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THE EFFECT OF AIR COLUMN IN TRANSPORT CANISTERS ON MEASURED GAS CONTENTS

Naj Aziz and Ali Mirza

ABSTRACT: Canister desorption is a widely used technique to measure the gas content of coal. The gas content data when normalised to volume / weight and multiplied by coal seam mass is used to estimate the gas in place in an area around the cored hole. However the gas content and the percentage of each constituent are likely to be influenced by trapped air in the canister at the time of the coal enclosure and subsequent sealing. Freshly cored coal samples were collected from three mines, mining coal from the Bulli seam, Sydney Basin. The underground mines were Appin West, West Cliff and Tahmoor. The research programme spanning a period of four years, focused only on the influence of the entrapped air in the canister on coal gas percentage of each constituent. It was found that the percentage of each coal gas constituent was influenced by the trapped air in the canister space. The effect of trapped air was extended to the component percentage of the gases in the crushed coal samples, normally used for the estimation of Q3.

INTRODUCTION

Canister desorption is a widely used technique to measure the gas content of coal. The gas content data when normalised to volume /weight and multiplied by coal seam mass is used to estimate the gas in place in an area around the cored hole. However the gas content and its components are likely to be influenced by the presence of trapped air column in the canister, particularly when the canister is not fully occupied by the coal column and the trapped air, if not removed, may likely to be a concern.

Gas composition has been widely used to mean the percentage of each gas in a mixture of gas liberated from solid intact coal. This is not an appropriate phrase to be used when dealing with gas content measurement using canisters. The use of the phrase "gas component percentage", is an acceptable terminology as it refers to the percentage of each gas in the canister space, which may be influenced by the trapped contaminant air

Three systems of countering the influence of air column on the gas content of coal have been recognised in some gas processing laboratories are (a) by neutralising the canister air by flushing the air with helium gas; b) by calculating the level of air components in the canister and then recalculate the gas content of the gas in the canister, and c) by filling the air space with inert solid blocks and flushing out the rest of the remaining air with inert gas. Polymeric solid blocks rods are known to be used for canister's unoccupied space filling, as these rods do not react with coal gases. No consideration has been given in this paper on the issue of water vapour correction as the objective of the paper was primarily for coal gas component percentages analysis and its variations with trapped air contaminants.

While all these techniques are used, however, no studies have previously been reported to scientifically examine the impact of the air trapped in canisters on the overall estimation of (a) the gas content of coal (Q_m), where $Q_m = Q_1 + Q_2 + Q_3$, (b) coal gas component percentages, (c) component percentages of both Q_2 and Q_3 . This paper reports on the findings of the study, and demonstrates the importance of eliminating or flushing out air pockets in canister columns.

MEASUREMENT OF GAS CONTENT OF COAL

Measurement of the gas content of coal samples involves three stages of Standards Australia (1999),

- (i) Determining the gas lost from the coal sample during core sample recovery (Q_1),
- (ii) Measuring the gas desorbed from the coal sample, while sealed in a desorption canister (Q_2),

(iii) Measuring the gas released from a coal sub-sample during crushing (Q3).

The gas content measured during the above listed stages is added together to give the total measured gas content (Q_m) as:

$$Q_m = Q_1 + Q_2 + Q_3$$

Q_m represents the total volume of gas released per unit mass of coal when the ambient gas partial pressure is maintained at one atmosphere. Given the potential for variable temperature and atmospheric pressure conditions during gas content measurement and differences in the mineral matter content of the coal samples, the results are typically normalised with Q_m being reported in NTP (20^o C and 101.325 kPa) and 10% non-coal matter (NCM) (Close and Erwin 1989 and AS, 3981-1999).

Two desorption methods are used in Australia, the fast and slow desorption methods, to directly measure the gas content of coal samples, as described in Australian Standard AS3980 (1999). Q₁ is an estimated quantity of the gas component in coal; it is generally accepted to be the least accurate component of Q_m (Mavor *et al.*, 1992; Diamond and Schatzel 1998; Diamond *et al.*, 2001). The desorbed gas component (Q₂) is a measure of the volume of gas released from a coal sample whilst contained in a desorption canister. The duration of the Q₂ test may be short in the case of a fast desorption method less than one day or much longer in the case of slow desorption testing, not less than five days.

The crushed gas component (Q₃) is a measure of the gas liberated from a coal sample following crushing. Following completion of the desorbed gas test the coal core is removed and a representative sub-sample collected and sealed into a crushing or grinding mill. Following crushing the volume of gas liberated from the coal sample is measured using a water column similar to that used in the desorbed gas measurement.

In fast desorption testing, where the desorption time is less than five days and typically less than one day, Q₃ represent a large percentage of Q_m. In slow desorption time lasting over a period of time equal to or greater than five days, Q₃ is quite low, and represent the residual gas content of the sample. Residual gas content is the volume of gas per unit mass of coal that is naturally retained within the coal and not readily released from an intact sample. The residual gas content also represents the portion of Q_m that will not be liberated into the mine atmosphere from mined or intact coal (Diamond and Schatzel, 1998).

Residual gas content is also an important consideration in the evaluation of coalbed methane gas recovery potential as it represents the portion of Q_m that will not readily flow to gas drainage boreholes (Diamond and Schatzel 1998). Gas Chromatography (GC) is used to analyse the gas component percentages in coal.

EXPERIMENTAL STUDY

The influence of the trapped contaminant air in the canister on gas component percentages of a coal column contained was studied experimentally. Fixed lengths of freshly drilled coal core samples were inserted into different length canisters. Two sets of three canisters 350 mm, 800 mm and 1000 mm in length were used, which allowed the analysis of samples with reduced air columns contained in their respective canisters. No attempt was made to determine the true gas content of coal in this particular study, as the objective was to examine the changes in gas mixture component percentage caused by the presence of mine air trapped in the canister. The procedure adopted consisted of:

- 1) Studying the effect of varying air columns in transport canisters on the coal gas component percentage, and

- 2) Elimination of the presence of trapped air in canisters by either flushing out the trapped air with inert helium gas, or filling the unoccupied canister space with polymer rods plus helium gas to completely expel air out of the transport canister.

Freshly cored coal samples, 45 mm in diameter were obtained from three mines, mining coal from the Bulli Seam, of the Sydney Basin. The mines were Tahmoor, Appin West and West Cliff. The 300 mm long coal samples, once cored were inserted and sealed in different length canisters. The loaded canisters were taken to the gas laboratories of both UOW and Illawarra Coal – South 32 at Cordeaux Colliery respectively. All three mines are known to have high levels of mine gases, with varied mixture gas component percentages, ranging from 90% methane to 90 % carbon dioxide (Lama and Bodziony, 1996). The duration of the study was prolonged to over four years, thus the sample collection for this study was varied over that period of the study.

The location of cores collected from three mines were:

Tahmoor Mine: Coal Core samples were collected from Panel 810, maingate A at about 5 m away from the intersection between 47 and 48 as shown in Figure 1a. Three canisters were used for sample collection with the shortest canister having internal space length of 350 mm, 55 mm ID.

West Cliff Mine: Core collections occurred in two different time frames, in 2011 and later in 2014. The samples collected in 2014 were drilled in Panel 516-38.5-1/1 shown in Figure 1b, the borehole direction was 45.5° making it perpendicular to the cleat. The samples were retrieved from the drilled hole at a depth of 350 m.

Appin West Mine: Four sets of samples were taken from Appin West Mine. Sample sets one and two were extracted from a drill hole located in the panel 705 maingate, 8 Cut Through (C/T). Sample set one was first drilled at a depth of 20 m before the hole was continued to a depth of 41 m and the core was excavated for sample set two. Samples for sample set three and four were also cut from 705 maingate, from A heading at 21 C/T. The direction of drilling was 15° to the cleat For sample set three the cores were retrieved from a depth of 60.5 m, while set four samples were drilled from a depth of 80 m. The collection of samples from Appin West mine was confined to one period of samples collected in 2011.

In this paper field results are confined to two mines, West Cliff and Tahmoor, and additional tests were made in the laboratory on coal samples subjected to gas saturation using indirect absorption method (Lama and Bodziony 1996).

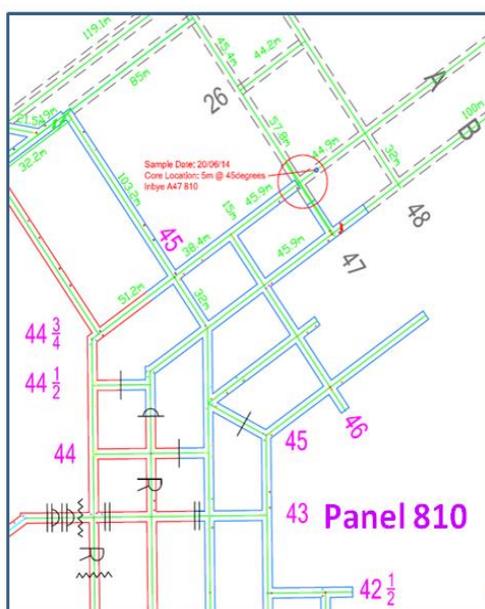


Figure 1a: Tahmoor Mine coal core sample location

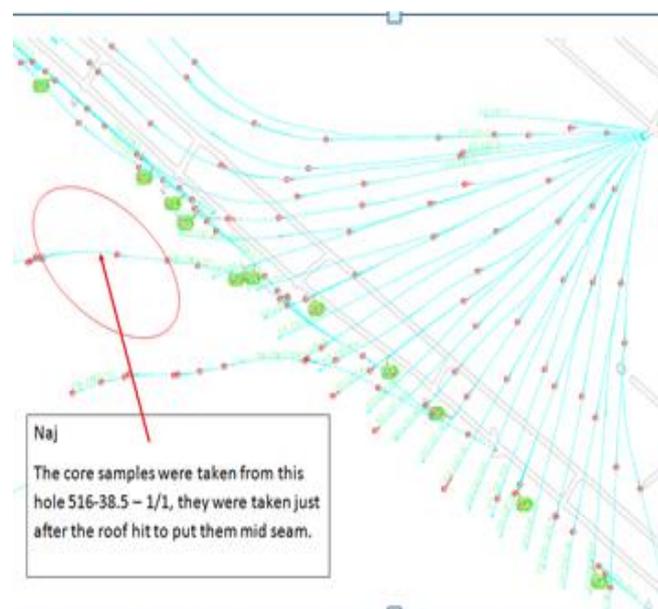


Figure 1b: West Cliff Mine coal sample location

RESULTS AND DISCUSSIONS

Transport of coal in air trapped canister

Figure 2 shows three typical canisters used for collecting equal length coal core samples. Coal samples were collected in canisters and transported to the laboratory for gas mixture components percentage analysis. Samples of canister gas were extracted from each canister and fed to the GC. Three canisters of different lengths were used. They were 350 mm, 800 mm and 1100 mm long. All canisters contained trapped mine air when sealed. Changes in gas components were examined for both Q2 and Q3 of Qm.



Figure 2: Coal transport canisters of varying length

Following tests in each canister for changes in gas components percentages (canister gas composition) from extracted gasses released in the canister, coal samples were removed from canisters and crushed down to 200 μm . The released gas from crushed coal was collected and fed to the GC to determine the gas components percentages in Q3 stage. Table 1 lists the analysis results of the gas contained in three different length canisters from West Cliff Colliery, and both the Q2 and Q3 levels. Figures 3 and 4 show the bar charts for gas at both the Q2 and Q3 stages respectively. The following were found:

- There was a clear variation in gas components percentage contained in different canister lengths,
- The levels of oxygen and nitrogen were dependent on the quantity of trapped contaminant air in the canister,
- The gas released from West Cliff Mine was rich in methane,

- d) As expected the variation of the gas mixture component percentages was consistent with the gas content of the coal in the panel, where coal was cored. The level of CH₄ recorded was higher in shortest canister with less trapped mine air. The methane component of the mixed gas reduced with increased air column. The changes in CO₂ percentage were opposite to CH₄.

Table 2 and Figures 5 and 6 show the results from Tahmoor Mine. Figures 7 shows the canisters with equal lengths of coal and Figure 8 show the procedure used for removing gas from the canister for GC analysis. The study found:

- a) There were variations in gas components percentage in different canister lengths and canister air volume,
- b) The level of O₂ and N₂ were higher in canisters with a large quantity of trapped air and in comparison with smaller shorter length canisters with relatively less trapped air,
- c) Gas components percentage of coal from Tahmoor Mine was relatively rich in CO₂, and poor in CH₄.

Table 1: West Cliff Mine gas percentage components at both Q2 and Q3 Stages

Q2 LAB (May 30-2014)			
Gas	Gas (%)		
	350mm	800mm	1000mm
CO ₂	4.73	3.79	4.49
N ₂	19.60	36.54	48.85
CH ₄	71.63	52.37	37.84
O ₂	4.00	6.37	7.74

Q3 May 2015			
Gas	Gas (%)		
	350 mm	800mm	1000mm
CO ₂	1.85	1.50	1.41
N ₂	45.79	48.77	50.73
CH ₄	39.4586	35.60	33.23
O ₂	11.3338	12.35	12.91

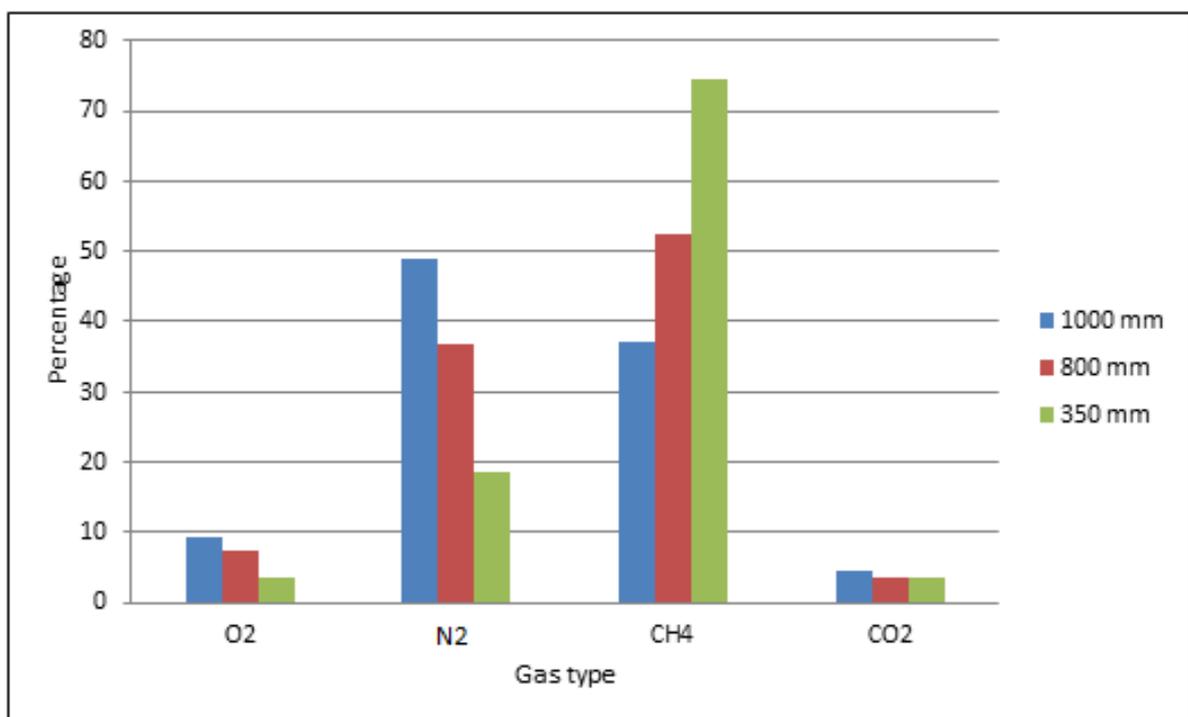


Figure 3: West Cliff Mine Q2 stage gas component in percentage in coal in different length Canisters

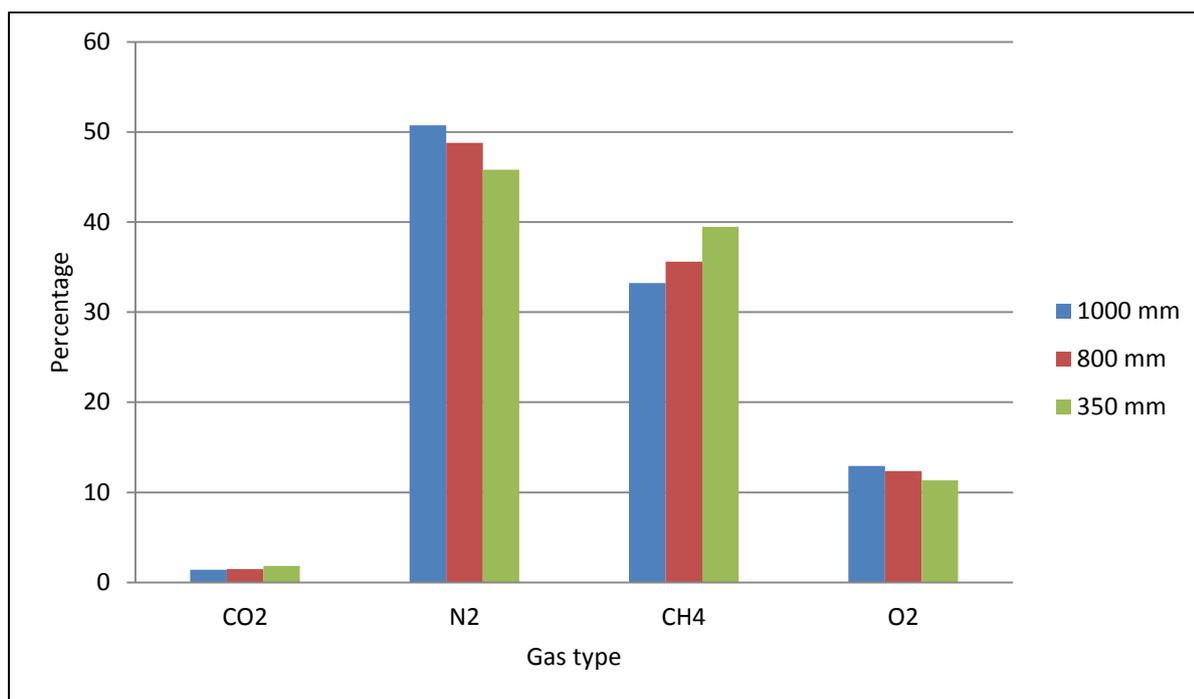


Figure 4: West Cliff Mine Q3 component percentage analysis from different canisters

Table 2: Component percentage analysis for Q2 and Q3 - Tahmoor Mine

Q2 (Tahmoor - UOW)				Q3 (Tahmoor - UOW)			
Gas	Component percentage (% mol)			Gas	Component percentage (% mol)		
	350mm	800mm	1000mm		350mm	800mm	1000mm
	CO2	0.34	13.35		23.03	CO2	25.50
N2	77.56	72.1	61.19	N2	55.58	58.09	64.99
CH4	0	0.9	2.86	CH4	3.35	2.86	3.34
O2	21.21	12.8	12.21	O2	14.40	15.05	17.03

Air Free canisters

In this part of the study, as no freshly drilled coal core samples were forthcoming from the local mines, it was decided to simulate gas components percentage study in the laboratory by the indirect absorption method. 50 mm diameter coal samples were cored out of freshly dug coal lumps brought to the laboratory from the mine. The cored coal samples were cut into 100 mm long samples and loaded individually into the sorption pressure vessel “bombs” and charged with methane gas to a pressure of 2000 kPa. The gas pressure was maintained constant until saturation. The gas saturated bombs were then opened and coal samples were readily transferred to two 800 mm long canisters (A and B canisters). Each canister was loaded with three 100 mm long core samples (total length of 300 mm) as shown in Figure 9. The first canister (Canister A) was sealed with normal atmospheric air trapped in the empty space. In the second canister (Canister B) 100 mm long 50 mm diameter polymer rods as shown in Figure 9b were inserted to fill the unoccupied space above the coal column. Canister B was next flushed with the gas to expel air and then sealed. Table 3 shows component percentages in two canisters with and without trapped air.

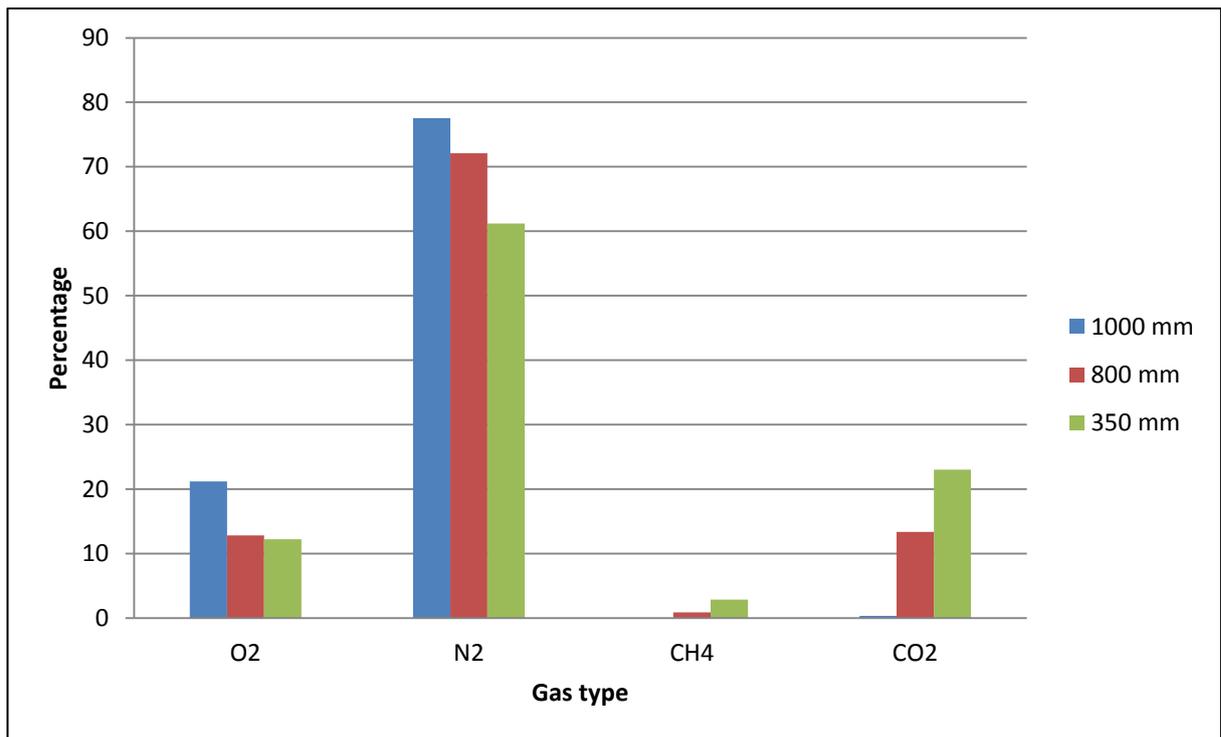


Figure 5: Tahmoor Mine Q2 gas component percentage analysis from different canisters

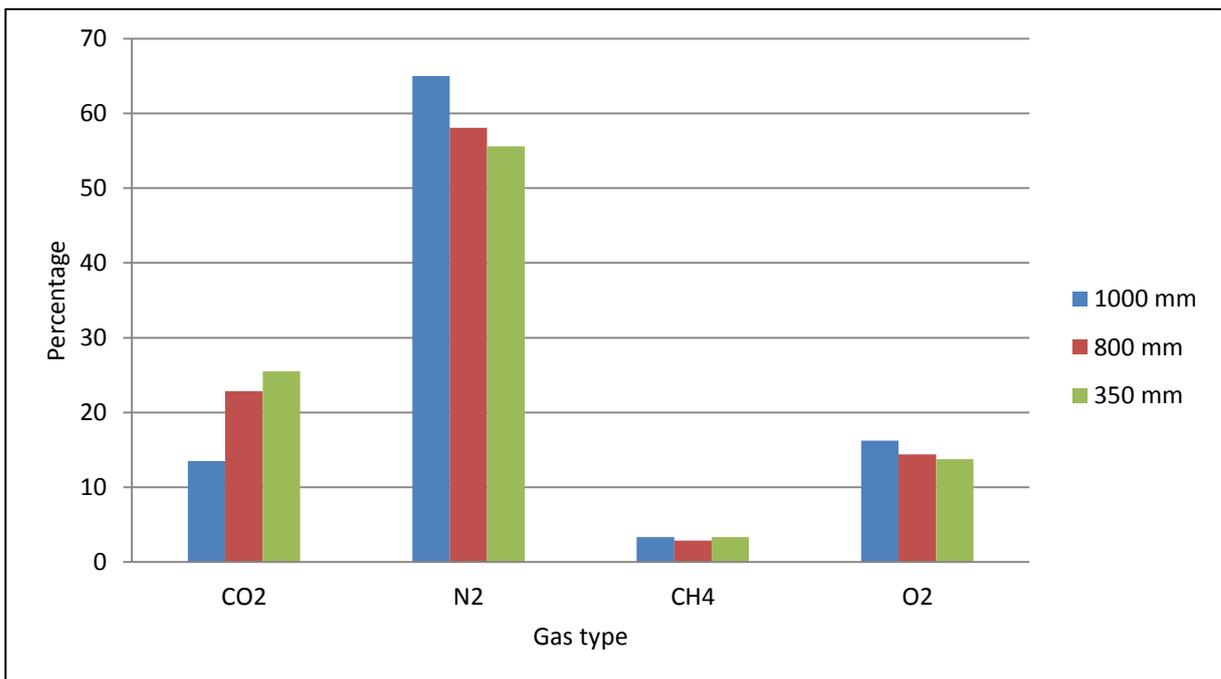


Figure 6: Tahmoor Q3 component percentage analysis from different canisters

After two weeks, samples of gas were extracted from the canisters and analysed for gas component percentage. Figure 10 shows component percentage results from two canisters charged with CH₄ gas. As can be seen from Table 3 and bar charts in Figure 10, there were variations between methane concentrations in two canisters, at both the Q2 and Q3 stages. This exercise demonstrated clearly that the trapped air in the canister unoccupied space has an influence on the gas component percentage similar to that obtained from cored coal samples directly drilled from the coal seam.



Figure 7: Equal coal column lengths inserted in canisters **Figure 8: Gas transferred from canister to bags**

It is clear from all the tests reported in this paper that the changes in the gas mixture components concentration show that as the air column is increased there would be a decrease in both CH₄ and CO₂ percentages volume /volume (%v/v) ratio, while O₂ and N₂ would show an increase in %v/v ratio, These variations are clearly depicted in Tables 1 and 2 respectively at the Q2 percentage gas mixture component analysis stages. More significantly the air column in the canister will have an effect on the gas component percentages due to the much lower partial pressures of the seam gas in the canisters with trapped air column during desorption.



Figure 9a: Canister A & B

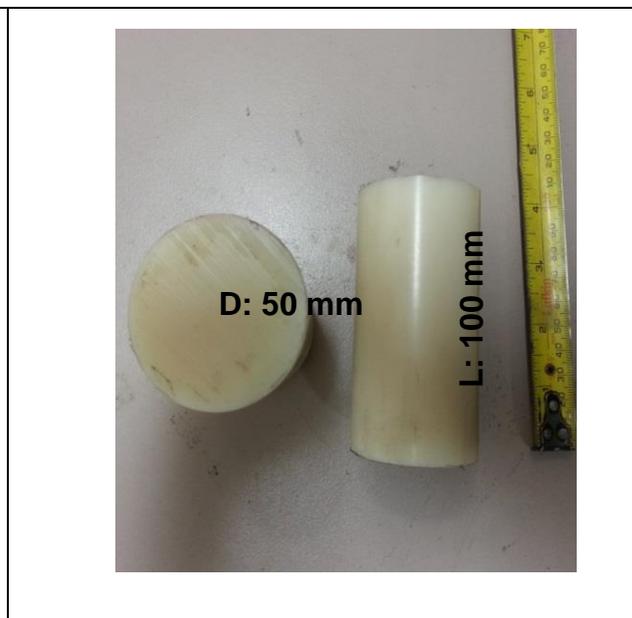
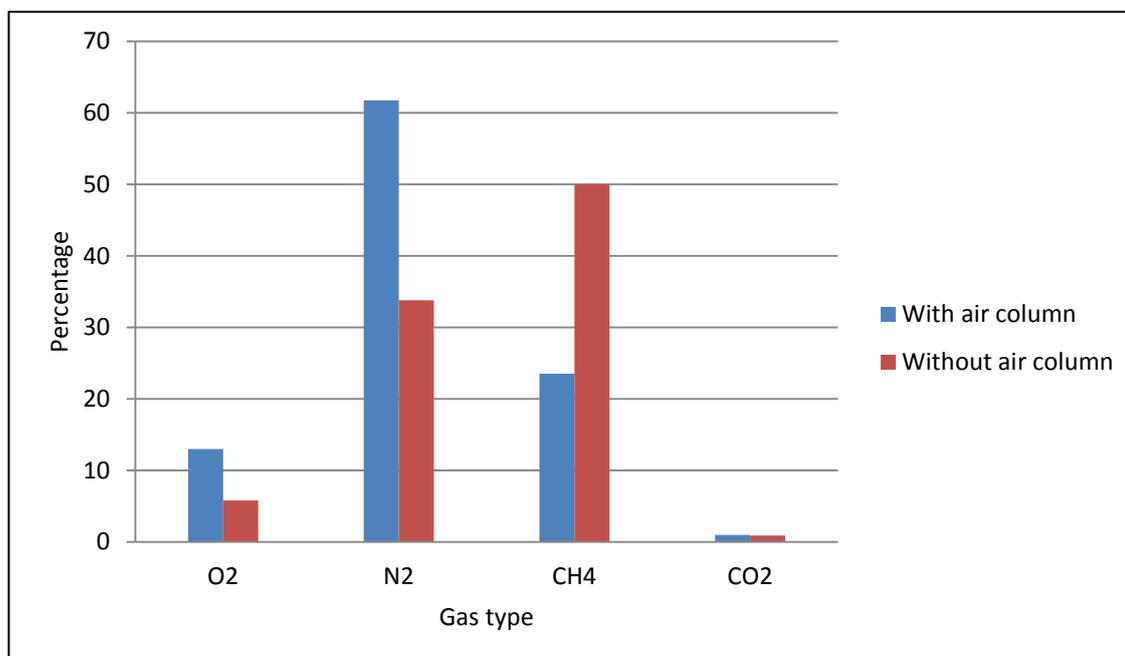


Figure 9b: Resin Rods placed in canister A

Table 3: Gas component percentage in two canisters with and without trapped air

Sample A	%	Sample B	%
Oxygen	13	Oxygen	5.81
Nitrogen	61.7	Nitrogen	33.8
Methane	23.5	Methane	50
Carbon dioxide	0.95	Carbon dioxide	0.9

**Figure 10: component percentage with and without trapped air in canisters**

CONCLUSIONS

The presence of mine air in the transport canister is an issue which may influence the gas content determination of the coal seam. This is particularly important when the transport canisters are not fully loaded with coal. The impact of the air column appears to influence released gas component percentages at both the Q2 and Q3 stages of Qm. Thus, it is important to address the issue of the trapped contaminant air when canisters are partially filled with coal cores. Possible ways of removing contaminant air include filling the void with inert material like Polymer rods, to be flushed with helium gas or flush the canister with the gas altogether. The alternative will be to use the % O₂ to determine the air-free gas percentage components. More significantly the air column length in the canister will have a decreasing effect on the gas mixture components percentage due to the much lower partial pressures of the coal gas in the canister during desorption.

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