International Journal of Coal Geology 112 (2013) 107–113

Contents lists available at SciVerse ScienceDirect

International Journal of Coal Geology

journal homepage: www.elsevier.com/locate/ijcoalgeo

Geostatistical drillhole spacing analysis for coal resource classification in the Bowen Basin, Queensland

Olivier Bertoli [a,*], Andrew Paul [b], Zach Casley [c], Doug Dunn [d]

[a] Geovariances Pty Ltd, PO Box 979, Wynnum,QLD 4178, Australia
[b] Ex BHP Billiton Mitsubishi Alliance Coal, GPO Box 1389, Brisbane QLD 4001, Australia
[c] Geovariances, 49b Av F. Roosevelt, 77215 Avon Cédex, France
[d] BHP Billiton Mitsubishi Alliance Coal, GPO Box 1389, Brisbane QLD 4001, Australia

ARTICLE INFO

Article history:
Received 20 July 2012
Received in revised form 14 December 2012
Accepted 15 December 2012
Available online 10 January 2013

Keywords:
Drill hole spacing analysis
Polygonal kriging
Australian Coal Guidelines
Bowen Basin
Global uncertainty

ABSTRACT

Geostatistical drill hole spacing analysis ('DHSA') for resource classification using the global estimation variance technique has been used across BHP Billiton Mitsubishi Alliance ('BMA') Coal Operation's various mines and projects since 2004. Analysis of the results points to the emergence of possible patterns in the results for projects pertaining to specific coal measures being mined by BMA. This correlation may be a useful guide to assist in developing resource classifications for projects based on the coal measures in which they occur. Comparison of the results of classification using the Coal Guidelines versus classification using the geostatistical DHSA method for a selection of BMA's operating mines in Queensland's Bowen Basin indicates that the non-geostatistical approach leads to level of uncertainty that does not always agree with the complexity of the geology.

1. Introduction

The coal industry in Australia has been actively working in recent years towards the (re-)integration of geostatistical techniques to the process of coal resource estimation and overall management of the coal resource. Whilst the actual estimation of key project variables may still not be routinely obtained by implementing geostatistical estimation techniques, the area of resource classification has been a topic where these integrative efforts have been more widely implemented in the industry.

BMA (BHP Mitsubishi Alliance) has been one of the key proponents of that success, having supported for almost a decade now the explicit integration of geostatistical techniques to the characterisation of global resource risk with a view to offer a quantitative framework to the derivation of adapted resource classification schemes.

Resource classification is a multi-facetted problem that needs to encompass a detailed characterisation of a wide range of factors (including but obviously not restricted to the estimation of mineable tonnages of coal) capable of impacting the level of confidence that can be placed on a coal resource. Any acceptable scheme of classification needs to be devised on the basis of quantitative measures of the uncertainty attached to these factors.

Bertoli et al. (2010) presented the use of a specific geostatistical technique to support classification of coal resources, namely geostatistical drill hole spacing analysis ('DHSA') based on global estimation variance which provides a quantitative measure of the global estimation precision with which a particular variable for a given seam/domain combination may be estimated at a particular drilling spacing.

From a theoretical view point, the current paper will not dwell upon the simple geostatistical setting that underpins the global estimation variance calculations but rather focus on the limitations and caveats for its use so that the results which are presented can be qualified accordingly.

Many deposits, variables, and most of all geological settings have been analysed in the course of this decade-long application of DHSA to the varied suites of deposits and projects being mined and explored by BMA in Australia. A simple taxonomy is proposed by which the results are broken down according to the coal measures to which the different seams being exploited belong. The simple but rather ambitious objective is to try and detect the existence of potential patterns of classification for the different coal measures being mined in Australia. Without presuming if such patterns (that are highly dependent on the corporate decisions being used to convert global precisions into resource categories) may be turned into industrially accepted guidelines, their mere existence may constitute an interesting platform to stimulate further work aimed at guiding the competent person for the classification of the resource in their derivation of sustainable and transparent classification schemes for coal deposits.

* Corresponding author.
E-mail addresses: bertoli@geovariances.com (O. Bertoli), Andrew.Paul@bmacoal.com (A. Paul), zach.casley@macquarie.com (Z. Casley), Doug.L.Dunn@bmacoal.com (D. Dunn).

0166-5162/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.coal.2012.12.010

2. Regional geology in the Bowen Basin

The Bowen Basin is part of a connected group of Permo-Triassic basins in eastern Australia that includes the Sydney and Gunnedah Basins. It occupies an area of approximately 160,000 km^2, the southern half of which is covered by the Surat Basin. Maximum sediment thickness in Bowen basin reaches about 10,000 m, concentrated in two north trending depocentres, the Taroom Trough to the east and the Denison Trough to the west (Fig. 1, Sliwa et al., 2008 provides the structural configuration of the Bowen Basin).

Tectonically, the Bowen basin may be subdivided into NNW–SSE trending platforms or shelves separated by sedimentary troughs. The units, from west to east, are Springsure Shelf, Denison Trough, Collinsville Shelf/Comet Platform, Taroom Trough, Connors and Auburn Arches, interrupted by the Gogango Overfold Zone.

Basin development started with an extensional phase during the Early Permian whereby volcanic, fluvial and lacustrine sediments were deposited in a series of half-graben in the east and a thick succession of coals and non-marine clastics were laid in the west.

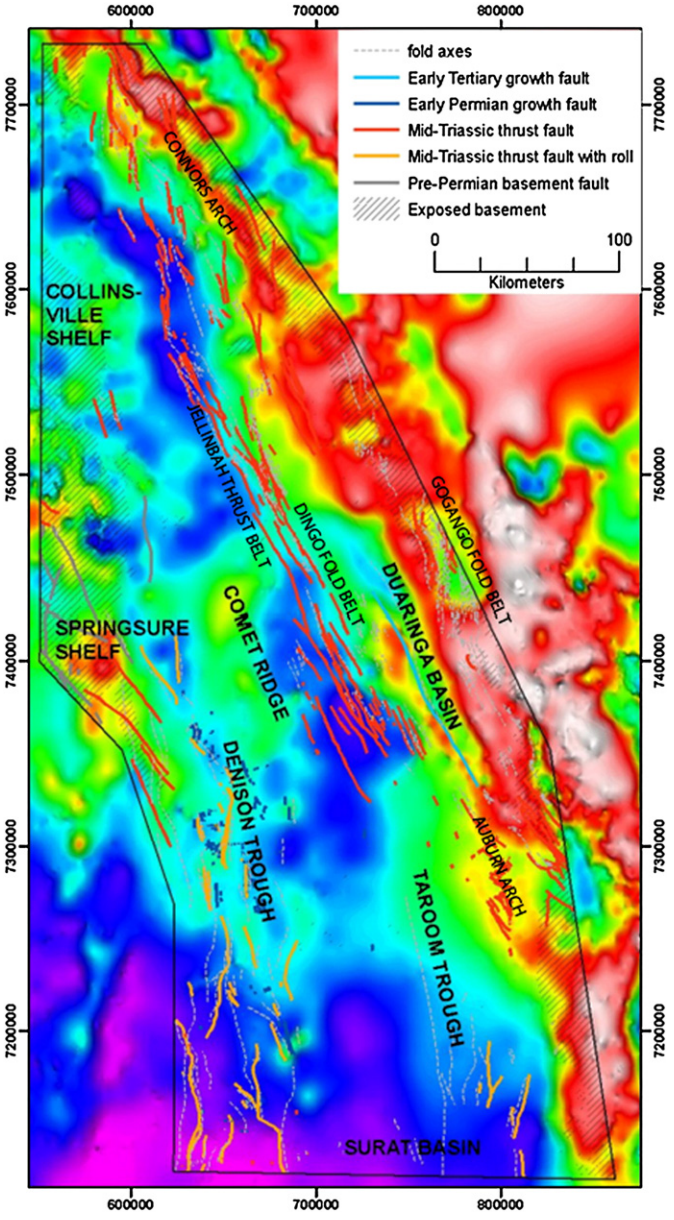

Fig. 1. Structural configuration of Bowen Basin (Sliwa et al., 2008).

The mid-Early to Late Permian is characterised by thermal subsidence. During this stage, basin-wide transgression allowed deposition of deltaic and shallow marine, predominantly clastic sediments as well as extensive coal measures (GeoscienceAustralia, 2009). Westward foreland loading during the Late Permian resulted to a period of accelerated subsidence, enabling the deposition of a thick succession of marine and fluvial clastics, accompanied by coal and Early- to Middle Triassic fluvial and lacustrine clastics. Basin sedimentation was terminated by a compressional event during the Middle to Late Triassic.

3. Coal geology

The economic coal seams of interest for BMA in the Bowen Basin are hosted by 3 coal-bearing units deposited during the Late Permian: a) the Moranbah Coal Measures, b) its facies equivalent, German Creek Formation, and c) the Rangal Coal Measures (Fig. 2). The reader is kindly referred to Fig. 3 for the regional stratigraphy of the Bowen Basin.

The Moranbah Coal Measures comprise the most extensive coal measures in the northern Bowen Basin. The formation was deposited in mid-late Permian and is characterised by several laterally-persistent, relatively thick coal seams of medium to low volatile bituminous rank, interspersed with several thin minor seams. Relatively uniform thicknesses of about 230–300 m are noted for the Moranbah Coal Measures on the western margin of the Bowen Basin, which increase eastwards towards the depocentre to a maximum thickness of 760 m (Mallett et al., 1995).

The German Creek coal measures, deposited in early Late Permian, is subdivided into a lower 160 m-thick, marine-influenced unit barren of coal and an upper coal-bearing interval about 110 m thick (Falkner and Fielding, 1990). The coal bearing unit of the German Creek coal measures is correlatable to the Moranbah Coal Measures.

The youngest coal-bearing units in the Bowen Basin Permian sequence are the Rangal Coal Measures (Quinn, 1985). It comprises of 100–300 m light grey, cross-bedded, fine to medium-grained labile sandstones, grey siltstones, mudstones and coal seams. Cemented sections are common in the sandstones, at times reaching 40 m in thickness.

Underlying the Rangal Coal Measures are the Fort Cooper Coal Measures which are typically comprised of tuffaceous sandstones, siltstones, mudstones and coal seams. At its type section in Hail Creek Syncline, the unit reaches 400 m thickness (Jensen, 1968). The transition between the Rangal Coal Measures and the Fort Cooper Coal Measures is generally clearly marked by the Yarrabee Tuff — a basin-wide marker bed comprised of weak, brown tuffaceous claystone. The presence of tuffaceous beds within the Fort Cooper Coal Measures distinguishes it from the Rangal Coal Measures.

The boundary between the Fort Cooper and the Moranbah Coal Measures is taken as the basal part of the lowermost tuffaceous seam in Fort Cooper. This boundary is sometimes difficult to identify because the Moranbah Coal Measures contain scattered tuffaceous units.

4. Australian Coal Guidelines

The Australian Guidelines for Estimating and Reporting of Inventory Coal, Coal Resources and Coal Reserves ('the coal guidelines'), are a set of non-prescriptive rules destined to guide the competent person in their classification of a coal inventory (exploration potential) or coal resource. The central element to the scheme of classification proposed in the guidelines is the essential notion of points of observation and the spacing between points of observation used to characterise a resource.

Points of observation as defined in the guidelines are intersections of coal bearing strata, at known locations, which provide Information about the coal. A point of observation for coal quality evaluation is normally obtained by testing samples obtained from surface or underground exposures, or from bore core samples having an acceptable level of recovery.