Interpretation of Ground Gas Purge and Recovery Tests

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Scope

Investigate the behaviour of gas in the subsurface by analysing continuous time series data from a variety of sources to better understand the driving processes for gas generation and migration.

OBJECTIVE

Analyse purge and recovery test data to determine whether diffusion can be used to explain the observed gas profiles.

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INTRODUCTION

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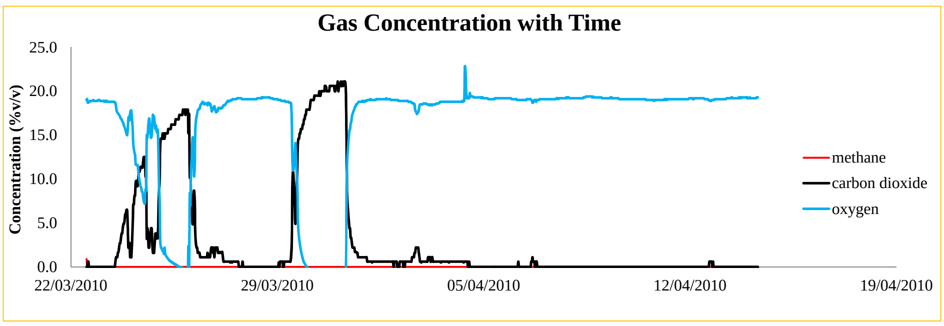
GasClam

- Portable, unmanned gas monitoring device
- Allows for long term gas monitoring
- Can measure methane, carbon dioxide and oxygen concentrations as well as atmospheric pressure and temperature. Optional CO, H2S and VOC's



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What are Purge and Recovery Tests?

- Use data to calculate a gas flow rate
- Used as an indication of active gas generation at a site
- Purge borehole with inert gas (Nitrogen)
- Seal and monitor rate of recovery of gas into borehole

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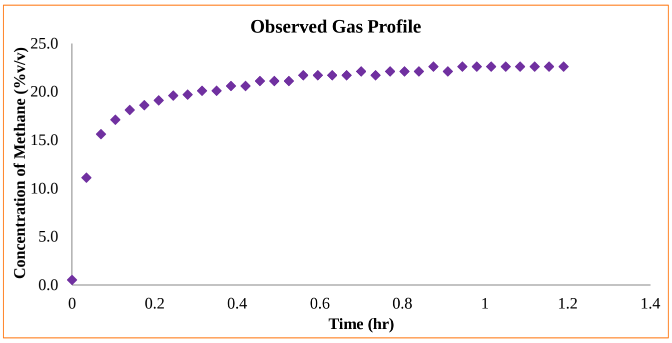
Observed Gas Recovery Profile



- Curve similar to a typical diffusion curve
- Data plotted as early time series
- Seen to stabilize within first couple hours

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Types of Flow

Advective Flow	Diffusive Flow
Darcy's Law	Fick's Law
$J = -\frac{k}{\mu} \nabla P$	$J = -D \nabla C$
Pressure Gradient	**Concentration Gradient**

Fick's Law of Diffusion

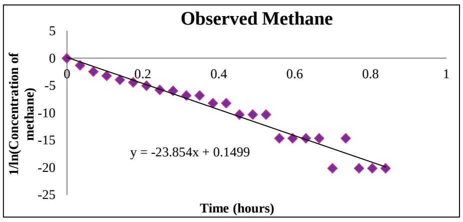
- Ficks law: $J = -D\Delta C$
- Second law: $\frac{\partial \emptyset}{\partial t} = D \frac{\partial^2 \emptyset}{\partial x^2}$
- Solution to Fick's law that most closely simulates the conditions of the purge and recovery test: $C_t = C_0 e^{\frac{-a^2}{4Dt}}$

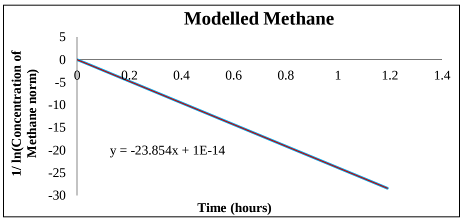
The diffusion coefficient is constant and the radius of the cylinder is defined

The initial concentration is zero

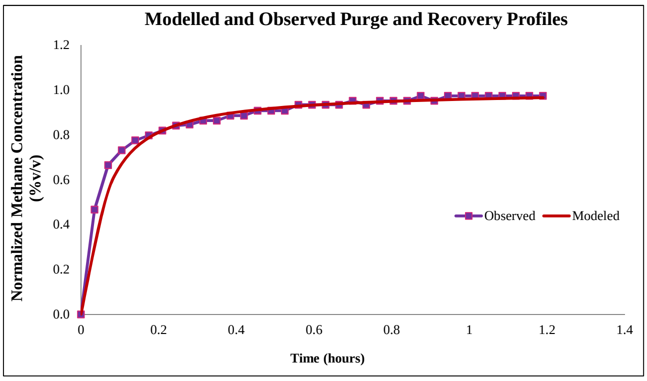
Diffusion Coefficient

- Diffusion coefficient: '*the rate at which a diffusing substance is transported through a volume of space while a concentration gradient is present*'
- Diffusion coefficient found by the gradient of the linear relationship of the natural log of the gas concentration through time
- Modelled and observed curves are matched by solving for the diffusion coefficient





Modelling



Observed and modelled curve 'matched' by diffusion coefficient

Results

Borehole	Max Observed Concentrations CH4	Diffusion Coefficient of CH4 (m^2/hr)	Correlation Coefficient between observed and modelled CH4	Max Observed Concentrations CO2	Diffusion Coefficient of CO2 (m^2/hr)	Correlation Coefficient between observed and modelled CO2
IRBH02	7.4	0.0040	0.95	2.0	0.0032	0.82
MWBH04	23.2	0.0037	0.97	4.8	0.0031	0.94
MWBH12	7.0	0.0017	0.70	8.4	0.0021	0.74
166RH2	2.7	0.0012	0.83			
290BH6				3.0	0.0004	0.79
291WS109	31.2	0.0050	0.93			
166WS2				2.4	0.0011	0.94
229WS4				2.8	0.0008	0.67
279WS101				2.6	0.0004	0.92
279WS109				2.9	0.0003	0.91
279WS105				6.3	0.0023	0.99
211BH01	61.7	0.0023	0.99	39.2	0.0023	1.00
211BH02	13.9	0.0010	0.97	11.9	0.0009	0.97
290BH06				3.0	0.0007	0.69
Average (mean)		0.0027	0.91		0.0015	0.86

Free air phase diffusion coefficient of CO_2 (m^2/hr)	0.050
Free air phase diffusion coefficient of CH_4 (m^2/hr)	0.054

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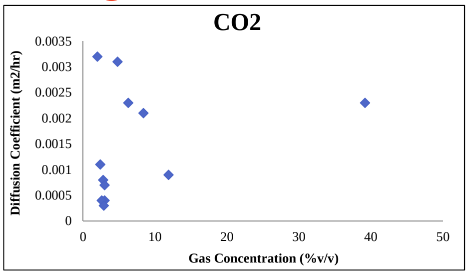
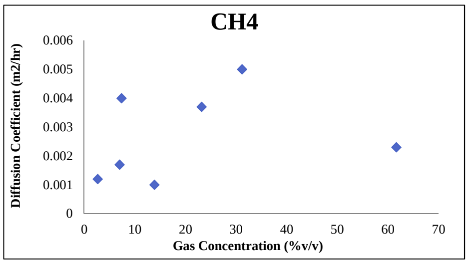
Lack of correlation between diffusion coefficient and gas concentration



Correlation Coefficient for Carbon Dioxide = 0.27



Correlation Coefficient for Carbon Dioxide = 0.24

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Gas filled porosity or effective porosity

$$D_{ij}^{e} = \tau \theta_G D_{ij}$$

Tortuosity, Effective Porosity

Borehole	Material of Surrounding Ground	Calculated Effective Porosity Range (%)	Literature Effective Porosity Range (%)
IRBH02	Glacial till and sandstone	15 - 17	12 - 41
MWBH04	Made ground - ash and clinker	14 - 16	1 - 25
MWBH12	Made ground - ash and clinker	7 - 10	1 - 25

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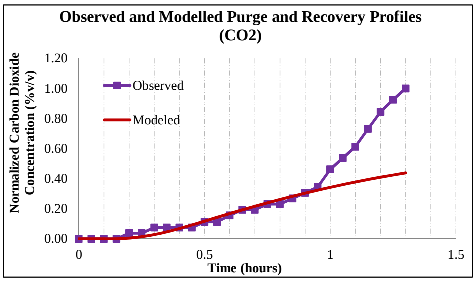
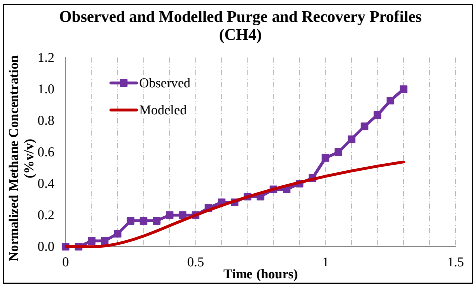
Advective Flow (Pressure Driven)





- Site known to have advection driven flow
- Poor fit of observed data to modelled curve
- High deviation away from the modelled curve especially after the early time monitoring data

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Conclusions

- Purge and recovery tests can be used to calculate the diffusion coefficient and effective porosity of the surrounding material around a borehole
- Diffusion coefficient dependent on the effective porosity
- Advection driven flow differs from the observed diffusion gas profile, area for further research
- Purge and recovery gas profiles are diffusion based flow rather than advective flow, not an indication of active gas generation

Further Work

- Describe how the observed profiles vary from the modelled diffusion curves when active gas generation is occurring
- Look further into the surrounding geology of the borehole and how this relates to the results

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