An overview of the production and operations of the Hillview # 1 and # 2 coalbed methane wells near Moura Queensland

by

C. Lewis, J. Allen and B. Camp

Seamgas Enterprises Pty Ltd

ABSTRACT

During the past fifteen years the production of methane gas from coal seams has become a reliable method for coal seam degasification prior to mining and as a viable and economic energy source. However, the only existing large scale commercial coalbed methane fields are in the United States. The application of state-of-the-art technology can optimise the production potential and improve safety in existing and undeveloped coal mines. This same technology has been successfully demonstrated at the two well pilot field near Moura, Queensland. In December, 1990 BHP Mitsui Coal (BHPMC) industry sponsor and Seamgas Enterprises implemented NERDDC Project 1390 - Long Term Gas Drainage By Vertical Hydrofracced Wells and Mine Through. Two wells, Hillview 1 and 2 located near Moura Queensland, were drilled, stimulated and equipped for production. After thirteen months of production, through March 1992, the Hillview # 1 well has produced 76,322 MCF and the Hillview # 2 well produced 28,198 MCF of methane gas. More importantly, the technology of vertical hydrofracced wells was applied successfully to Australian coals. The Hillview # 1 well is located approximately 440 metres downdip from the D seam workings in BHPMC Moura No 2 mine and the Hillview # 2 well is 380 metres downdip from the Hillview # 1 well. The D seam is 4.7 metres thick an was hydraulically stimulated in both wells as a single seam completion. This paper will review the production results of the two wells through March 1992. In addition, information related to well installations, operations and production analysis from the Hillview wells will be discussed.

INTRODUCTION

In December 1990, BHP Mitsui Coal Pty Ltd (BHPMC), as industry sponsor and Seamgas Enterprises implemented NERD&D Project 1390 - Long Term Gas Drainage by Vertical Hydrofracced Wells and Mine Through.

The primary objective of NERD&D Project 1390 was to prove the effectiveness of the technology of vertical, hydraulically stimulated, wells for the degasification of Australian coals. In many underground mining operations the quantities of methane gas emitted during mining from the seam mined and the adjacent seams affected by coal extraction are so great as to affect safety and production. Some high capacity operations lose as much as 15% of potential production (face) time because of methane emissions.

For this demonstration, an operating mine with high insitu gas contents of 10 m^3/tonne and greater is desirable. The Moura Lease of BHP Mitsui Coal Pty Ltd (BHPMC) was picked as an ideal location for this demonstration, Figure 1.

The scope of work called for two coal seam gas wells to be drilled, cased, hydraulically stimulated and equipped with pumping units and instrumentation to measure and monitor water and gas production.

GEOLOGIC AND RESERVOIR CHARACTERISTICS

The BHPMC Moura lease is located in Central Queensland in the south eastern portion of the Bowen Basin. It lies approximately 10km east of the township of Moura and 180km west of Gladstone, Figure 1.

The Permian aged Baralaba coal measures contain the coal seams of interest, with a total of 5 laterally persistent seams occurring within the project area, Figure 2. The D seam is currently being mined by BHPMC and is also the seam targeted for hydraulic stimulation under Project 1390.

The two production wells are located down dip from the Moura No 2 Mine D seam mine workings, Figure 3. The well locations were designed to obtain the effects of interaction and reservoir pressure drawdown. The HV No 1 well is located down dip of the mine workings 422 metres to the east and 492 metres to the north east. The HV # 2 is located approximately 390 metres down dip from HV # 1. The D seam is at a depth of 254 metres in HV # 1 and 291 metres in HV # 2 and averaged 4.6 metres thick in both wells.

The D seam in the Hillview area is a medium to high volatile bituminous coal with a vitrinite reflectance value of approximately 1.1%. The coal rank is considered to be in the optimal range for coal seam drainage development.

Many gas content measurements were available on the D seam within the Moura mine area from previous tests conducted by BH-PMC. The gas content of the D seam in the area of the production wells was estimated to be 12 m^3/tonne based on this existing information.

A permeability slug test was conducted on the D seam in an existing nearby borehole since no measurements were available from previous work related to the mining operations. A permeability value of 58 millidarcies was measured on the D seam at a depth of 260 metres.

Tectonically, the Bowen Basin is intersected by several major thrust faults which trend north west to south east. These thrust faults are the result of compression forces which originated from the north east. Faulting, jointing and cleating are manifestations of the regional stress regime. Measurements of in-situ stresses in the close vicinity of the production area were carried out by CSIRO as part of the NERDDP Grant No 82/2244 shown on Figure 4. The ratios of the major horizontal stresses and the overburden stress were important geologic factors in the design and execution of the hydraulic stimulation.

WELL DRILLING AND COMPLETION

The two production wells were drilled in November 1990 and commissioned for production in March 1991.

The well casing and completion design utilised standard size casing (139.7 mm) and one joint of fibreglass casing through the D seam to accommodate future mining. A lightweight cement was used for cementing of production casing and the D seam was accessed via high density perforations. Stimulation operations consisted of using approximately 77,000 gallons of hydroxypropylguar (HPG) polymer crosslinked with a borate salt. This fluid was used to transport 113,000 pounds of 20/40 sand at concentrations of up to 8.5 pounds per fluid gallon. As anticipated the fracture gradients were in excess of 1 psi/ft (1.32 psi/ft for HV # 1 and 1.23 psi/ft for HV # 2) suggesting a complex fracture geometry (T-shaped, bifurcated etc) or possibly a horizontal fracture.

PRODUCTION ANALYSIS

After thirteen months of production (390 days) Hillview # 1 had produced 76,322 MCF of gas and 3,820 barrels of water. Hillview # 2 had produced 28,198 MCF of gas and 3,826 barrels of water. Gas and water production graphs for HIllview # 1 and # 2 (through March 31, 1992) are shown in Figures 5 and 6, respectively.

Detailed analysis of gas and H_2O production resulted in the identification of four different and distinct production trends that correspond to the same time intervals in each well, as shown in Figure 7. Each of the four production periods are characterised by changes in the production rates due to well operations and/or reservoir pressure variations. The following is a summary of the four production periods.

Period 1 - Production Day 1 to 90 (Figure 7)

- HV# 1 - Rapid increase in gas production due to partial de-pressurisation by nearby mine workings and all available free gas being brought back with the stimulation fluid.
- HV# 2 - Slow increase in gas production characteristic of an exterior down dip

well under virgin reservoir pressure conditions.

- Note - Period ends with the downhole being changed to accommodate lower water production.

Period 2 - Production Day 91 to 140 (Figure 7)

- HV# 1 - Rapid decline in gas production as the current reservoir pressure remained constant and all available free gas was produced.
- HV# 2 - Continued increase in gas production as the reservoir pressure is further reduced and approaching similar pressures as HV# 1.
- Note - At the end of this period both wells appeared to be at the point where significant production increases should occur due to sufficient reservoir de-watering.

Period 3 - Production Day 141 to 211 (Figure 7)

- HV# 1 - Constant gas rate and an abrupt decline in water production characteristic of operational problems
- HV# 2 - Same as HV# 1
- Note - Reservoir pressure in both wells began to increase as a result of operational problems and lack of water production. The pump on HV# 2 was changed on day 200, but water production did not increase indicating formation damage.

Period 4 - Production Day 211 to 385 (Figure 7)

- HV# 1 - Slow steady increase in gas production corresponding to a slow decrease in gas production from HV# 2, indicating communication between wells. Increase in gas production is due to migration of gas up dip from HV# 2. Reservoir pressure near wellbore continues to increase due to lack of pumping.
- HV# 2 - Decline in gas production due to increasing reservoir pressure and probable formation damage, causing obstruction of water and gas flow into the wellbore. Available gas migrating up dip to HV# 1. Remedial action to clear formation blockage was conducted on day 385.
- Note - Pump on HV# 1 completely shut down due to mechanical problems on day 240 and did not operate.

PRODUCTION FORECAST

An understanding of the complex processes (mechanisms) controlling methane release (and hence production) is necessary for reliable forecasting of production rates. In contrast to a conventional gas reservoir where methane is contained in a pressurised gaseous state, methane in coal is chemically adsorbed on the internal surface area of the coal by pressure. In most areas the pressure mechanism is hydrostatic pressure.

Thus, the reservoir pressure controls the adsorption mechanism along with coal rank. To effect the release of the methane from the adsorbed state the reservoir pressure regime must be reduced by a reduction of the hydrostatic pressure. The pressure reduction is achieved by pumping water from the coal reservoir. Pumping reduces the formation pressure in the immediate area of the well, but the pressure reduction will not extend more than a few hundred metres from the well bore within a commercially reasonable period of time.

Therefore, if commercially significant quantities of methane are to be produced, groups of wells must be implemented in such a manner and at a spacing that allows the development of "interference" (or "communication") among the wells of the group.

The resulting flow of water and gas from the reduction of the reservoir pressure is then controlled by the permeability of the coal reservoir to gas and water flow. As water is removed and the reservoir pressure is reduced the flow through the coal cleat structure will move from single phase fluid flow to two phase flow of water and gas bubbles. At this point the relative permeabilities to gas begins to increase and the relative permeability to water decreases. It is during this two phase flow period that gas production is maximised.

For the Moura Pilot Field of two wells it was necessary to develop methane gas production forecasts for the D seam prior to implementation of the wells and prior to the availability of conventional measurements of gas contents, permeability, etc. Production profiles are normally constructed from case studies of existing production wells or by computer simulation models. The simulation models depend on numerous geologic and reservoir parameters which were unavailable for the Moura No. 2 Mine area. However, file data of the mining operations and observations of underground and surface mine conditions were evaluated and used to define the reservoir parameters using empirical techniques. The parameters were then used to effect a "match" with similar reservoir conditions of producing wells and fields in the United States.

From this data a 10 year production forecast was generated, Figure 8.

First year (through February 1992) actual production, projected production and the average of HV # 1 and HV # 2 (Figures 5 and 6) is summarised as follows:

PROJECTED VERSUS PRODUCED GAS AT 1 YEAR

	Gas Produced	Production Deviation From Projection	Percent of Projection
Hillview #1	69 MMCF	+ 36 MMCF	209 %
Hillview #2	27 MMCF	- 6 MMCF	82 %
Avg - Both Wells	48 MMCF	+ 15 MMCF	145 %
August 1990 Projection	33 MMCF		

CONCLUSIONS

After 1 year of production history, the Moura Project has successfully demonstrated that:

1. Effective, single seam hydraulic stimulations can be implemented, in the Moura area, using existing coal seam fracture technology.

2. Gas production rates met the estimated projections and with proper field design, sufficient in-place gas content reductions for effective degassing of the coal seam can be realised.

3. Fracture stimulators developed for USA Coal basins can be applied to Australian Coal seams if necessary reservoir parameters are available for reliable input data.

BIBLIOGRAPHY

Battino, S., Malone, P. and Bishop, R., 1989, Coalbed Methane Extraction and Utilisation - The Australian Experience in the Coal Journal, No 26, 417-425.

BHP Engineering Pty Ltd, Vertical Well Methane Drainage, Moura Lease for BHP-Utah Coal Limited, 45 p., August 1990.

Horner, D.M. and Enever, J.R., In-situ Stresses: A Critical Factor Influencing Hydraulic Fracture Performance in Australia Coal Basins in Proceedings of the 1989 Coalbed Methane Symposium, Alabama, 445-450.

Seamgas Enterprises Pty Ltd, Vertical Well Degassification Project; Third Interim Report on Mine Through of Underground Frac Zone at German Creek Central Colliery, for Capricorn Coal Management Pty Ltd, 9/1989.

Koenig R.A., In-Situ, Inc and Schraufnagel, Gas Research Institute, Application of the Slug Test in Coalbed Methane Testing, Proceeding of the 1987 Coalbed Methane Symposium, Alabama, 195-206.

Malone, P.G., Briscoe, F.H., and Camp, B.S., A Study of Coalbed Methane Production Trends as Related to Geologic Features, Proceedings of the 1987 Coalbed Methane Symposium, Alabama, p.293.

Confidential BHPMC Files

Confidential SE Files

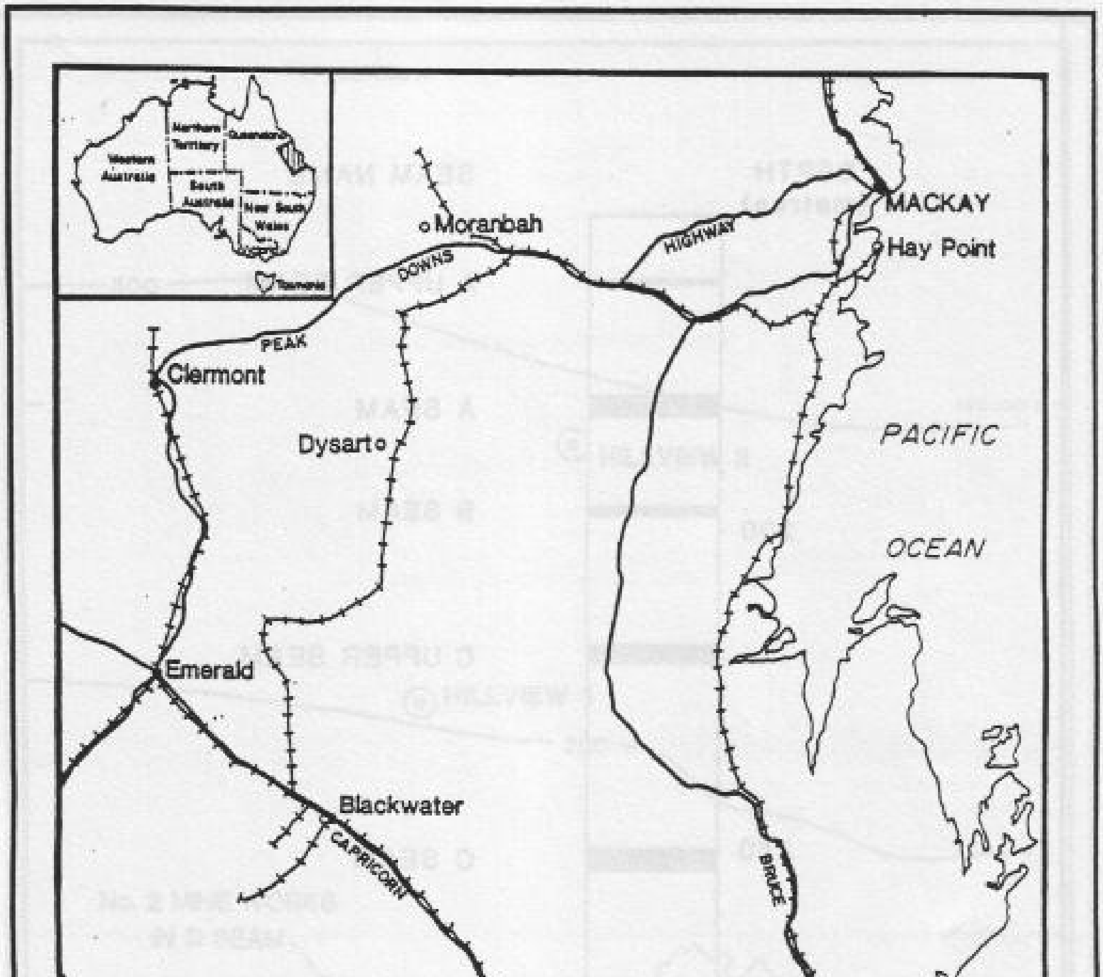

Figure 1. Location map of Moura area

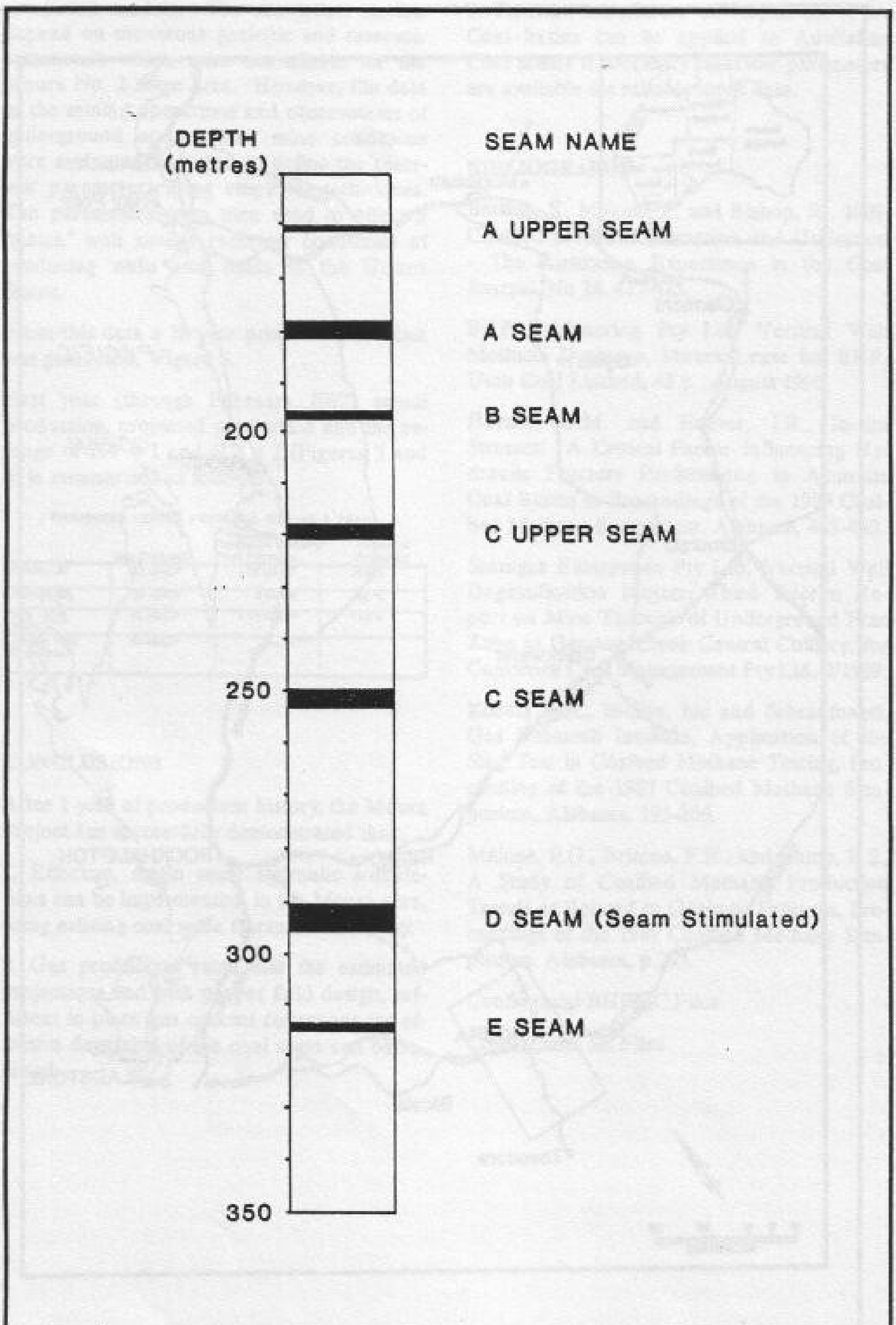

Figure 2. Typical stratigraphic sequence Hillview area.

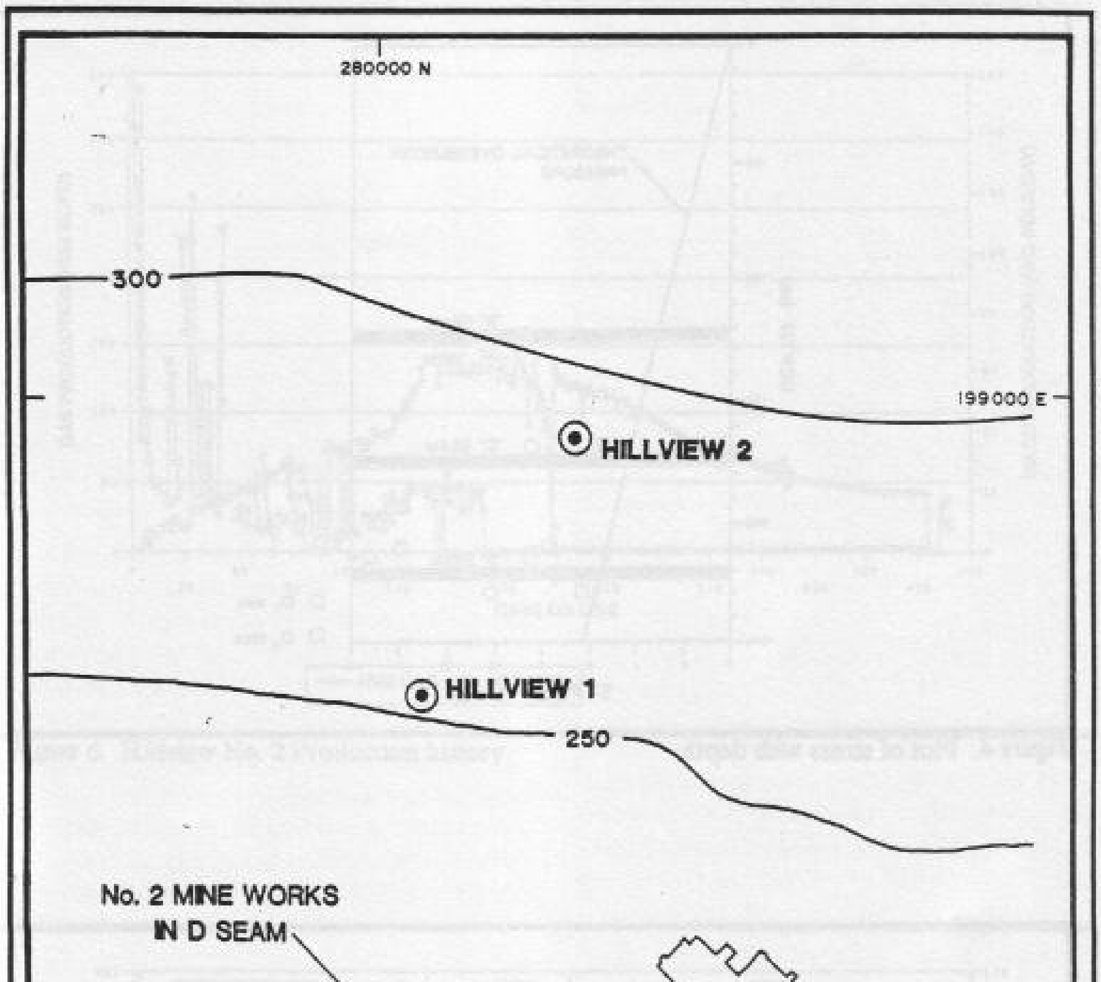

Figure 3. Well location map

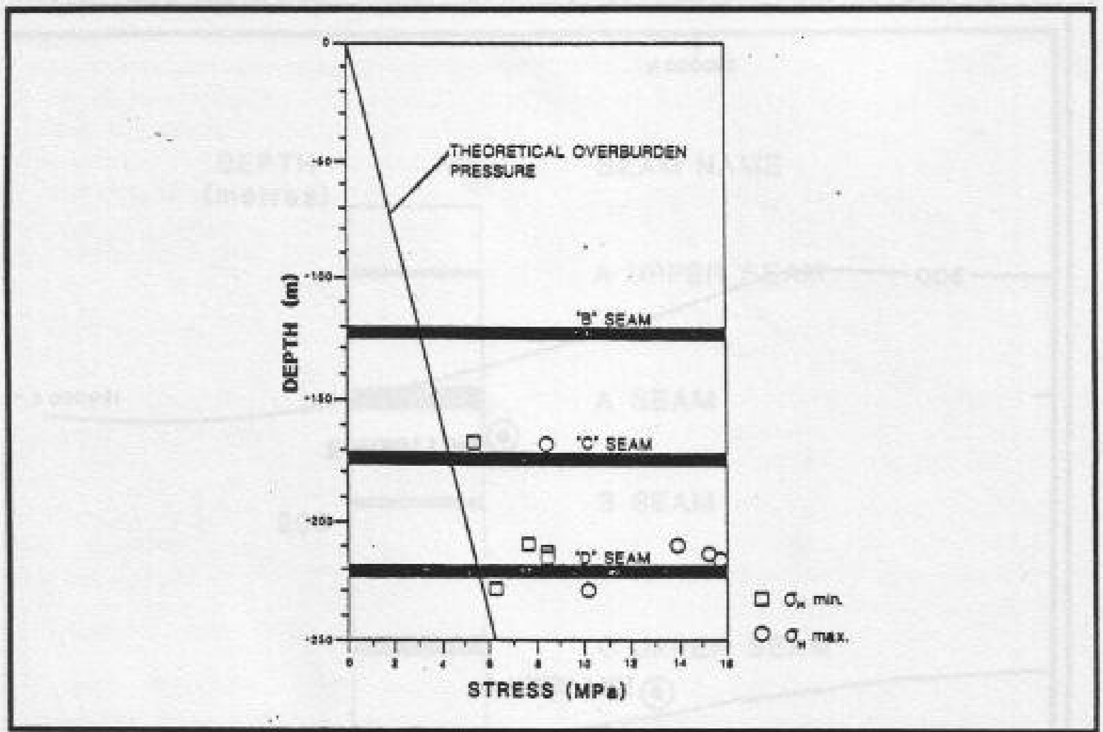

Figure 4. Plot of stress with depth

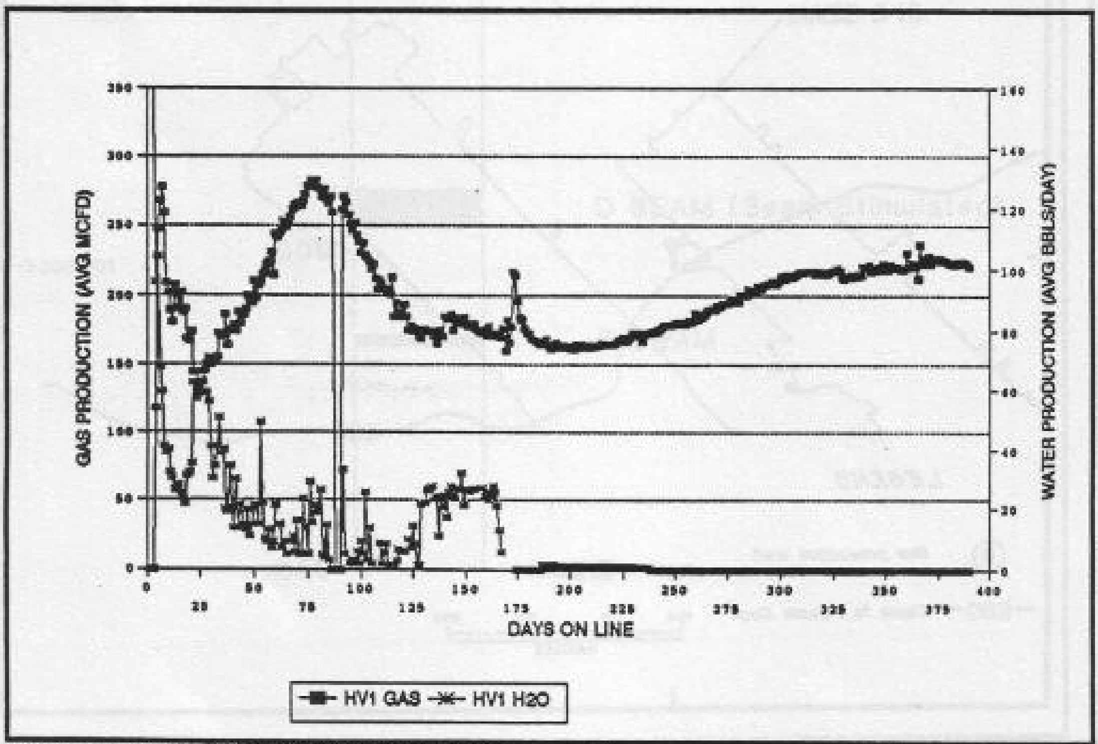

Figure 5. Hillview No. 1 Production history

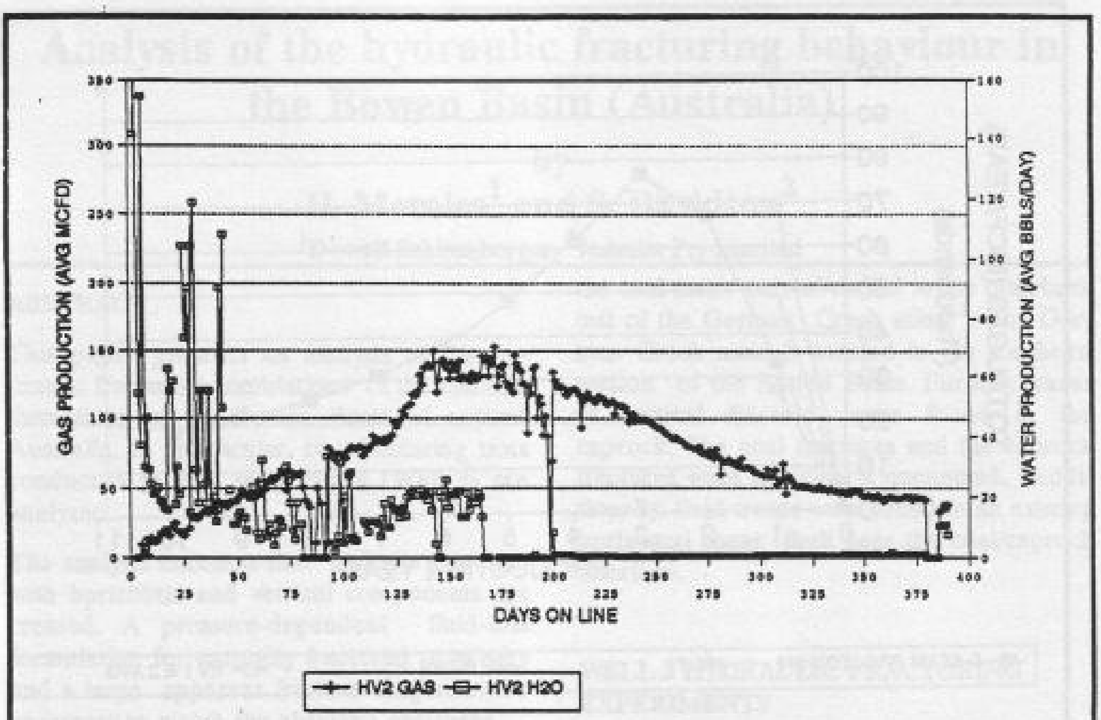

Figure 6. Hillview No. 2 Production history

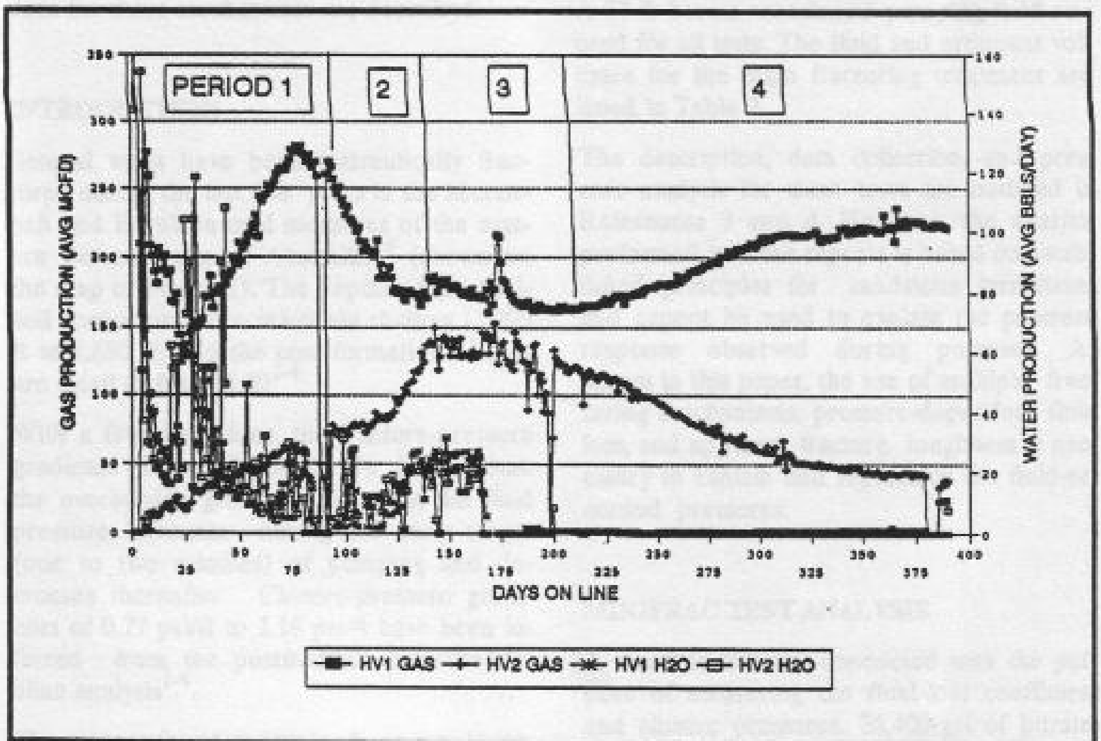

Figure 7. D Seam production history for Hillview 1 and 2

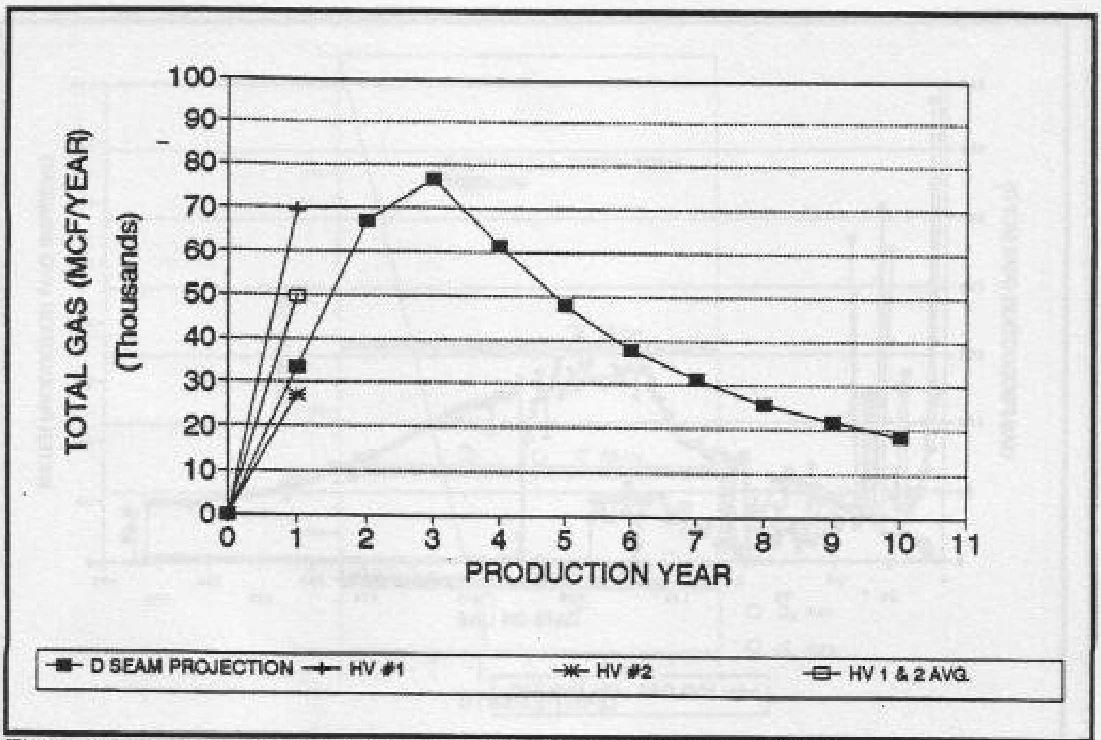

Figure 8. D Seam production Hillview Nos. 1 and 2 vs. projected D Seam