

Illinois Basin Tanquary Field Project

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Regional Carbon Sequestration Partnership
Initiative Review Meeting
October 6-8, 2008



Midwest Geological
Sequestration Consortium
www.sequestration.org



S/ECBM Coal Pilot Test

Purpose: To determine the CO₂ injection and storage capability, and the ECBM recovery potential of Illinois Basin coal

- Single Coal Seam
- CO₂ (gas) injection test
- Injection of up to 200 tons of CO₂ depending on injectivity rate and monitoring well results

Winter 2007 Pre-Drill Design



- COMET Modeling Results
 - Perm 10, 25, 50 md
 - wells spacing 150 feet (orthogonal) in cleat direction
- Nearby mine suggested face and butt cleat orientation

Summer 2007 Drilling

- Injection well and butt cleat observation well drilled, cored, logged and DST'd
- DST permeability lower than anticipated
 - Permeability 2 and 7 md; skin +6 and +9
 - Initial pressure equal to fresh water gradient
- COMET modeling: 150 ft spacing too large for low permeability
- Drilling face cleat well was postponed until pressure transient tests conducted to confirm DST results
- Wells cased and cemented to surface
- Cased hole logs run

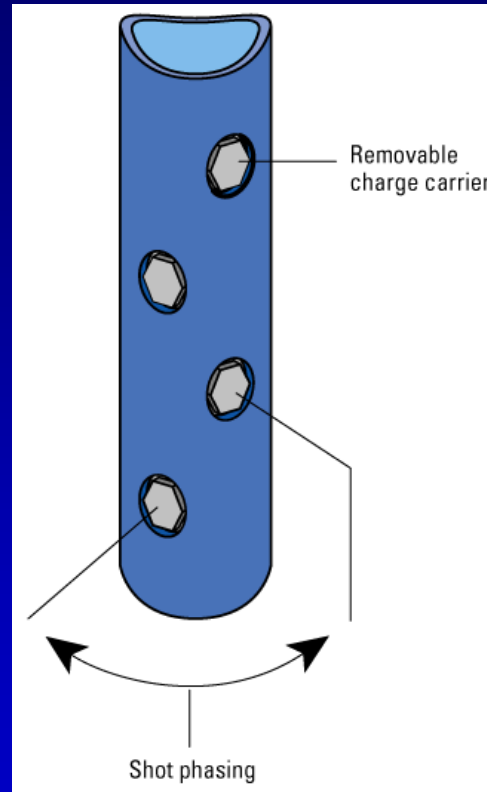
Fall 2007 Completion

■ Perforation

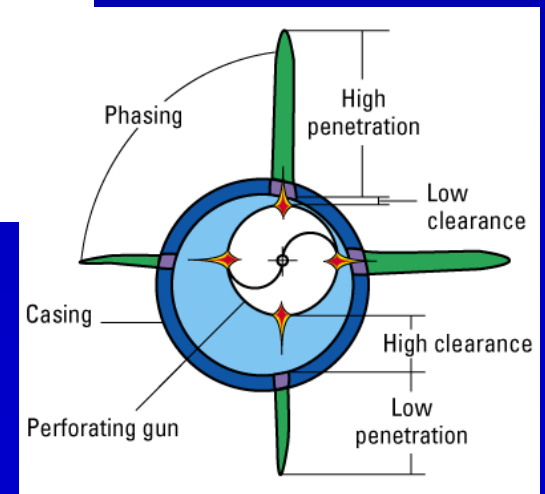
- 6 shots per foot
- 60° phasing
- 3/8" diameter

■ Acid

- 9% formic acid
- 250 gallon
- 1000 gallon water
- 1250 gallons swabbed



Pictures:
Schlumberger
Glossary



Fall 2007 Two Well (Water) Pressure Transient Tests

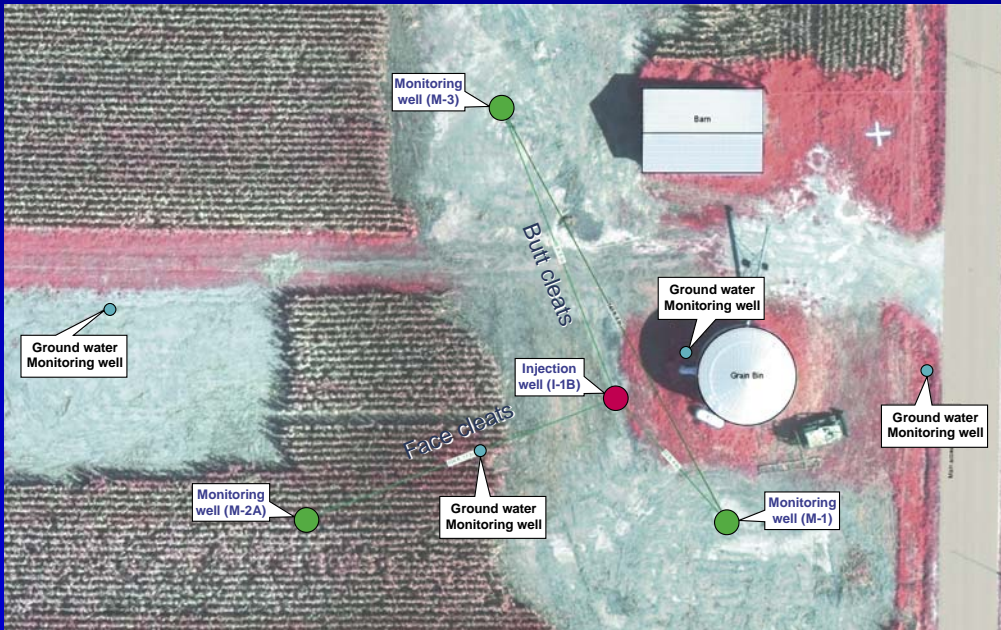
- Tests
 - Injection falloff in each well
 - Pulse test
 - Step-rate test
- Falloff tests give permeability similar to DST
 - 3.3 and 4.4 md; -1.5 and -3.0
- 2-3 psi pulse in 10 hrs
- 0.96 psi/ft fracture gradient

Fall 2007 COMET Modeling

- Several possible coal models simulated
- Measureable response for given CO₂ budget and time required reduced spacing
- 100 ft spacing (from pre-drill 150 ft estimate)

Summer 2008: Drilling

- Drill two more wells to achieve 100 ft spacing
 - New injector
 - New face cleat observation well
 - Two existing wells are 50 and 100 ft butt cleat observation wells



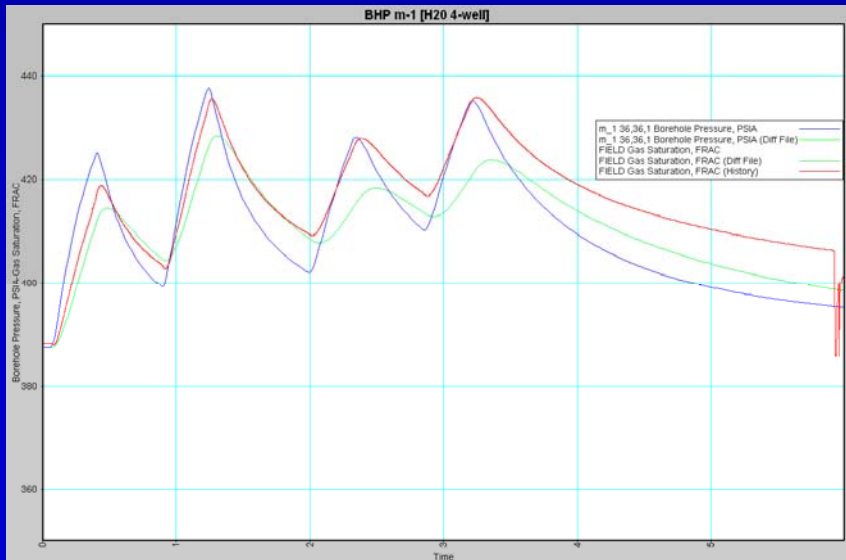
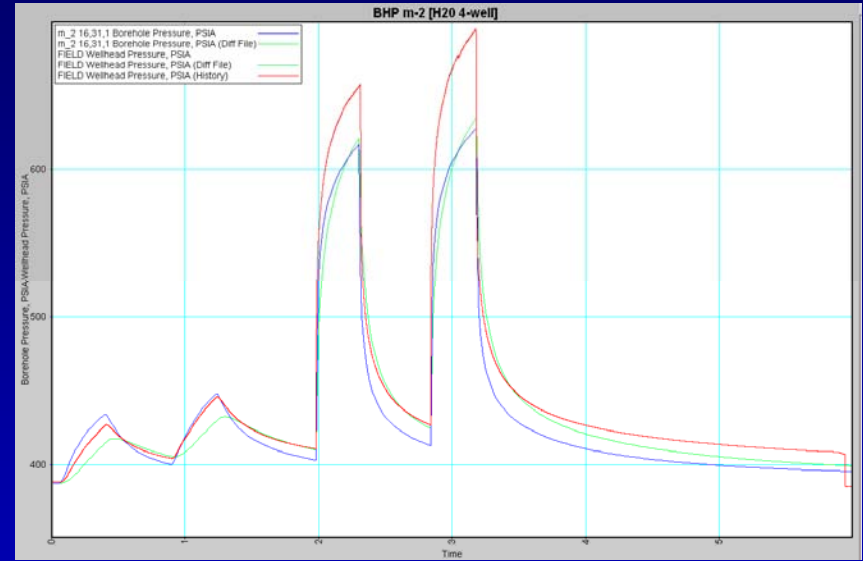
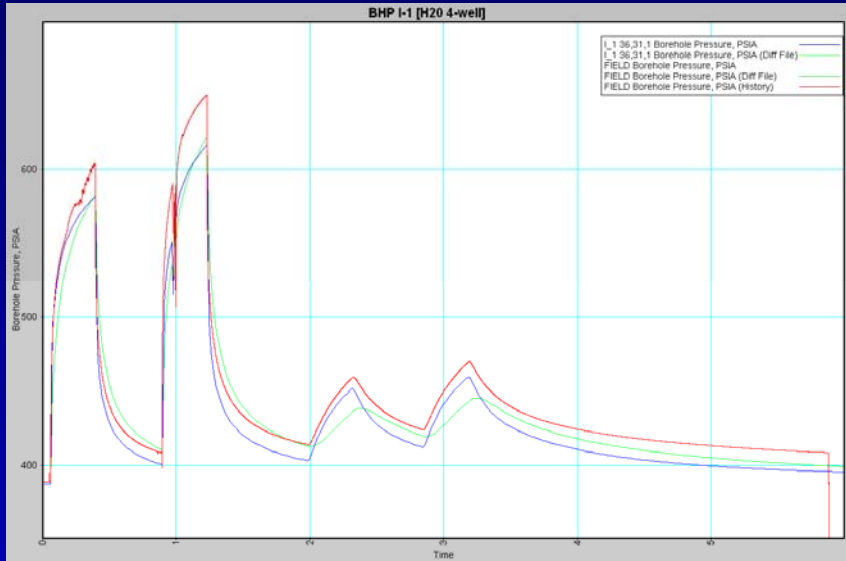
Summer 2008: Drilling Operations and Completion

- Rig availability, township winter road restrictions, and flooding prevented earlier drilling
- Cored and DSTd coal
- Same casing, perforating and acidizing program as other wells
- Interestingly, face cleat well high by 6 feet...compared to other wells 150 ft away

Summer 2008: Multiwell (Water) Pressure Transient Tests

- ***Preliminary results***
- Falloff tests: injection well and face cleat observation well
 - Permeability 4.7 md; skin -1.5 to -2.5
 - Face cleat – Butt cleat permeability ratio 8:1
- Numerical modeling and analytical modeling to history match all wells' pressure responses

Multiwell Pressure Transient Tests



Summer 2008: Multiwell (Water) Pressure Transient Tests

- *Variables:* face and butt cleat permeability, skin, compressibility, initial pressure, surrounding coal properties
- Water injection provides baseline characterization of coal flow properties to better understand the CO₂-coal interaction
- Face cleat direction quickest, largest pressure response

Summer 2008: Site Preparation



Injection Well with Monitoring Instruments



CO₂ Storage Tank and Pump Skid

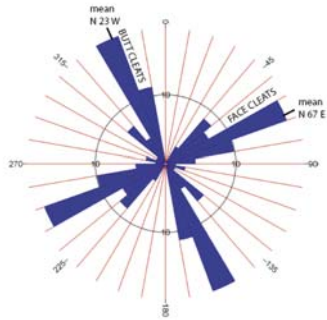


Injection Equipment & Wellhead

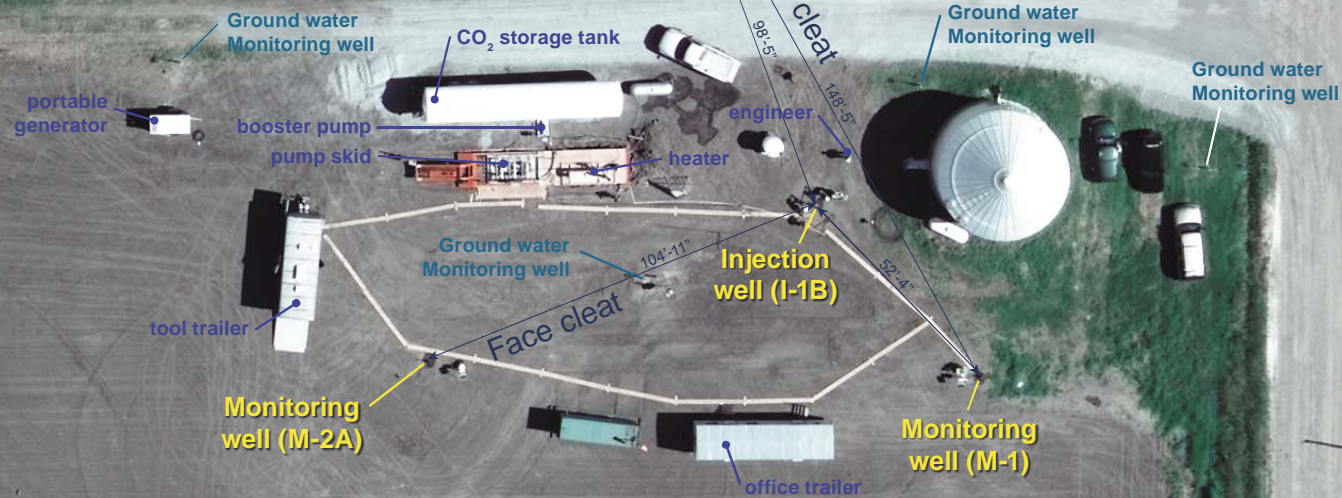


Injection and Storage Equipment

Well Layout Parallels Cleat Orientations in Near-by Wabash Mine



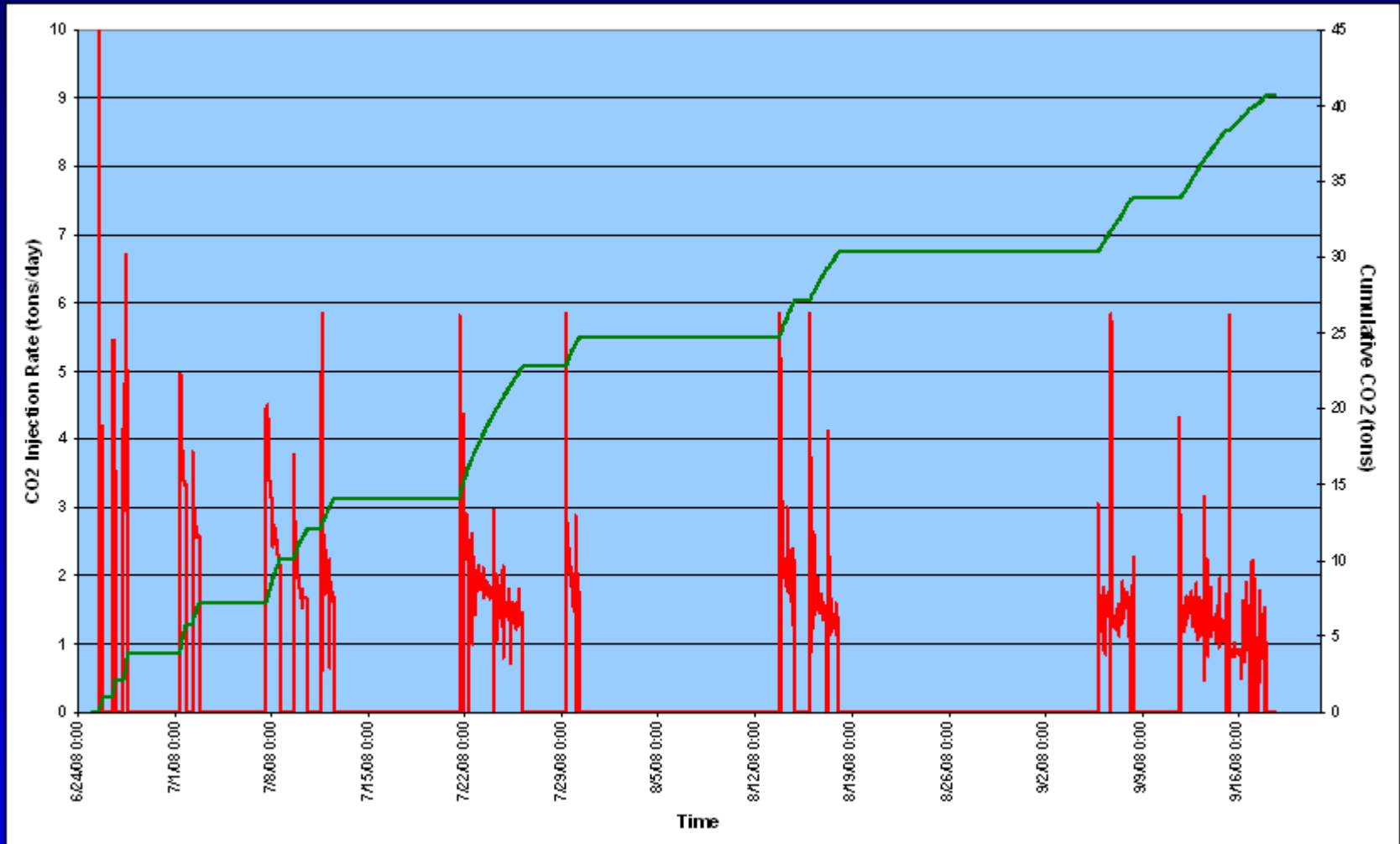
Coal Mine Cleat Orientations



Summer 2008: CO₂ Injection

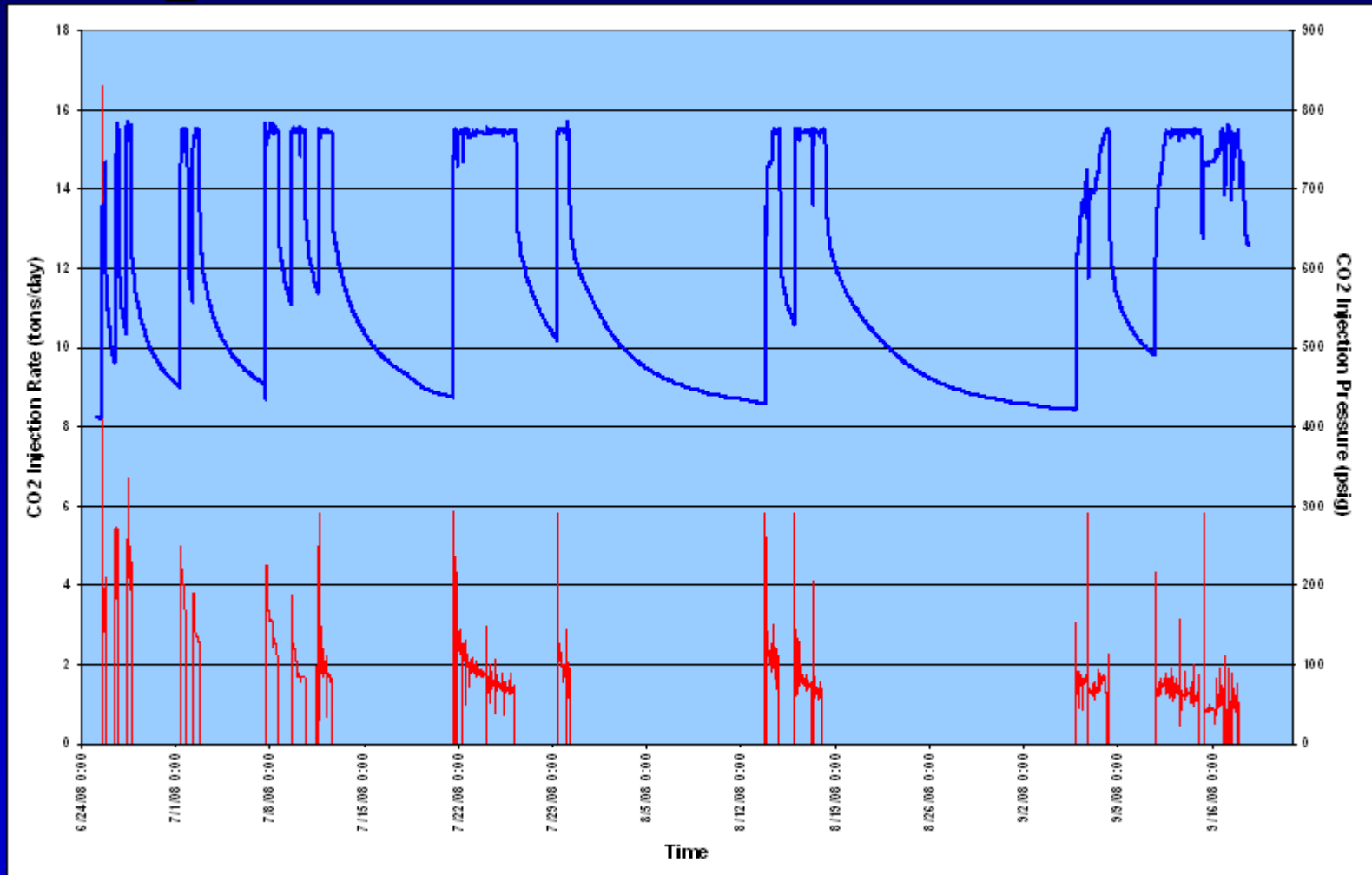
- CO₂ injection started June 25, 2008
- Series of CO₂ injection transients or pulses followed by shut-in periods
 - Week 1: three 8 hours injection pulses
 - Week 2: two 12 hour injection pulses
 - Week 3: three 24 hour injection pulses
- Several multiday injection and shut-in.

CO₂ Injection Rate and Cumulative

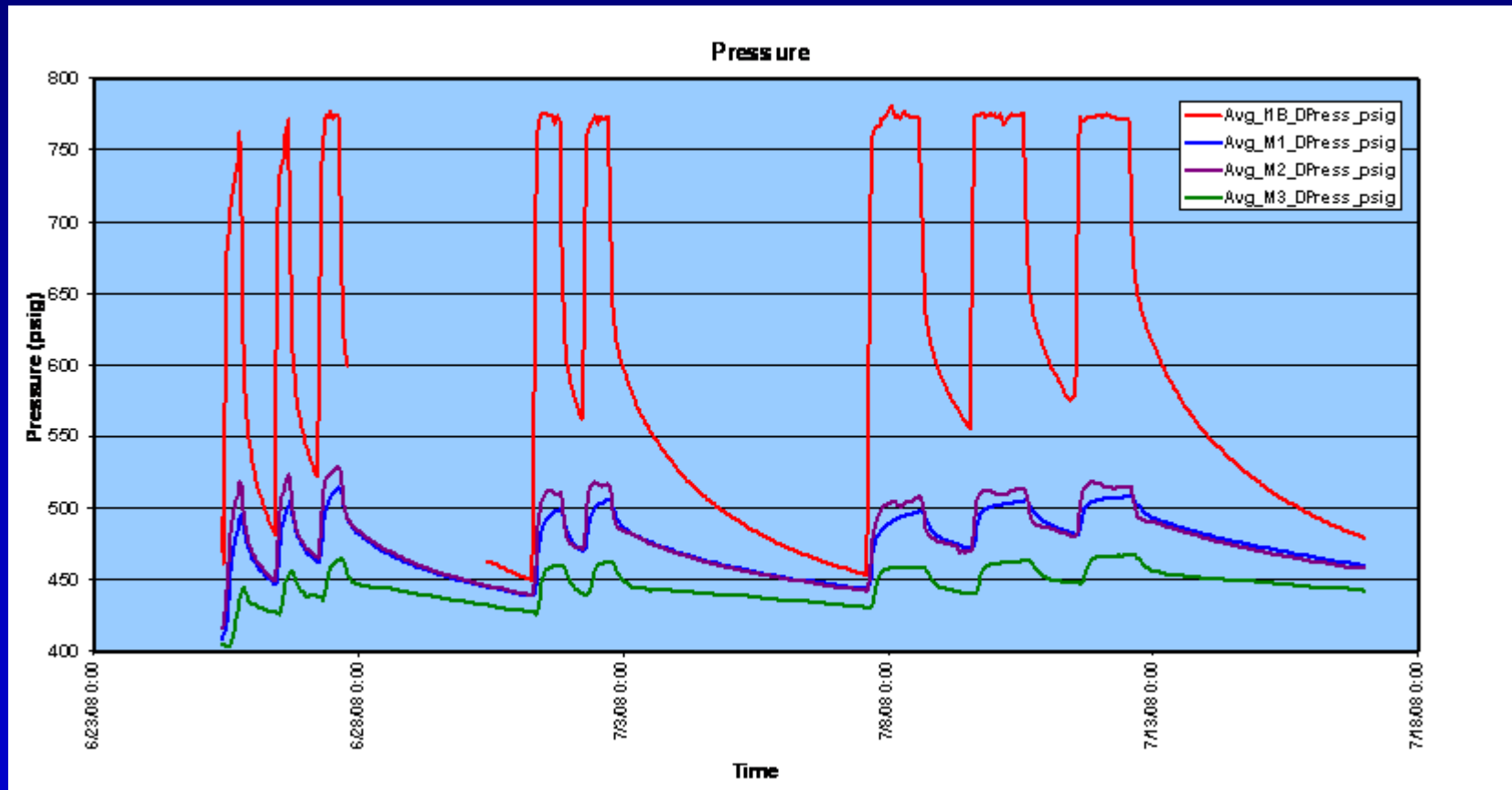


Approximately 45 tons injected

CO₂ Injection Rate and Pressure

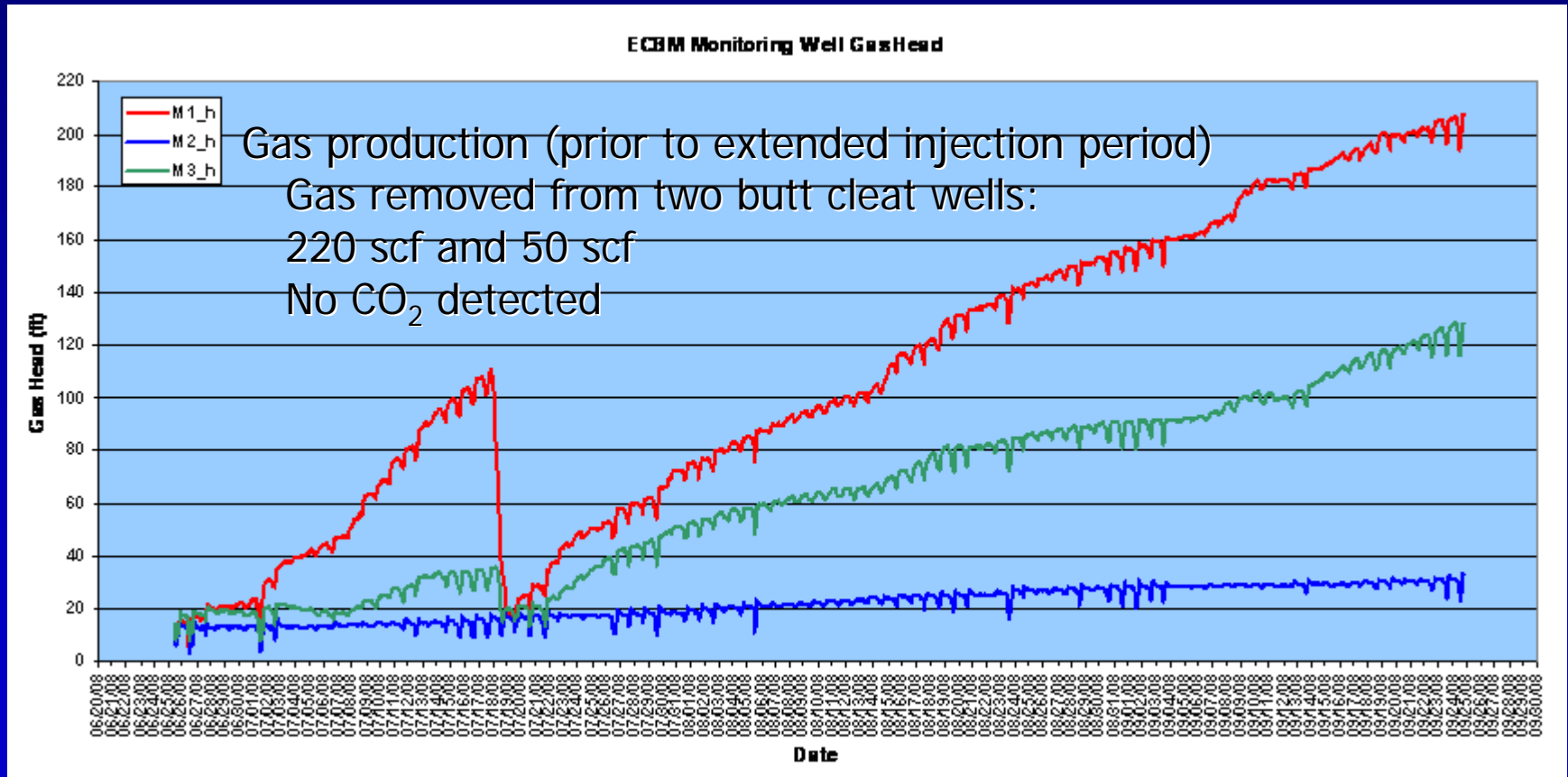


CO₂ Observation Well Response



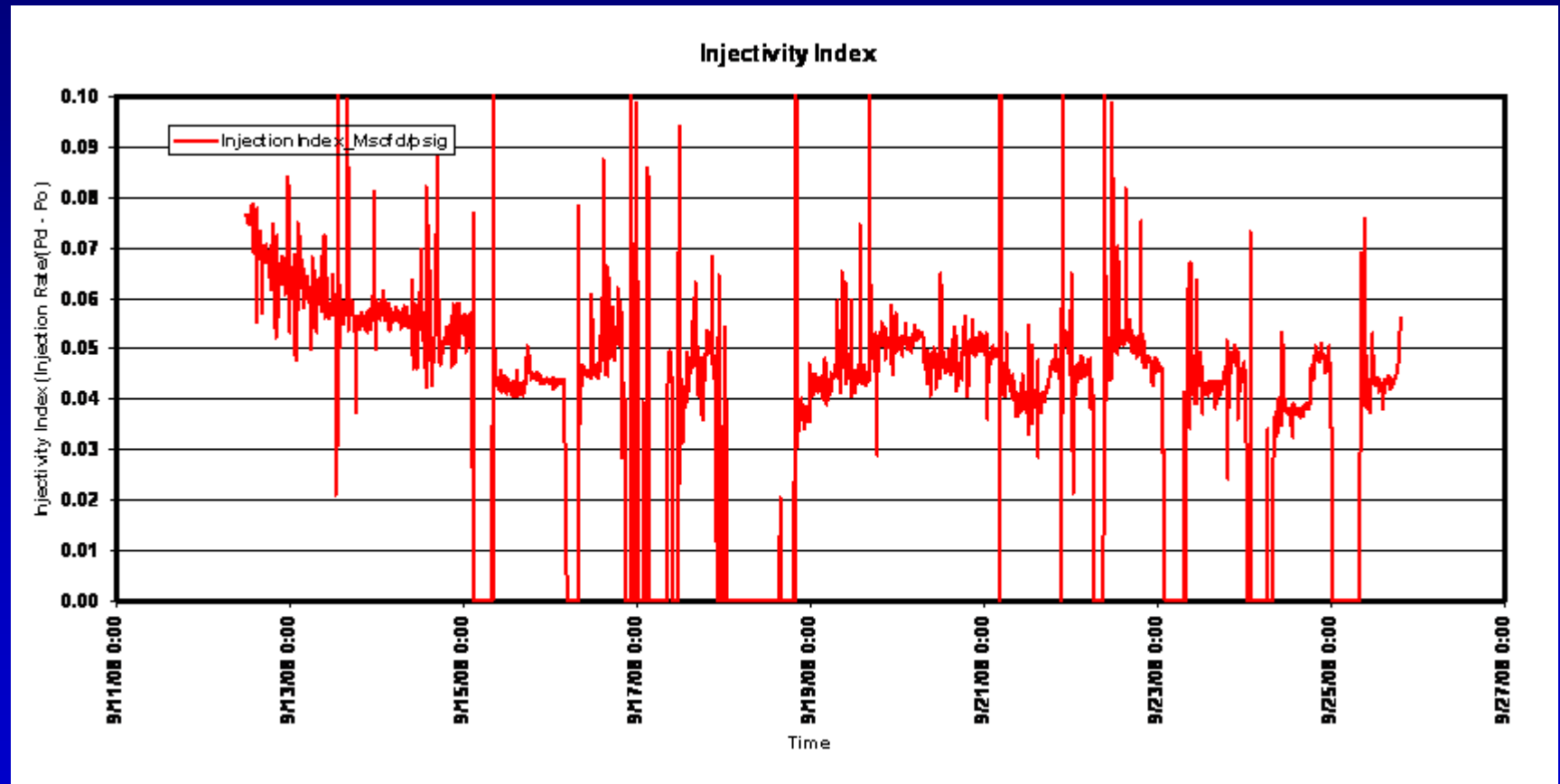
Fastest, largest pressure response in Face Cleat direction

Gas Column in Observation Wells



Pressure above adsorption pressure, free gas via competitive desorption from CO₂

CO₂ Injectivity Index



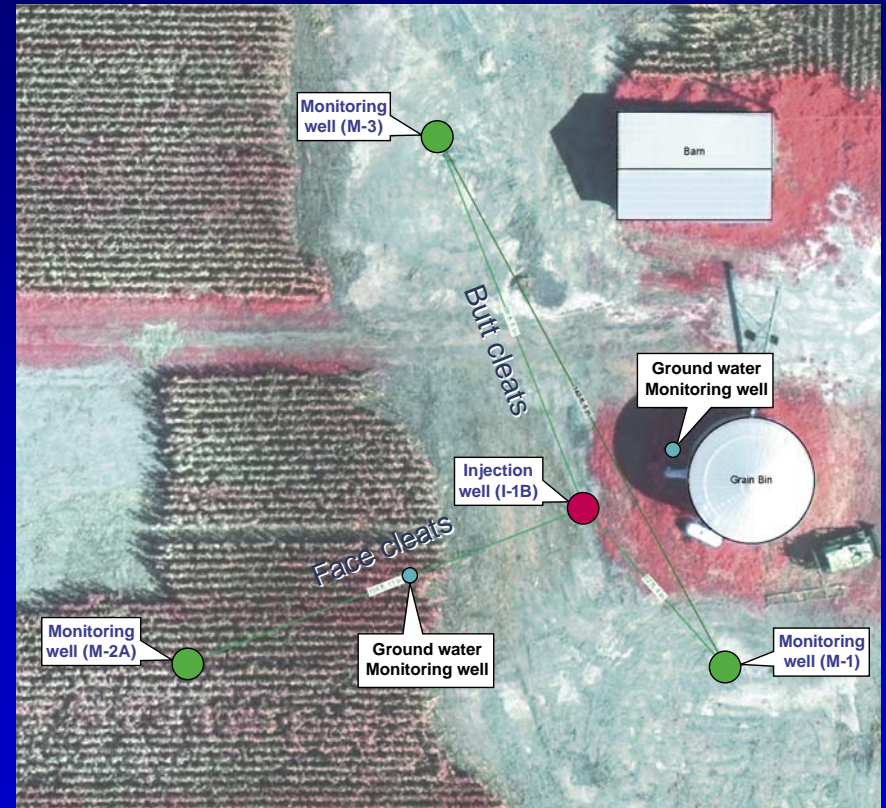
No indication of injectivity reduction (coal swelling)

Fall 2008: CO₂ COMET Modeling (In progress)

- Permeability anisotropy and compressibility established from water PTA
- Variables for CO₂ modeling: pressure dependent permeability, adsorption time, and gas/water relative permeability
- Normalize water and CO₂ data to infer interaction of CO₂ with coal

Observation Well Samples

- CH₄ gas breakthrough at M-1 and M-3 within hours of CO₂ injection
- CO₂ breakthrough at M-1 within a month of injection at 11-13%; to date remains constant
- M-2 water only



Fall 2008: Remaining Field Work

- Continue injecting until EOR Pilots require surface injection equipment
 - Project 100 tons of injection into 6.7 ft coal
- Possible observations:
 - increase in CO₂ at M-1
 - CO₂ at M-3
 - Gas of any kind at M-2
 - Changes in injectivity with time
- Post-injection MMV

Preliminary Results

- CO₂ has enhanced CH₄ production in low perm direction.
- No indication of reduced injectivity

Tanquary Pilot Staff

- Dave Morse: drilling/coring logistics, gas content
- John Rupp, Maria Mastalerz: lab experiments
- Satya Harpalani: laboratory experiments
- Jim Kirksey: pilot coordination, operations
- Damon Garner: database management/ analyses
- Ivan Krapac, Abbas Iranmanesh, Bracken Wimmer: water and gas sampling
- Keith Hackley and Joe Chou: gas analyses
- Gary Crawford: pressure transient analyses

Tanquary Pilot Staff

- Mike Dodd: pump operations
- Kevin Wolfe: data acquisition, site logistics, data analyses
- Steve Sargent: data acquisition
- Andrew Anderson: COMET Modeling
- Gallaghers: field operations and logistics, drilling and completion design
- Trimeric Corp: equipment design

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