Coalbed gas in New Zealand: A potential energy source

by

W E Vance[1] and M P Cave[2]

[1]School of Engineering, The University of Auckland, [2]Resource Information, Energy and Resources Division, Ministry of Commerce, New Zealand

ABSTRACT

The occurrence of coalbed gases, predominantly methane, has been a hazard in New Zealand coal mines and there have been several major explosions initiated by ignitions of methane. It is only recently that attention has been focused on the potential energy source of this gas.

Much of New Zealand's coals are of low rank compared with other parts of the world with 71% of the total resource being lignite. Coal ranks rarely exceed low volatile bituminous but some semi anthracites occur locally. Known gas contents are also low compared to overseas but the presence of thick lenticular seams provides the potential for a large gas in-place resource. In addition, New Zealand coals are typically very rich in vitrinite compared with elsewhere and are therefore perhydrous. Thus, overseas criteria may not apply to New Zealand conditions.

This paper quantifies the known coal resources of New Zealand and analyses their potential to provide a gas resource. Only limited investigations have been undertaken on the gas content of New Zealand coals. Recent investigations have centred on the Ohai Coalfield where the Southgas project has evaluated the potential of the production of methane from Upper Cretaceous coals. The New Zealand Coal Resources Survey funded and operated by the Ministry of Energy (now the Energy and Resources Division of the Ministry of Commerce) also evaluated the Ohai gas resource and carried out smaller scale studies in Upper Cretaceous coals of the Greymouth Coalfield. Studies undertaken to determine the gas content of the Eocene Kupakupa seam in the Waikato coalfield were carried out by the Department of Mining Engineering, University of Auckland.

Over 1,000 million tonnes (MT) of coal have been identified as having potential for coalbed methane in the Huntly Coalfield (Waikato Coal Region) with an in-ground gas resource of around 2,300 million m3 or 82,800 terrajoules (82.8 PJ). In the South Island, the biggest available resource is in the Rapahoe Sector and Dobson area of the Greymouth Coalfield. The combined Rapahoe and Dobson resource could range from a minimum of 3, 140 million m^3 of gas to a maximum of 3,530 million m^3 of gas or between 118,149 to 132,824 terrajoules (118.15 to 132.82 PJ). Of this between 59.07 to 66.41 PJ could be recoverable. At Ohai between 1,200 million m^3 and 2,800 million m^3 could be available. In energy terms this represents between 45,152 and 105,356 terrajoules (45.15 to 105.36 PJ) of which 22.58 to 52.68 PJ could be recoverable. The Aratika Coalfield is the only other coalfield currently indentified as having a potential for coalbed methane. Between 270 million m^3 and 720 million m^3 of gas in-ground or 10,159 to 27,091 terrajoules (10.16 to 27.09 PJ) could be available. Around 5.08 to 13.55 PJ of this could be recoverable.

In total, the New Zealand resource could be between 6,910 and 9,904 million m^3 of gas in-ground (256.26 to 373 PJ) of which 128 to 186.5 PJ may be recoverable.

Overall, the level of investigation into New Zealand's coalbed methane potential has been limited except at Ohai where both Southgas and the Ministry of Energy have investigated the coalbed methane potential. Further work is necessary before the full potential of this energy source can be realised.

INTRODUCTION

The most commonly occurring gas in New Zealand coals is methane with a small amount of secondary ethane. The available gas compositional analyses show that it is rare to get more than a trace of gases other than methane and ethane. Methane from coal seams is a well known hazard in mines and the ignition of methane have caused several major explosions, most recently in September 1992 when an explosion closed Huntly West Mine. Little published information has been available on the gas content of New Zealand coals and the feasibility of marketing and extracting methane from coal seams. Some data is available from unpublished exploration reports held on open-file government databases. Graham (1953) published information on the gas emission rates associated with various coal mines. More recently the authors, Cave and Boyer (1989), Beamish and Vance (1990), and Beamish *et al.,* (1991) have reported on gas content measurements and investigations into the possiblity of using coalbed methane as an energy source.

In the South Island, the Greymouth and Ohai Coalfields have been identified as having the best potential for methane extraction and it is possible that the Aratika Coalfield also has a potential resource. In the North Island, the Huntly Coalfield in the Waikato Coal Region has been identified as having the best potential.

Most of New Zealand's coal resources are of low rank compared with coals in the United States and Australia where most coalbed methane investigations have been carried out. The currently identified gas contents of New Zealand coals are also low compared with other parts of the world. Gas contents of New Zealand coals are known to fall in the range of 1 to 9 m^3 per tonne but higher volumes are possible, particularly in the Greymouth Coalfield. Compared to the US and Australian studies, however, New Zealand coalfields have very thick lenticular seams and as a consequence represent a significant potential natural energy resource despite the low gas per tonne values.

COAL RESOURCES, RANK AND PRODUCTION

In the late 1970s and early to mid 1980s New Zealand embarked on an ambitious coordinated programme of countrywide coal resource evaluation (the New Zealand Coal Resources Survey or NZCRS). Consequently, much is known about the quantities and quality of New Zealand coals. New Zealand has a total of 15.7 billion tonnes (15,705 million tonnes) of in-ground coal resources, 13.1 billion tonnes of which occur in the South Island. Much of this coal in the South Island occurs in Southland and Otago away from the main centres of population and industry and is a low grade lignite (Table. 1). Potentially recoverable coal resources comprise around 8.6 billion tonnes of which 1.9 billion tonnes is of measured status. Coal that is of measured status and has been subject to studies detailed enough to determine the feasibility of mining, however, comprises less than 200 million tonnes. By rank 65% of the resource is lignite, 25% sub bituminous and 10% bituminous; minor amounts of semi-anthracite occur locally (Fig. 1a). Although the Waikato and Nelson-Westland dominate current production, they contain only 9.8% and 3.9% of the total recoverable resources respectively. Southland contains 71%, Otago 13.2% and Taranaki 2% (Fig 1b).

New Zealand coals are characteristically very rich in vitrinite and very poor in inertinite when compared with Carboniferous and Gondwana coals which are typically high in inertinite (Black 1980). This high vitrinite content in New Zealand coals (typically 90% vitrinite 10% exinite) means that they have very high reactivity compared with American, European, Australian, Indian and South African coals.

A characteristic feature of New Zealand coals sequences is their lenticular nature and great thickness. Seams in excess of 20 metres thick are common and seams of 40 metres thickness are also known. Rather than extending for many kilometres, such seams tend to form localised pods of 5 to 10 km^2. It is common for particular coalfields to have a number of such pods within a particular coal horizon. In the typical coalfield setting a number of seams will be present. In some instances, the pods of such seams overlie each other reflecting continued subsidence around a central locus but elsewhere they may be offset reflecting variations in the loci of subsidence.

Despite the large volume of potentially available resource, annual production has not significantly changed in recent years hovering around 2.5 million tonnes per year. Thus the coal mining industry in New Zealand is small and in general poorly developed.

New Zealand's coalfields have been grouped into several coal regions. In the North Island there is the Northland, Waikato and Taranaki Coal Regions while in the South Island there are the Nelson Westland, Canterbury, Otago and Southland coal Regions (Fig 2). The majority of coal is currently produced from the Huntly and adjacent coalfields in the Waikato, from the Buller, Greymouth and Reefton/Garvey Creek Coalfields on the West Coast, from the Kaitangata Coalfield in Otago and from the Croyden-Waimumu and Ohai coalfields in Southland.

EVALUATION OF THE POTENTIAL ENERGY RESOURCE

Waikato Coal Region - Huntly Coalfield

Gas content determinations for the Kupakupa seam have been made at the Huntly West Mine in the Huntly Coalfield [Beamish and Vance (1990), Beamish, *et al.*, (1991)]. These investigations were undertaken to determine the rate of methane emission into the mine for ventilation planning purposes. The gas content of the Kupakupa seam has been evaluated in three different ways;

(i) by the statistical method of Greedy (1986),

(ii) desorption studies combined with residual gas content; and

(iii) from analytical data using the general adsorption equation of Kim (1977).

The results obtained are summarised in Table 2.

The measured values imply gas content undersaturation. Theoretical adsorption isotherms based on the equation of Langmuir and Kims (1977) theoretical equation have been constructed (Fig. 3) for the Kupakupa seam. At a value of gas content of 2.2 m3/t this equates to a seam gas pressure of 2100 kPa and 1900 kPa. The gas pressure measured adjacent to a pre-existing roadway was 500 kPa which corresponds to a gas content of 1.25 m3/t. Gas content measurements from this area were in close agreement.

The Waikato Coal region contains thirteen named coalfields (Fig 2). The coals have rank range of subbituminous C to subbituminous A with sub bituminous B rank coal dominating. Petrographic work by Black [1980] showed the coal to be vitrinite rich (80%) and inertinite and exinite poor. Ash contents are locally variable averaging 36% with low sulphur contents. The largest resource occurs in the Huntly Coalfield which the NZCRS (Anckorn et al 1988) identified as having a resource of 1263 million tonnes coal-in-ground, with 436 MT potentially recoverable by conventional mining methods. Other significant resources are located in the adjacent Maramarua (209 MT), Waikare (219 MT), Kawhia (181 MT) and Tihiroa Coalfields (187 MT). Using the adsorption equation of Kim to determine gas contents, a gas in-place resource of 2300 million m^3 or 82,800 terrajoules (82.8 PJ) has been estimated. Assuming 50% recovery and a 20 year life this equates to 5.7 terrajoules per day. Further investigation is required to investigate the potential of this energy source. Some flow data obtained from the Kupakupa seam from the Huntly West Mine (Beamish and Vance, 1990) indicate that low rank coals readily release their absorbed gas.

South Island Coalfields

A number of coalfields in the South Island may have potential for coalbed methane and the Greymouth and Ohai Coalfields (Fig. 2) have been identified as having the best potential for methane extraction. Greymouth satisfies most geological criteria but is too far from potential markets to consider a viable proposition at this stage. Aratika Coalfield, situated east of Greymouth Coalfield, contains coal of the same rank as at Ohai and may also be prospective.

Ohai

The Southgas Coalbed Demethanation project was established in 1984 to investigate the feasibility of extracting and marketing methane from coal seams in the Upper Cretaceous Morley Coal Measures in the Ohai Coalfield. At the same time, State Coal

Mines embarked on a major exploration programme to establish reserves for the Wairaki Mine at Ohai and carried out an investigation into the methane content of seams as a part of this programme. Subsequently, the NZCRS identified and investigated a new deposit adjacent to previously investigated parts of the coalfield and the determination of the methane content of seams was a routine part of this programme. Consequently, the coalbed methane database for the Ohai Coalfield is the best currently available in New Zealand with methane measurements from multiple seams from around 40 wells put down over a 4 year period (Fig.4).

The coals in the investigation area at Ohai range from sub bituminous A to high volatile bituminous C in rank. Much of the current coal is mined from areas of sub bituminous A rank coal. Around 200 million tonnes of coal of measured to inferred status are available for coalbed methane investigations at Ohai. Another 200 million tonnes identified by seismic and gravity survey but not drilled is also potentially available.

Methane measurements were established using the conventional desorption method. The methane contents were, in general terms, consistent with rank variations and depths although the measured contents were invariably lower than the theoretical contents determined by the Kim method. There were anomalies, however, high gas flows from wells was a common occurrence and one blowout recorded flows of a 250,000 ft^3 (7079 m^3) per day until it was controlled. Also anomalous was the occurrence of condensate from one shallow well (200m). A methane influx into the now abandoned Morley Mine also flowed at an average rate of around 7080 m^3 per day over a number of years. High resolution seismic data showed that the very high gas flows relate to the mine and wells intersecting naturally fractured zones containing significant volumes of free gas. The condensate is believed to have migrated laterally and updip along a fault from deeper more mature coal measures.

The potential total in-place gas resource at Ohai may be 2,800 million m^3 or 105,356 terrajoules (105.36 PJ) of which 1,200 million m^3 (45.12 PJ) can be categorised as a proved to probable and a further 1,600 million m^3 (60.20 PJ) as possible to hypothetical. Assuming that around 50% can be extracted, a maximum of around 52.68 PJ may be recoverable.

The Southgas investigations comprised an initial exploration programme which was followed by a limited production testing programme. Four production test wells were put down. Two intersected virgin seams, one intersected the high flow zone in the Morley Mine while the last attempted to dewater and extract gas from the goaf of an old abandoned mine which had shown historically high levels of gas discharge. The mine goaf well did not succeed due to high groundwater recharge resulting in a failure to adequately dewater the mine. The two wells drilled to intersect the virgin seam were partially successful from a technical point of view both showing significant flows of gas and exhibiting typical Demethanation well behaviour (Fig.5). Inadequate casing and pump design for the ground conditions and a refusal of the nearby mine operators to allow fracing of the wells meant, however, that the full potential of the wells could not be realised. Both wells were subsequently shut in and field operations by the well operator suspended. Periodic checking of the wells by Energy and Resources Division staff shows that gas remains available in each well seven years later and recompleting and fracing of the wells would probably yield significant gas flows.

The well drilled to intersect the high gas flows in Morley Mine was a technical success but was subject to disagreements between the mine owners and the well operators over access and control. At the time the mine operators were in a transition from a traditional State run operation (State Coal Mines) to a State Owned Enterprise (CoalCorp). The difficulties experienced with the coal mine operators in their transition to an SOE was the fundamental stumbling block resulting in the suspension of field operations by Southgas. The company is still interested in developing the field, however, and is currently negotiating with other companies for a farm-in arrangement.

Greymouth Coalfield

The Greymouth Coalfield has a history of gas and other hydrocarbon shows in mines and in exploration wells. Areas to the south and east of the coalfield have been explored by a number of oil exploration wells. The coalfield has a long history of mining and exploration and is the scene of New Zealands worst mining disaster which occurred in 1896 when an explosion caused the death of 65 miners. The explosion was caused by the ignition of methane that propagated through the mine by coal dust raised by the initial explosion.

The coalfield has coals ranging from high volatile C to low volatile bituminous in rank and has a total identified resource of around 540 million tonnes. The Dobson part of the coalfield was not explored by the NZCRS but was drilled in earlier years. The areas that were not explored by the NZCRS have a good potential for coalbed methane extraction based on historical records of gas and oil shows and coal rank. The field has been investigated for its coalbed methane potential but only to a limited extent and a company is currently considering further investigations in this area.

Methane gas measurements have only been made in the Rapahoe sector where a resource of around 320 million tonnes has been identified. The sector is the proposed site for a major underground mine with a targeted annual production of 1 to 2 million tonnes. Thus the mine operators will be looking to control of the gas make within the mine. Gas measurements recorded in this area were anomalously low in comparison with the expected norm for coals of that rank (high volatile bituminous C) and also compared with the lower rank Ohai coalfield. Conversely, however, one coal exploration well flowed oil and another suffered a major gas blowout and gas shows were common during drilling. Earlier wells drilled in the Dobson area recorded signs of hydrocarbons and small oil seeps have been recorded in and adjacent to the now closed Spark and Party mine between Rapahoe and Dobson. In addition, the theoretical gas bearing capacity (9 to 13 m^3/tonne) is significantly higher than the measured content. The low measured values are ascribed in part to poor data collection resulting from leaking gas cannisters, incomplete analysis of results and in part to natural drainage of *in situ* gas to the surface via outcrop and faults. Re-analysis of the raw data to take account of the likely residual gas content has resulted in values more consistent with coals of high volatile bituminous C rank. The gas content of Rapahoe coals are shown in Table 3.

Using the minimum amount of *in situ* gas inferred by the Kim method it is calculated that the Rapahoe sector has an in-ground gas resource of 2,880 million m^3 or 108,366 terrajoules (108.36 PJ). This could represent a recoverable gas resource of 54.18 PJ.

In the Dobson area, the existing poor database suggests that around 20 million tonnes of high to medium volatile bituminous coal may be present. This resource estimate is based entirely on a relatively small number of early drillholes and experience elsewhere within the coalfield suggests that significantly more resources can be established if the area is properly investigated. Based on the known resource and coal rank data, an in-ground gas resource of 260 million m^3 or 9,783 terrajoules (9.78 PJ) may be present which could represent a recoverable resource of 4.89 PJ. Discovery of additional resources could push the in-ground gas resource to 650 million m^3 or 24,457 terrajoules (24.45 PJ) resulting in a recoverable resource of 12.23 PJ.

The combined Rapahoe and Dobson in-ground resource could range from a minimum of 3, 140 million m^3 of gas to a maximum of 3,530 million m^3 of gas or between 118,149 to 132,824 terrajoules (118.15 to 132.82 PJ). Of this between 59.07 to 66.41 PJ could be recoverable.

Aratika Coalfield

The Aratika Coalfield underlies and is adjacent to the small Kotuku Oilfield which yielded limited production early this century. Oil was recovered from shallow strata above the coal measure sequence with one early well intersecting oil-bearing strata in Quaternary gravels. The oils are considered to have migrated from deeper mature coal measures to the west prior to the eversion of the basin that now comprises the Greymouth Coalfield. The coals occur at the base of the sequence and are of sub bituminous A to high volatile bituminous C rank. Limited drilling and seismic exploration indicates an inferred resource of around 90 million tonnes. Based on the experience of the similar rank coals at

Ohai it is inferred that a gas content of between 3 and 8 m^3/tonnes is possible.

The total in-ground gas resource at Aratika may range from 270 million m^3 to 720 million m^3 or 10,159 terrajoules (10.16 PJ) to 27,091 terrajoules (27.09 PJ). This resource must be regarded as being of possible to hypothetical status until suitable resource studies are carried out. Based on the possible in-ground gas volume, a recoverable resource of 5.08 to 13.55 PJ is inferred.

CONCLUSIONS

Although investigations into the coalbed methane potential of New Zealand coals began in 1984 no project has proceeded through to development. A large part of this is due to the rapid and dramatic changes that occurred in the energy sector in the mid 1980s. Technically, a number of New Zealand coalfields appear to show significant potential for the development of this energy resource.

Although New Zealand's coals are generally of low rank compared with other parts of the world they are also vitrinite rich and highly reactive in comparision with Carboniferous and Gondwana coals. This along with the generally thick lenticular nature of coal seams means that the total gas volumes within a deposit may be significant despite the low quantities of gas per tonne.

New Zealand has a total of 15.7 billion tonnes of in-ground coal resources, 13.1 billion tonnes of which is a low grade lignite occurring in Southland and Otago away from the main centres of population and industry. Potentially recoverable coal resources comprise around 8.6 billion tonnes and 1.9 billion tonnes of this is of measured status. Coal that has been subject to studies detailed enough to determine the feasibility of mining comprises less than 200 million tonnes. By rank 65% of the resource is lignite, 25% sub bituminous and 10% bituminous; minor amounts of semi-anthracite occur locally.

Recent investigations have centred on the Ohai Coalfield where the Southgas project has evaluated the potential of the production of methane from Upper Cretaceous coals. Other evaluations have been carried out by the NZCRS in Ohai and in the Upper Cretaceous coals of the Greymouth Coalfield. Greymouth coalfield has also been studied by Westgas a sister venture to the Southgas project. The Department of Mining Engineering at Auckland University has studied the gas content of the Eocene Kupakupa seam in the Waikato coalfield.

Over 1,000 million tonnes (MT) of coal have been identified as having potential for coalbed methane in the Huntly Coalfield (Waikato Coal Region) with an in-ground gas resource of around 2,300 million m3 or 82,800 terrajoules (82.8 PJ). The coalfield has the advantage of being adjacent to the existing gas pipelines that reticulate gas from Taranaki to Auckland. There are also a number of major industries nearby that could use the gas recovered from the field. In the short term, however, there is an overall surplus of gas supply in the North Island which suggests that developing this resource is unlikely to be immediately attractive. This situation should change as known conventional gas begins to run down after 2005.

The Greymouth resource is the biggest available resource and could range from a minimum of 3, 140 million m^3 of gas to a maximum of 3,530 million m^3 of gas or between 118,149 to 132,824 terrajoules (118.15 to 132.82 PJ). Of this between 59.07 to 66.41 PJ could be recoverable. One constraint for the development of a West Coast coalbed methane resource is the lack of a suitable local market. The population of the area is low (around 30,000 people) and there are few major energy intensive industries. There are possibilities of this changing in the short term, however, with several new major mining operations (coal, gold and ironsands) proposed for the area.

At Ohai between 1,200 million m^3 and 2,800 million m^3 could be available. In energy terms this represents between 45,152 and 105,356 terrajoules (45.15 to 105.36 PJ) of which 22.58 to 52.68 PJ could be recoverable. Although the rank of Ohai coals is relatively low, the resource is proven compared with elsewhere and there is potentially a significant local market for both gas and for electricity generated from gas.

The Aratika Coalfield may also have a potential for coalbed methane. Between 270 million m^3 and 720 million m^3 of gas in-ground or 10,159 to 27,091 terrajoules (10.16 to 27.09 PJ) could be available. Around 5.08 to 13.55 PJ of this could be recoverable. The Aratika resource is the poorest known resource of those discussed in this paper and considerable additional evaluation would be required before the full potential of the field is established.

In total, the New Zealand resource could be between 6,910 and 9,904 million m^3 of gas in-ground (256.26 to 373 PJ) of which 128 to 186.5 PJ may be recoverable.

Overall, the level of investigation into New Zealands coalbed methane potential has been limited except for at Ohai where both Southgas and the Ministry of Energy have investigated the coalbed methane potential. Further work is necessary before the full potential of this energy source can be realised.

ACKNOWLEDGEMENTS

The authors wish to thank R.C. MacDonald Ltd for permission to use data relating to the Southgas project, Coal Corporation of New Zealand Ltd and in particular the management of the Huntly West Mine for providing facilities for the measurements, Linda Murphy of Resource Information reviewed the text and made many useful comments.

REFERENCES

Anckorn, J.F., Cave, M.P., Kenny, J., Lavill, D.R., Carr, G. (1988) The Coal Resources of New Zealand. Coal Geology Report 4, Resource management and Mining, Ministry of Energy, New Zealand.

Beamish, B.B., Ashton, B.H., and Vance, W.E. (1991) Seamgas parameters of the Kupakupa Seam Huntly West Mine. In Proceedings 25th Annual Conference, New Zealand Branch, the AUSIMM, Waihi, August 176 - 186.

Beamish, B.B. and Vance, W.E. (1990) Gas Research at Huntly West Mine, New Zealand, Department of Mining Engineering, University of Auckland, New Zealand, 32p.

Beamish, B. B. and Vance, W.E. (1991) Natural Gas from Coalseams - Hazard or Resource? In, Proceedings, Fourth New Zealand Coal Conference 14-16 October 1991, Wellington, New Zealand, Coal Research Association of New Zealand.

Black, P.M. (1980) A Reconnaissance Survey of the Petrology of New Zealand Coals with recommendations as to their utilisation. New Zealand Energy and Research Development Committee report 51.

Cave, M. P. and Boyer, C. M. (1990) Natural gas from coal, Southgas Investigations at Ohai, New Zealand. In Ministry of Commerce (1990) 1989 New Zealand Oil Exploration Conference Proceedings, Petroleum and Geothermal Unit, Energy and Resources Division, Ministry of Commerce, 357-363.

Creedy, D.P. (1986) Methods for the evaluation of seam gas content from measurements on coal samples. Mineral Science and Technology, 3, 141 - 160.

Graham, J.I. (1953) Environmental conditions in the coal mines of New Zealand. In Proceedings Mining Conference. School of Mines and Metallurgy, Otago University, New Zealand, May 1953, paper 37, 24p.

Kim, A.G.,(1977) Estimating methane content of bituminous coalbeds from adsorption data.United States Department of the Interior, Bureau of Mines report RI 8245, 21p.

Coal Region	Measured	Indicated	Inferred	Total (MT)
Waikato	274.58	390.81	177.47	842.86
Taranaki	0.15	147.04	26.25	173.44
North Island total	274.73	537.85	203.72	1,016.30
Nelson-Westland	49.40	199.81	88.35	337.56
Canterbury	0.00	0.01	0.70	0.71
Otago	331.75	735.2	67.17	1,134.12
Southland	1,225.51	4,358.31	529.40	6,113.22
South Island total	1,606.66	5,293.33	685.62	7,585.61
New Zealand total	1,881.39	5,831.18	889.34	8,601.91

Table 1. Recoverable coal in New Zealand

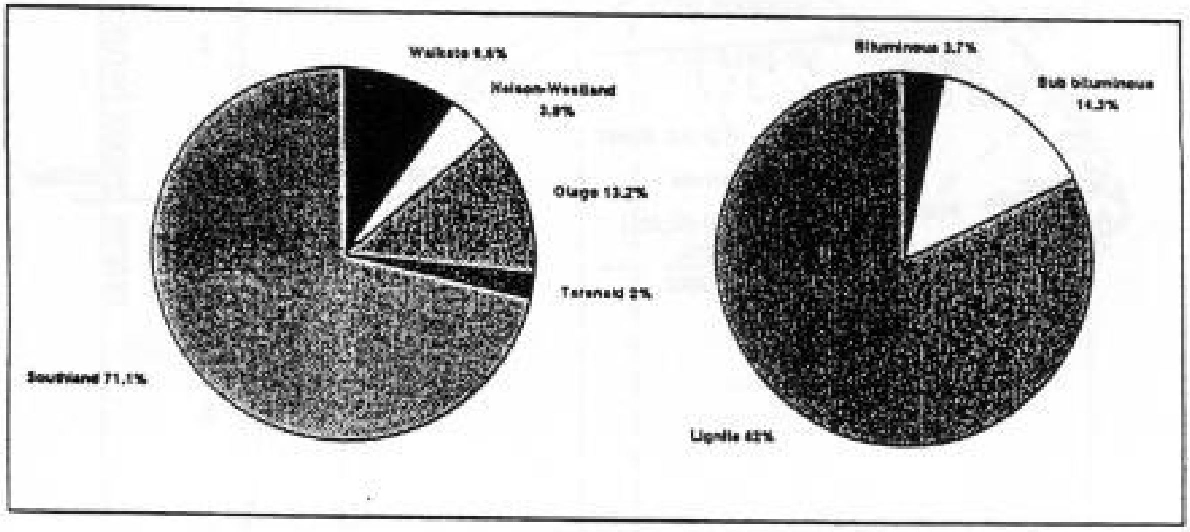

Figure 1a. Recoverable Coal by Region *Figure 1b.* Recoverable Coal by Rank

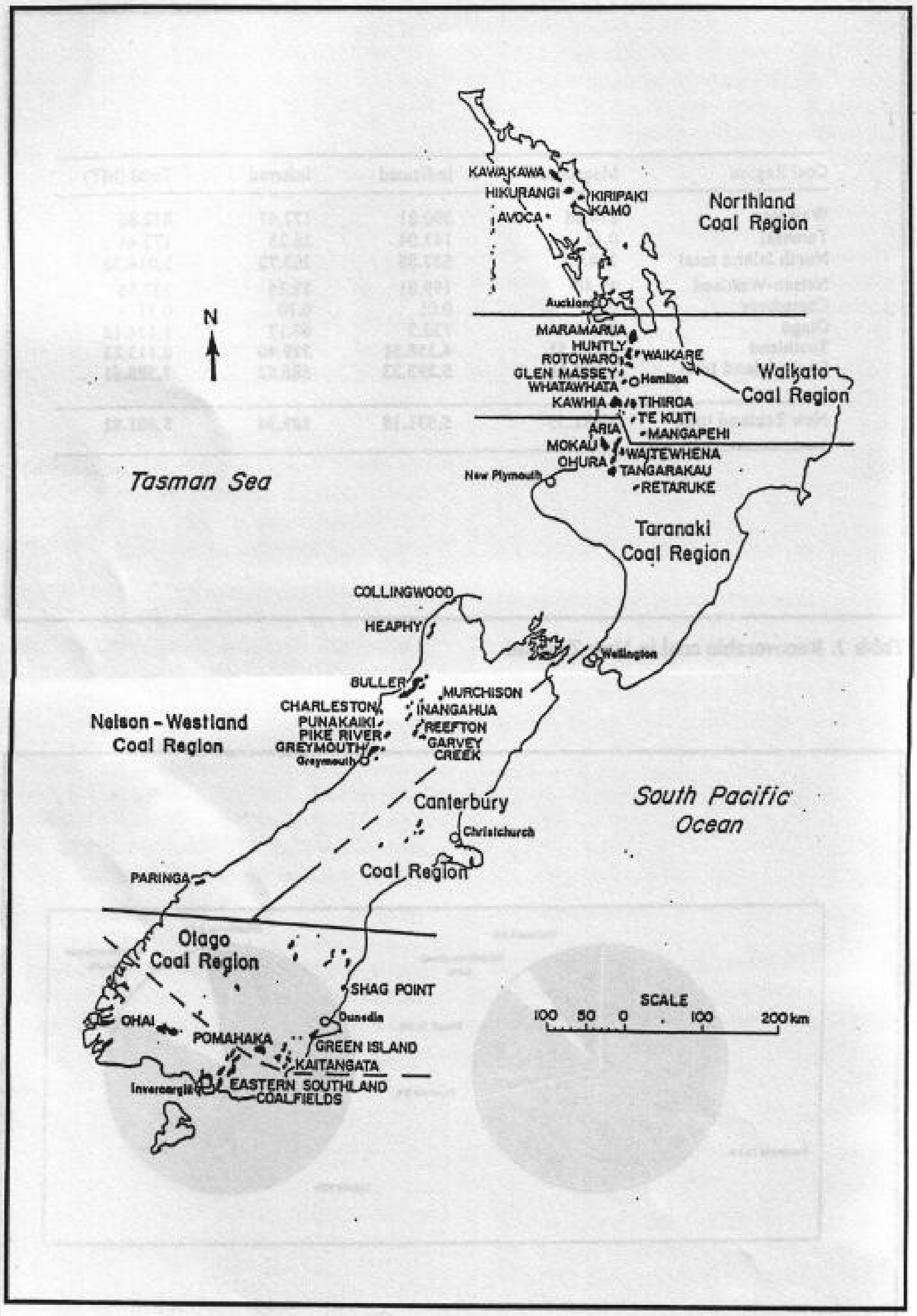

Figure 2. Map of New Zealand Coal Regions and Coalfields

Method of determination	Gas Content m³/t
Statistical method	1.8 (Set A)
	1.7 (Set B)
Desorbed and residual	1.9
Analytical	2.2

Table 2. **Gas Contents, Kupakupa Seam, Huntly West Mine**

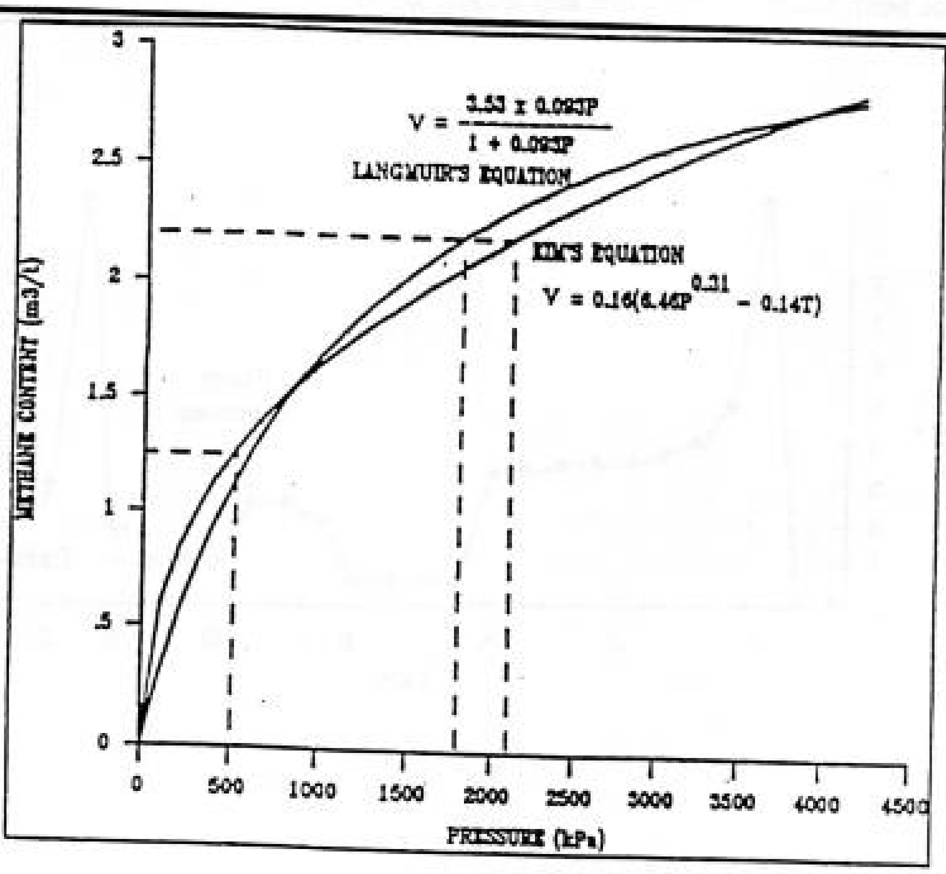

Figure 3. Theoretical Isotherms for the Kupakupa Seam (from Beamish and Vance, 1990)

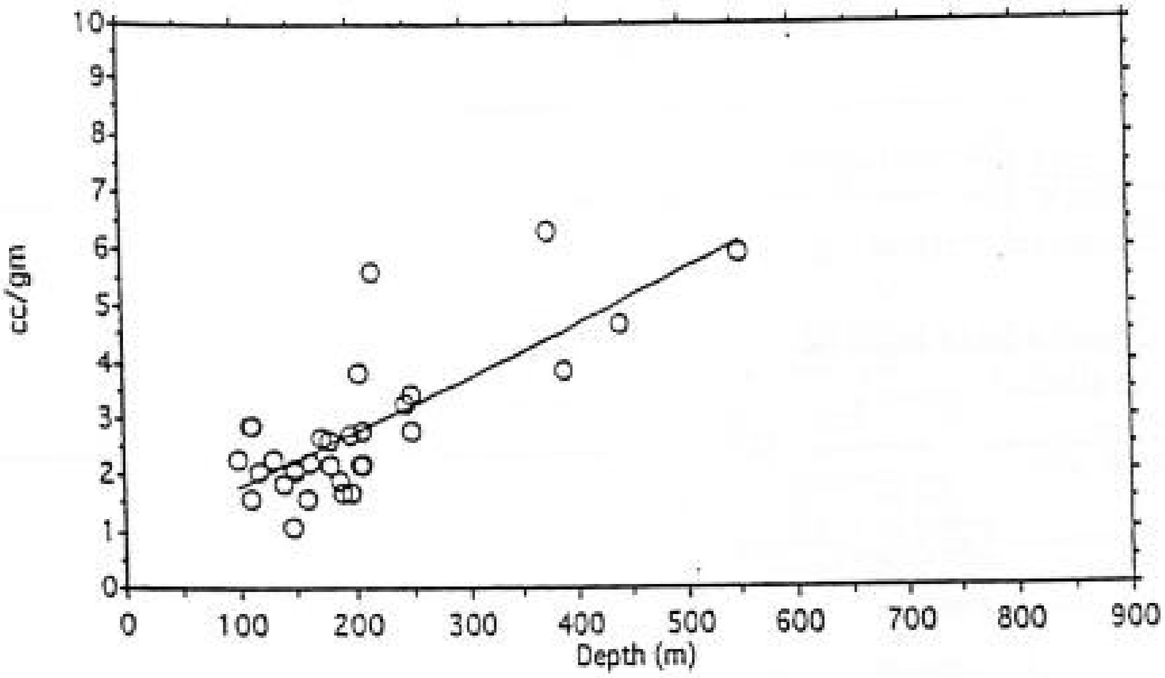

Figure 4. Measured gas contents from Ohai coal seams related to the depth at which the seam was intersected. The majority of measurements have been made in the course of exploration in an area subject to mining over a long period of time. The deeper samples come from sectors that have not been mined (from Cave and Boyer, 1990)

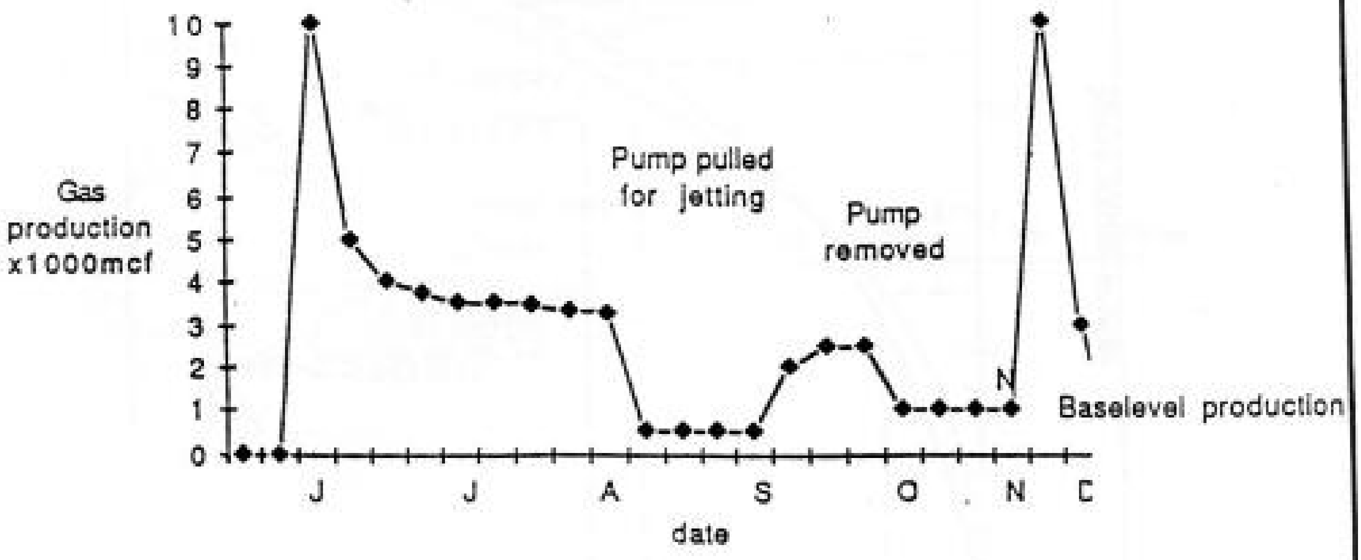

Figure 5. Initial and baseline gas production from the Southgas TP2 well, Ohai. The well

Drillhole	Seam	Depth (M)	Desorbed + lost gas	Residual gas	Total gas
697	Main	347	0.51	0.84	1.35
698	D	272	1.22	2.01	3.23
698	Main	305	0.80	1.32	2.12
699	Main	348	1.70	2.80	4.50
700	Sub main	230	2.39	3.94	6.33
701	D Lower split	224	1.19	est 1.96	est 3.15
701	Main	263	0.61	1.00	1.61
704	D Upper Split	311	0.22	0.36	0.58
705	Main	345	1.42	2.35	3.77
706	Main	317	0.70	1.28	1.98
707	Main	408	0.89	0.73	1.62
711	Main	230	0.21	0.82	1.03

Table 3. **Gas contents of Rapahoe sector coals (measurements in cc/g)**