The Surveyor's Responsibility in Outburst Management

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The Outburst Management Plan

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What are the key elements of any Outburst Management Plan?

The Outburst Management Plan

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1. Prediction
2. Prevention
3. Protection

1) Prediction

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- Confident Prediction relies on accuracy and completeness of input data
- Input data is collated to produce a hazard map or prediction plan and authority to mine
- The Mine Surveyor generally processes and publishes data from:
  - The Exploration Department
  - Mine Geologist
  - Gas Drainage Department

The Professional Surveyor's duty

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- Know the accuracy required by Legislation and the key Prescribed Drill Pattern Parameters in the relevant Outburst Management Plan (maximum hole spacing, core spacing, flank hole position and accuracy)
- Know the capability and limitations of surveying equipment and techniques employed
- Measure actual accuracy achieved so as to give realistic and reliable tools for outburst prediction
- Make relevant people aware of and allow for limitations in accuracy

Surface Exploration Accuracy

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- Location of surface boreholes and seismic lines
- What is the minimum Legislative requirement?
- What do we actually achieve?

Required Accuracy

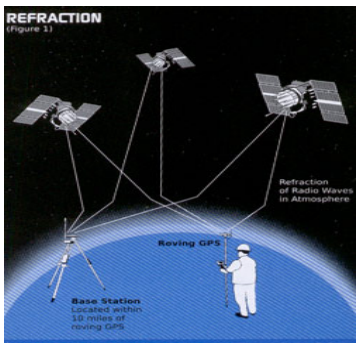
Environmental Guideline - NSW Department of Mineral Resources: EDG01 Borehole Sealing Land.doc

5.5 Survey Requirements
All boreholes shall be properly surveyed to determine their horizontal and vertical positions and survey details are to be furnished with written reports.

All boreholes shall be surveyed with a vertical position accuracy of +/- 0.3 metres

and a horizontal position accuracy of +/- 1.0 metres

GPS Satellite Positioning



GPS Satellite Positioning

To eliminate errors caused by the earth's atmosphere, a secondary receiving station called a base station is set up over a known, surveyed point.

This known coordinate is input into the base station, and then as it receives satellite information, it compares that data to its known location and continually transmits correction data to the roving GPS receivers and GPS machine control units on the job site.

This correction data is then used in conjunction with the GPS satellite signals received by the moving GPS system to provide highly precise information despite the motion.

Actual Accuracy

The typical nominal accuracy for these systems is:

1cm ± 2 parts-per-million (ppm) horizontally
and
2cm ± 2 ppm vertically.

The more GPS satellites you are receiving, the better your accuracy will be.

Typical Exploration Rig

Survey Accuracy at Seam Level

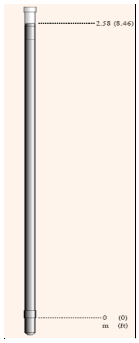
Old vertical exploration holes (10 years +) were generally not surveyed

These usually spiral down to the seam or deflect with the strata in up to a 10m diameter in X,Y Plane

Geological & Core data is fixed strongly in the Z (Height) but approximately + or – 5m in X,Y

All exploration holes are now surveyed

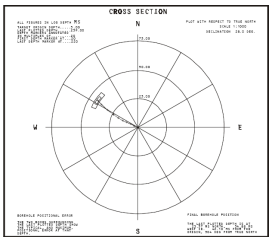
Tools – VO1/4 Verticality

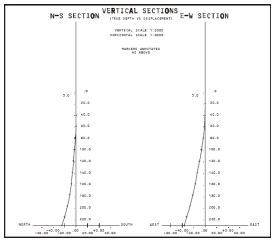


- **VO1 Verticality**
- **Measurements** **X,Y,Z magnetometers**
- **X, Y tilt cells (VO1); accelerometers (VO4)**
- **Applications** **Borehole trajectory**
- **Formation dip orientation (Dipmeter)**
- **Constraints** **System will not work in steel rods or casing.**
- **Gyroscopic azimuth systems do work through steel, but have not been available Qld; system currently being assessed by one Qld major.**
- **Outputs from three magnetometers and two level cells (accelerometers) allow tool orientation wrt vertical and Magnetic North to be determined. Input of Magnetic Declination for area allows orientation wrt True North.**
- **Other options behind steel casing include hole survey tools run by drillers, such as multi-shots. These can be run either prior to casing or after casing has been retrieved.**
- **Positional Error:**

	Tilt	Azimuth
Typical Error	+/- 0.333 degrees	+/- 10.000 degrees
Maximum Error	+/- 0.500 degrees	+/- 10.000 degrees

Tools – VO1 Verticality





Surface To Seam *Surveyed* Hole Accuracy

- Over nine holes surveyed at seam level
- Including four inclined holes and one Medium Radius Drill (MRD) hole
- Spread from 1.8m to 0m from Target
- Average 1.0m
- Average Depth 500m
- Equates to 1 in 500 = 0.1 degree in vertical deviation from underground target

2) Prevention

Effective gas drainage is based on:

- Accurate drill patterns
- Effective gas flow from these holes
- Accurate core sampling (before & after drainage)

Inseam Borehole Accuracy

.9 Survey of Boreholes (Survey & Drafting Directions for Mine Surveyors 2007) (NSW – Coal)

oreholes are to be identified by unique name or number and are to be shown on the Mine Workings Plan. Collar and/or commencement locations of Boreholes, are to be established from a **control** or **subsidiary survey**, with both Map Grid of Australia (MGA) coordinates and Australian Height Datum (AHD) levels in accordance with these Directions.

he following information will also be recorded, wherever possible, whether from direct survey or other source (i.e.: drillers log, geophysical survey): -

a) total length (or depth);

b) inclination (or declination), and

c) plan projection (bearing or azimuth) when other than near vertical.

Inseam Borehole Accuracy (Prediction and Prevention)

- Control and Subsidiary Surveys are planned and surveyed to “achieve a standard of accuracy as prescribed in Inter-Governmental Committee on Surveying and Mapping (ICSM), Standards and Practices for Control Surveys (SP1) to achieve Class D or better”
- In layman’s terms Class reflects the precision of observations and the suitability of the control network. For a mine 10km from the surface baseline this equates to a positional uncertainty of approximately 0.5m
- Surveys to the locate the Boreholes, as with mine workings, come into the class of Secondary Surveys. It is not unreasonable to expect the borehole collars to be located to within + or – 0.2 in X,Y,Z

Accuracy Of Survey Information

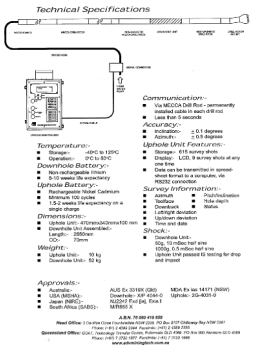
What contributes to the accuracy? Or error?

- Accuracy of survey control
- Survey pick up or set out of hole collars = + or – 0.2m in x,y,z
- Accuracy of survey drilling tool (based on magnetic field i.e. magnetometer & inclinometer)
- Magnetic interference to the magnetometer from nearby steel (or magnetic ore body)
- Interpretation and relay of survey and drilling information from gas drainage department
- Plotting of hole

Survey Drilling Tool Accuracy

/ Inclination =
/ + or - 0.1 deg

/ Azimuth
/ + or - 0.5 deg



How do we ensure that the survey tool is operating correctly ?

- Survey baseline set up on surface with known grid bearing (e.g. 0deg00'00'')
- Survey tool is placed on baseline and read (e.g.348deg00'00")
- Magnetic declination 12 deg (i.e. add 12 deg to survey tool to read grid)

Typical Survey Tool Calibration Baseline

Survey Tool Calibration

Radiate holes from survey control after being intersected by the mine workings

Compare with plotted positions

Actual Accuracy Achieved

- Approximately 30 per cent of boreholes intersected by workings are surveyed
- Experience with 3 downhole survey units of varying vintage and methods of data transmission have yielded similar results.
- Surveyed position of intersected holes are up to +or-5m from plotted position over 300m or + or – 1 degree (average 3m or 0.6 degrees)

Observations

Long holes with curved trajectory holes are less accurate than those drilled straight

There can be a difference in observed magnetic declination depending on the direction of drilling

Surface baseline calibrations are more accurate when the baseline is oriented in the predominant drilling direction

Observations

Magnetic effects that have adversely impacted on drilling accuracy include:
- steel rib bolts up to 18m from the collar
- previously drilled inseam holes lined with steel
- the continuous miner, when drilling flank holes past it

To ensure flank hole accuracy, drill sights must be set to ensure correct starting orientation

Information From Gas Drainage Department

Structure Detection

- Vigilant, experienced drillers can detect and record small structures through changes in drilling characteristics, sticky drilling, drill pressure return water

Seam Characteristics
- Seam thickness
- Seam dip
- Fault displacements
- Coal hardness

The Vigilant Drill Rig Operator

Surveyor's duty during drafting & compilation

- To accurately plot the gas drainage holes and core results
- Clearly indicate anomalies and lost drilling gear
- Check that the drilling and coring pattern conforms to the Outburst Management Plan of the mine
- Highlight to Gas Drainage and Geological Department any shortcomings in patterns or areas which may require remedial drilling and coring

Observations

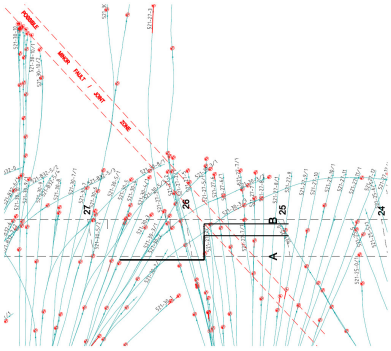
- Areas of geological complexity usually cause the most problems with drilling and drainage.
- All the fatal outbursts in the Bulli Seam have occurred on structures

Surveyor's Duty During Routine Survey

The Surveyor should complement Geological Mapping with Accurate Survey of :

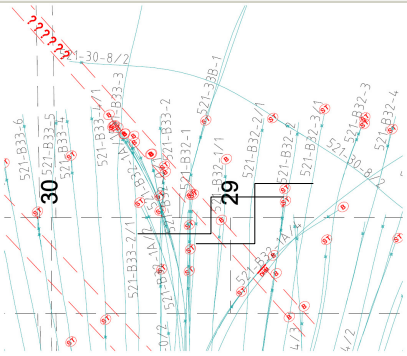
- Jointing – the orientation tends to be parallel to more significant Structures
- Minor faulting / mylonite
- Intrusions
- Intersected inseam and surface to seam boreholes

Drilling Information for Structure Prediction



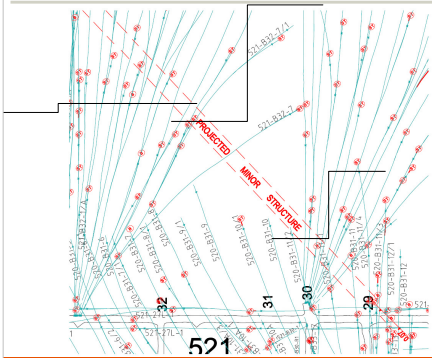
Identification by astute Rig Operators

Drilling Information for Structure Prediction



Identification by astute Drill Rig Operators

Accurate Survey & Drill Information for Structure Prediction



Identification by Astute Drill Rig Operators

Identification & Projection by Accurate Survey & Mapping

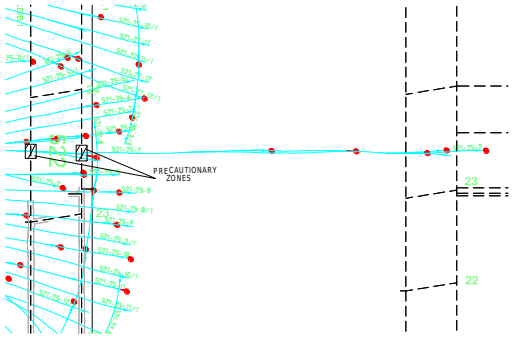
Why do holes need to be located & plotted accurately?

A typical inseam hole with 2 branches can be 1100m long by 96m diameter giving 7.2m3 of reservoir

Long holes with several branches can become pressure vessels if they become blocked, or intersect geological structures.

Virgin gas pressures can reach 4000kpa(580p.s.i)

How do we treat long exploration holes?



3) Protection (during routine underground survey)

As is the case for all mine workers if the surveyor :

- Identifies outburst warning signs or changed mining conditions
- He or she has ability to suspend mining, notify the mining official and initiate an inspection
- The Surveyor is trained in the use of First Response Rescue and Escape Equipment

The Surveyor's Duty in Record Keeping

For the Outburst Management Plan at a mine to be 100 per cent effective it must evolve to accommodate changes in:

- **Gas content**
- **Gas composition**
- **Coal permeability**
- **Ash content**
- **Technology**

The data collected for the Authority to Mine, and for Prediction and Prevention of outbursts provides an invaluable source of evidence for seam gas modeling and the continued refinement of the Outburst Management Plan