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Title: Explosive Fracturing for Permeability Enhancement

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UNGI Abstract

Explosive Fracturing for Permeability Enhancement

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Los Alamos and other national laboratories have been involved with unconventional fracturing for energy extraction intermittently since the late 1960's. This research included some experiments using nuclear explosions in tight gas formations like GASBUGGY (1967) in the Mesa Verde Sandstone and RULISON (1970) in the Piceance Basin tight gas formation. There has also been some considerable effort in using conventional high explosives in the Unconventional Gas Research (UGR) Programs at Lawrence Livermore Laboratory in the Marcellus Shale and at Los Alamos during the UGR Multi-well Experiment (MWX) in Colorado in the late 1970's and 1980's.

Currently, Los Alamos is involved in conventional and unconventional fracturing. Fortuitously, much of the data on tight gas and oil formations gather by DOE earlier can be harvested for particular properties useful in our current projects like shock hugoniots and elastic and strength properties. I will be presenting some information from our past research and how we are applying it to some current projects in unconventional gas. Hydrodynamic simulations in example formations show that plastic strain may be used as a proxy for fractured permeability enhancement.

Ref:

Heard, H.C. and W. Lin, 1986, High Pressure and Sonic Properties of Devonian Shale from West Virginia. Lawrence Livermore National Laboratory Report, UCID—20612, Unlimited Release.

Reynolds, M. Jr., 1971, Project Rulison – Summary of Results ansd Analysis, Austral Oil Company Inc., Presented at the American Nuclear Society Winter Meeting, October, 1971, Unlimited Release.

EXPLOSIVE FRACTURING FOR PERMEABILITY ENHANCEMENT

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Example: Rulison Nuclear test in Piceance Basin

Project Plowshare
Near Rifle, CO 1969, Nominal
40 Kt (80 X10^6 lbs TNT)

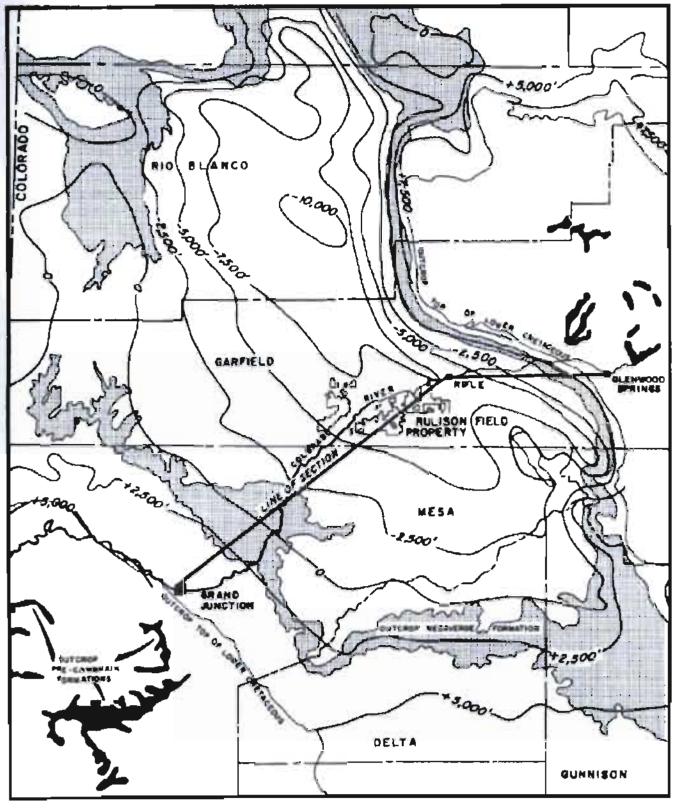


FIGURE 21. PICEANCE CREEK BASIN-REGIONAL MAP AND STRUCTURAL INTERPRETATION

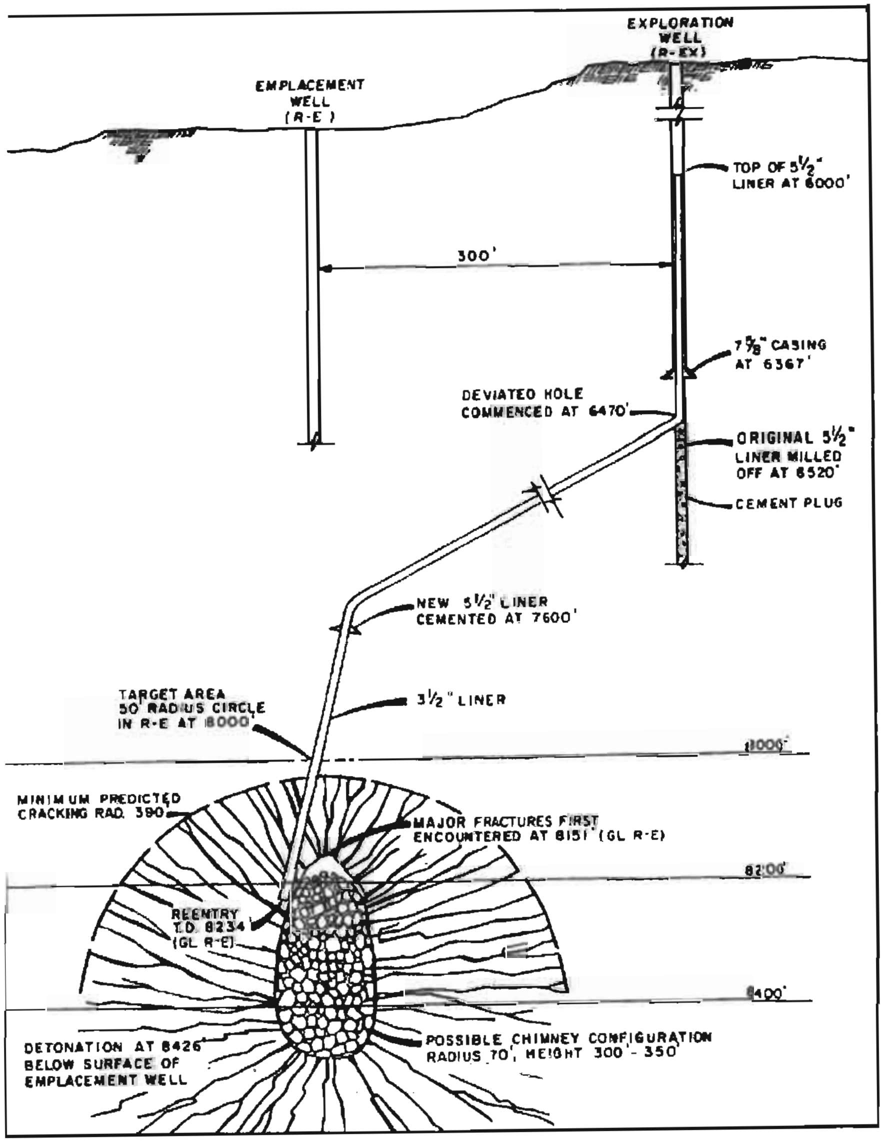


FIGURE 6. SCHEMATIC DIAGRAM OF REENTRY WELL

Requirements:

- ❖ Shock Hugoniots for Piceance Basin Shales and Sandstone
- ❖ Understanding of basic phenomenology from a UGT

Results:

- ❖ 455 MMSCF in 108 days: approx 10 years of production from a standard well at that time
- ❖ Radioactive by-products accounted for during controlled venting

Unconventional Gas Research

- UGP, LLNL Devonian Shale (West Virginia)
  - Propellants and HE stimulation
  - Predict fracture intensity, geometry and extent
- MWX, LANL Colorado 1970s-1980s
- Current Work: Discrete Elements and Finite Element modeling with damage models

Combined SPH-DEM Capabilities: Taylor Pulsed Loading Experiments From Swift, 1972

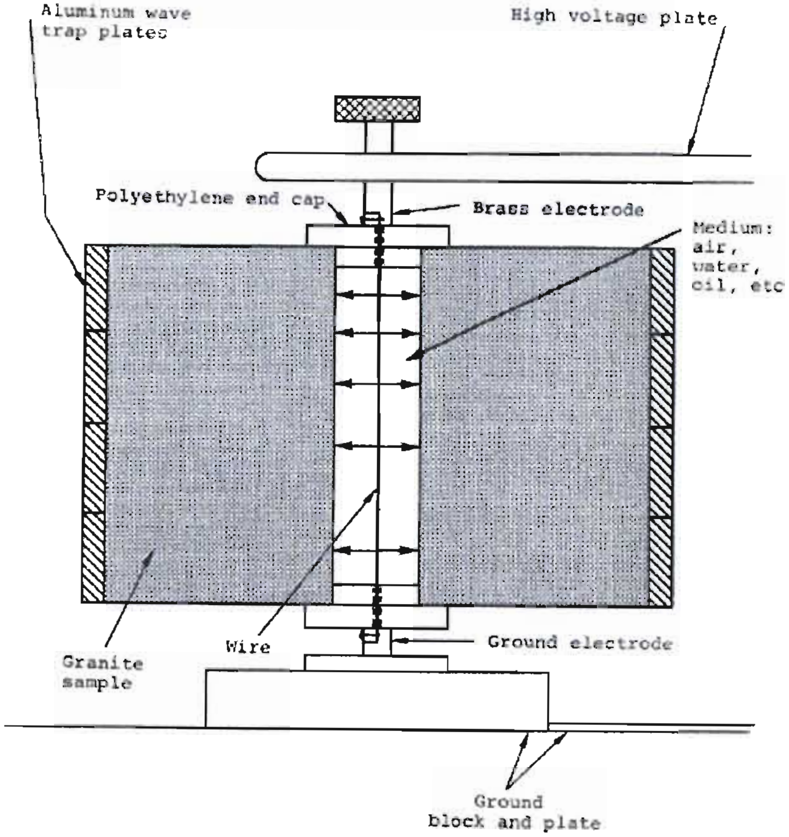


Figure 29 Cross section configuration of tensile fracture experiment.

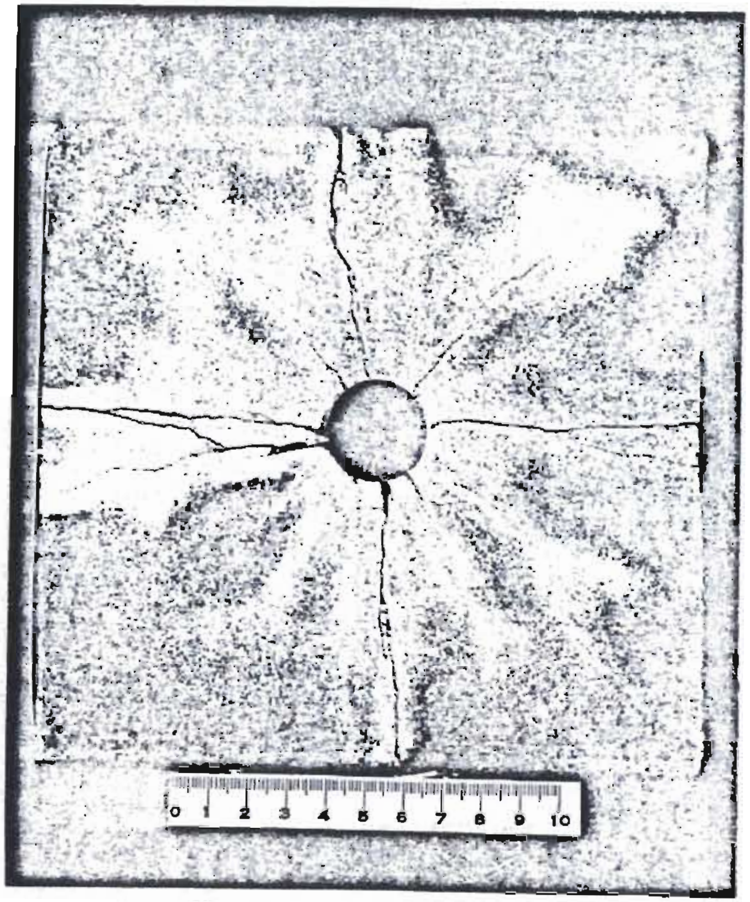


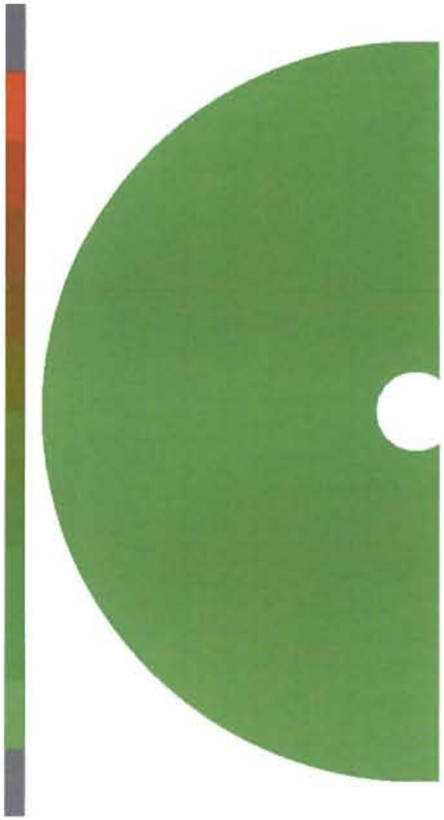
Figure 31b No momentum plates, shot 007.

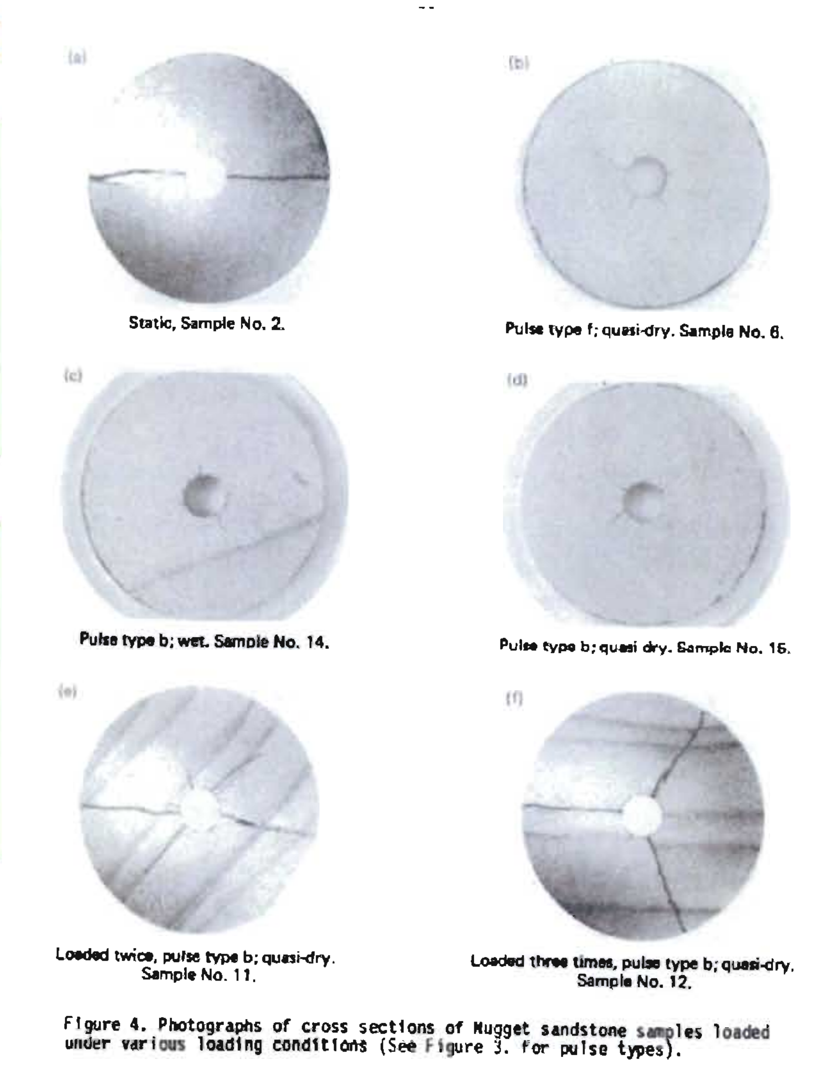
Combined Capabilities

Applications

Fracturing of boreh

D





(a)

Static, Sample No. 2.

(b)

Pulse type f; quasi-dry. Sample No. 6.

(c)

Pulse type b; wet. Sample No. 14.

(d)

Pulse type b; quasi dry. Sample No. 15.

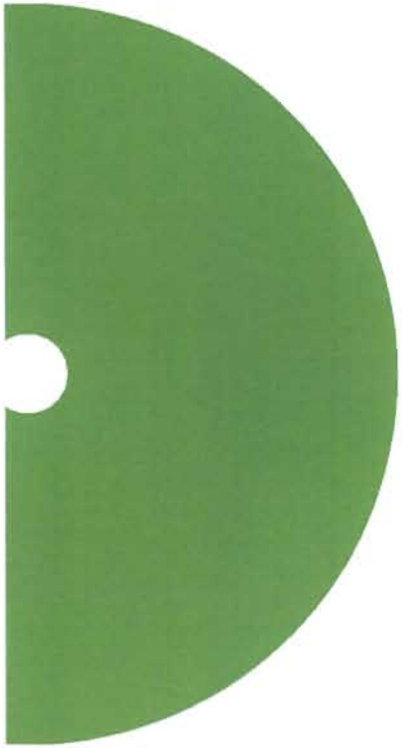
(e)

Loaded twice, pulse type b; quasi-dry. Sample No. 11.

(f)

Loaded three times, pulse type b; quasi-dry. Sample No. 12.

Figure 4. Photographs of cross sections of Nugget sandstone samples loaded under various loading conditions (See Figure 3. for pulse types).



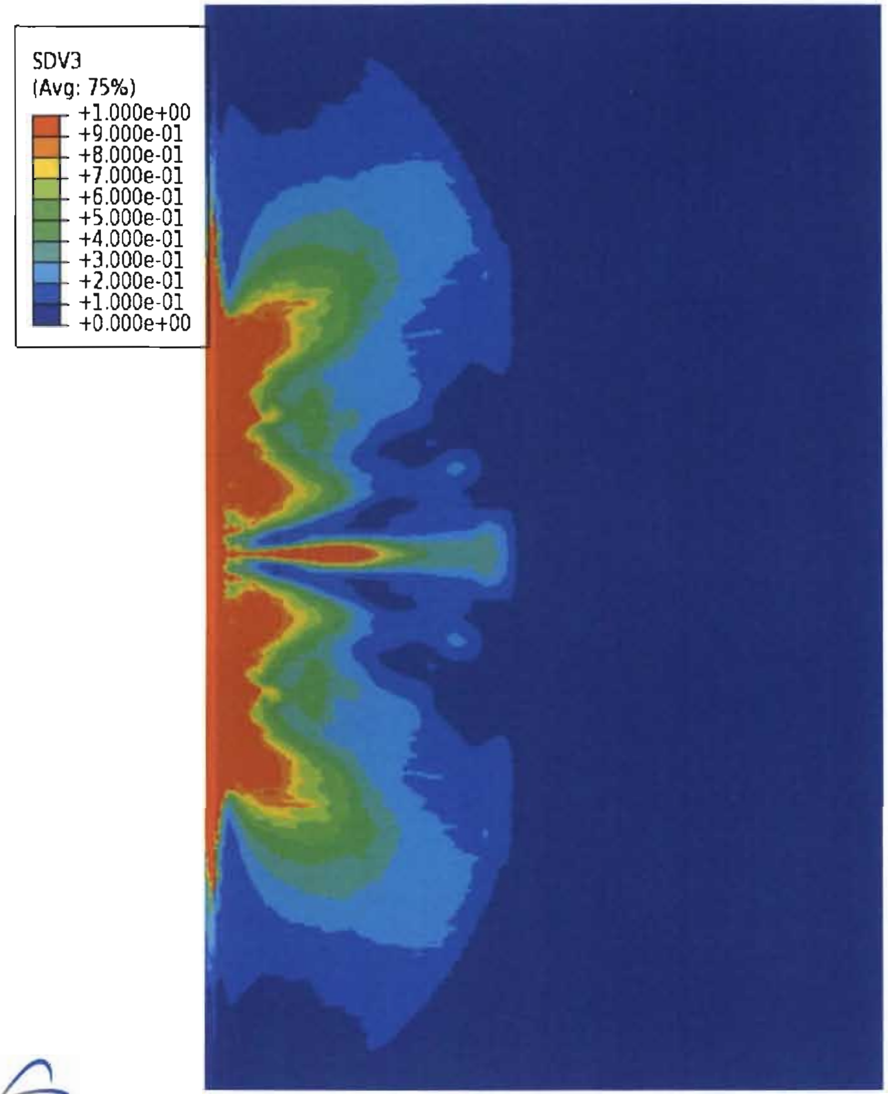
Peak Pressure

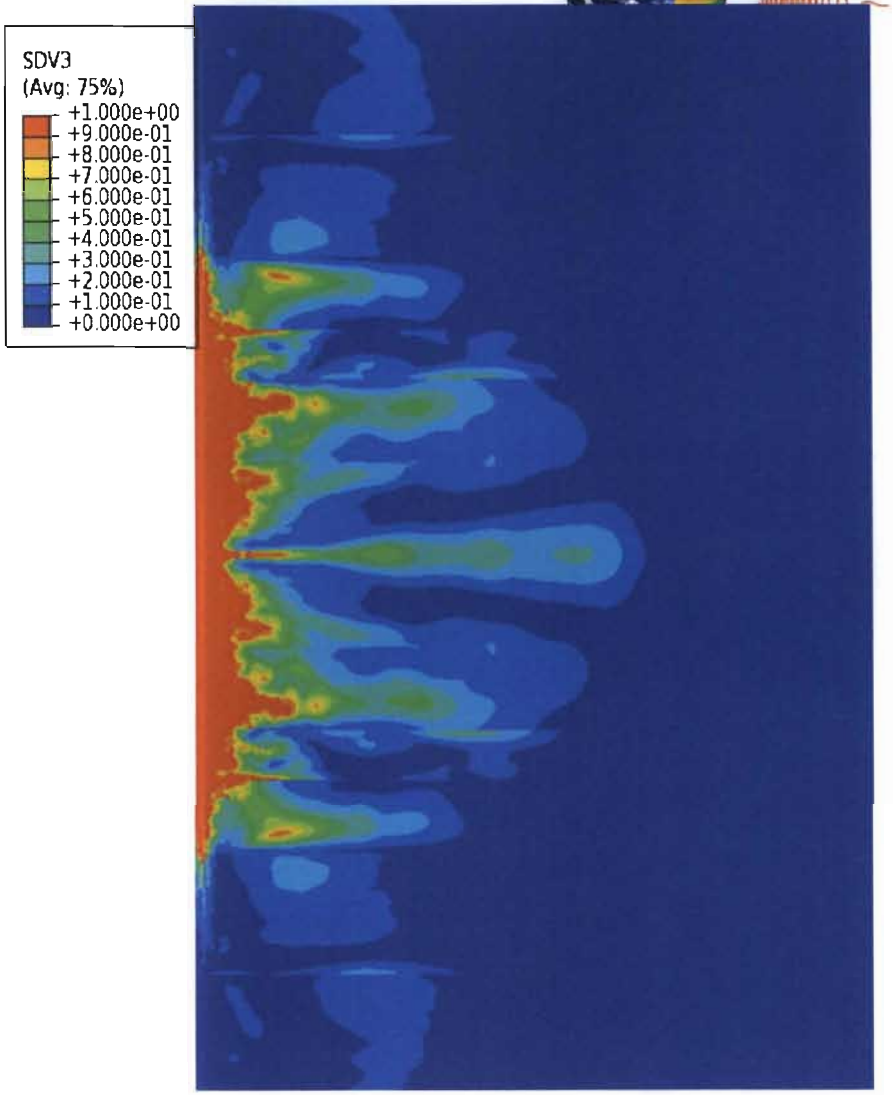
Rise Time =

ure = 200 Mpa

= 0.100 ms

Damage Calculation in Tight Gas





Damage Calculation in Tight Gas