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EXPLORATION FOR RESULTS MOURA COAL MINE

John Hoelle [1]

ABSTRACT: Moura Coal Mine operates 3 draglines, 2 excavators, and 2 highwall mining systems producing 6.5 million tons per annum for 3 products from 7 different seams and operates a commercial seam gas recovery operation - with active mining spread over 40 kilometers of strike length and dips up to 20-degrees. To minimize the impact of geological-geotechnical problems, the exploration program has to be thorough and comprehensive since the data may be used for several different types of operations.

For open cut mining, strength data is obtained on overburden and floor strata for low wall stability design. Strength information of the overburden strata and fracture data are used in the design of pre-split and overburden shots and highwall stability analysis. Successful highwall mining requires geotechnical data for analysis for roof, pillar and floor stability analysis. Once mining commences the feedback on the response of strata to mining is hazy; adequate information is required to lessen the possibility of unpleasant surprises. The impact of seam gas content on highwall mining production is analyzed using routine seam gas sampling. Samples of coal seams are obtained routinely for seam gas data for the seam gas operation and highwall mining.

INTRODUCTION

The Moura Coal Mine is located on the east flank of the Bowen Basin. At present, all mining is open cut mining with highwall mining being conducted after economical limits of the pits are reached. The active mining is 40 kilometres long with reserves covering 150-km of strike length. The width of active mining is up to 3 kilometres. Mining is complicated by the range in geologic conditions in strata types and the steep dips (up to 20 degrees).

The exploration programs attempt to obtain data to satisfy the design requirements of open cut, highwall mining and commercial seam gas recovery operations. At times, the requirements are mutually exclusive and choices have to be made. The exploration programs at Moura Coal Mine are similar to other mines in the type of data that is obtained. Table 1 lists the information that is routinely obtained from a core hole.

Two examples of typical exploration dilemmas will be presented – one in which a choice of what data to collect had to be made and one in which a large quantity of data had to be obtained in order to successfully start a new pit.

RESERVE WITH HIGH QUANTITIES OF SEAM GAS

An area located down dip from an open cut and highwall mining reserve had previously been identified as a potential seam gas recovery reserve based upon gas desorption tests obtained from a number of boreholes. The high levels of methane gas (up to 7.6 cubic metres per tonne) down dip also indicted that these gas quantities may impact on the proposed highwall mining. Coal quality samples from this same area indicated that the coal could be a semi-soft coking coal. A proposal was made to re-open an open-cut previously mined over 25 years ago for an additional cut on the highwall and then conduct highwall mining.

Additional boreholes were required to delineate both the gas quantities as well as the coal qualities in the area of the proposed mining. However, the area between the "known" reserve down dip and the proposed open cut pit was an active dragline pit in an overlying seam and unavailable for exploration. The area under consideration is shown in Figure 1.

[1] Mining Engineer Moura Coal Mine

Table 1 - Information usually obtained from boreholes in an exploration program

- Geologic Data
  - Coal thickness
  - Samples for coal quality
  - Geological features
    - Strata type
    - Structure
    - Dip
- Geophysical electric logging
  - Density
  - Natural gamma
  - Calliper
  - Sonic
  - Dipmeter
- Geotechnical Data
  - Sample for laboratory testing
  - Field logging
    - Estimated field strength
    - Point Load Tests (diametric and axial)
    - Rock Quality Designation (RQD)
    - Fracture Frequency Index (FFI)
    - Joint Roughness Coefficient (JRC)
- Seam gas quantity

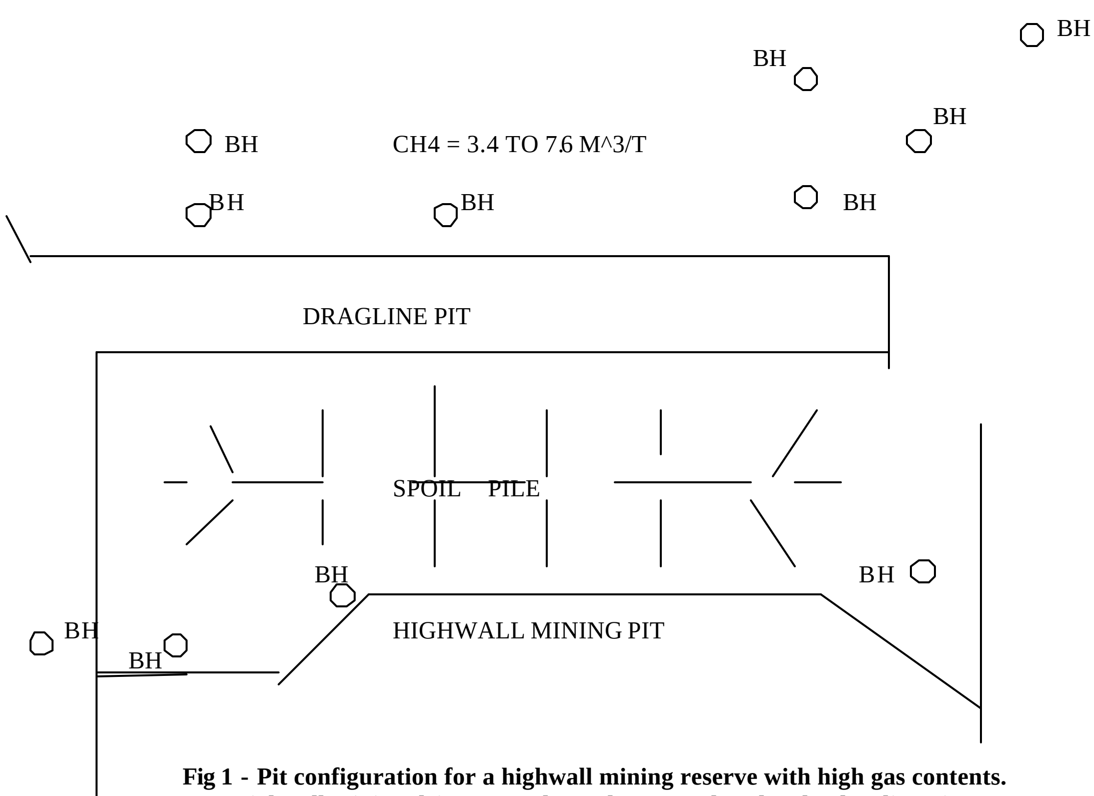

Fig 1 - Pit configuration for a highwall mining reserve with high gas contents. Highwall mining drives are planned to extend under the dragline pit

This active pit left a limited area for 4 boreholes and these boreholes would have to be placed within 50 to 70 metres of the highwall. The coal quality characteristics were critical to the viability of the proposed pits. Although the quantity of the seam gas was required, historically at Moura, seam gas samples obtained from coal seams with less than 50 metres of overburden usually showed low gas contents. Coal samples obtained for seam gas content cannot be used for testing for coking coal properties since the time delay and the oxidation of the seam during the desorption process significantly alter the properties of the coal. Samples that have been tested for seam gas are only tested for raw coal quality parameters.

Therefore the decision was made to obtain samples for coal quality. The experienced field geologists were to determine if copious quantities of gas were desorbed from the core whilst logging. The reserve was determined to be of a coking coal quality.

There are limits to mining in methane, even though the steep dip system uses inert gas forced into the drive to reduce the quantity of oxygen and prevent the occurrence of an explosive atmosphere. Prior to mining, it was estimated that methane levels that would be encountered would be in the range from 4 to 6% and that these levels would be encountered approximately 250-metres into a drive. In practice, high levels of methane were encountered approximately 40-metres into the drives and the levels have range up to 11%, a level that has to some extent adversely affected production.

DESIGN OF A BOXCUT IN ADVERSE CONDITIONS

Moura Coal Mine is on the edge of the Bowen Basin and the dragline pits start on the crop line with a box cut. Box cuts are notorious for potential stability problems so that the strength characteristics of the various strata (immediate floor, coal, immediate roof, weathered coal, weathered roof strata and soil) are all required to properly design a stable pit.

In starting a new pit, one important issue that has to be addressed is the exact starting point of the initial cut. Too far up-dip and weak strata is encountered and unsaleable soot is recovered. Too far down-dip and saleable coal is sterilised at low overburden ratios. The limit of oxidation (Lox) line is invariably not a straight line; whilst a straight line is a requirement for the dragline.

The parameters for this box cut consist of:

- A thick coal seam (about 5 to 5.5-metres thick);
- Steep dipping (14-degress, which is moderate for Moura);
- Weak roof strata in the box cut area;
- Moderately strong floor;
- A wet seam;
- Faulting that cuts across the crop creating offsets in the crop.

Previous studies have recommended one of two design parameters for the boxcut depending on the clay content of the roof above the coal. If there are no clay seams in the roof strata, then a 20-metre berm should be left between the crest of the low wall and the toe of the spoil. If clay seams were present, then the toe of the spoil should be moved further from the projected crop of the coal seam, creating an approximate 70-metre wide bermas indicated in Figure 2. Other alternatives have also been suggested, such as a false box-cut or removal of the wedge of strata above the coal.

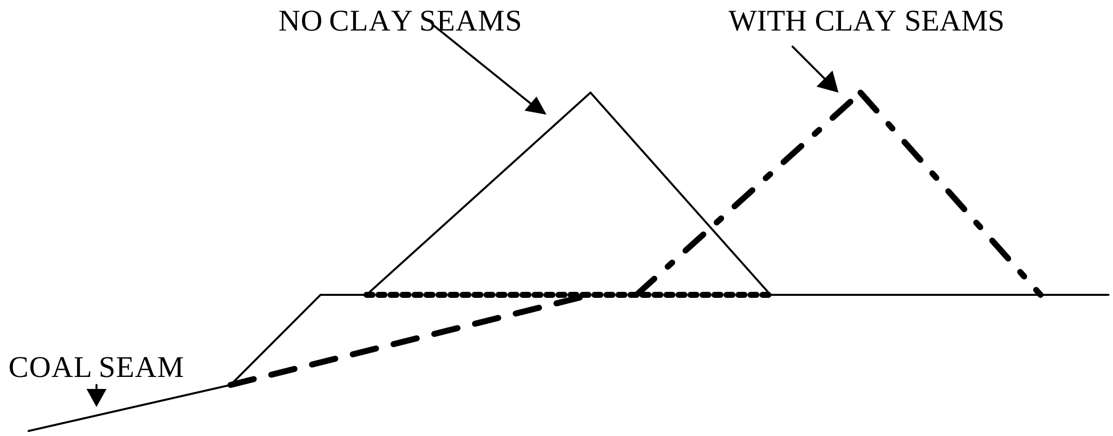

Fig 2 - Configuration comparing the two different spoil pile locations depending on the strength of the strata overlying the coals seam.

The exploration program required answers to the following questions:

- Cut-off limits for LOX line
- Minimum thickness of coal seam in which to start mining
- Coal quality
- Good definition of the coal location horizontally and vertically
- Location of the several faults
- Strength of the in-situ material above the coal
- Coal strength
- Partings within the coal
- Fracture orientations

A large number of chip holes (91) were drilled in rows across the anticipated LOX line. Whilst the main reason was to define the location of the coal and to determine the LOX line, sonic geophysics was used to obtain strength characteristics as well as an indication of the degree of weathering of the coal. The proposed pit is slightly over 2000 metres long and the main objective of this exploration program was to determine the limits of the pit.

A smaller number of cored boreholes were drilled in order to obtain samples of the strata above the coal seam for geotechnical testing and to obtain field geotechnical information.

The exploration drilling determined that clay seams were present in the area of the proposed box cut. In addition, the strata above the coal was highly fractured with numerous high angle fractures and shear zones that approached gravel in consistency. Due to the weathered and fractured nature of the samples, lab testing was difficult. Only 5 of 9 samples obtained during the exploration process were suitable for testing. Direct shear tests were conducted by a soils laboratory. These direct shear tests produced the following strength values.

Cohesion of 20 to 30 KPa

Internal friction angles of 17 to 28 degrees

Based upon the lab test results as well as estimates of the strata strength obtained during the logging process, stability analyses were conducted using the software slope stability program Galena. The final design produced a boxcut with a 40-degree low wall slope, a 20-metre wide berm and a spoil pile with nominal 37-degree slopes. Shallow failures in the low wall were anticipated; however, these projected slips did not affect the stability of the spoil (which had a Stability Factor = 1.20). Refer to Figure 3.

The first pit and over half of the second pit has been completed and the anticipated movement in the low wall did not occur. There were just 3 areas where very limited shallow slips occurred, none of which encroached on the berm. The success of the box cut was created by the quality and quantity of the basic geological and geotechnical data obtained during the exploration program.

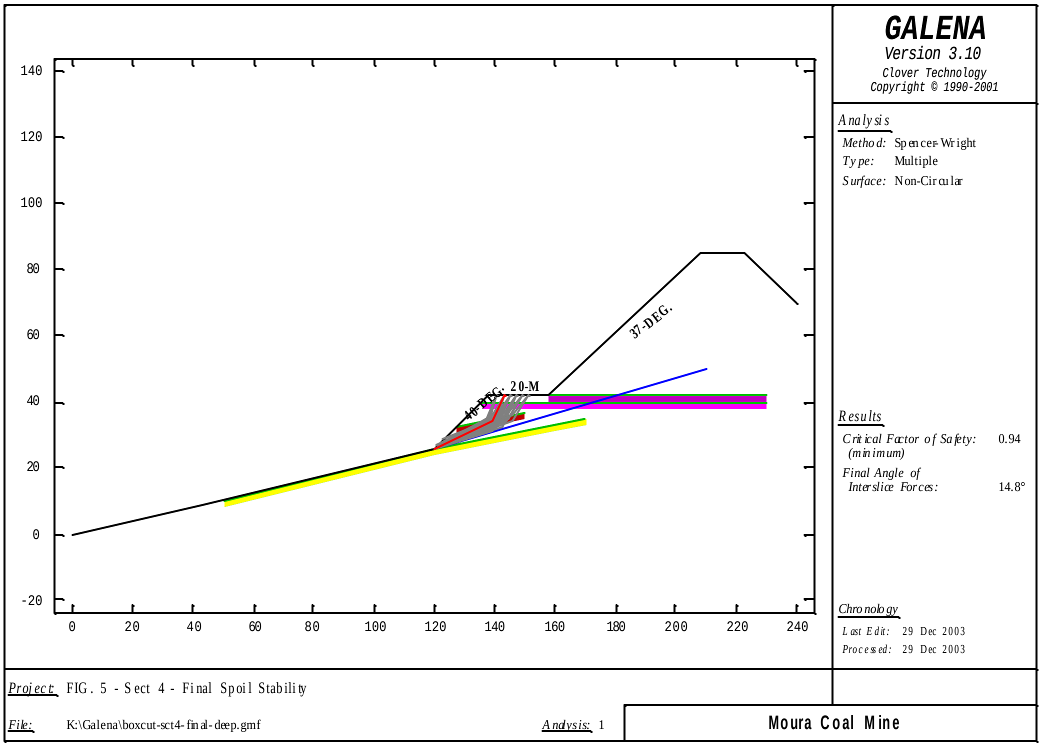

Fig 3 - Example of slope stability analysis indicating shallow failure in low wall. Analysis of spoil stability after removal of "failed" low wall produced a stable spoil pile with a Stability Factor of 1.20

CONCLUSION

Any exploration program is always less than is desired. The object is to strive to obtain as much information as possible from each core hole and borehole. At times, this is not always possible. The two examples presented indicate some of the problems created in making choices.