Advanced Environmental Technologies for Coal Permeability Enhancement

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1. Identify stimulants that enhance coal permeability
   - Liquid (Acids, Bases, Oxidants, H₂O-displacing oil)
   - Gas (Inert and reactive gases)

2. Elucidate the mechanistic basis for coal response
   - Mineral dissolution, alteration, plugging
   - Maceral infilling, plasticisation
   - Fracture induction, extension, dilation, stabilisation

3. Assess the viability of the stimulation pathways
   - Environmental compliance, cost efficacy, specificity

Project Objectives

1. Demineralisation of natural fractures
   - Calcite dissolution (HCl)
   - Clay dissolution (HF)
   - Oxidative dissolution of pyrite (H₂SO₄-H₂O₂)

2. Degradation of coal maceral components
   - Oxidative cleavage of organics (H₂O₂, KMnO₄)

3. Fracture creation and stabilisation
   - Pneumatically-induced, mineral-stabilised
   - Air, CO₂, N₂, O₃

Scientific Approach

1. Core stimulation studies (k/k₀)
   - Probing tests (chemical screening)
   - Application test (CSG coal specific)

2. Structural and mineralogical imaging (Φ, f)
   - X-ray µCT with GeoRef Core
   - Synchrotron X-ray

3. Physico-chemical analyses
   - Coal assays, SEM-EDS, ICP-OES, TOC
   - XPRD, Optical imaging

Technological Pathways

Dissolution of calcareous fracture infills
- Decalcification increases Φ, f and k
- Mineral plugging limits k enhancement

Oxidative dissolution of pyrite
- Pyrite dissolution increases Φ, f and k
- Oxidative cleavage increases Φ, f and k
- Mineral deposition decreases Φ, f and k

Key Findings

- k/k₀ = 1.24
- k/v₀ = 2.50
- k/h₀ = 4.15
- k/v₀ = 0.11

Figure 1. X-ray µCT visualisation of CSG cores pre and post HCl injection and the k-influencing mechanisms.

Figure 2. Skeletised 3D visualisation of a decalcified fracture shown at various angles as rotated along the z-axis. The measured vertical (kᵥ) and estimated horizontal (kₕ) permeabilities as well as the structures (bottlenecking for kᵥ, continuous fracture for kₕ) that are likely to dictate fluid flow are also shown.

Figure 3. Permeability enhancement via dissolution of pyrite by H₂O₂ - H₂SO₄

Figure 4. Mapping the permeability pathway of the H₂O₂ - H₂SO₄ stimulated coal core using Synchrotron radiation. The 3D visualisation of the permeability pathway (blue, voxel resolution = 11 µm) for each sector are shown.

Figure 5. Permeability enhancement due to the oxidative degradation of macerals in coal by H₂O₂ stimulation.

Figure 6. Permeability deterioration due to MnO₂ deposition in coal after KMnO₄ – KOH injection.

Publish Outcomes