Appendix A

The coal permeability is generally controlled by properties of fracture network, which is given as (Chen et al., 2022):

$$K\_{f}=\frac{R\_{c}}{δ}D\_{f}\frac{b^{3}}{12} (A1)$$

where $δ$ is a tortuosity parameter, $R\_{c}$ fracture connectivity coefficient, $D\_{f}$ is the fracture intensity and $b$ is the fracture aperture.

The fracture porosity, $φ\_{f}$, is a function of fracture aperture $b$, and area of fractures per unit volume of rock,$ A$:

$$φ\_{f}=bA (A2)$$

Combining Eq. (A2) with Eq. (A1) yields:

$$K\_{f}=\frac{R\_{c}}{δ}\frac{D\_{f}}{A^{3}}\frac{φ\_{f}^{3}}{12} (A3)$$

Differentiating Eq. (A3) with respect to mean stress and rearrangement give as:

$$dK\_{f}=\frac{R\_{c}}{δ}\frac{D}{A^{3}}\frac{φ\_{f}^{3}}{4}\frac{∂φ\_{f}}{φ\_{f}∂\overbar{σ}\_{ef}}d\overbar{σ}\_{ef} (A4)$$

where $\overbar{σ}\_{ef}=\overbar{σ}-α\_{f}p\_{f} $is the effective mean stress in fractures, $\overbar{σ}$ is mean stress.

The fracture compressibility is:

$$C\_{f}=-\frac{∂φ\_{f}}{φ\_{f}∂\overbar{σ}\_{ef}} (A5)$$

Inserting Eqs. (A3) and (A5) into Eq. (A4) gives:

$$\frac{dK\_{f}}{K\_{f}}=-C\_{f}d\overbar{σ}\_{ef} (A6)$$

Therefore, the fracture permeability can be calculated by integrating Eq. (A6), given as:

$$K\_{f}=K\_{f0}e^{-3\left[C\_{f}∆\overbar{σ}\_{ef} \right]} (A7)$$

where $K\_{f0}$ is the fracture permeability at reference stress state.

The fracture compressibility depends stress and gas adsorption, expressed as (Chen et al., 2022):

$$C\_{f}=C\_{f0}\frac{1-e^{-α\_{c}\overbar{σ}\_{ef}}}{α\_{c}\overbar{σ}\_{ef}(1-\frac{γp\_{gm}}{p+p\_{L}} )} (A8)$$

where $C\_{f0}$ is the initial fracture compressibility, $α\_{c}$ is the fracture compressibility change rate, $γ$ is a material constant for maximum increase of fracture compressibility due to gas adsorption. In this work, the effect of gas adsorption is not considered.

With the help of cubic law, the porosity can be written as:

$$\left(\frac{φ\_{f}}{φ\_{f0}}\right)=\left(\frac{K\_{f}}{K\_{f0}}\right)^{1/3} (A9)$$

Reference

Chen, M., Masum, S., Sadasivam, S., Thomas, H., 2022. Modelling anisotropic adsorption-induced coal swelling and stress-dependent anisotropic permeability. Int. J. Rock Mech. Min. Sci. 153, 105107.