Geovariances
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White Paper



Drill Hole Spacing Analysis

Geostatistical Assessment of Borehole Spacing Relative to Resource Confidence

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Use your data to inform and support your resource classification and drilling decisions.

Not all coal seams and quality variables have the same continuity or variability, so investigating drill hole spacing for your data makes sense.

Drill Hole Spacing Analysis (DHSA) lets you understand variations in estimation precision across your deposit for different seams, domains and variables.

Many deposits, variables, and most importantly, a range of geological settings have been analysed using DHSA to obtain the optimal drill spacing information to support resource classification decisions.

DHSA has been implemented internationally by Geovariances for over 12 years. In Australia, DHSA has been applied to coal operations and projects in the Bowen, Surat and Gunedah Basins.

Variability in coal quality

Continuity and variability are unique for each coal seam and deposit. So why apply the same drill hole spacings for resource classification at different mine sites or even across a deposit?

Does your resource classification process reflect the variability you see at your operation?

The Coal Guidelines for coal resource classification are based on the perceived precision of estimates. The recommended spacings apply to all seams, variables, coal measures and geological settings. These spacings do not consider the continuity and variability of the individual coal seams or plies, nor the specific geology.

If you have sufficient drilling data to understand the continuity and variability of coal properties for your site, why not use it to assist with operational decisions, like resource classification, product specifications or drilling optimisation?

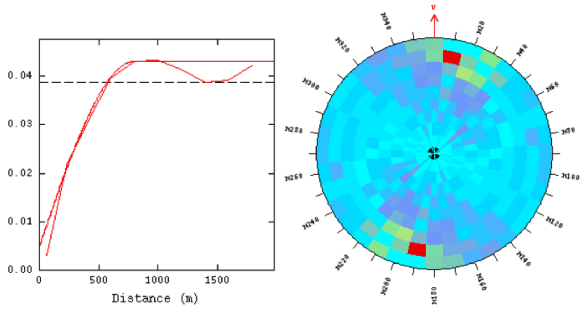


Fig. 1 - The spatial continuity of a deposit is captured in a DHSA study thanks to variography.

DHSA - an objective measure

DHSA provides a geostatistical means of assessing the estimate precision for coal resource estimates based on the sampling data and its geostatistical properties. The DHSA results can be used to objectively inform your resource classification and drilling decisions.

Objectively inform your resource classification and drilling decisions.

DHSA results can be used to:

- Support changes to resource classification.
- Prioritise drilling targets by identifying areas requiring increased or reduced sampling density.
- Indicate further drilling required to attain a given resource classification. This can be critical in budget planning for project development.
- Suggest grade control drill densities required to capture the short-term variability to meet mill or product specifications.
- Compare different domains and seams or plies to identify areas of greater variability (or insufficient data) that require

References

- Coalfields Geology Council of New South Wales and the Queensland Mining Council, 2003 Australian guidelines for estimating and reporting of Inventory Coal, Coal Reserves
- O. Bertoli (Geovariances), C. Mawdesley (Geovariances), S. Martinez (BMA), A. Paul (formerly BMA), D. Dunn (BMA), 2012 - "Measure for Measured - Geostatistical coal resource classification in the Bowen Basin", 34th Int. Geol. Congress, Brisbane 5-10 August 2012

further work to define or mitigate the potential impact of high variability on planned mine production.

Through DHSA, use *your data* to understand, inform and support your resource classification decisions.

The use of a geostatistical method, where the classification of a resource is driven by the actual in situ variability of the given resource, is strongly recommended as best practice for the industry (Bertoli et al, 2012).

Benefits

The principal benefit of DHSA is gained from using ***your data*** and its characteristics to develop site-specific resource classification recommendations.

DHSA is repeatable and objective, which can be crucial as projects progress and drilling is updated.

Experience shows that DHSA spacing recommendations for resource classifications can differ significantly from the Coal Guidelines.

DHSA methodology

DHSA is a geostatistical technique that uses the global estimation variance to calculate the precision levels for various sample densities for a specific deposit.

Firstly, exploratory data analysis and variography are completed for the available sampling data (and where appropriate, domaining may also be applied to achieve stationarity).

The continuity and variability of a specific area and variable are characterised by the variogram model. DHSA uses the variogram model to determine the estimation variance for a single block.

The annual area mined (or uncovered) is required as an input into the DHSA process. This gives the size of the area for the global estimate.

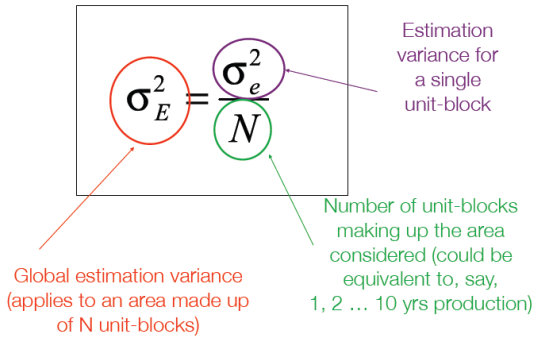


Fig. 2 - Calculating global estimation variance

Benchmarking DHSA

The precision of the DHSA results have been benchmarked against a suite of conditional co-simulations (CCS). The DHSA spacings were in very close agreement with CCS results over periods equating to five years of production.

Geovariances recommend using DHSA instead of conditional simulation approaches for the significant time savings and relative simplicity.

Many different drill spacings (e.g. block sizes) are tested, with the global estimation variance calculated based on the total area and the number of drill holes that will cover that area at a specified drill spacing. This analysis is repeated for many different sample spacings and the global estimation variances are used to approximate the precision.

Current coal industry practice for coal resource classification is to derive global estimation precisions for the variables thickness and ash over a five year period and apply the following resource categories:

Measured	**<10%**
Indicated	**10-20%**
Inferred	**>20%**

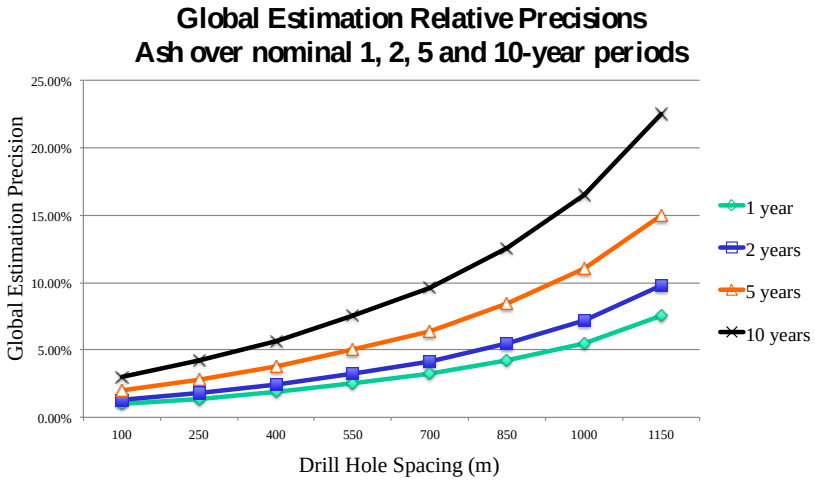


Fig. 3 - DHSA utilises the site variability (captured by the variogram model) to recommend drill spacings for resource classification

Drill hole spacings are determined for a defined global estimation precision.

In the example above, for Raw Ash, if a measured coal resource is assigned as having a global estimation precision lower than 10% over a 5 year period, a DHSA study advises a drill hole spacing of 900 metres.

DHSA is typically carried out for a range of variables, including thickness, ash, volatiles, sulphur and phosphorous. DHSA will provide a separate drill hole spacing recommendation for each variable investigated. The DHSA results for all variables will not have equal weighting or consideration for resource classification. Current coal industry practice for coal resource classification is to consider global estimation precisions obtained from DHSA for the variables thickness and ash.

Case Story for the Bowen basin

DHSA has been used at 14 of BHP Billiton Mitsubishi Alliance (BMA) coal operations and projects in the Bowen Basin. The DHSA results suggest that in the Rangal Coal Measures, the Coal Guidelines are probably too strict for Indicted Resources (Bertoli et al, 2012).

THICKNESS	MEASURED (±10%)	INDICATED (±20%)	INFERRED (±50%)
Seam/Domain	Drill hole Spacing Required – Rounded down the closer 50 meters (area equivalent to 5 years production)		
THICKNESS	2,000	3,650	7,650
RAW ASH	900	1,700	3,100
WASHED ASH	1,200	2,250	4,700

With DHSA results like these, would you reconsider your resource classification decisions and drilling decisions? You should.

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Who is Geovariances?

Geovariances is a specialist geostatistical consulting and software company. We have over 45 staff, including specialist mining consultants and statisticians.

Our software, Isatis, is the accomplishment of 25 years of dedicated experience in geostatistics. It is the global software solution for all geostatistical questions.

Other technical specialties

Geovariances are world leaders in developing and applying new and practical geostatistical solutions to mining operations. We have strong experience in all commodities, and have gained trust from the biggest international companies.

Our expertise is in applying geostatistics to resource evaluation. Our services are through consulting, training, and software.

Our expertise

Geovariances has 12 years of experience in DHSA projects. Most of the work has been performed for the Australian coal industry.

We can provide a unique expertise through both our French and Australian offices.

Geovariances is dedicated to applied geostatistics and has set the standards in geosciences, providing the mining industry with the Isatis software for more than 25 years.

For more information

Let us help you understand the variability and continuity of your coal deposit and use the global precisions and drill spacings to refine your resource classification and drilling decisions.

Contact our consultants:

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