Pulsed Arc Electrohydraulic Discharge Stimulation of Coal Seam Interburden for Gas Development

Research team: Fei Ren[1,2], Lei Ge[2], Huilin Xing[1], Tom Rufford[2], Victor Rudolph[2]   1 School of Earth Sciences, 2 School of Chemical Engineering

Background & Objectives

Interburden is the mixture layer located between the coal measures. Many existing coalbed methane (CBM) wells have already drilled through these undeveloped layers (Fig. 1). However, the potential of coal seam interburden reservoirs (Fig. 2), mainly consisting of mud, clay and organic matter, has not yet been well researched or developed, when compared to that of coal or shale. This project aims at developing and validating an alternative stimulation method to replace traditional fracturing techniques, such as hydraulic fracturing, to effectively crack the thick but malleable mudstone layers without importing any outside chemical fluids into the subsurface or causing clay swelling, to improve the gas recovery from CBM wells.

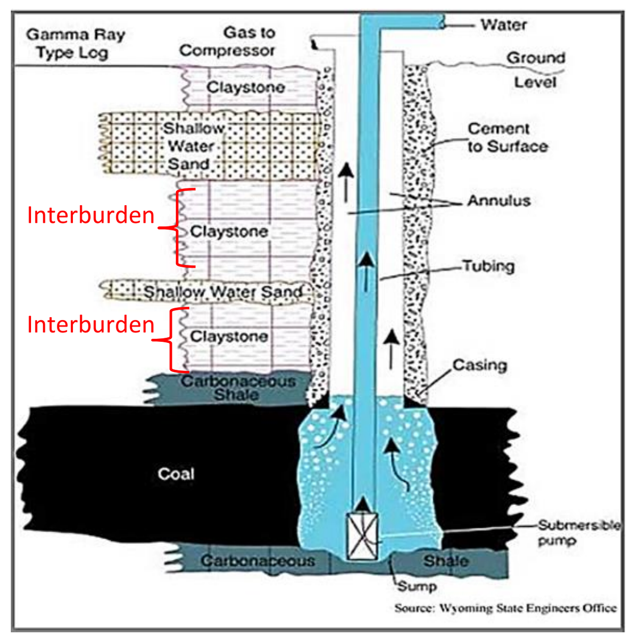


Fig. 1 Schematic of a coalbed methane well

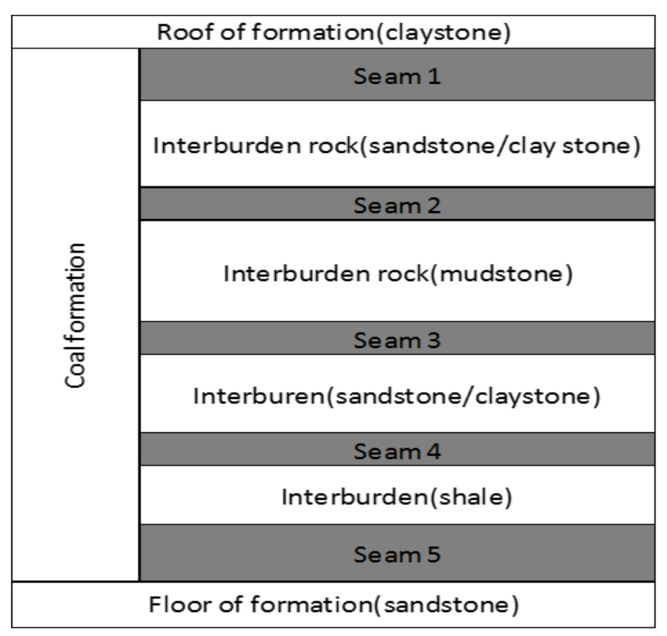


Fig. 2 A typical layout of coal formation

The project is structured around the following objectives:

- **Experimentally measure the coal seam interburden properties relevant to gas development**
- **Develop pulsed arc electrohydraulic discharge (PAED) and employ it to enhance/improve interburden permeability**
- **Understand the mechanism of interburden breakage by PAED and simulate the multiphysics coupling using finite element method**

Experimental Setup

Develop and employ PAED stimulation technique to crack the interburden specimens at the labscale. The schematic of PAED setup is shown in Fig. 3

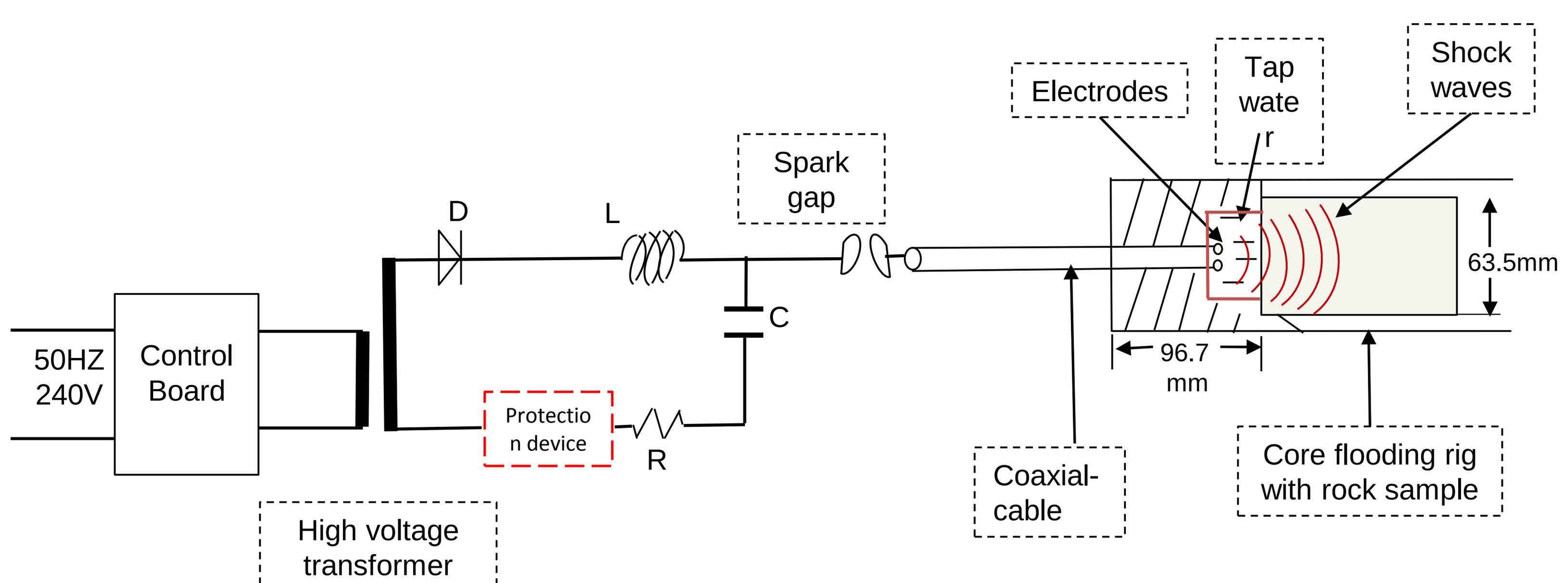


Fig. 3 Schematic of PAED setup for interburden stimulation

The rationale of PAED stimulation is that two underwater copper electrodes are connected with a set of capacitor banks charged with a high voltage. When the circuit is switched on, a plasma is generated between the electrodes reaching temperatures of thousands of K, resulting in a compressive pressure pulse, the strong pulse/shockwave will propagate in the water and crack the interburden specimen nearby.

Fig. 4 Photograph of PAED testing setup

Parameter settings for testing

Shockwave generation:

- Charging voltage: 20 ~60 KV
- Capacitance: 2 ~ 12 uF
- Discharging period: nanoseconds ~ 70 us
- Pulse number: adjustable
- Electrodes gap: 5 mm

Permeability measurement:

- Confining pressure: 20 bar
- Inlet pressure : 2 bar
- Outlet pressure : atmosphere

Testing Sample Information

In the current stage, to explore and summarize the most efficient discharging circuit and parameter settings for strong shock wave fracking, preliminary tests on homogeneous mortar sample (Fig. 5) and identified coal sample (Fig. 7) were carried out.

The testing specimens here are homogenous mortars with the compressive strength of approx. 6 MPa (Fig. 6).

Fig. 5 Testing mortar samples made in lab

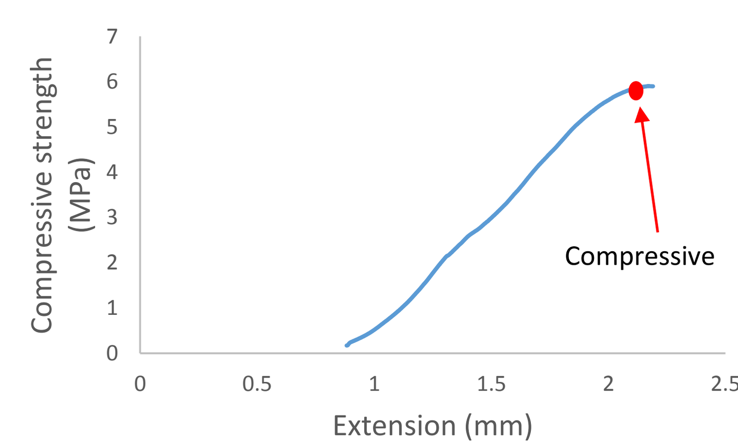
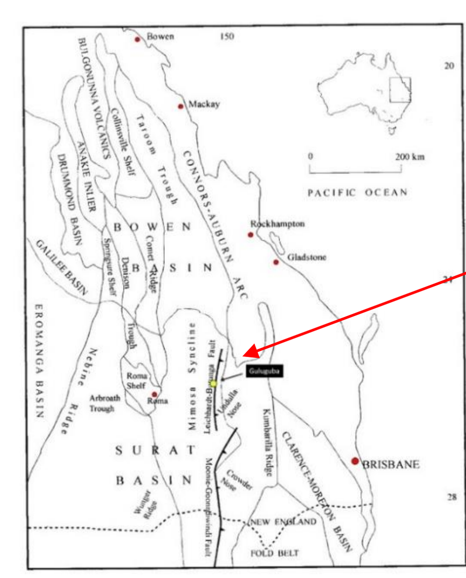


Fig. 6 Compressive strength of mortar sample

Another testing coal specimen from the Surat basin was covered in epoxy on the outside to make a cylindrical shape for PAED testing.



Sample info. : Surat Basin
Gluluguba-2 GD017
Depth: 284 m
Wrapped-up by epoxy

Fig.7 Gluluguba-2 coal from Surat Basin

All the testing specimens are with the same diameter of 63.5 mm, the core flooding testing and X-ray CT scanning were conducted on the samples before PAED to obtain their original structure and permeability.

Results

After the stimulation on C2 by PAED (Fig. 5), the permeability (Fig. 8) and porosity (Fig. 9) of testing C2 mortar specimen have both increased due to the impact of shock waves compared to the properties before PAED.

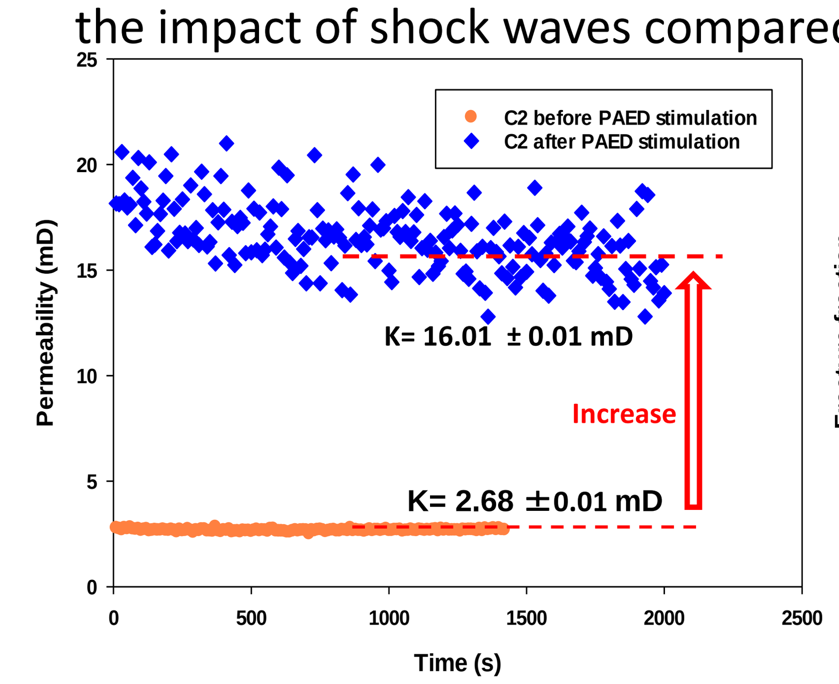


Fig. 8 C2 permeability before and after PAED stimulation

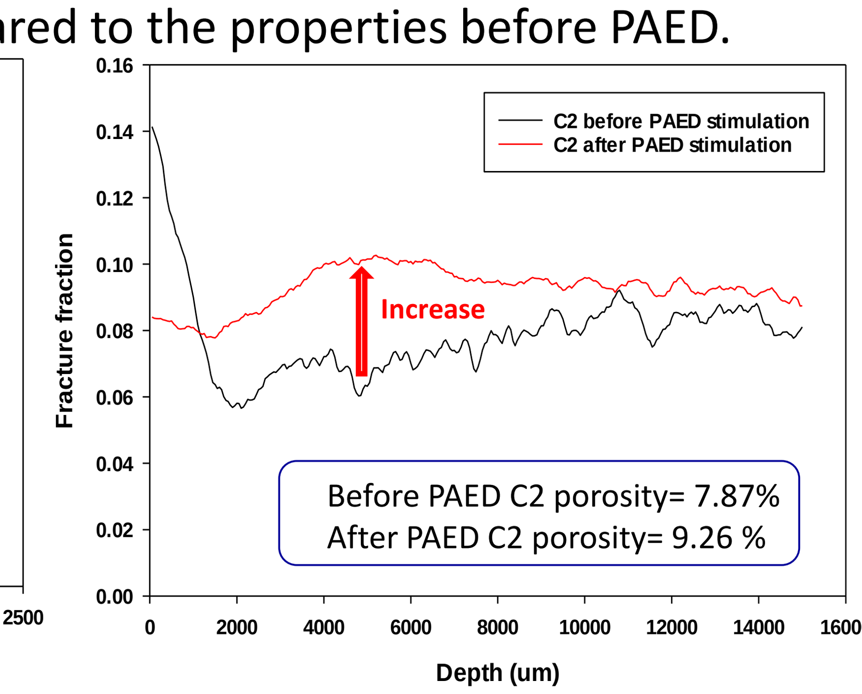
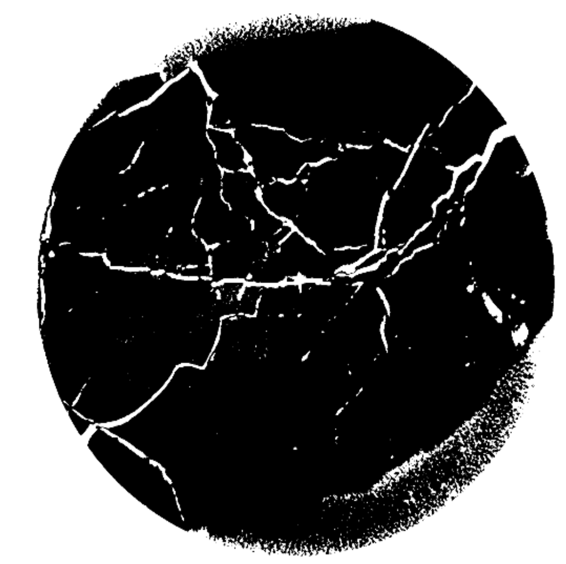


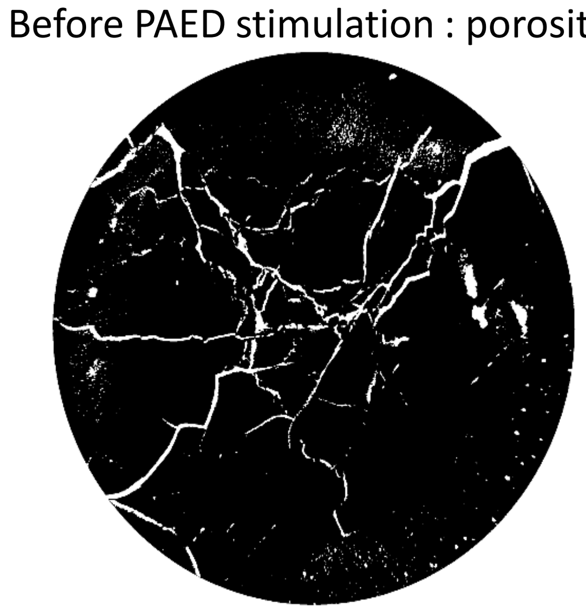
Fig. 9 C2 porosity before and after PAED stimulation based on CT image

The CT scanning was utilized to analyse the fracture and void evolution before and after PAED stimulation on Gluluguba-2 coal (Fig. 7).



a

Before PAED stimulation : porosity =3.11%



b

After PAED stimulation : porosity =3.34%

Fig. 10 CT image thresholding at the stimulation side of the coal core sample before (a) and after (b) stimulation (white: fracture and pore)

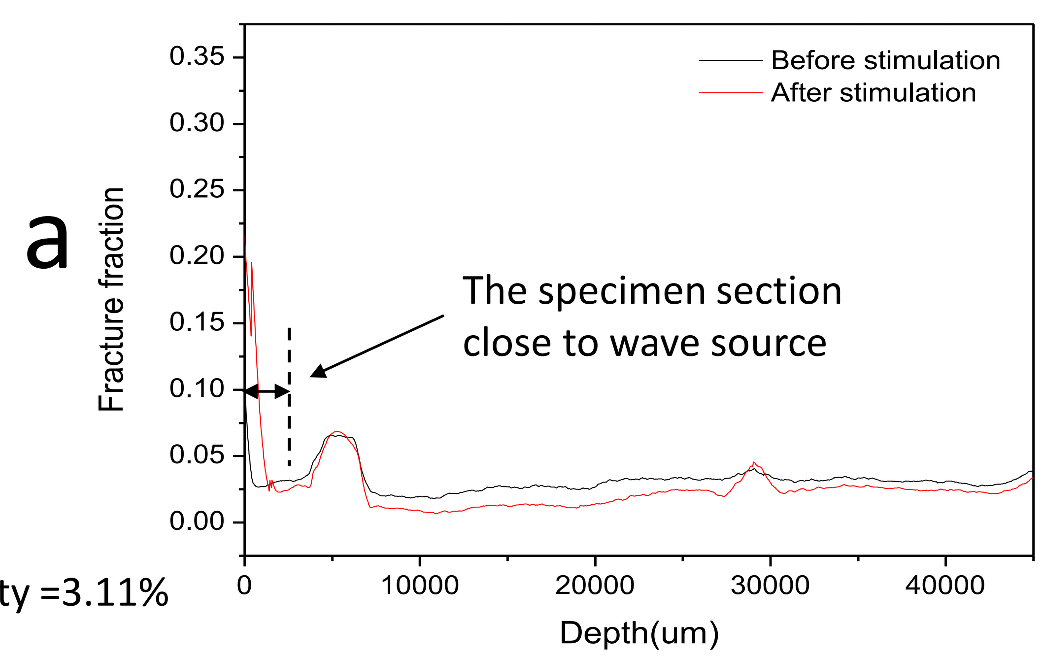


Fig. 11 Fracture fraction change with depth from stimulation side

Both fracture and void of coal specimen after PAED stimulation have increased (Fig. 10), particularly the front part which is close to the shockwave source (Fig. 11).

Acknowledgement & References

The funding and assistance from ARC , the School of ITEE, and CCSG at UQ is highly appreciated.

1. Rudolph V. et al. 2014. Mudstones as methane sources: stimulation and gas production from coal seam interburden. *Project Proposal*.
2. Saghafi A. et al. 2010. Parameters affecting coal seam gas escape through floor and roof strata. *2010 Underground Coal Operators' Conference*: 210-216.