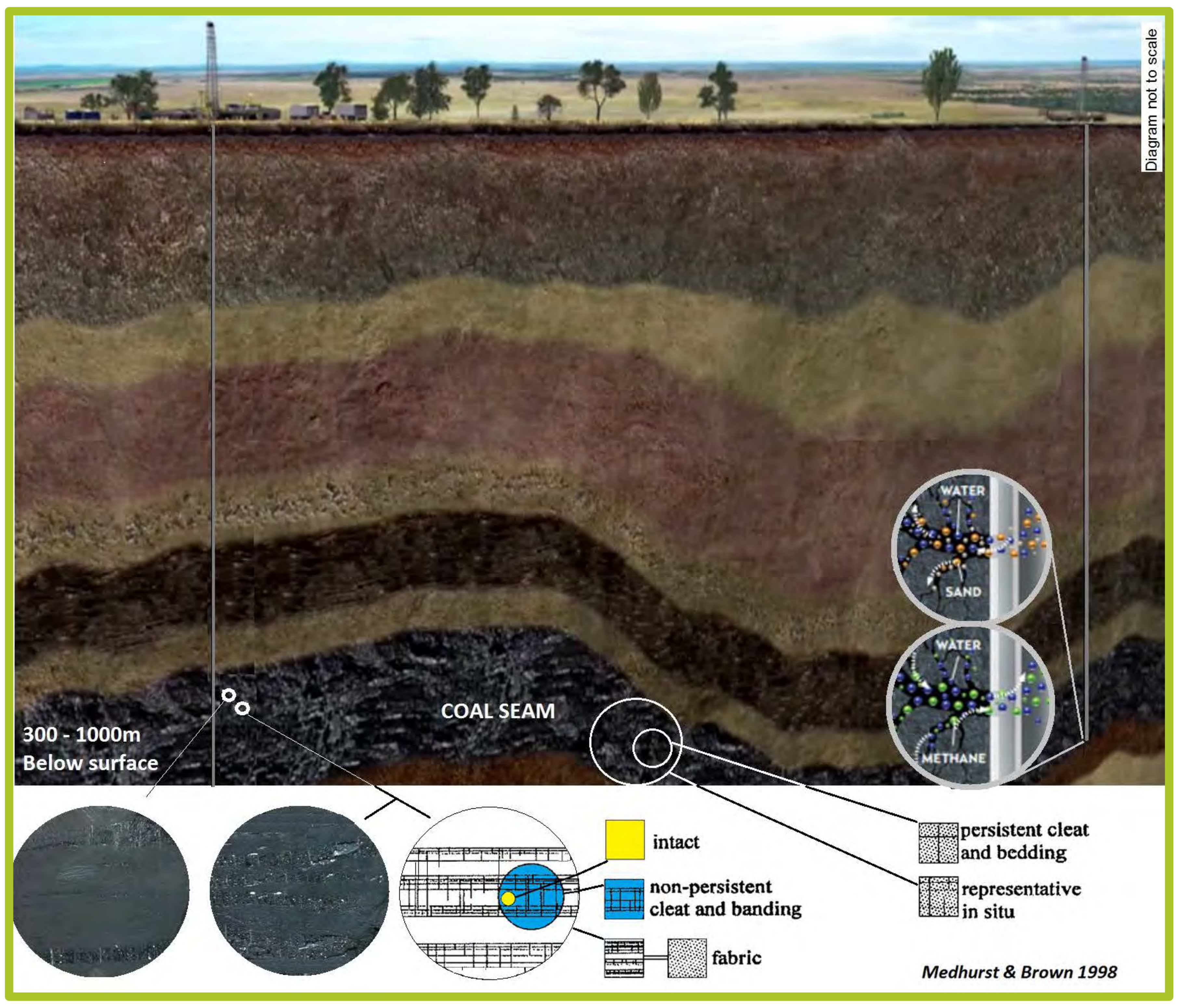
Coal Strength from Synthetic Rock Mass: Critical Points to Reproduce Rock Mechanical Behaviour, an Approach to Improve Inferences of Permeability and Reservoir Performance

Karina Barbosa - PhD - *School of Earth Sciences*

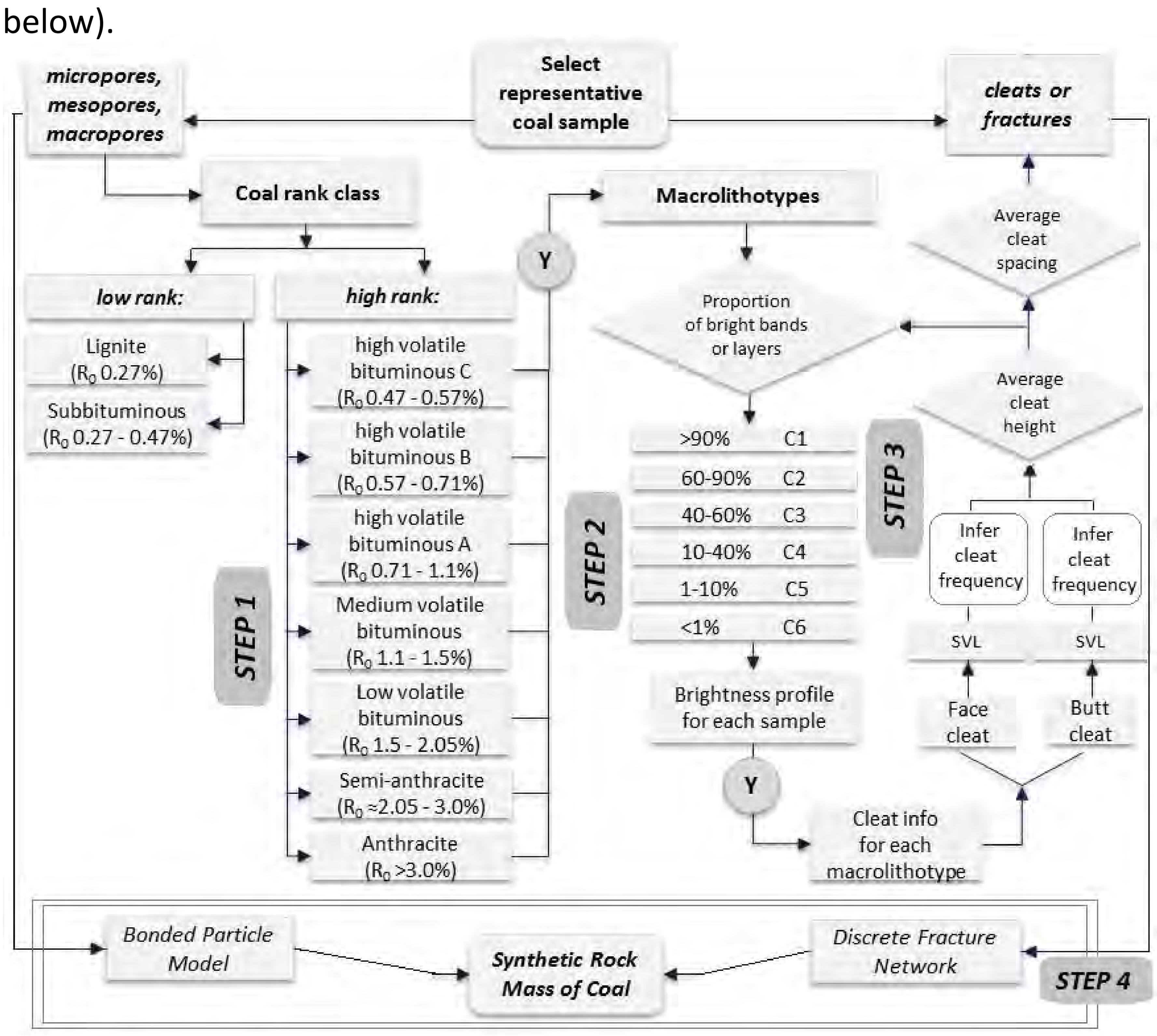
Supervisors: Joan Esterle and Marc Ruest

INTRODUCTION

Coal is formed slowly from organic and inorganic or mineral matter under in-situ pressure and temperature conditions buried to various depths, over periods of up to several hundred million years. Hydrocarbons (often mainly methane) whether thermogenic or biogenic, are held in place by various forces, but mainly adsorption onto the coal surfaces within the coal matrix. The cleat system within the coal is mainly water saturated.

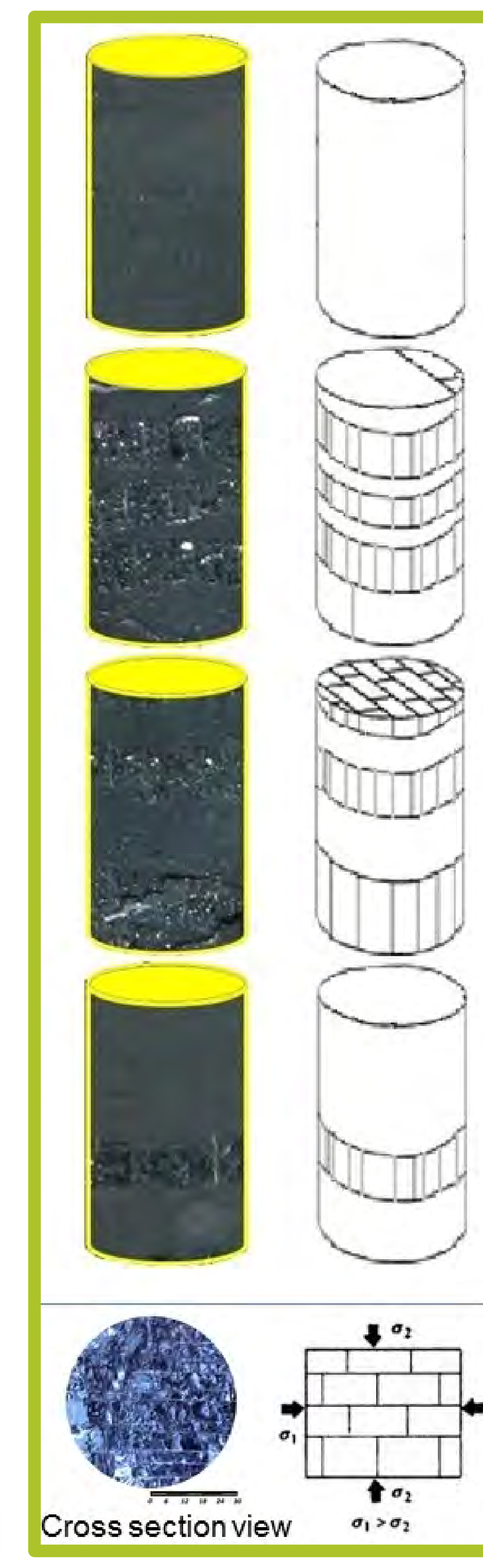


The majority of coal samples tested in the laboratory are not intact. The samples consist of a matrix of complex heterogeneous porous structure, cross cut by natural fractures (cleats) and some portions of intact rock. We use the following methodology to build a *Synthetic Rock Mass* model of coal (process shown below).



Geomechanically, cleats represent weak components of anisotropy inherent to coal bright and dull compositional layers that influence coal strength.

Face cleats are more prominent set orthogonal to butt cleats. The spacing between cleats tends to be quite uniform with aperture typically <0.1mm.



AIM

The *Synthetic Rock Mass* (SRM) model of coal will be used to investigate the coal configuration in detail, including the natural sequence of dull and bright layers, and the cleats frequency and interconnectivity for a given rank class.

Outcomes from the SRM approach will be used to improve inferences on the CSG extraction process, gas production, and wellbore stability.

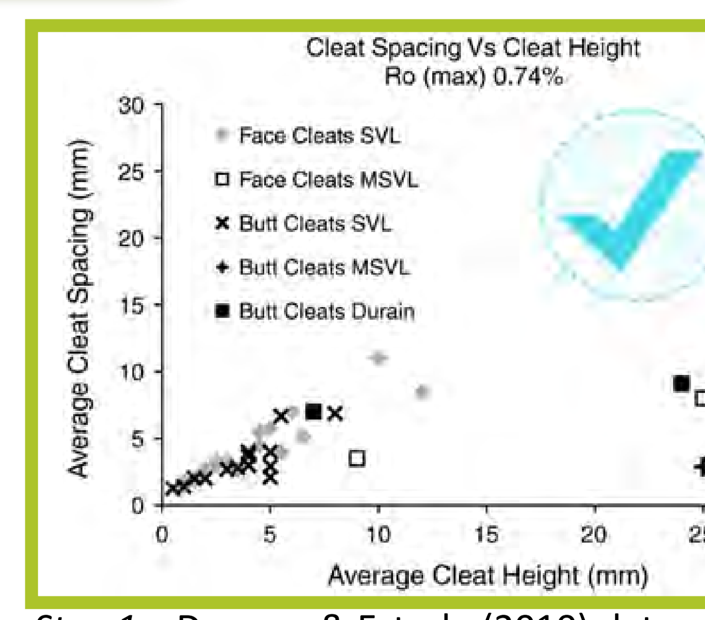
WORKFLOW TO BUILD SRM

Step 1 requires the identification of rank class using the maximum vitrinite reflectance.

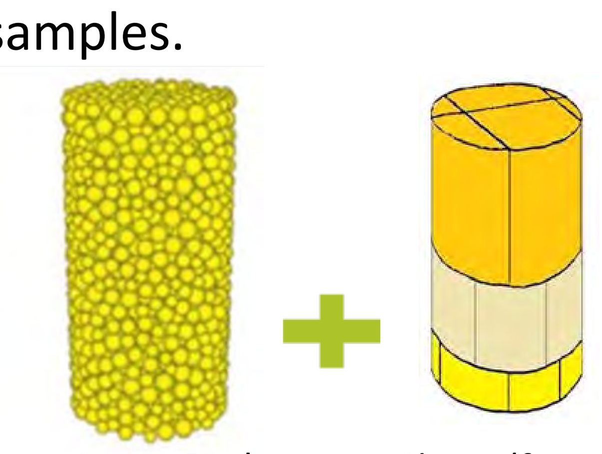
Step 2 involves gathering and interpreting the geometry data in order to confirm the macrolithotype sequence on core samples tested in laboratory by Medhurst (1996).

Step 3 involves extrapolating the data set presented by Dawson & Esterle (2010).

Step 4 involves building the SRM model of various coal samples.

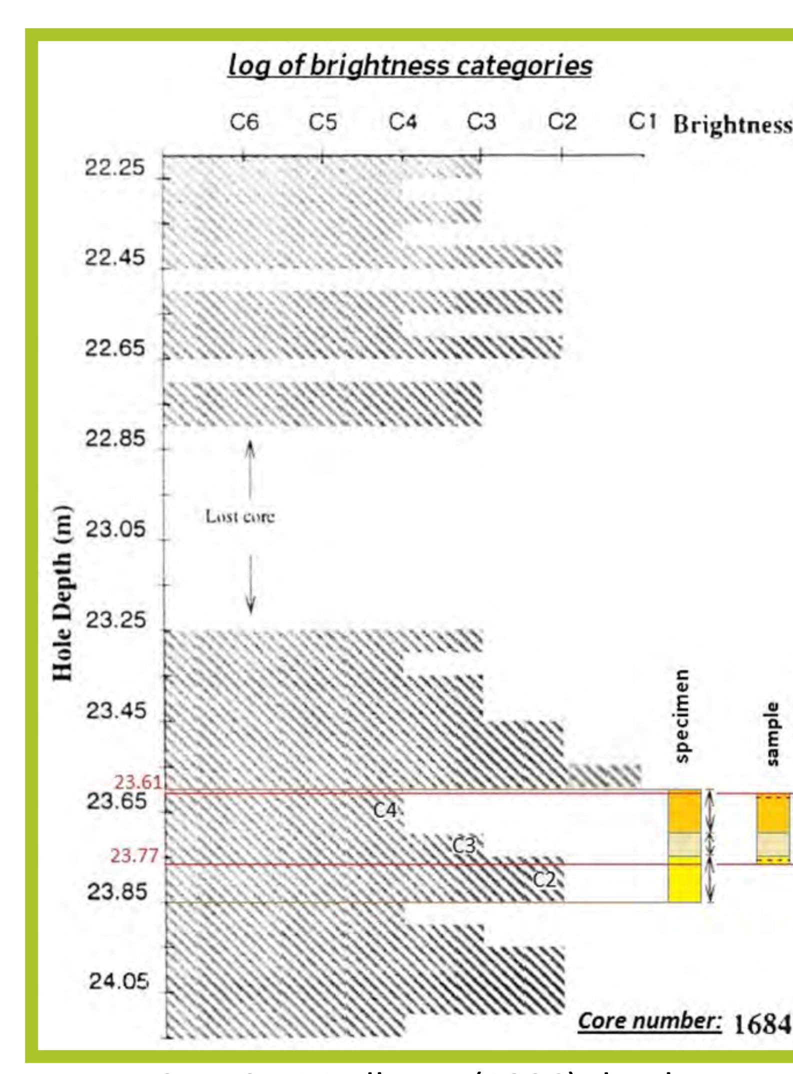


Step 1 – Dawson & Esterle (2010) data set

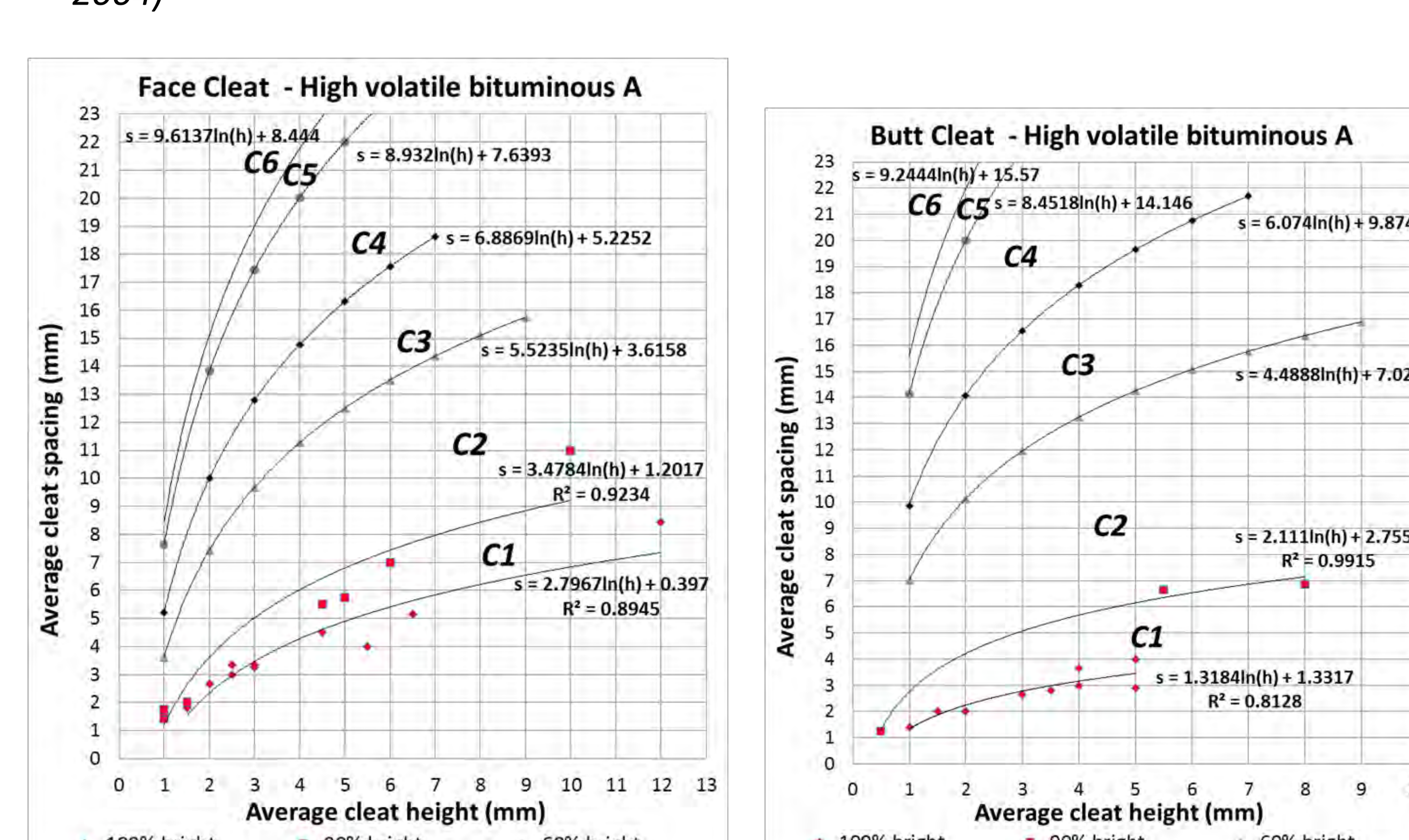


Intact Rock
Bonded Particle Model
(Potyondy & Cundall 2004)

Cleats (fractures)
Discrete Fracture Network



Step 2 – Medhurst (1996) database



Step 3 - extrapolating Dawson & Esterle (2010) data set – face and butt cleat

Step 4 – model boundaries and Discrete Fracture Network

Sample No.	Specimen length (m) upper location	Specimen length (m) lower location	Sample length (mm)	$\sigma_{1,peak}'$ (MPa)	E_{av} (GPa)	Poisson's ratio (v)	Brightness category	specimen thickness (mm)	sample thickness (mm)	Average cleat spacing (mm) Face	Average cleat spacing (mm) Butt

Sample diameter: ϕ = 61 mm   Confining stress: σ3'= 0.2 MPa

Sample No.	Specimen length (m)		Sample length (mm)	$\sigma_{1,peak}'$ (MPa)	E_{av} (GPa)	Poisson's ratio (v)	Brightness category	specimen thickness (mm)	sample thickness (mm)	Average cleat spacing (mm)	
	upper location	lower location								Face	Butt
16845B	23.61	23.77	129.87	21.62	4.0	0.2	C4	100.0	74.9	36.9	37.8
							C3	50.0	50.0	25.2	24.6
							C2	100.0	4.9	17.2	12.5

REFERENCES

1. Dawson, G.K.W., Esterle, J.S., 2010—Controls on coal cleat spacing. Int. J. Coal Geol. 82: 213–218.
2. Esterhuizen, G.S.; Bajpayee, T.S.; Ellenberger, J.L., Murphy, M.M., 2013. Practical estimation of rock properties for modelling bedded coal mine strata using the Coal Mine Roof Rating. NISOH - 47th US Rock Mechanics / Geomechanics Symposium held in San Francisco, CA, USA, 23-26
3. Medhurst T.P., 1996—Estimation of the in-situ strength and deformability of coal for engineering design. PhD Thesis, University of Queensland.
4. Medhurst, T.P., Brown, E.T., 1998—A study of the mechanical behaviour of coal for pillar design. Int. J. Rock Mech. Min. Sci. Geomech. 35 (8): 1087–1105.
5. Potyondy, D.O., Cundall, P.A., 2004—A bonded-particle model for rock. Int. J. Rock Mech. Min. Sci. 41: 1329-1364.
6. Poulsen, B.A., Adhikary, D.P., 2013—A study of the scale effect in coal strength. Int. J. Rock Mech. Min. Sci. 63: 62-71.
7. Su, X., Feng, Y., Chen, J., Pan, J., 2001—The characteristics and origins of cleat in coal from Western North China. Int. J. Coal Geol. 47: 51–62.