

Loading to Rupture

Project: Utah Forge Project
ID: Barre#5
2025-03-21

Axial loading to rupture; cp=70MPa; pp=30MPa; displacement Control

Test Features

Loading, Unloading, Heating, Local Axial Strain, Local Radial Strain, Failure Strength, Hydraulic Fracturing, Pore Fluid Control, Uniaxial Stress/Strain, Triaxial Stress/Strain, Differential Stress, Acoustic Velocity, Acoustic Events, P-Wave Velocity

Author

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SAMPLE

Name: Barre#5
ID: Barre#5
Description: Thermally Cracked Barre Granite

Parent Sample

Name: Barre#5_Original
ID: Barre#5_Original
Description: Barre Granite Core

Material

Type: Igneous Rock
Name: granite
State: Homogeneous
Note: Barre Granite

Mineralogy

Mineral	Fraction	Unit	Grain Size
Quartz		Vol%	
Feldspar		Vol%	
Mica		Vol%	

Provenance

Formation: Barre Granite
Source: Quarry
Location: Barre, VT, USA

Texture

Parameters

Parameter	Value	Unit	Note
Other		mm-sec-1	P Wave Velocity

Other		mm·sec-1	S-Wave Velocity
Temperature	500	degC	Thermally Fractured ..

FACILITY & APPARATUS

Facility

Name:	Rock Physics Laboratory
Institute:	Massachusetts Institute of Technology
Department:	Earth and Planetary Sciences (EAPS)
Type:	University Lab
Description:	This facility is located on the 7th Floor in the Green Building at MIT (E54). Besides basic research, we do provide external services for interested parties (academic and non-academic). For more information, please contact the laboratory administrator.
Address:	77 Massachusetts Avenue, Bldg.54-715, Cambridge, MA, 02139, USA
Contact:	Matej Pec (mpec@mit.edu)

Apparatus

Name:	NER Autolab 3000
Type:	Triaxial (conventional)
ID:	MIT_NER3000
Location:	E54-715
Description:	This apparatus was acquired in 2015 and is currently installed on the 7th floor of MIT EAPS (Fig. 3). This triaxial testing machine uses silicon oil as confining medium and allows for simultaneous measurements of permeability, resistivity, acoustic velocities, and mechanical properties of rocks at reservoir conditions. The large sample size (10 cm diameter x 20 cm length) allows up to sixteen acoustic transducers to be attached to the exterior of the rock samples; each may be used in either active or passive modes. Four additional built-in acoustic sensors are located along the sample axis. Acoustic data are collected in continuous streaming mode at 250 MS/s. The mean-lithostatic and pore-fluid pressures are independently controlled up to 120 MPa; axial loads up to 4.89 MN can also be applied. An external furnace produces temperatures of up to 120°C. Tests of mechanical failure, joint reactivation, hydraulic transmissivity and permeability, and hydrofracturing can be performed. We can also measure changes in acoustic wave velocity, locate acoustic emissions, and analyze the moment tensors of the events. The NER 3000 apparatus supports a comprehensive suite of physical rock properties measurements as a function of stress and temperature. The system runs most standard rock mechanics test regimens, such as hydrostatic compression, pure shear, unconfined compression, confined compression, creep, and uniaxial strain. In addition, the system is equipped to measure permeability (Gas, Water) as well as resistivity. Each of these tests can be performed at pore pressures and temperatures representative of reservoir conditions. The apparatus is particularly suited for large samples including core drill sizes up to 4 inch diameter. Standard sample sizes are 4, 2, and 1.5" diameter. The system is also equipped with three pore pressure ports (one electrically isolated) and 16x4 pins electrical feedthroughs. Part of the feedthroughs are specifically designed for acoustic measurements. End plugs with built in piezo source and receivers P, S-wave) are available for measuring axial velocities.
Features:	Loading, Unloading, Heating, High Pressure, Hydrostatic Tests, Elasticity, Local Axial Strain, Local Radial Strain, Elastic Moduli, Yield Strength, Failure Strength, Strength, Creep, Stepping, Dynamic Tests, Hydraulic Fracturing, Reactive Flow, Pore Fluid Control, Permeability, Steady-State Permeability, Transient Permeability, Drained/Undrained Pore

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Fluid, Uniaxial Stress/Strain, Triaxial Stress/Strain, Differential Stress, Resistivity, Electrical Resistivity, Acoustic Velocity, Acoustic Events, P-Wave Velocity, S-Wave Velocity, Source Location

Parameters:

Type	Min	Max	Unit	Note
Confining Pressure	1	138	MPa	
Pore Pressure	1	129	MPa	
σ_1 -Load		2312	kN	depends on confining..
σ_1 -Displacement		25	mm	10-35mm absolute
Temperature	23	100	degC	nominal 120C
Permeability	0.01	100	mDarcy	steady state
Permeability	0.001	0.1	mDarcy	transient

Documents

Picture: NER 3000_Im

NER 3000 in E54-715

Path: https://strabospot.org/i/c96b76cf-e62b-4e43-bbea-78ff0a51cc59/20180105_130436.jpg

Manual: NER-3000_Man

NER 3000 Manual

Format: pdf | Path: https://strabospot.org/i/ddf5fa3d-d300-480c-bf33-1b191686c3b3/AutoLab_3000_rev5.pdf

SAMPLE ASSEMBLY GEOMETRY

1. Sample

Geometry: Cylinder

Material: Sample

Dimensions:

Length: 77.79 mm

Diameter: 38.5133 mm

2. Spacer

Geometry: Cylinder

Material: Hardened Steel

Dimensions:

Length: 76.2 mm (2x2" Top Spacer)

Width: 50.8 mm (2"Top Spacer)

DATA ACQUISITION (DAQ)

Name: NER 3000 DAQ + NI Continuous Acoustic + TiPie Triggered Acoustic

Type: Proprietary

Location: MIT E54-715

Description: This setup uses the NER 3000 data system for mechanical data as well as the TiPie Setup for triggered AE responses (Wave Velocity+Events). Some channels are continuously monitored using a 10MS/s NI DAQ System

Device 1: NER 3000 DAQ

Ch#	Type	Header	Unit	Sensor
0	Analog Input	Pressure / Confining / Ve..	MPa	
1	Analog Input	Displacement / Total / Co..	mm	

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2	Analog Input	Pressure / Pore / Upstrea..	MPa	
3	Analog Input	Pressure / Pore / Upstrea..	MPa	
4	Calculated	Displacement / Total / Po..	%	
5	Analog Input	Displacement / Total / Po..	mm	
6	Analog Input	Displacement / Total / Po..	mm	
7	Analog Input	Pressure / Pore / Downstr..	MPa	
9	Analog Input	Displacement / Total / Po..	mm	
10	Calculated	Pressure / Differential /..	MPa	
11	Calculated	Pressure / Differential /..	MPa	
12	Analog Input	Pressure / Pore / Upstrea..	MPa	
13	Analog Input	Pressure / Differential /..	MPa	
17	Analog Input	Pressure / Differential /..	MPa	
18	Analog Input	Displacement / Axial / Ex..	%	
19	Analog Input	Stress / Axial / Internal..	MPa	
20	Analog Input	Stress / Axial / Internal..	MPa	
21	Analog Input	Displacement / Axial / Ex..	mm	
22	Analog Input	Displacement / Axial / Ex..	mm	
23	Analog Input	Displacement / Axial / In..	mm	
24	Analog Input	Displacement / Axial / In..	mm	
25	Analog Input	Displacement / Radial / I..	mm	
27	Analog Input	Strain / Axial / Internal..	mStrain	
28	Analog Input	Strain / Axial / Internal..	mStrain	
29	Analog Input	Strain / Radial / Interna..	mStrain	
30	Analog Input	Strain / Radial / Interna..	mStrain	
31	Analog Input	Temperature / Room / Top ..	deg C	Thermocouple

Device 2: TiePie DAQ

Ch#	Type	Header	Unit	Sensor
1	Analog Input	Electrical / AC Voltage /..	Volt	
2	Analog Input	Electrical / AC Voltage /..	Volt	
3	Analog Input	Electrical / AC Voltage /..	Volt	
4	Analog Input	Electrical / AC Voltage /..	Volt	
5	Analog Input	Electrical / AC Voltage /..	Volt	
6	Analog Input	Electrical / AC Voltage /..	Volt	

Device 3: National Instrument Continuous DAQ

Ch#	Type	Header	Unit	Sensor
		Electrical / AC Voltage	Volt	

EXPERIMENTAL PROTOCOL

Step 1: Loading

Objective: Axial Loading
Description: Move Top Platen to Sample (Touch Point)
Parameters:
 Stress σ_1 : 10 MPa - Touch Point (minimum 10mm top Displacement)

Step 2: Triaxial Stress/Strain

Objective: Apply CP
Description: Fill Vessel - Increase Confining Pressure

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Parameters:

Confining Pressure P_c : 10 MPa

Step 3: Pore Fluid Control

Objective: Fill Pore Pressure - Water

Description: Saturate with Water as Pore Fluid - Increase Pressure

Parameters:

Saturation: Water %

Pore Pressure P_p : 5 MPa

Step 4: Heating

Objective: Heating to Set Point

Description: Approximately 1day Heating

Parameters:

Temperature T : 80 degC - Nominal Temperature

Step 5: Loading

Objective: Set to Initial Conditions

Description: increase c_p , p_p to initial conditions, find touch point (axial displacement)

Parameters:

Confining Pressure P_c : 90 MPa - nominal

Temperature T : 79 degC

Pore Pressure P_p : 30 MPa - nominal

Displacement Δs_1 : 11.79 mm - touch point

Step 6: Uniaxial Stress/Strain

Objective: Stepwise loading to Failure

Parameters:

Stress σ_1 : 25 MPa - First Step

Stress σ_1 : 75 MPa - 2nd Step

Stress σ_1 : 125 MPa - 3rd Step

Stress σ_1 : 175 MPa - 4th Step

Stress σ_1 : 225 MPa - 5th Step

Stress σ_1 : 275 MPa - 6th Step

Stress σ_1 : 300 MPa - 7th Step

Step 7: Failure Strength

Objective: Load to Failure

Parameters:

Stress σ_1 : 295 MPa - Max Stress Axial

Displacement Δs_1 : 12.86 mm - Max Displacement

Pore Pressure P_p : 85 MPa - Increase to 85

Step 8: Unloading

Objective: Unloading to zero Axial Load/Stress-Release Pore Pressure-Release Confining Pressure

Parameters:

Confining Pressure P_c : 0 MPa

Stress σ_1 : 0 MPa

Pore Pressure P_p : 0 MPa

Step 9: Unloading

Objective: Shut Down Furnace

Parameters:

Temperature T : 23 degC

DATA

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Dataset 1: Imaging

Type:	Picture
ID:	Pre_Exp_Barre#5
Rating:	Very Good
File:	https://strabospot.org/i/8fa5713d-b1bb-4617-809a-824ffb418405/image8.jpeg

Dataset 2: Time Series

Type:	Data
Format:	Other
ID:	Barre#5_Water Permeability
Rating:	Good
File:	https://strabospot.org/i/dc035e48-87c6-418f-a2b3-4288aab55c19/Barre#5_Permeability-2.xlsx

Dataset 3: Time Series

Type:	Data
Format:	Other
ID:	Barre#5_Gas Permeability
Rating:	Good
File:	https://strabospot.org/i/2a202454-b953-4090-956c-41a29ad9e99b/Barre#5_Permeability-1.xlsx

Dataset 4: Time Series

Type:	Data
Format:	Other
ID:	Barre#5_Stress_Strain
Rating:	Very Good

Time Series Headers:

Col#	Header	Type	Unit	Rating
0	Time / Absolute / Total / Time	System Clock	sec	Good
1	Pressure / Confining / Vesse..	Analog Out..	MPa	Good
2	Pressure / Pore / Upstream / ..	Analog Out..	MPa	Good
3	Pressure / Pore / Downstream..	Analog Out..	MPa	Good
4	Stress / Axial / Sample / ds	Analog Out..	MPa	Good
5	Stress / Axial / Sample / dl..	Analog Out..	MPa	Good
6	Displacement / Axial / Exter..	Analog Input	mm	Good
7	Strain / Total / Sample / dl..	Analog Input	mStrain	Good
8	Displacement / Axial / Inter..	Analog Input	mm	Good
9	Strain / Axial / Internal / ..	Analog Input	mStrain	Good
10	Displacement / Axial / Inter..	Analog Input	mm	Good
11	Strain / Axial / Internal / ..	Analog Input	mStrain	Good
12	Strain / Axial / Sample / Ax..	Analog Input	mStrain	Good
13	Strain / Radial / Sample / R..	Analog Input	mStrain	Good

File:	https://strabospot.org/i/afdc10f4-49f6-4e9b-9416-73c92435887f/1759170756_ds_rupture.xlsx
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Dataset 5: Time Series

Type:	Data
Format:	Other
ID:	Barre#5_Bulk_Gas
Rating:	Acceptable

File: https://strabospot.org/i/7ec3ccdd-e87d-4128-bb95-a42150cee10a/1758824318_bulk.pdf

Dataset 6: Parameters

Type: Data
Format: Other
ID: Time Synchronisation_Barre
Rating: Good
File: https://strabospot.org/i/59579eb9-3c61-4e01-8a7d-c819eb68298a/Time_Synchronisation_Table.jpg

Dataset 7: Imaging

Type: Picture
Format: Other
ID: CT_Barre5_4
File: https://strabospot.org/i/68fa4e12-3b17-4a35-9d50-9c0a5de770ac/Barre5_fault_004.png