Impact of Flow Regimes on Coal Fines Generation during Coal Seam Gas (CSG) Production

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Background

Coal fines are generated during CSG production, and these fines give rise to several phenomena that are detrimental towards CSG production. The generation process of coal fines may vary under different flow regimes.

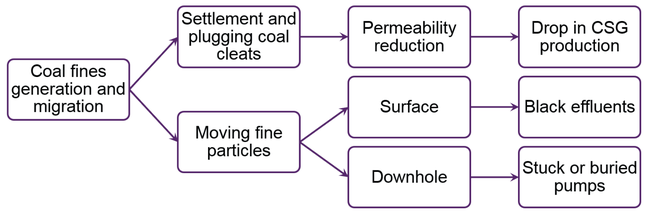

Figure 1. Detrimental effects of coal fines issue towards CSG production.

Objectives

This research aims to unlock the complexity of coal fines generation in coal seams under different flow regimes. The specific research objectives include:

1) **To quantify fines generation from coal cleats due to fluid flushing (both single- and two-phase flow);**
2) **To identify critical factors affecting fines generation;**
3) **To gain fundamental understanding of coal fines generation during CSG production.**

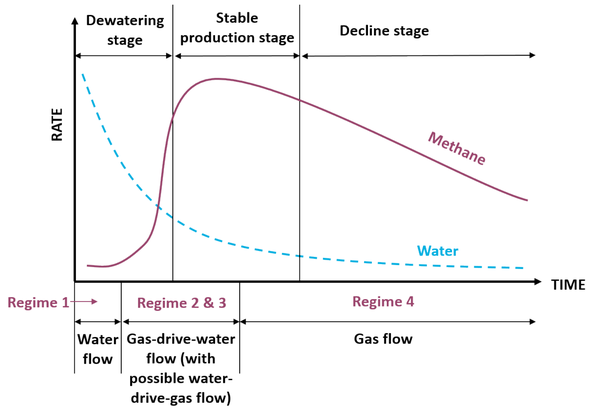

Figure 2. CSG production stages and corresponding flow regimes in coal seams.

Methodology

1) **Scanning Electron Microscopy (SEM) of coal samples to visualize cleat geometries;**
2) **Fully-coupled numerical modelling (COMSOL Multiphysics) to duplicate investigations in different flow regimes using the same cleat geometries;**
3) **Dimensional analysis to gain general trends for coal fines generation and upscaling.**

Numerical Simulations

Coal fines generation is examined in four flow regimes corresponding to CSG production stages:

1) **Water flow;**
2) **Gas-drive-water flow (both hydrophilic and hydrophobic);**
3) **Water-drive-gas flow (both hydrophilic and hydrophobic);**
4) **Gas flow.**

Both shear failure and tensile failure are considered as the failure criteria.

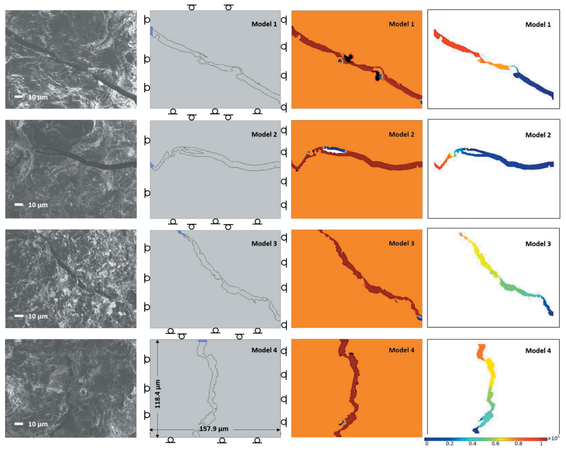

Figure 3. Cleat geometry derived from the SEM images and simulation results for hydrophilic gas-drive-water scenario (fines generation and pressure distribution).

Observations from numerical simulations:

1) **Displaced phase trapped in micro-structures (snap-off and bypassing trapping mechanisms);**
2) **Local collapse in hydrophobic gas-drive-water scenario;**
3) **The interface between two phases separates high and low pressures.**

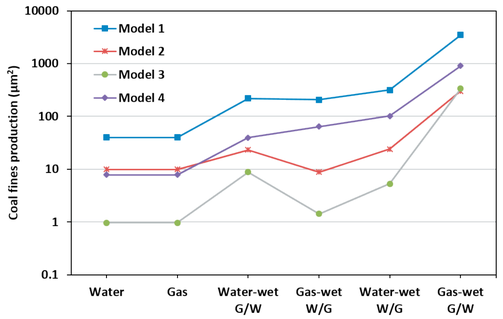

Figure 4. Coal fines production for different flow regimes.

Dimensional Analysis

Dimensional analysis is performed based on local simulation results at micro-scale. The Capillary number (Ca) and Euler number (Eu) are found to be responsible for fines generation in two-phase flow systems.

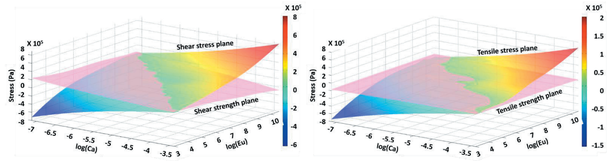

Figure 5. Stress and strength planes for both shear and tensile failures as a function of Ca and Eu.

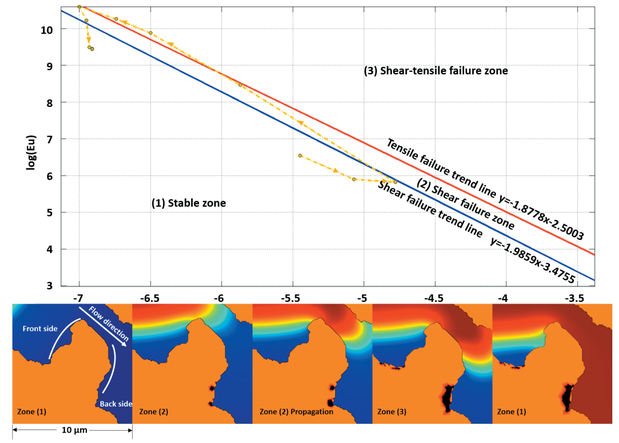

Figure 6. Map of failure zones as a function of Ca and Eu, with an example in Model 1.

Conclusions

1) **More coal fines are generated from two-phase flow conditions; hydrophobic gas-drive-water scenario produces the most coal fines;**
2) **Wettability and cleat geometry play significant roles in generating fines; the change of flow regime generates substantial coal fines;**
3) **A new criterion based on Capillary number (Ca) and Euler number (Eu) is developed to predict coal fines generation and fines failure mechanisms.**

Acknowledgement

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References

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