

Utah Forge Project

StraboExperimental Project Report

Description:

We examine the seismic behavior of thermally fractured Barre Granite undergoing mechanical damage and/or rupture. Thermally cracked Barre granite cores (1.5" diameter; 3" length) are pre-stressed by increased deviatoric axial (σ_1) load about 80% to failure. Subsequently we Increase pore pressure which will lead to successive failure. We record the seismic events during this process and categorize their characteristics using machine learning algorithms. Tests are conducted within a range of conditions (pp: 30MPa+ and cp: 40-90MPa) at 80C.

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Experiments:	5
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Experiments in this Project:

- 1. Barre#1
- 2. Barre#4
- 3. Barre#5
- 4. Barre#3
- 5. Barre#2

Loading to Rupture via Pore Pressure Increase

Project: Utah Forge Project
ID: Barre#1
2025-11-10

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

Ulrich Mok (Lab Manager)
Email: u_mok@mit.edu

SAMPLE

Name: Barre#1
ID: Barre#1
Description: Thermally Cracked Barre Granite

Parent Sample

Name: Barre#1_Original
ID: Barre#1_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

STRABOEXPERIMENTAL

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: 77.78 mm

Diameter: 38.54667 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	

STRABOEXPERIMENTAL

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		Electrical / AC Voltage /..	Volt	
3		Electrical / AC Voltage /..	Volt	
4		Electrical / AC Voltage /..	Volt	
5		Electrical / AC Voltage /..	Volt	
6		Electrical / AC Voltage /..	Volt	
0	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

STRABOEXPERIMENTAL

Description: Fill Vessel - Increase Confining Pressure

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 : 60 MPa - nominal

Temperature T : 80.5 degC

Pore Pressure P_p : 30 MPa - nominal

Displacement Δs_1 : 11.09 mm - touch point

Step 6: Uniaxial Stress/Strain

Objective: Stepwise loading to Failure

Parameters:

Stress σ_1 : 50 MPa - First Step

Stress σ_1 : 75 MPa - 2nd Step

Stress σ_1 : 100 MPa - 3rd Step

Stress σ_1 : 125 MPa - 4th Step

Stress σ_1 : 150 MPa - 5th Step

Stress σ_1 : 175 MPa - 6th Step

Stress σ_1 : 200 MPa - 7th Step

Step 7: Failure Strength

Objective: Load to Failure

Parameters:

Stress σ_1 : 200 MPa - Max Stress Axial

Pore Pressure P_p : 30-56 MPa - slowly increasing until sample failure

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

Dataset 1: Imaging

Type: Picture
ID: Post_Exp_Barre_1
Rating: Very Good
File: https://strabospot.org/i/8fa5713d-b1bb-4617-809a-824ffb418405/IMG_3734.jpeg

Dataset 2: Imaging

Type: Picture
Format: Other
ID: Post_Exp_Barre_1_2
Rating: Good
File: https://strabospot.org/i/b34efbb2-c2ca-435b-a2a6-a6509637acb4/IMG_3736.jpeg

Dataset 3: Time Series

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

Dataset 4: Time Series

Type: Data
Format: Other
ID: Barre#1_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/1762787043_ds_rupture.xlsx

Dataset 5: Parameters

Type: Data
Format: Other
ID: Time Synchronisation_Barre

Rating:	Good
Description:	
File:	https://strabospot.org/i/4a70d238-9dca-409d-b4c8-156bcf96b11e/Time_Synchronisation_Table.jpg

Dataset 6: CT Scan

Type:	Picture
ID:	CT-Barre1_7
File:	https://strabospot.org/i/263cc866-00fe-4fc7-a0d4-0e87490dba0b/Barre1_fault_007.png

Loading to Rupture

Project: Utah Forge Project
ID: Barre#4
2025-07-02

Loading to rupture; cp=40MPa; pp=30MPa; displacement Control; Preload to 200MPa ds; increase pp to failure

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

Ulrich Mok (Lab Manager)
Email: u_mok@mit.edu

SAMPLE

Name: Barre#4
ID: Barre#4
Description: Thermally Cracked Barre Granite

Parent Sample

Name: Barre#4_Original
ID: Barre#4_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
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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,

STRABOEXPERIMENTAL

Permeability, Steady-State Permeability, Transient Permeability, Drained/Undrained Pore 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: 77.81 mm

Diameter: 38.73 mm

2. Spacer

Geometry: Cylinder

Material: Hardened Steel

Dimensions:

Length: 76.2 mm (2x2" Top Spacer)

Width: 50.8 mm (2"Top Spacer)

Documents

Other: Protocol_1

Format: jpg | Path: https://strabospot.org/i/93320fce-bdc0-46e1-b22e-c5d51b554ddd/IMG_2737.jpg

Other: Protocol_2

Format: jpg | Path: https://strabospot.org/i/9cc16e40-1679-44eb-9931-4a30fab494a4/IMG_2738.jpg

Other: Protocol_3

Format: jpg | Path: https://strabospot.org/i/167defb6-4ecd-45b1-83d7-d0ba2e16b3ab/IMG_2739.jpg

DATA ACQUISITION (DAQ)

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

Type: Proprietary

STRABOEXPERIMENTAL

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	
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
4	Analog Input	Electrical / AC Voltage / ..	Volt	
5	Analog Input	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
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 : 40 MPa - nominal
Temperature T : 78 degC
Pore Pressure P_p : 30 MPa - nominal
Displacement Δs_1 : 11.07 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 : 200 MPa - 5th Step

Step 7: Failure Strength

Objective: Load to Failure
Parameters:
Stress σ_1 : 202 MPa - Max Stress Axial
Displacement Δs_1 : 13.01 mm - Max Displacement
Pore Pressure P_p : 37 MPa - Max Pore Pressure

Step 8: Unloading

Objective: Unlaoding 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

Dataset 1: Sample Description

Type: Data
Format: Other
ID: Barre#4_Permeability
Rating: Good
File: https://strabospot.org/i/dc035e48-87c6-418f-a2b3-4288aab55c19/Permeability_Measurements.pptx

Dataset 2: Imaging

Type: Picture
Format: Other
ID: Post_Exp_Barre#4_1
Rating: Very Good
Description: Fracture Showing
File: https://strabospot.org/i/8fa5713d-b1bb-4617-809a-824ffb418405/IMG_2620.jpg

Dataset 3: Imaging

Type: Picture
Format: Other
ID: Post_Exp_Barre#4_2
Rating: Good
File: https://strabospot.org/i/8b89a2bb-faa9-4118-bc60-d24160b0697b/IMG_2697.jpg

Dataset 4: Imaging

Type: Picture
Format: Other
ID: Post_Exp_Barre#4_3
Rating: Good
File: https://strabospot.org/i/a0b15ff8-fe14-488b-86a6-6ac8dbd2f6e4/IMG_2701.jpg

Dataset 5: Time Series

Type: Data
Format: Other
ID: Barre#4_Gas Permeability
Rating: Good
File: https://strabospot.org/i/2a202454-b953-4090-956c-41a29ad9e99b/Barre#4_Permeability-1.xlsx

Dataset 6: Time Series

Type: Data
Format: Other
ID: Barre#4_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/1751473025_ds_rupture.xlsx

Dataset 7: Time Series

Type: Data
Format: Other
ID: Barre#4_Gas Permeability
Rating: Good

File: https://strabospot.org/i/1515ba13-fe56-458a-97ad-a87f07715217/Barre#4_Permeability-2.xlsx

Dataset 8: Time Series

Type: Data
Format: Other
ID: Barre#4_Water_Permeaility
Rating: Good

File: https://strabospot.org/i/81ad9d0e-d610-4227-adfe-3b8ea06da244/Barre#4_Permeability-3.xlsx

Dataset 9: Time Series

Type: Data
Format: Other
ID: Barre#4_Water_Bulk Modulus
Rating: Good

File: https://strabospot.org/i/800f78ab-daa8-4446-904b-60fd259c7f1a/1751392952_bulk.csv

Dataset 10: Time Series

Type: Data
Format: Other
ID: Barre#4_Rupture_Bulk

File: https://strabospot.org/i/c47fa462-aba3-4c1a-ae6b-6dc4aebcc672/1751473025_bulk.csv

Dataset 11: Parameters

Type: Data
Format: Other
ID: Time Synchronisation_Barre
Rating: Good
File: https://strabospot.org/i/66de7cbc-6ded-44de-9675-b9a715e0edc1/Time_Synchronisation_Table.jpg

Dataset 12: CT Scan

Type: Picture
ID: CT_Barre4_3
File: https://strabospot.org/i/9c7e10d1-b0f3-498d-af02-1053a9c0d506/Barre4_faultRender_03.png

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

Ulrich Mok (Lab Manager)
Email: u_mok@mit.edu

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

STRABOEXPERIMENTAL

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	

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

STRABOEXPERIMENTAL

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: Approximatly 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: Unlaoding 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

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

Loading to Rupture

Project: Utah Forge Project
ID: Barre#3
2025-05-23

Axial loading to rupture; cp=40MPa; 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

Ulrich Mok (Lab Manager)
Email: u_mok@mit.edu

SAMPLE

Name: Barre#3
ID: Barre#3
Description: Thermally Cracked Barre Granite

Parent Sample

Name: Barre#3_Original
ID: Barre#3_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

STRABOEXPERIMENTAL

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: 77.97 mm

Diameter: 38.72 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	

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 / l..	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		Electrical / AC Voltage /..	Volt	
3		Electrical / AC Voltage /..	Volt	
4		Electrical / AC Voltage /..	Volt	
5		Electrical / AC Voltage /..	Volt	
6		Electrical / AC Voltage /..	Volt	

Device 3: National Instrument Continuous DAQ

Ch#	Type	Header	Unit	Sensor
5	Analog Input	Electrical / AC Voltage /..	Volt	
7		Electrical / AC Voltage /..	Volt	
4	Analog Input	Electrical / AC Voltage /..	Volt	
6	Analog Input	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
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 : 78.4 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 : 40 MPa - nominal
Temperature T : 78.4 degC
Pore Pressure P_p : 30 MPa - nominal
Displacement Δs_1 : 11.09 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 : 124 MPa - 3rd Step
Stress σ_1 : 175 MPa - 4th Step
Stress σ_1 : 220 MPa - 5th Step

Step 7: Failure Strength

Objective: Load to Failure
Parameters:
Stress σ_1 : 229 MPa - Max Stress Axial
Displacement Δs_1 : 12.24 mm - Max Displacement

Step 8: Unloading

Objective: Unlaoding 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

Dataset 1: Time Series

Type:	Data
Format:	Other
ID:	Barre#3_Argon Permeability
Rating:	Good
File:	https://strabospot.org/i/dc035e48-87c6-418f-a2b3-4288aab55c19/Barre#3_Permability_MP.xlsx

Dataset 2: Time Series

Type:	Data
Format:	Other
ID:	Barre#3_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/1747928562_ds_rupture.xlsx
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Dataset 3: Parameters

Type:	Data
Format:	Other
ID:	Time Synchronisation_Barre
Rating:	Good
File:	https://strabospot.org/i/0ef23b2d-2839-4ebb-9039-e6d32c2fb27e/Time_Synchronisation_Table.jpg

Dataset 4: Imaging

Type:	Picture
Format:	Other
ID:	CT-Fault
Rating:	Good
File:	https://strabospot.org/i/c2f78aa8-75e7-4302-b66a-02263f32b9aa/Barre3_fault_003.png

Loading to Rupture

Project: Utah Forge Project
ID: Barre#2
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

Ulrich Mok (Lab Manager)
Email: u_mok@mit.edu

SAMPLE

Name: Barre#2
ID: Barre#2
Description: Thermally Cracked Barre Granite

Parent Sample

Name: Barre#2_Original
ID: Barre#2_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: 77.77 mm

Diameter: 38.43667 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	

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		Electrical / AC Voltage /..	Volt	
3		Electrical / AC Voltage /..	Volt	
4		Electrical / AC Voltage /..	Volt	
5		Electrical / AC Voltage /..	Volt	
6		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: Approximatly 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 : 70 MPa - nominal

Temperature T : 78 degC

Pore Pressure P_p : 30 MPa - nominal

Displacement Δs_1 : 10.79 mm - touch point

Step 6: Uniaxial Stress/Strain

Objective: Stepwise loading to Failure

Parameters:

Stress σ_1 : 75 MPa - First Step

Stress σ_1 : 122 MPa - 2nd Step

Stress σ_1 : 160MPa MPa - 3rd Step

Stress σ_1 : 200 MPa - 4th Step

Step 7: Failure Strength

Objective: Load to Failure

Parameters:

Stress σ_1 : 295 MPa - Max Stress Axial

Displacement Δs_1 : 13.01 mm - Max Displacement

Step 8: Unloading

Objective: Unlaoding 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

Dataset 1: Imaging

Type: Picture

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ID: Post_Exp_1
Rating: Very Good
Description: Fracture Showing
File: https://strabospot.org/i/8fa5713d-b1bb-4617-809a-824ffb418405/20250324_150658.jpg

Dataset 2: Time Series

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

Dataset 3: Time Series

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

Dataset 4: Time Series

Type: Data
Format: Other
ID: Barre#2_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/1742486486_ds_rupture.xlsx

Dataset 5: Parameters

Type: Data
Format: Other
ID: Time Synchronisation_Barre
File: https://strabospot.org/i/2ecea7d6-e15c-4a41-9752-c73c0c11cb36/Time_Synchronisation_Table.jpg