GeoGAS Pty Ltd

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PROPOSAL TO:

Mr. Greg Ambrose
Exploration Manager
Central Petroleum Ltd
PO Box 197 South Perth,
Western Australia, 6951

PROPOSAL ON:

Gas Content and Isotherm Testing
CBM Exploration in Pedirka Basin,
South Australia

PREPARED BY:

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DATE:

29th April 2008

M. Blanch
General Manager

Introduction

This proposal was prepared in response to a request from Mr. Greg Ambrose, Exploration Manager for Central Petroleum Ltd, for gas content testing, isotherm testing, and coal lithotype/fracture logging for an exploration program in the Pedirka Basin, South Australia. Central Petroleum will drill the coal beds of Permo-Triassic age to depths of 1,250 m. Permian age coals (Purni Formation) contain 40 m net coal across a sequence of beds ranging from 5 to >7 m thick. Triassic age coals (Peera Peera Formation) contain 20 m of net coal with beds ranging from 2 to 7 m thick (Heugh and Dawes, 2008) [1]. Drilling for coal bed methane (CBM) will be interspersed with conventional oil exploration drilling over a 3 month period. Five wells are planned, of which 3 are for CBM prospectively. The coal measures will be conventionally cored using a Hunt Rig that will produce core diameters of 66.8 mm (2 $^5/_8$ in). The wells will be maintained for subsequent flow testing.

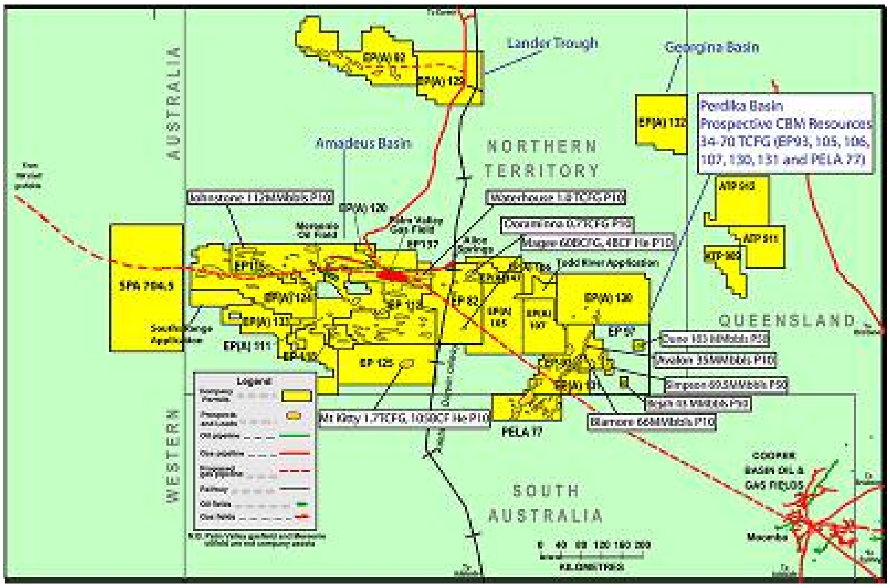

Figure 1 Location of prospective CBM exploration area in Pedirka Basin (source: http://www.centralpetroleum.com.au/exploration.php)

Scope of Work

Based on discussions with Mr. Ambrose, GeoGAS would provide:

- Training for the field component of the gas content test Q1 according to the GeoGAS method
    - Training can be conducted at one of the GeoGAS laboratories at no cost; field training would incur additional costs

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[1] Heugh, J. and Dawes, B., 2008. Revitalising Australia's Hydrocarbon Centre, Presentation prepared by Central Petroleum Ltd.

- Field measurements will be conducted by well site geologist provided by Central Petroleum at ambient temperatures[2]
- Due to the long trip time of the conventional coring (3 to 4 hours), lost gas may be a significant proportion of the total measured gas content. It is important to seal the coal in canisters as quickly as possible
- Coal will be stored in canisters without splits due to accommodate slightly larger diameter

- Provision of canisters and Q1 field desorption equipment over 3 month period
  - Estimated 15 canisters (0.8 m length) per well for 5 wells
    - Due to remote drilling locations, 30 canisters will be supplied initially with revolving replacement as required
    - GeoGAS will organise transfer of canisters from Wollongong to Alice Springs for dispatch to the rig sites
  - Two Q1 kits with 4 canister capacity each (more can be supplied if necessary)
- Gas content testing by the fast desorption method. This testing would provide and include:
  - Measured gas content Qm (Q1+Q2+Q3[3])
  - Gas desorption rate (IDR30 and derived desorption time constant)
  - Apparent relative density, relative density, proximate analysis
  - Gas quality testing for CH_4, CO_2 and N_2 from Q2 and Q3
    - Q3 commonly accounts for 70 to 80% of Qm in fast desorption method
    - Additional Helium flushed Q3 test to obtain more accurate assessment of N_2 for the CBM wells are recommended
  - Slabbing of the core prior to Q3 crushing (depending upon core quality)
  - Detailed geological logging of the slabbed core (macrolithotypes, cleat and fracturing)
    - Forwarding for petrographic analysis of maceral composition and vitrinite reflectance to recommended provider
    - Forwarding of samples for other analyses as required
  - Gas sorption isotherm testing to 10000 kPa for CH4 (and CO2 if that component proves significant at lower pressures); at least one per seam per well are recommended; based on generalised stratigraphy of Purni and Peera Peera this would be ~5 samples per CBM well
    - All testing would have an isotherm sample set aside (wrapped and frozen) so that samples can be selected after the gas content data are assessed
    - Basis for gas sorption isotherm testing to be discussed ("as received[4]" or Equilibrium Moisture basis). GeoGAS conduct both, but find that "as received" is more accurate and has been validated by well test gas desorption pressures
- Results reported to the client as preliminary (spreadsheet, as results are obtained) and as final formal report (pdf format).

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[2] GeoGAS regard desorption testing at reservoir temperature expensive, unnecessary and in the case of Q1 determination, incorrect; refer to associated document "On GeoGAS laboratory testing for coal bed methane".

[3] Refer appendix for definition of terms

[4] "As received" means the moisture content of the coal at the time of gas content testing without any air drying. It should be close to bed moisture.

In the field, it is necessary to run temperature logs and measure reservoir pressure at the target horizons. Based on discussions with Greg Ambrose, the wells will be cased and suspended with either slotted liner or cemented casing for flow testing.

The general work flow for a single well is provided below. A more detailed description of general sampling and testing is provided in an Appendix along with a document describing the GeoGAS approach to Gas Testing for Coal Bed Methane.

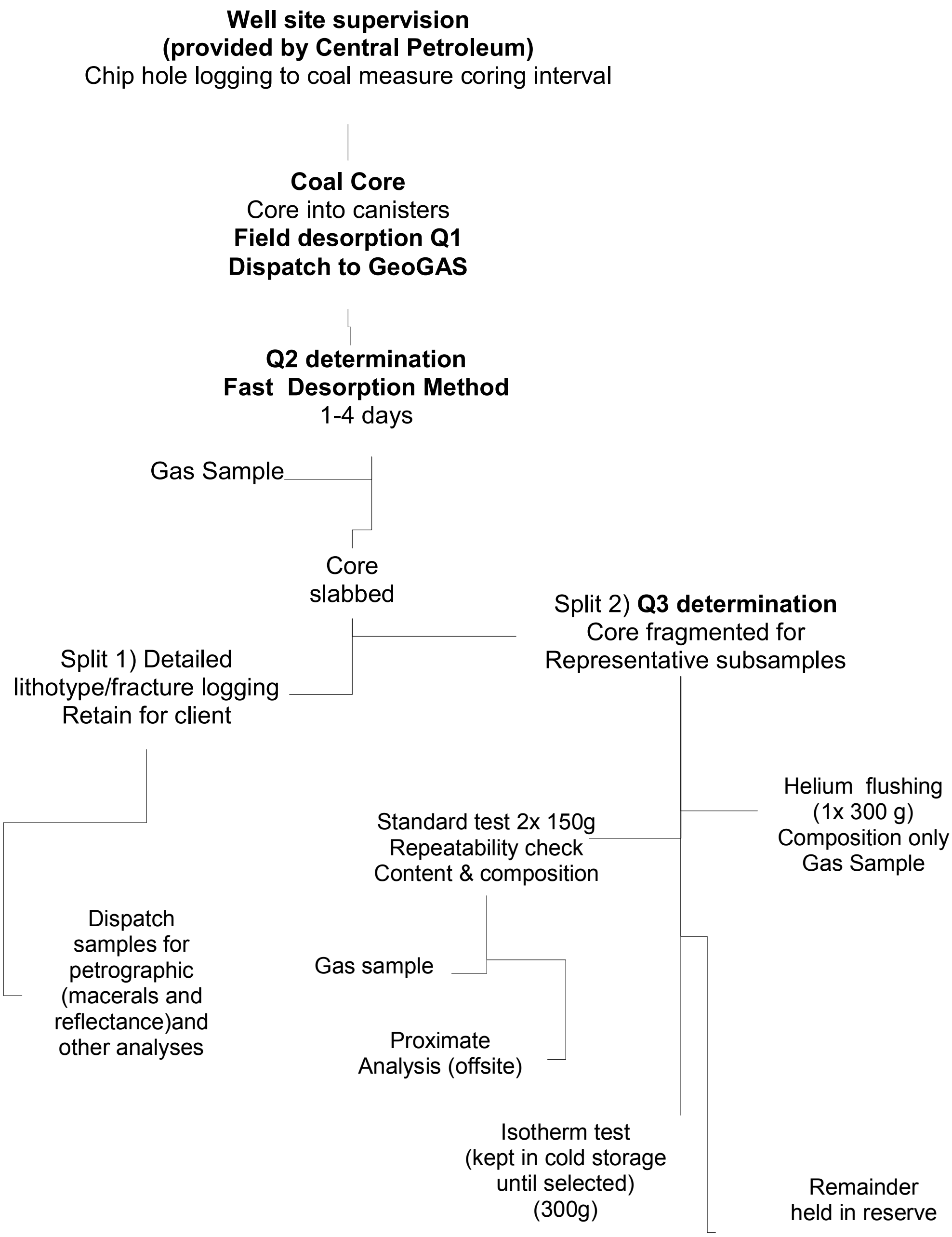

Figure 2 Work flow chart

Deliverables

Preliminary results will be issued on a well by well basis. On completion of the testing program when all relevant data has been received, a written report will be issued including the most recent methods of data validation. A validation process has been developed and is applied to each test, with the aim of identifying any anomalous tests that may have been affected by leakage. Gas content is reported at sample ash and corrected to seam ash (or other bases as requested by client).

Fees and Charges

The following schedule of rates for gas content testing and adsorption isotherms is provided. Charges will be made according to the number of tests carried out. This estimate is based on 5 wells with approximately 15 gas samples per well across 5 seams (3 in Purni; 2 in Peera Peera), all of which will be analysed for gas content and composition using fast desorption method (60 samples). An additional 3 samples per seam per well are recommended for Helium flushed gas compositions (45 samples). At least one isotherms per seam per well are recommended (15 samples). Canisters, stands and Q1 kits are based on a 90 day hire period, with at least 30 canisters in the field at any one time.

Item	Charges per test (Ex GST)	Charges per day (Ex GST)	Units		Totals (Ex GST)
Fast Desorption, non helium flush gas content	$623.04	-	60	tests	$37,382
Helium flush gas composition	$204.80	-	60	tests	$12,288
Core slabbing	$102.40		60	tests	$6,144
Canister hire	-	$6.14	30	canisters***	$16,578
4 cylinder Q1 field kit	-	$13.49	2	kits***	$2,428
Q1 Canister stand	-	$3.38	2	stands***	$608
Est. Prox/RD (non GeoGAS)	$66.00	-	120	tests****	$7,920
Adsorption Isotherm as received moisture up to 5,000 kPa	$1,203.79	-			
Adsorption Isotherm as received moisture up to 10,000 kPa	$1,686.01		15	tests	$25,290
Additional charge for equilibrium moisture	$100.00				
Detailed coal logging & reporting		$1,700.00	3	days	$5,100

***Hire period of 90 days with revolving replacement of canisters
****on both powder and lump coal

The estimated total for gas content testing and isotherm analysis for the 3 wells over a 3 month period is $113,739 ex GST ($126,250 inc GST).

These are estimates for budgeting purposes only. The testing would be reviewed with the client well by well and rationalised as necessary.

Associated charges for freight have not been included. Goods and services paid for directly by GeoGAS will attract a 10% administration fee.

Invoices would be issued on a monthly basis on 30 days credit.

Charge rates are current to 30th June 2008. For work in the 12 months beyond that date, charges would be increased according to the CPI (Sydney All Groups). This will most likely be approximately 3% and has been factored into budget estimate.

GeoGAS Personnel

Testing and analysis will be conducted through the Wollongong laboratory managed by Ms Amanda Hardwick and Dr. Joan Esterle will conduct detailed coal profiling. Technical support is provided by Dr. Ray Williams and Dr. Joan Esterle. The project will be managed by Ms Stephanie Neilsen.

APPENDIX General Sampling and Testing Approach

Gas Content Testing

The basic test methodology, whether by slow or fast desorption is similar and involves the determination of Q1 (lost gas), Q2 (desorbed gas), and Q3 (gas released on crushing). The sum of these three components is the "Measured Gas Content Qm" as defined in AS3980-1999. Gas content testing conducted by GeoGAS would be undertaken according to the standard on 0.8 m surface drilled borehole samples. All tests are conducted at ambient temperature.

The geological contractor would conduct **field Q1 testing**. To ensure accuracy in Q1 tests GeoGAS recommend field test staff be certified in the procedure. Competency based training in the procedures may be obtained free of charge at GeoGAS' Mackay or Wollongong offices by prior arrangement. Travel of GeoGAS staff to site for training would be charged at standard rate plus expenses.

Equipment for Q1 field testing and gas canisters are available for rental. GeoGAS uses an all stainless steel construction with "O" ring seal. The design has been pressure tested to 2000 psi, and each canister is pressure tested annually to 300 psi – more than twice their highest measured operating pressure. For additional quality assurance, with each test and before dispatch to the field, canisters are leak checked by pressurising to between 60 psi and 80 psi and the pressure measured the following day. Result reliability and safety critically depend upon high quality, fit-for-purpose gas canisters.

GeoGAS Canisters

Q2 testing procedures (Australian Standard AS3980-1999) are as follows:

- On receipt to the laboratory, the canister is immersed in water to check for leakages.
- The canister is noted in our canister hire registers.
- The paperwork of the sample is processed and each sample is provided a GeoGAS sample number.
- Record canister pressure using a pressure gauge.
- Connect sample to Q2 desorption cylinders. Check again for leakage.
- Open canister and bleed off gas. Record gas data, temperature, and pressure.
- If sufficient gas, take a gas sample (A) for gas composition analysis.
- Continue to log desorbed gas from Q2 (along with temperature and pressure

readings), typically 30 minutes to 4 days (depending on the rate of desorption and urgency of the result) until ready for Q3. For shortened slow desorption, the desorption period is extended with canister valves remaining open throughout.

Core will be slabbed prior to the crushing for the Q3 determination leaving an intact half for subsequent detailed logging and testing.

Core slabbing is performed at the completion of Q2 desorption. The core is slabbed along its length using a rail saw, according to documented GeoGAS procedures. One half is to be retained for the client, while the other half is dedicated to gas content testing (fully broken down and sub sampled for Q3 determination). This would include setting aside a sub sample for isotherm testing and an additional helium flush crush if required. Core trays are usually required to facilitate return of the core. *Slabbing the core is not part of our regular gas content test and incurs an additional charge.*

Rail Saw

Prior to crushing, the core (or core half after slabbing) is completely fragmented and two x 150 g representative sub samples are taken for Q3 determination. This tests repeatability of the analysis for gas content. For helium flush gas composition determination, an additional 300 g sample is taken and crushed.

Associated with the gas content test is determination of gas composition (CH_4, CO_2, N_2) and desorption rate indices (IDR30, DRI and desorption time constant for shortened slow desorption testing). Gas composition analysis would be carried out on two samples per test (Q2 and Q3 components), sample quantities permitting.

Varian CP-4900 Gas Chromatograph

GeoGAS has two Varian CP-4900 micro gas chromatographs. Gas components for analysis will be CH_4, CO_2, N_2, O_2. *If there is a requirement for testing for higher hydrocarbons or isotopic analysis, we would need to forward the samples to another laboratory at additional cost to the client.*

Helium gas flushing, which provides an accurate assessment of N_2, is recommended for all fast desorption samples. This is achieved by an additional Q3 crush, where all the measuring equipment is flushed with helium displacing oxygen and preventing oxidation of the coal. *This is not part of our regular gas content test and incurs an additional fee. It is reasonable to only flush say two samples per seam if required.*

For full seam gas content evaluation, any untested sections (coal not placed within gas canisters) are bagged and labelled with borehole and depths and accompany gas content samples.

It is of fundamental importance to specify what material has been tested. On completion of our gas testing, proximate analyses and relative density will be undertaken on both the powdered and uncrushed samples. Untested sections will also need proximate analysis carried out, so that their gas content can be indirectly calculated, thus enabling the gas content for the whole seam/s to be quantified. Relative density and proximate analysis are normally carried out by SGS unless another laboratory is nominated. Subsamples would be sent, at the request of the client, for ultimate analysis at additional cost.

Isotherms

The gas sorption isotherm describes the equilibrium, gas sorption capacity of a particular coal for varying (pore) pressure conditions. It is a fundamental parameter determining how pressure changes will effect gas content and hence gas production. They provide gas sorption properties, which are used as inputs for well production modelling and to define gas saturation. Seam temperature logging data is required for specification of isotherm tests.

The testing is conducted on either an "as received" moisture basis (moisture remaining in the coal sample, once it is removed from the gas canister, wrapped and stored in the freezer) or “equilibrium” moisture basis. GeoGAS's experience indicates that "as received” moisture isotherms match desorption pressures obtained in the field better than “equilibrium” moisture isotherms.

It is best to conduct isotherms on the same coal which is tested for gas content. More recently GeoGAS has been completing isotherms at two temperatures[5] to provide a basis

[5] Test temperatures should span the range of seam temperatures obtained from a temperature log on the exploration borehole

for temperature corrections and as a measure of sensitivity of the isotherm parameters to changes in temperatures, which may be encountered across the area.

A sub-sample is taken from each core at the time of gas content testing and stored in the freezer until completion of the program. Samples for isotherm testing are subsequently chosen after completion of gas content testing and proximate analysis to best represent the average seam ash.

Detailed Core Logging

Detailed coal lithotype and cleat measurements can would be made on the retained slab. Lithotype analysis is conducted to Australian Standards 2519 (10mm resolution) and can give an estimate of microscopic (maceral) composition. In general, the density and interconnectivity of cleating increases with increased proportion of vitrain (bright) bands which serves to increase the permeability of the coal (assuming no secondary mineralisation). Face and butt cleat spacing, pervasive joints, broken or crushed core and secondary mineralisation are also recorded.

Other tests

At the request of the client, gas samples from selected canisters can be collected and sent for further analyses, provided there is enough gas to test. It is recommended that these are taken from a helium flushed Q3 test by fast desorption method. The costs of these analyses would be charged directly to the client by the testing company. Similarly, samples can be forwarded for petrographic analyses of maceral composition and vitrinite reflectance, or other tests as required.

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11th April 2008 (R. Williams)

On GeoGAS Laboratory Gas Testing for Coal Bed Methane

GeoGAS undertakes two basic tests in support of gas resource and reserves assessment – gas content testing and gas sorption isotherm testing. Gas testing is aimed at providing near, model ready data for gas production, resource and reserve assessments.

In the discussion that follows, the reader is assumed to be familiar with gas content terminology basics (Q1, Q2, Q3 – refer AS3980-1999) and gas sorption isotherm basics (Langmuir equation).

GeoGAS's fast desorption method was developed in 1993 in response to the need for rapid result turnaround (1.5 hours with gas analysis) for coal mine safety applications. Since that time, the method has been extended to coal mine and coal bed methane exploration programs, utilising the validation methods developed to ensure a low risk of error in the coal mine gas safety applications.

Internal and external research (collaborative BHP, CSIRO, GeoGAS) into the fast desorption technique has been undertaken and publicly reported in ACARP reports C6023 (December 1998) and C8024 (June 2003)
http://www.acarp.com.au/Completed/Underground/CompUGVentilation.htm

GeoGAS's fast desorption method is by far the most widely used in Australia with over 20,000 samples being tested from its Wollongong and Mackay laboratories. In addition to the gas content measurement ("Measured Gas Content, Qm" as per AS3980-1999) the method inherently determines gas quality, gas desorption rate and apparent relative density.

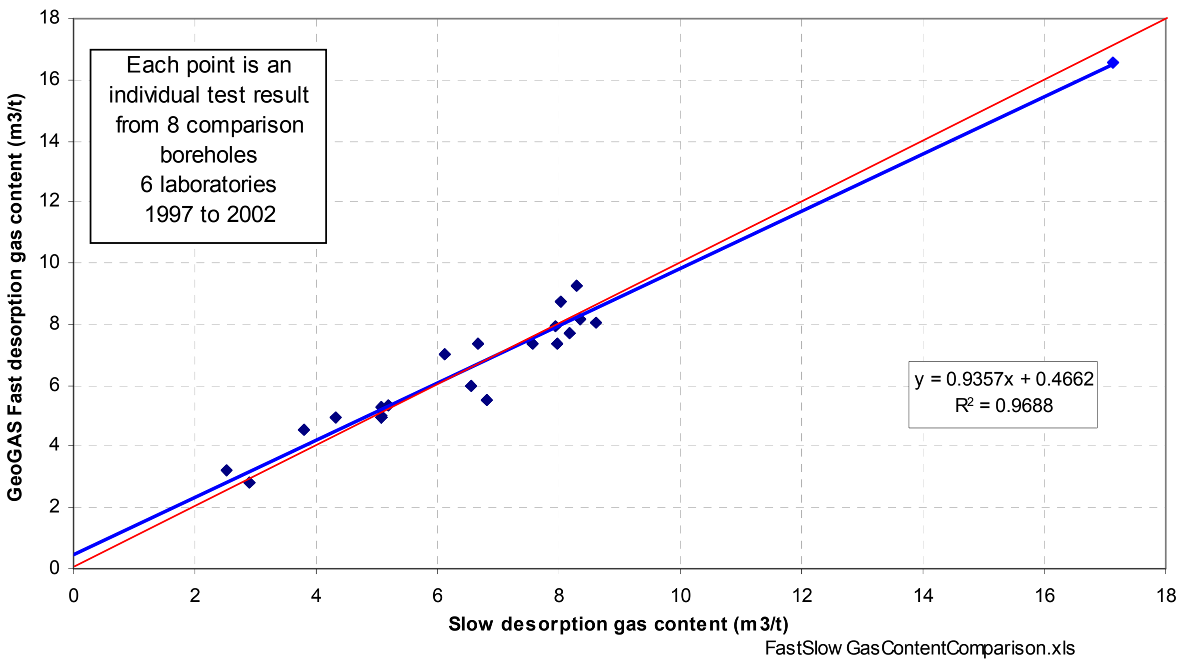
Traditionally, the coal bed methane industry has used the slow desorption method of gas content testing developed in the United States (USBM, GRI), where the gas is allowed to desorb to near atmospheric, equilibrium conditions. At the completion of this stage, the coal is either, crushed to determine remaining gas or simply taken off test. The main reasons the slow desorption method is preferred in the US are historical (they did not have a compelling need to develop a fast method) and that it provides a particular measurement of gas desorption rate. This is the desorption time constant (tau), the time taken for 63.2% of the gas to desorb from the intact core. Until quite recently, the US has not embraced the fast desorption method.

In April 2003, GeoGAS published the results of an ACARP project (C10008) “Improved Application of Reservoir Parameters”. Included in that study was treatment of the desorption time constant (tau), in essence saying:

- From modelling sensitivity studies, gas production rates are not all that sensitive to tau.
- Tau is empirically related to GeoGAS’s IDR30 desorption rate index, so values of tau for gas reservoir modelling are reasonably forthcoming
- Tau is an imprecise term, where it is not clear if the desorption time starts with Q1 or Q2 and includes Q3 in its assessment of the total gas. It is also dependent on the vagaries of core diameter.
- Diffusion coefficient can be backed out of the data, but for application in ECLIPSE CBM, a less précis shape factor needs to be included (GeoGAS’s SIMED II simulator uses tau).

Not withstanding the above, values of tau can be determined from a shortened slow desorption method, where the 63.2% of the gas desorbs in under say 10 days. This assumes continuous desorption of gas from the canister, but some practices actually turn off the gas canister overnight, thus upsetting the desorption rate, but avoiding loss of any CO_2 in solution. (AS3980-1999 mandates the fast desorption method if the CO_2 concentration is greater than 20%). CO_2 is common in Australian coals.

It can be argued that the slow desorption test is more susceptible for small leaks over time and therefore more error prone. Regardless, direct testing with other laboratories has produced quite similar results.



Another practice emanating from the US is the measurement of gas content at reservoir temperature. It is claimed that a more accurate Q1 is determined by undertaking field measurements at reservoir temperature. While it is true that temperature does have a significant effect on desorption rate, application of this approach in Australia can introduce even greater errors due to increased lost gas time (waiting for temperature to stabilise), and the assumption that the core at the time of pulling is at reservoir temperature. In the latter case, the core can be within the inner tubes for up to 2 hours, exposed to circulating drilling fluid that is quite cool compared to reservoir temperature. So at the deemed time of gas desorption, the core temperature will most likely be closer to the circulating fluid temperature. Whether or not this is taken into account, Q1 provides only an approximation of lost gas, as the standard method assumes (incorrectly) the gas desorbs at an unrestricted rate regardless of its state of confinement and reservoir pressure. Q1 determinations are mostly about minimising the error, and that involves making the lost gas time as short as possible (10~20 mins) by wireline retrieval and rapid handling on the surface.

In the application of the results to modelling and assessing gas saturation, the Measured Gas Content Qm needs to be corrected to the Total Gas Content Qt, an absolute measure of the gas content of the coal, and one that is required as input to gas reservoir modelling and gas saturation. (Isotherm Langmuir coefficients are also reported at absolute zero pressure for modelling inputs). In the ACARP research project C10008, the method of determining the additional gas (Q3') for GeoGAS's test is described as part of the research.

The fast desorption method is well accepted in the Australian coal mining industry and is becoming increasingly accepted in coal bed methane applications. Local CBM clients using the fast desorption method are Arrow Energy, Eastern Star Gas, Molopo, Anglo Coal Dawson CBM and Upstream Petroleum. Getting fast turnaround of results is highly appreciated and was one reason that the BHP Billiton CBM group asked GeoGAS to set up our fast desorption gas content test facility in support of their work in China. In addition to an operating laboratory in China, our method is also licensed to Petrologic for CBM use in Canada.

Gas saturation, as defined from laboratory testing using the gas content test, gas sorption isotherms plus field pore pressure and reservoir temperature, is a critical production parameter. The gas sorption isotherm is affected by a number of parameters, and one of the most important is moisture. The higher the moisture, the lower the gas sorption capacity. It is important that the test be conducted under moisture conditions similar to "bed moisture". The normal approach is to undertake the testing after bringing the coal to "equilibrium moisture" (EqM). Field results show that the EqM based testing gives critical gas desorption pressures much higher than realised and that frequently, measured gas contents plot above the isotherm – an impossibility for desorbable gas. An in depth assessment of this problem is contained in ACARP report C10008.

Much better correlation with field results is obtained when gas sorption isotherms are tested under "as received" conditions. By "as received" it is meant the moisture conditions of the core at the time of fast desorption gas content testing, with a sub sample being taken, wrapped and frozen before any drying can take place. It is possible that the EqM method being applied to finely ground coal actually results in more water being bound to the surfaces of the coal particles.

In any event, GeoGAS have the equipment to test at both EqM and "as received".

The fundamental purpose of the testing is to provide data that can be readily used in downstream applications for resource and reserve assessments and modelling of gas deliverability. GeoGAS have been the most extensive users of the SIMED II gas reservoir simulator (since 1994) and as such we tend to be the "clients" of the data we produce. Testing, validation and data handling is therefore set up in a way that facilitates this process.

To better ensure more ready acceptance of data for reserves certification by US company's, the Australian CBM industry has tended to follow "by rote", a number of "holy grails" coming out of the US. While a lot has been learned from the US, significantly a number of their premises have been shown not to readily apply in Australian conditions.

A few such "holy grails" are:

- *Pore pressure plus the gas sorption isotherm will give a good gas-in-place estimate.* This is no longer generally believed but was popular in the 1990's and resulted in some quite erroneous assessments of gas-in-place. Australian coals are commonly under-saturated, and GeoGAS experience is that gas production from saturations less than 70% is quite difficult.
- *The fast gas desorption method is unsuitable for CBM and not recognised by US certifiers*. Netherland and Sewell Inc. are quite familiar with our method having certified acreage using results from Arrow Energy. There is good equivalence in results, the desorption time constant can be derived from the GeoGAS IDR30. The fast desorption method overcomes problems posed by solution of CO_2 in water.
- *Gas content testing needs to be undertaken at reservoir temperature*. For field Q1 measurements, it is argued to be no more accurate (and probably much less so) than testing at ambient conditions. Minimisation of Q1 time is the most critical factor. Given the relative lack of sensitivity to variation in tau across the range of uncertainty as defined from GeoGAS's IDR30 index, the added expense involved in getting a better tau is arguably not worth the trouble.
- *Gas sorption isotherm testing must be undertaken under equilibrium moisture conditions*. Reliably knowing the gas desorption pressure is a key parameter, and regardless of what method is used, it should be validated against gas desorption pressures assessed from pumping down test and production wells in the field. The far greater agreement is with isotherm testing conducted under moisture conditions in the coal at the time of gas content testing. Because GeoGAS take a sub sample for testing at this time, we call that our "as received" basis.