A DISCUSSION ON CORRECTION OF GAS CONTENTS TO MINERAL MATTER FREE BASIS USING SPECIFIC GRAVITY DATA

Barry Ryan[1]

ABSTRACT

This note discusses an alternative way of correcting gas content data to a uniform base. Often data are corrected to a dry ash-free base, but this introduces errors proportional to the ash content of the original sample. It is much better to correct data to a mineral matter free base(mmfb), however this is perceived as being more difficult or costly in terms on analyses. The use of density data or an ash *versus* gas plot can provide the basis for making the mmf correction.

Barry Ryan, A discussion on correction of gas contents to mineral matter free basis using specific gravity data in Summary of Activities 2006*, BC Ministry of Energy, Mines and Petroleum Resources, pages 135-138.*

[1]Resource Development and Geoscience Branch, BC Ministry of Energy, Mines and Petroleum Resources, PO Box 9323, Stn Prov Govt, Victoria, BC, V8W 9N3

Keywords: Specific gravity, coal, mineral-matter free, gas content, air-dried basis, coalbed gas

INTRODUCTION

Coalbed gas (CBG also referred to as coalbed methane CBM) resource and reserve calculations are usually made using gas content and in situ density values (or specific gravity SG). The SG values are calculated using the as-received ash contents and by making the assumption that the measured equilibrium moisture value is the same as in situ moisture. There are a number of papers that discuss methodology and pitfalls of this approach (Mavor *et al.,* 1996). However, for comparative purposes gas content data are often normalized to a constant base, being either dry ash-free (daf) or dry mineral-matter-free (dmmf) before plotting onto a depth or pressure *versus* gas content diagram. This allows data to be compared to a single isotherm and estimates made of the relative degree of gas saturation of the various samples. However, correcting samples with varying ash contents to a common base often introduces errors, that may make the plot misleading.

The daf calculation is simple, requiring only ash and moisture analyses; but it can be deceptive if it is applied to samples with a wide range of ash contents. Ash content is not the same as mineral matter content and usually the ratio of "weight of original mineral matter" / "weight of ash after combustion" varies from 1 (mineral matter = 100% quartz) to over 1.2 (high carbonate content in mineral matter). If the ratio (WTLOS ratio) is known, then it is a simple matter to calculate the theoretical value of gas content for a mineral matter free sample. The underlying assumption that WTLOS is constant for samples of varying ash and maceral content is probably not valid and represents an approximation. If base/acid ratios, obtained from an oxide analysis of the ash, correlate with ash content then this probably means that the WTLOS ratio is also changing with ash content.

If the mineral matter free (mmfb) correction uses the Parr Equation (mineral matter = 1.08* ash+0.55* sulphur) then it requires ash and sulphur analyses. This correction is better than the daf correction but assumes constant mineral matter chemistry and consequently does not reflect changes from sample to sample or project to project. Many laboratories measure sulphur contents and use the Parr Equation to derive gas contents on a mineral matter free basis. The Equation actually assumes that a constant amount of pyritic sulphur in coal is converted to ferric oxide (remains in ash) and a constant amount of sulphur dioxide is lost to atmosphere.

It is possible to use an alternative approach in some situations. This requires a data suite with a range of ash contents and measurement of the SG of each sample on an air-dried basis (ASG). The relationship of ASG to ash has the form

ASG=1/(A-B*ash) (1) (Ryan, 1991), which can also be expressed as

1/ASG=A-B*ash (2)

The constant A= 1/(density for zero ash coal, DC)

The constant B incorporates the density of rock (DMM) and the WTLOS ratio

B slope=(DMM-DC)/(DMM*DC)*WTLOS

It is not possible using the constants A and B to derive a unique solution for WTLOS but it is possible to derive a number of possible pair solution of WTLOS and DMM from which the most realistic pair can be selected.

Data from a project (Figure 1) provides an estimate of WTLOS of 1.15. Using this value it is simple to correct all the Ash adb values to equivalent mineral matter content values and then to derive gas contents on a mineral matter free basis (Gas mmfb= gas db/(1-ash db*WTLOS)).

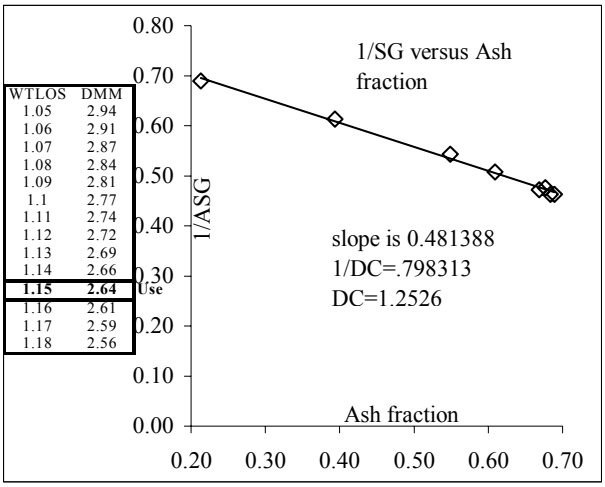

Figure 1. Plot of actual data to determine SG pure coal (DC) SG mineral matter (DMM) and WTLOS ratio.

If all samples from a project are gas saturated, then after correcting gas contents to a mmf basis, all samples should have the same gas content. This will not be the case if the samples are corrected to a daf basis. As a demonstration, a theoretical sample suite with samples all having a gas content of 10 cc/g mmfb and ash having a WTLOS ratio of 1.15 is plotted in Figure 2.

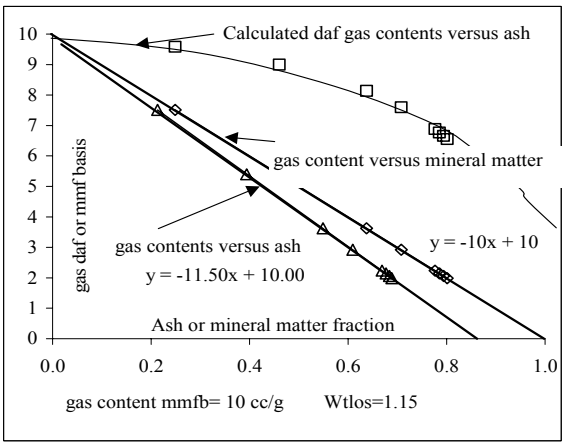

Figure 2. Theoretical data plot of gas content daf *versus* ash and gas content versus mineral matter.

The plot of gas content daf basis *versus* ash content indicates that the error introduced increases as one corrects for higher ash contents. Samples with higher ash contents after correction to a daf basis will appear to be under saturated compared to samples with lower ash contents. The line, gas content *versus* mineral matter, projects to 100% mineral matter at zero gas content and has a slope of (- gas content mmfb). The slope of the line, gas content *versus* ash, is (- gas content mmfb x WTLOS) and the line intersects the X axis at 1/WTLOS x 100. This may provide another way of deriving the value of WTLOS and making mmf corrections to gas content data.

Often variation in petrography with increased vitrinite content in low ash samples causes an increase in gas content mmfb for low ash samples and the line, gas content *versus* ash, has a bend at low ash contents with an increase in slope for low ash samples.

The SG equation (Figure 3**)** can provide values of in situ SG, if a suite of ASG data is used to solve for DC, DMM and WTLOS. This is most easily done using the 1/ASG=A-B*ash relationship and the linear plot. It is then possible to estimate in situ SG based on assumptions of free water content and void porosity. Varying free water contents and void porosity volumes can provide better estimates of in situ SG to be used in CBM resource or reserve calculations.

The measurement of ASG on coal particles crushed to 60 mesh and air-dried provides a measure of SG for samples with all free water and fracture porosity removed. On the other hand measurements of in situ SG using geophysical logs provide estimates of SG with free moisture and fracture porosity present. The difference between the two measurements provides information about the fracture porosity based on assumptions of water content (Figure 4).

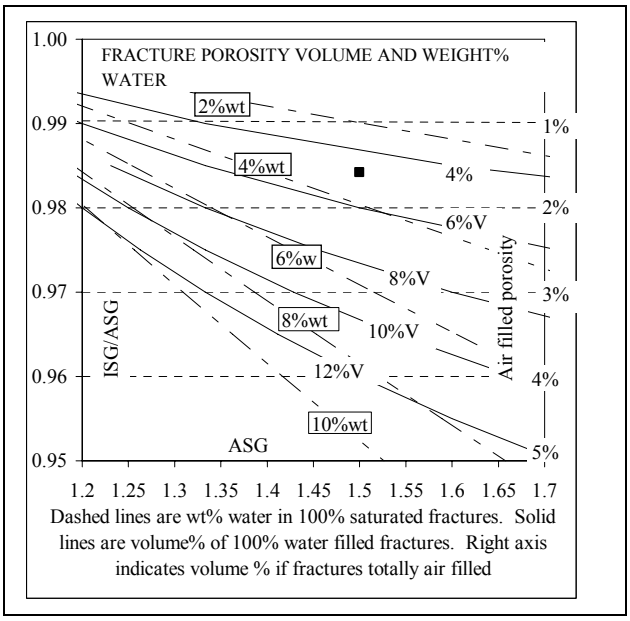

Figure 4. Calculation of fracture porosity using in situ and air-dried specific gravity.

Coal and gas content data is calculated to various bases such as as-received, air-dried and dry. Table 1 illustrates the way the various bases are calculated.

CONCLUSIONS

It is important when comparing gas content data to understand how the data were normalized to a common base. Comparing gas data corrected to a daf basis, when samples have a range of ash contents, can be misleading. It is better to compare data on a mineral matter free basis and there are various ways of making the calculation. One that is not regularly used involves measuring apparent specific gravity. This information is also very useful for estimating in situ SG when calculating reserves or resources.

If in situ and air-dried SG data are available then it is possible to make some estimates of in situ fracture porosity, which is key to permeability.

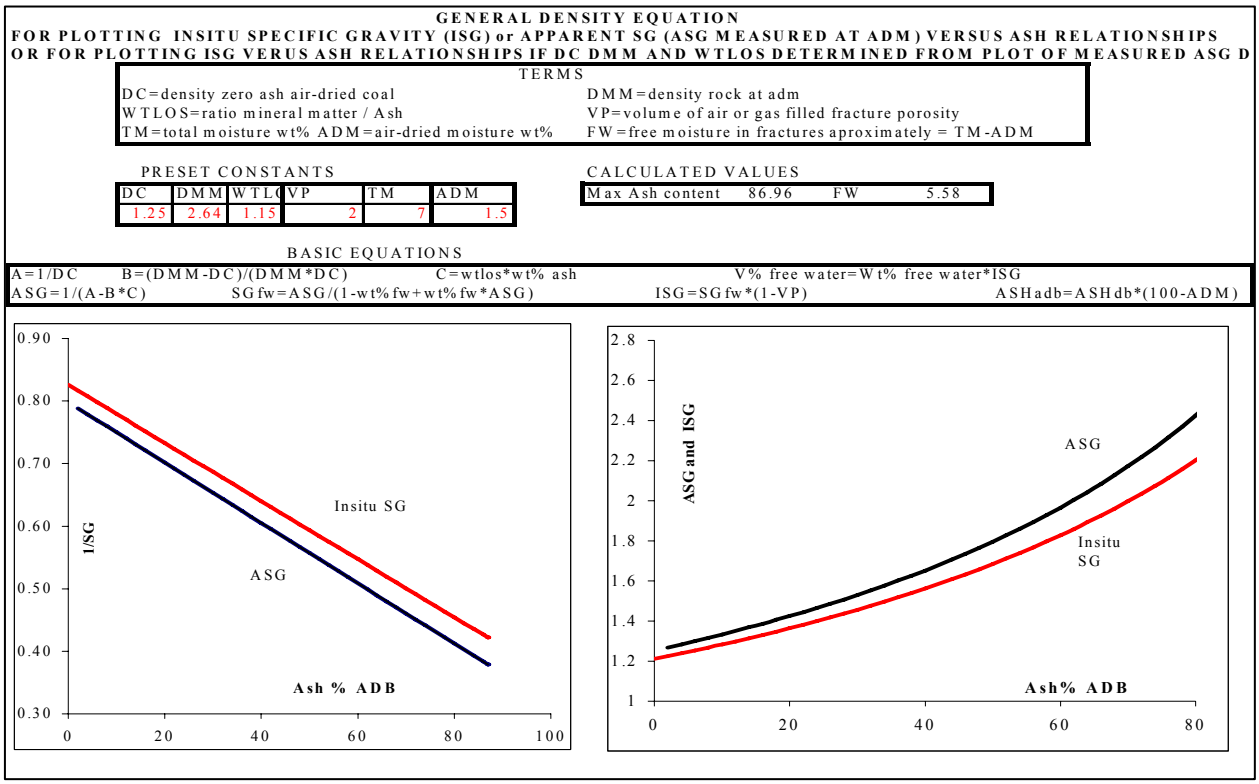

Figure 3. Equation for calculating SG at various water and porosity levels.

TABLE 1. CALCULATION OF MOISTURE CONTENTS AT DIFFERENT BASES

It is very important to know how various water contents are calculated

Example calculations		enter	
Enter As Received weight	W1	115	
Enter weight after air drying	W2	102	
Enter weight after drying at 110°C	W3	100	
Weight after heating air-dried sample to 750°C	W4	25	
Gas cc stp total	V	1000	
		result	**formula**
As received moisture	ARM	**13.04**	(W1-W3)/W1
Air dried loss	ADL	**11.30**	(W1-W2)/W1
Air dried moisture	ADM	**1.96**	(W2-W3)/W2
Free moisture as % of total sample	FM	**11.30**	(W1-W2)/W1
Free moisture	FM	**11.30**	1-(1-ARM)/(1-ADM)
Ash content adb %	Aadb	**24.51**	W4/W2*100
gas content arb	G arb	**8.70**	V/W1
Gas content adb	G adb	**9.80**	V/W2
Gas content db	G db	**10.00**	V/W3
Gas content daf basis	G daf	**13.33**	V/W3/(1-Aadb/(100-(W2-W3)/W2*100))
Gas content daf basis	G daf	**13.33**	Gadb/(100-Aadb-ADM)*100

REFERENCES

Mavor, M.J., Pratt, T.J., Nelson, C.R. and Casey, T.A. (1996): Improved gas-in-place determination for coal gas reservoirs; Paper SPE 35623, *Proceedings of SPE Gas Technology Symposium*.

Ryan, B.D. (1991): Density of Coals from the Telkwa Coal Property, Northwestern British Columbia (93L/11); *in* Geological Fieldwork 1990, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1991-1, pages 399-406.

Ryan, B.D. (1992): An Equation for Estimation of Maximum Coalbed Methane Resource Potential; *in* Geological Fieldwork 1991, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1992-1, pages 393-396.

Ryan, B.D. and Dawson, F.M. (1993): Coalbed Methane Canister Desorption Techniques; *in* Geological Fieldwork 1993, Grant, B. and Newell, J.M., Editors, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1994-1, pages 245-256.

Ryan, B.D. and Takkinen, M. (1999): In situ fracture porosity and specific gravity of highly sheared coals from southeast British Columbia (82G/7); *in* Geological Fieldwork 1999, *British Columbia Ministry of Energy and Mines*, Paper 2000-1, pages 359-372.