Sample Date	Total HC ppm	Wetness % C ₂ to C ₅	C1/C2 mol/mol	iC ₄ /nC ₄ mol/mol	Balance Ratio C1+C2/C3-C5	Mass Spec Date	δ ¹³ C ₁ ‰ VPDB	δ ¹³ C ₂ ‰ VPDB	δ ¹³ C ₃ ‰ VPDB	δ ¹³ iC ₄ ‰ VPDB	δ ¹³ nC ₄ ‰ VPDB	δ ¹³ iC ₅ ‰ VPDB	δ ¹³ nC ₅ ‰ VPDB	δD _{C1} ‰ VSMOW	Comments
16080688	DIG-9669	Chestnut 21Q-321	8/26/2016	989233	18.5	7.0	0.5	13.7	9/22/2016	-47.6	-31.1	-27.5	-30.8	-26.9	-28.2	-27.6		
16080688	DIG-9670	Chestnut 21T-201	8/26/2016	984367	18.6	6.6	0.5	14.8	9/22/2016	-46.9	-30.9	-27.2	-30.2	-26.7				
16080688	DIG-9671	Chestnut 21Y-401	8/26/2016	992689	18.1	6.5	0.6	17.3	9/22/2016	-46.3	-30.6	-27.0	-29.9	-26.6				
16080688	DIG-9672	Chestnut 21Y-341	8/26/2016	989623	11.3	9.9	0.6	41.6	9/22/2016	-46.3	-30.5	-26.8	-28.9	-26.8				
16080688	DIG-9673	Jacobucci 32K-443	8/26/2016	982627	15.0	8.2	0.4	20.5	9/22/2016	-51.0	-34.0	-29.9	-32.7	-29.5				

* Stable isotope results based on multi-point laboratory calibration
Values in red exhibited low peak ht, interpret w/ caution
Precision d13C < 0.5 ‰
Precision dD < 5 ‰

Methane $\delta^{13}\text{C}$ vs Wetness Genetic Classification Plot

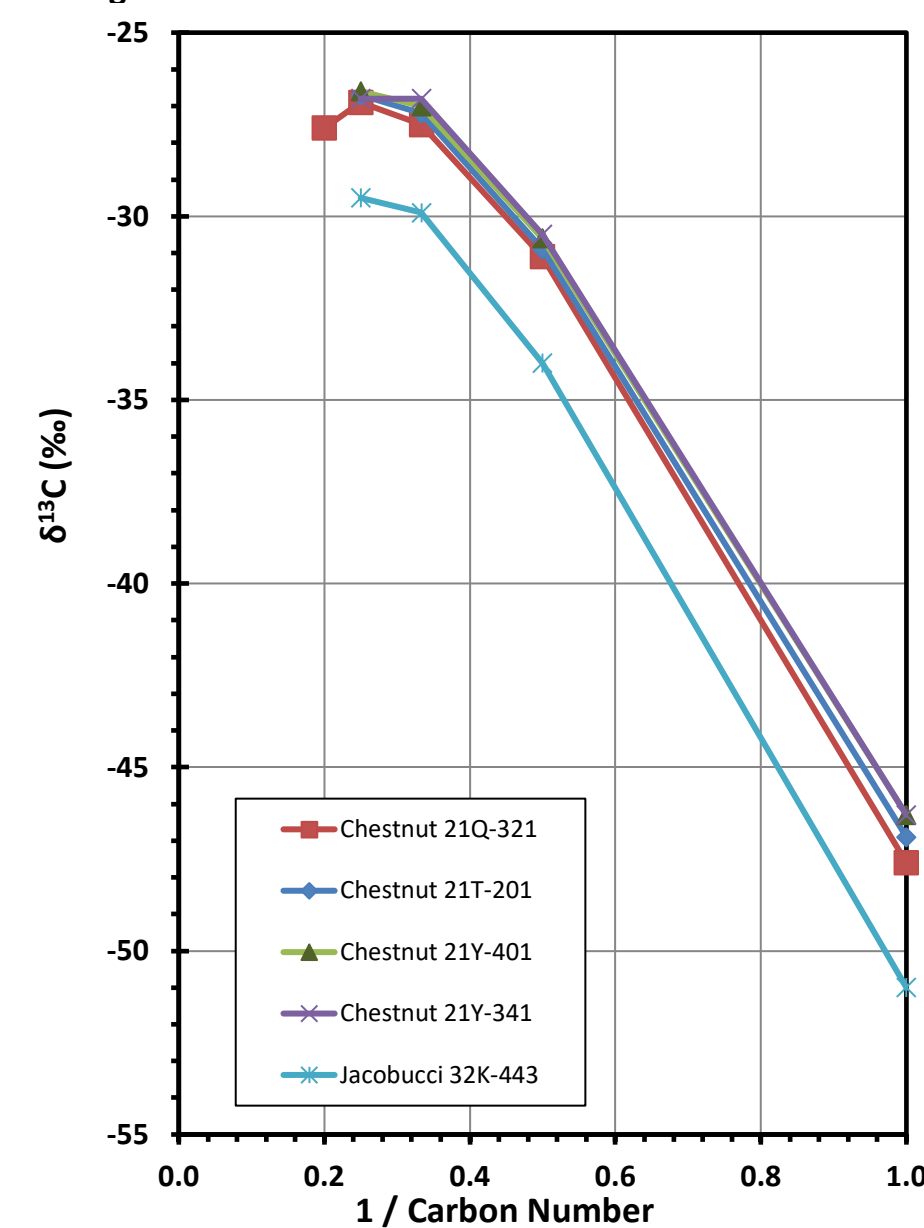


Hydrocarbon Composition Plot

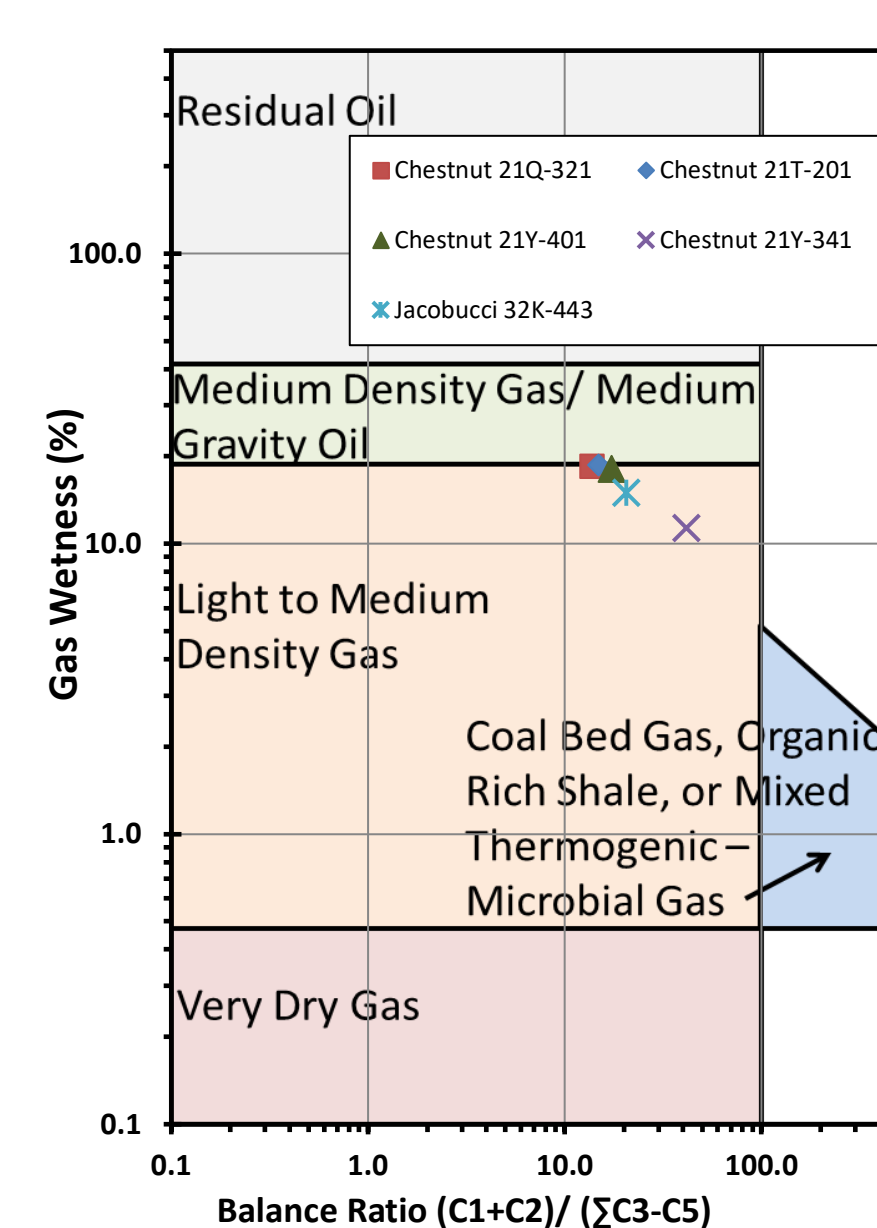


Page 3

Chung Plot

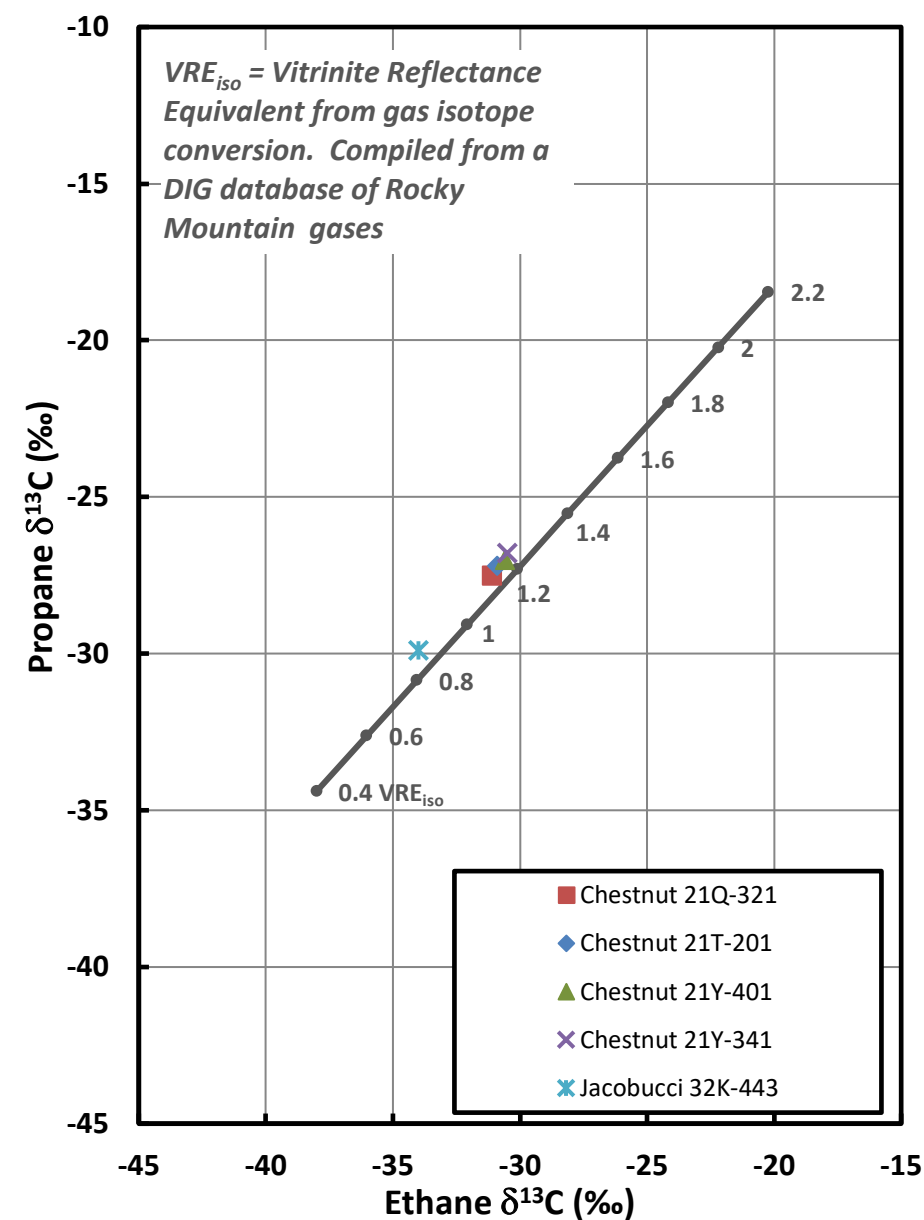


Haworth Ratio Plot - Characterization of Hydrocarbon Type



Page 4

Ethane - Propane Maturity Plot



Page 5

16080688
DIG# 9669-9673

Send Data and Invoice to:

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 Company: Olsson Associates
 Address: 4690 Table Mtn Dr. #200
Golden, CO 80403
 Phone: 303.237.2072
 Fax: 303.237.2659
 Email: jhix@olssonassociates.com

AFE #: _____
 Report Ctr: _____
 Project: PDC Bradenhead Testing
 PO #: 016-2409 Phase 300
 Location: PDC Energy - Weld Co
Chestnut / Jacobucci wells
 Sampled By: James Hix

Sample Description

Container #	Sample Identification	Date Sampled	Time	Analysis Requested						Comments
				Gas Composition* N ₂ , O ₂ , CO ₂ , He, H ₂ , C ₁ -C ₆ +	RSK-175* (see composition) N ₂ , O ₂ , CO ₂ , He, H ₂ , C ₁ -C ₆ +	with dissolved C ₁ , C ₂ & C ₃	δ ¹³ C Methane (Carbon)	δD Methane (Hydrogen)	δ ¹³ C Ethane-Pentane (C ₂ -C ₅ , if present)	
	Chestnut 21A-321	08/26/2016	09:40	✓						
	Chestnut 21T-201	08/26/2016	10:00	✓						
	Chestnut 21Y-401	08/26/2016	10:08	✓						
	Chestnut 21Y-311	08/26/2016	10:18	✓						
	Jacobucci 32K-443	08/26/2016	11:50	✓						

Chain-of-Custody Record

Signature	Company	Date	Time
Relinquished by <u>James Hix</u>	<u>Olsson Associates</u>	<u>08/29/16</u>	<u>1005</u>
Received by <u>Michael Dolan</u>	<u>Dolan Integration</u>	<u>8/30/16</u>	<u>10:05a</u>
Relinquished by			
Received by			

*Gas composition vs RSK-175- Gas composition is a basic analysis of the concentration (ppm) of gases within the headspace of the sample (headspace is created at the lab). RSK-175 is a specific analysis technique combined with calculations to give the total dissolved gas of each species in the water sample (mg/L).

Why one or the other? Gas composition gives us a quick, general look at relative concentrations and ratios (e.g., gas wetness). RSK-175 gives us an exact total of gas present in the sample (headspace and dissolved in the water). Questions? Give us a call at 303-531-2030