Gas Production Composition Determined With Direct Quadrupole Mass Spectrometer (DQMS) While Drilling.

Scott Lashbrook and Bruce Warren, Crown Geochemistry, Inc., Burns Flat, OK 73624

INTRODUCTION

The accuracy and reliability of well data has become crucial in developing oil and gas production. The use of well data ranges from reservoir evaluation to production planning. A useful parameter often overlooked due to a history of poor accuracy and reliability is hydrocarbon composition from mud gas. Hydrocarbon composition can be used as an indicator of thermal maturity and production type (liquid or dry gas). DQMS analysis of mud gas while drilling provides hydrocarbon composition with greater accuracy than other field instrumentation and with faster results than laboratory production analysis. The DQMS hydrocarbon compositions from mud gas were compared to laboratory analyses of gas production from 8 horizontal shale wells with varying production character (1316-1021 BTU). DQMS derived compositions compare very well with laboratory gas compositions. Hydrocarbon basis BTU calculated from DQMS data for 8 wells had an average error of 1.16% and a standard deviation of 1.02% from hydrocarbon basis BTU lab analysis.

METHODS

Data was collected during the routine drilling of a horizontal well. The first step in determining the composition is to integrate the raw data into an algorithm that reflects the composition of the gas phase production. This step is critical in the calculation since not all analytes are measured at the dominant peak. They are measured where interference from other gas species is minimal or non-existent as shown in Figures 1 and 2.

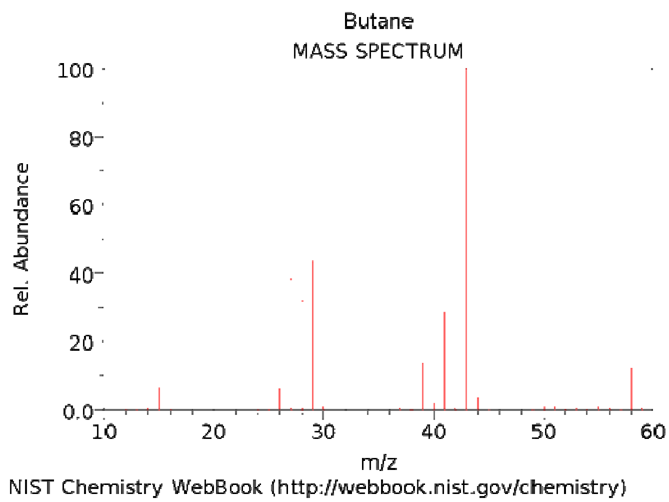


Figure 1

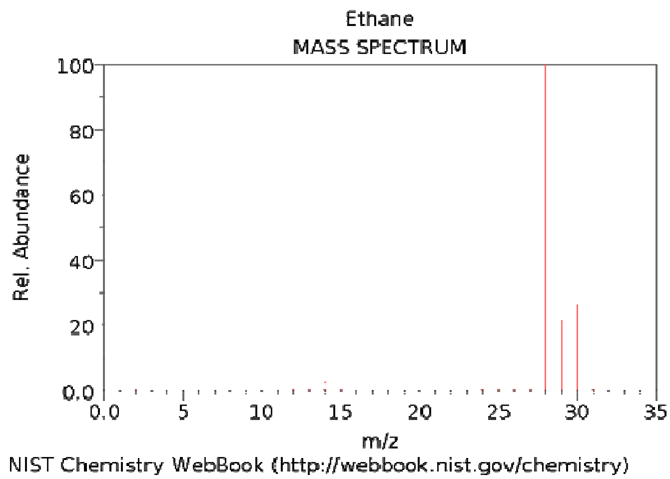


Figure 2

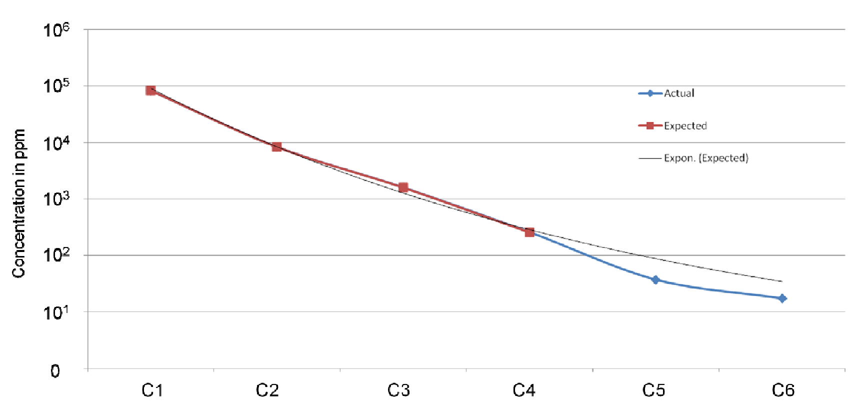


Figure 3

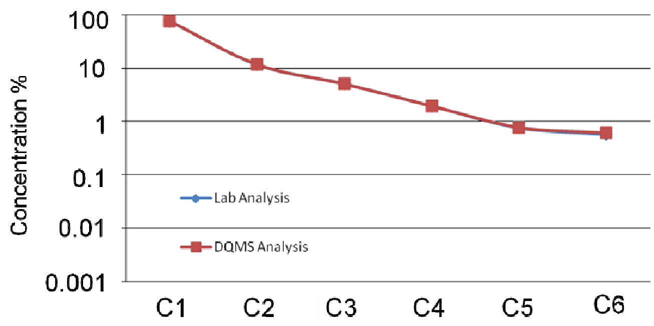
While the dominant peak for ethane is located at m/z 28 (fig. 1), we evaluate ethane at m/z 26 due to lower interference from butane at m/z 26 as seen in Figure 2. The error from butane on the ethane measurement is low. The relative abundance of butane being measured at m/z 26 is about 5 percent. The theoretical maximum error is thus no more than 10%. Mathematically however, the natural distribution of gas phase hydrocarbons is such that ethane will be in greater abundance than butane thus decreasing the amount of actual error in the reading. A practical example from a 1200 BTU gas sample would contain 11% ethane and 2% butane. Taking 5% from the butane concentration adds 0.2% to the ethane concentration of 11%. The percent error in the reading then becomes 1.82%. Therefore, the reading for ethane is over 98% accurate for this type of measurement.

Another factor included in the algorithm takes into account the increasing solubility of larger hydrocarbons to the mud system. This must be done to account for the less than 100% extraction of hydrocarbons from the mud. A 100% hydrocarbon extraction of the mud would be impractical due to the cost and time required to perform the analysis. The final factor used to determine the production composition is related to low concentration skew. The amount of gas phase hydrocarbons in the mud is directly related to the rate of penetration. Faster drilling results in higher gas volumes in the mud system. When ROP is low, heavy hydrocarbons can drop below the useable limit of the application. Since the natural distribution of gas phase molecules follows closely to an exponential function, the dominant gas phase molecules are used to generate a decline curve that estimates a correction for the skew associated with the lower abundance readings as seen in Figure 3. The low concentration species are then corrected with the residual difference between the estimated and the actual reading.

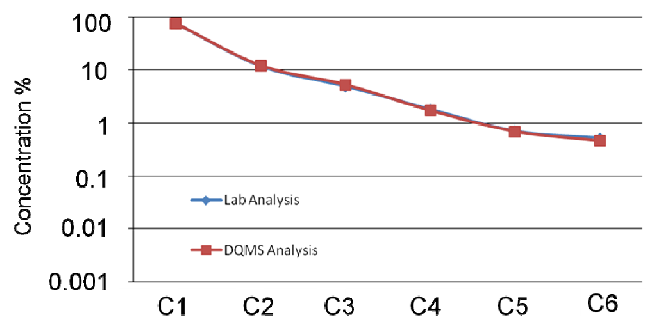
RESULTS

Below are the results of the DQMS derived composition compared to laboratory analysis of produced gas. This illustrates that the accuracy and reproducibility of the calculation. The range of tests include mature dry gas only production as well as mixed gas and liquid production. The same algorithm is applied the same way to each data set to derive the composition. The BTU is calculated on a hydrocarbon basis since CO_2 readings can be anomalous due to atmospheric and mud chemistry influences. The average error for the 8 well set was 1.16% with a standard deviation of 1.02%.

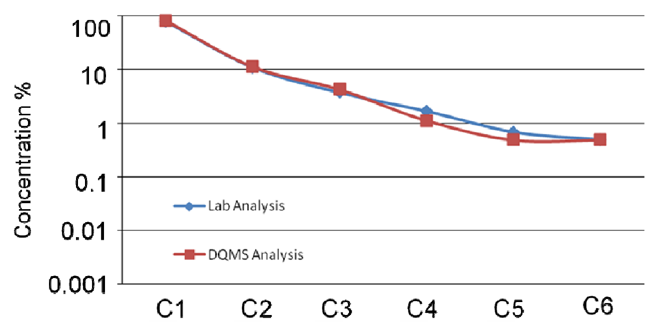
	DQMS	Laboratory
C1	76.167	75.924
C2	11.672	11.773
C3	5.065	5.088
C4	1.959	1.962
C5	0.762	0.780
C6+	0.581	0.618
BTU	1327.9	1316.5



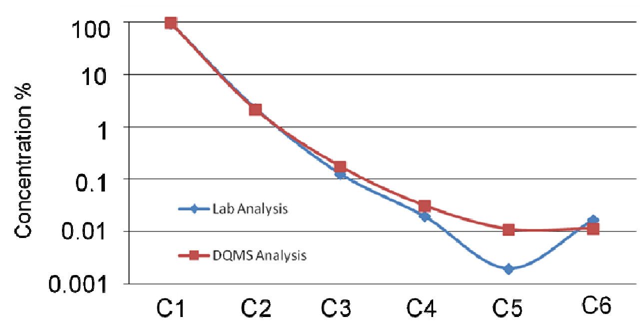
	DQMS	Laboratory
C1	77.166	77.200
C2	12.075	12.429
C3	4.983	5.370
C4	1.828	1.745
C5	0.707	0.700
C6+	0.524	0.464
BTU	1254.0	1265.6



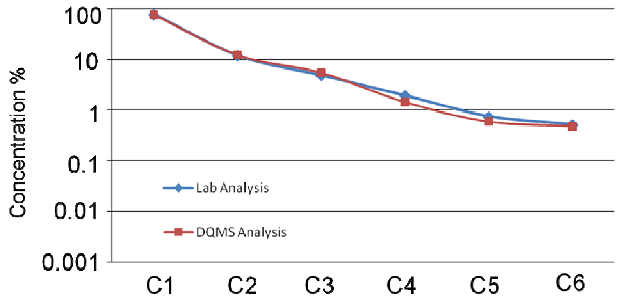
	DQMS	Laboratory
C1	81.040	80.349
C2	11.240	11.110
C3	4.239	3.737
C4	1.119	1.679
C5	0.487	0.683
C6+	0.487	0.492
BTU	1197.3	1235.5



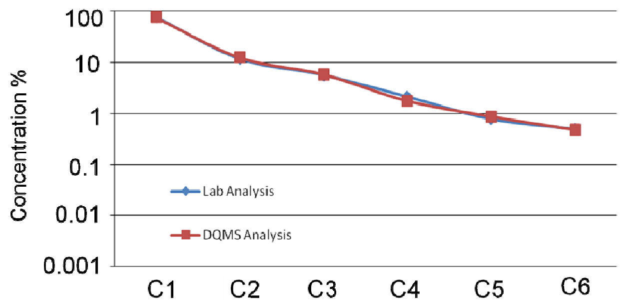
	DQMS	Laboratory
C1	95.126	94.265
C2	2.150	2.248
C3	0.178	0.128
C4	0.032	0.020
C5	0.011	0.002
C6+	0.012	0.017
BTU	1031.2	1031.0



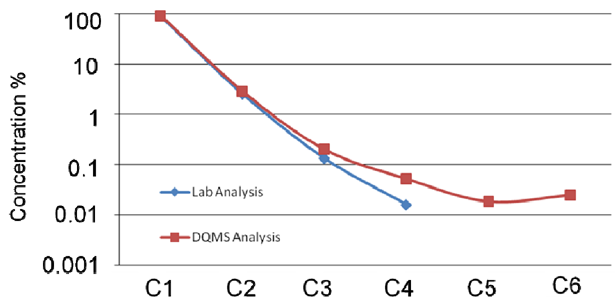
	DQMS	Laboratory
C1	77.779	77.490
C2	12.365	11.971
C3	5.523	4.805
C4	1.460	1.929
C5	0.597	0.746
C6+	0.487	0.514
BTU	1238.0	1264.8



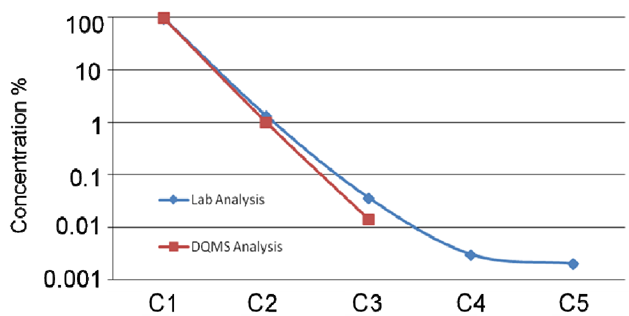
	DQMS	Laboratory
C1	75.774	76.563
C2	12.449	11.681
C3	5.798	5.634
C4	1.760	2.117
C5	0.866	0.776
C6+	0.476	0.492
BTU	1298.7	1280.3



	DQMS	Laboratory
C1	94.493	93.924
C2	2.927	2.606
C3	0.203	0.134
C4	0.053	0.016
C5	0.019	0.000
C6+	0.025	0.000
BTU	1038.6	1032.9



	DQMS	Laboratory
C1	95.388	94.799
C2	0.993	1.314
C3	0.014	0.036
C4	0.000	0.003
C5	0.000	0.002
C6+	0.000	0.000
BTU	1018.1	1021.1



*possible lab error in C5 measurement

CONCLUSIONS

DQMS mud gas analysis data collected while drilling provides a very reasonable estimate of hydrocarbon production with respect to composition and hydrocarbon basis BTU. Given the accuracy for the wide range of compositions tested, this analysis technique is suitable for early use in reservoir characterization. Given enough data points over a geographic location, DQMS derived compositions have been shown to be mappable. Further investigation of the data may provide information concerning well characteristics such as bbl/mmcf production rates.