SZ4D Activities within the Experimental Communities

SZ4D Community Meeting
11/14/2022

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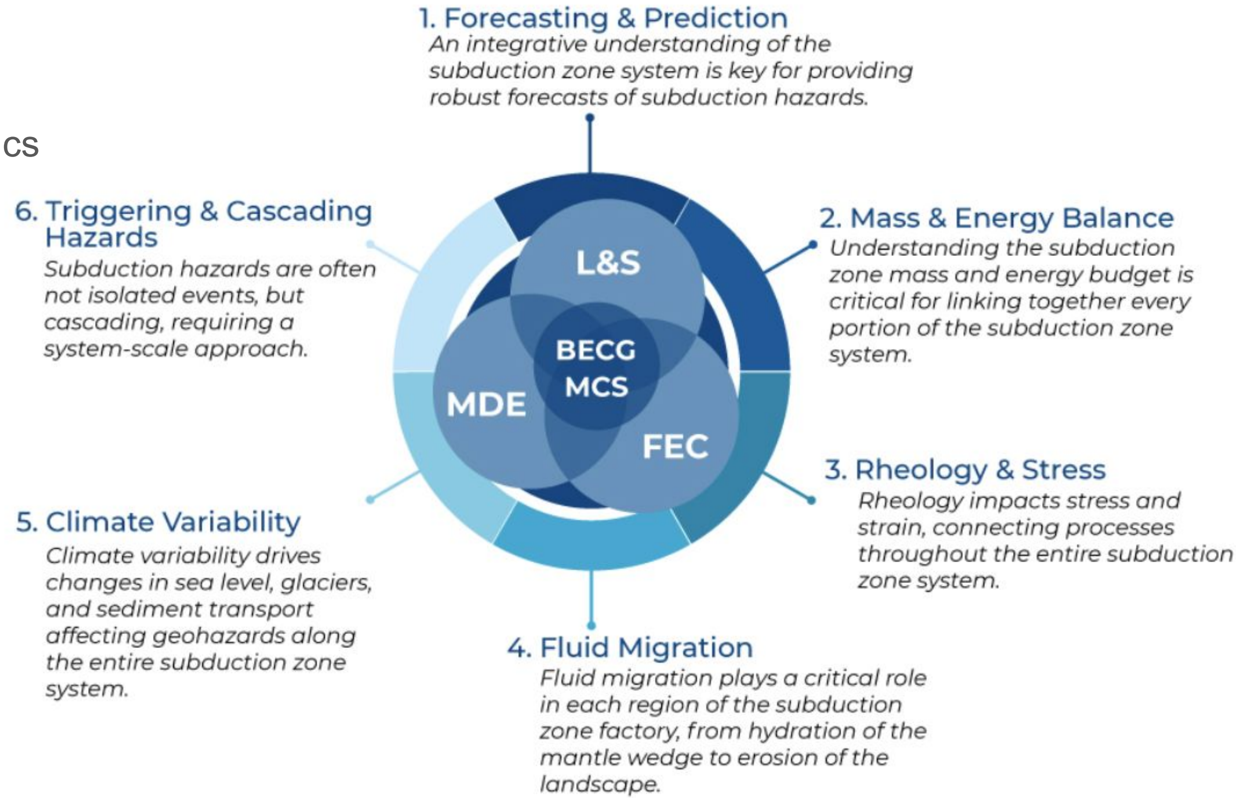
Laboratory Activities in SZ4D

- Geochemistry
- Petrology
- Geochronology
- Sediment Transport and Mechanics
- Petrophysics
- Rock Deformation
- Analog Experiments

working group overlaps in processes AND infrastructure needs

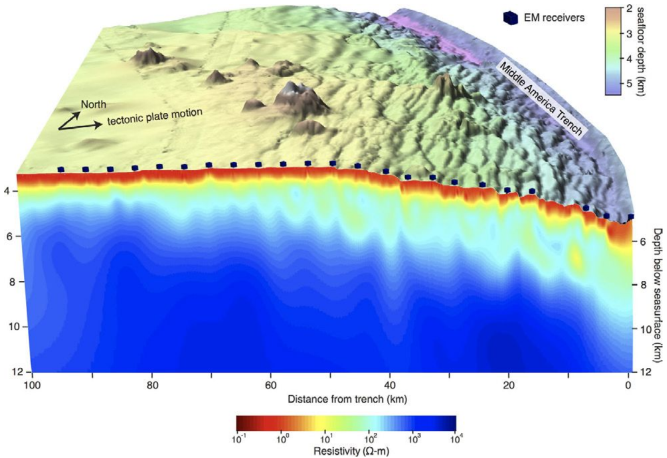


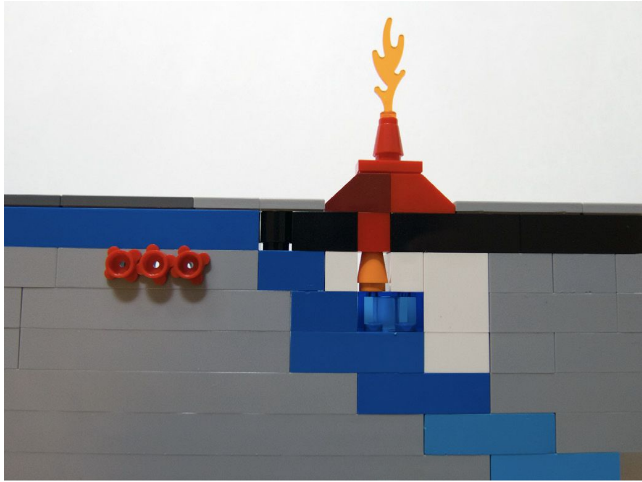
Laboratory Activities in SZ4D

Synergies with other activities

- Modeling - Models inform experimental needs and vice versa
- Field geology - Together identify and quantity process
- All 3 needed to interpret and guide Array Observations

Figure MCS-1 from Implementation Plan. Left: Electric conductivity structure for Central America (from Naif et al., 2015). Right: Concept of a modular, building-block-based framework for physics-based modeling.





Timeline of Experimental Activities

SZ4D

- **June 2018:** *Experimental Studies of Subduction Zone Processes* workshop, WUSTL
- **April 2021:** Virtual Townhall on **Field Geology and Experimental Plans**
- Subcommittee of Experimentalists to Discuss Coordination of Experimental Activities
  - **Laboratory Consortium** in Implementation Plan

Experimental Rock Deformation Activities

- **June 2022:** Community input on the **experimental deformation data needed** to answer science questions
- **June - July 2022:** Ad-Hoc Committee met to discuss
  - Outcome of virtual workshop - sought out representation for L&S and MDE
  - Experimental measurements and equipment needed to collect the data
  - Technical developments necessary to make measurements
  - Models for implementation
- **August 12-13, 2022:** **In person workshop** after the GRC on Rock Deformation
  - Discuss recommendations by the Ad-Hoc Committee
  - Community input

SZ4D Laboratory and Sample Consortium

Section 5.4 of Implementation Plan: Program Governance and Structure

Goals: Leveraging a community structure to collect experimental data that fulfills SZ4D information and data needs

- Coordinate collection of critical data
- Value creativity and flexibility in research design
- Promote collaborative experimental research
- Increase accessibility and training opportunities

Experimental petrology laboratory at the University of Oregon

SZ4D Laboratory and Sample Consortium

SZ4D

Network of laboratories who contribute to SZ4D research planning and data collection

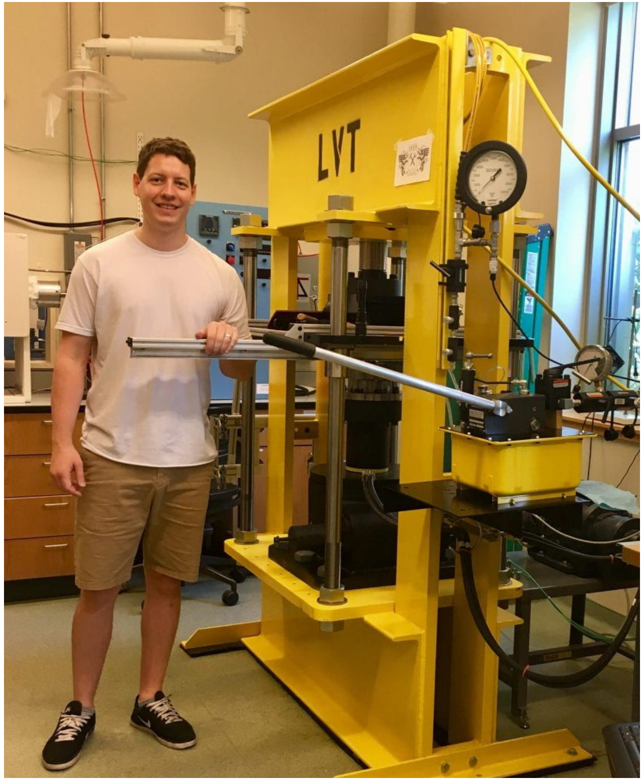
- Support to coordinate laboratory visits and exchange
  - Supported by community staff (logistical)
  - Virtual infrastructure
- Access to SZ4D samples and resources
- Funding for student and postdoc led projects
- Interface with existing consortia (NCG)

TIMS in the Isotope Geology Laboratory at Boise State University from the AGES website

Experimental Rock Deformation SZ4D

- In the Implementation Plan:
  - **Activities and data needs** in all 3 Working Group reports
  - Development of **new technologies** to answer the driving science questions of all 3 working groups
  - Part of a proposed **laboratory and sample consortium**

- In the Catalyst Proposal:
  - Development of a plan for rock deformation technical **development and implementation**
    - Need community input!
    - Need to specify and prioritize!



Rock deformation laboratory at WUSTL

Ad-Hoc Committee on Experimental Rock Deformation

SZ4D

22 members of the experimental rock deformation community

Experimental Rock Deformation Traceability Matrices

Q4: Under what physical conditions and by what processes will slip during an earthquake displace the seafloor and increase the likelihood of generating a significant tsunami?

Information Needed		Experimental Conditions Needed / Other needs
Fault strength	Dynamic weakening	Low normal stress (<10 MPa), no controlled/measured fluid pressure, 1 m/s, 5 m/s^2 acceleration, unlimited displacement, solid rock and granular samples
		Moderate normal stress, unconfined, 35 mm displacement, 3 m/s,acceleration of 10^3 m/s^2, ambient temperature, solid rock samples
		High normal stress, confined, (~ 200 MPa), 200 C, small to large displacements, acceleration of 1-10 km/s^2, pore pressure monitoring, granular samples In-situ/synchronton for constraints on phase changes
	Mechanical and chemical consolidation and lithification (e.g., healing)	Strain rates >= 10-7 s-1 & <=10-3 s-1 Pressures up to 300 MPa, controlled fluid pressures <=300 MPa, temperature to 300 C, large samples
		10-8 s-1 <= Strain rates < 10-7 s-1 & >10-3 s-1 Corrosive fluids
		Strain rates < 10-8 s-1
Sediment and accretionary prism strength	Dynamic loading	Seismic frequencies (i.e. 1 Hz), amplitudes of ~2 MPa, pressure/pore pressure to 200 MPa, temperature to 200 C
		accelerations of 1-10 km/s^2, seismic frequencies, seismic strain/stress amplitudes
	Mechanical and chemical consolidation and lithification	Strain rates >= 10-7 s-1 & <=10-3 s-1 Pressures up to 300 MPa, controlled fluid pressures <=300 MPa, temperature to 300 C, large samples
		10-8 s-1 <= Strain rates < 10-7 s-1 & >10-3 s-1 Corrosive fluids
		Strain rates < 10-8 s-1
Physical and hydraulic properties		Physical properties and permeability at pressures <=400 MPa, Fluid pressures <=300 MPa, temperature up to 150 C Coupling of physical properties measurements to volume change measurements at T< 150 C
		Permeability measurements on samples 1 cm at pressures = 400 MPa, Fluid pressure = 300 MPa, temperatures up to 300 C Digital rocks/tomography and pore topology coupled with numerical simulations Coupling of physical properties measurements to volume change measurements at T> 150 C
		Permeability measurements during in-situ/synchrotron measurements

KEY

Relatively straightforward to accomplish

Accomplished in a 1-2 cases or theoretically straighforward

Has not been done and is not easy to do

4 FEC Matrices
3 MDE Matrices
2 L&S Matrices

Community Prioritization: In-Person Workshop

SZ4D

August 2022: 40 Participants, 50 % ECR

Step 1: Identify Highest Priority Information Needed to Answer the Science Questions

Step 2: Determine what we can do now and what we need technical advancements to achieve

Step 3: Determine what is best achieved through a community effort and what can be accomplished at the PI level

Sample and Virtual Infrastructure & Collaboration

Sample Storage and Distribution

- Repository of large volumes and/or difficult to acquire rocks and minerals
- Standardized characterization of natural samples - e.g., XRD, XRF
- Materials for voluntary interlaboratory comparisons and standardization
- Should try to exploit sample repositories that already exist

Distribution of data and technical information through virtual infrastructure

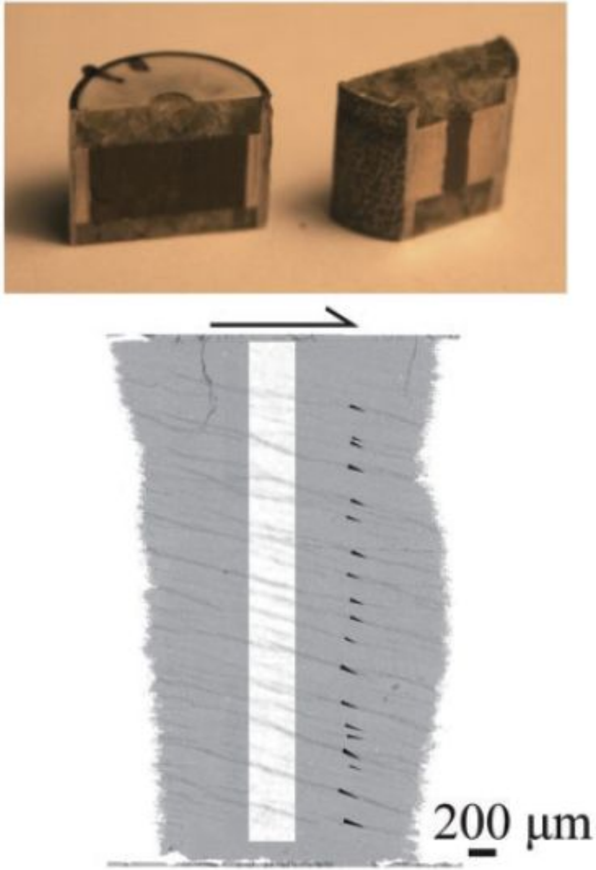
Polar rock repository, one example of a rock repository

3 Pronged Community Effort

No Single Laboratory or Apparatus can answer the questions and provide the quantity of data. 3 efforts that would be most effective with a community approach:

1. Centralized technical development

- Engineering support to develop key technical advancements
- Implemented in existing labs
- Examples for MDE:
  - High pressure vessels and high-T sensors
  - High P and T combination to study chemical reactivity during deformation and melt extraction
  - Development of jacketing technologies to study intermediate partial melt fractions



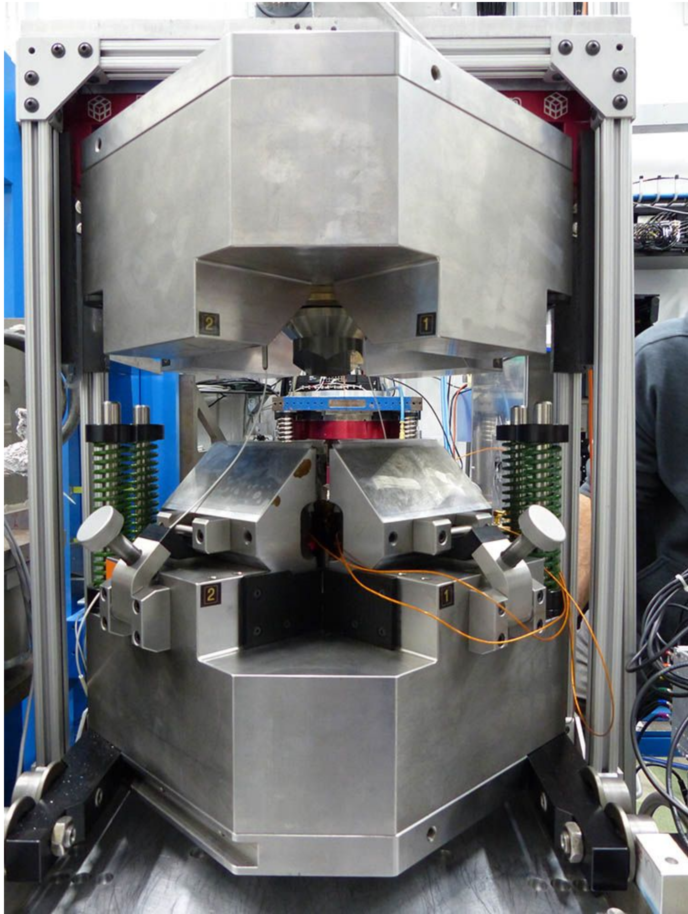
Top: Cut sample from partial melt torsion experiment from King et al. (2010). Bottom: BSE image of sample showing melt bands

3 Pronged Community Effort

No Single Laboratory or Apparatus can answer the questions and provide the quantity of data. 3 efforts that would be most effective with a community approach:

2. Beamline Support for In-situ Experimentation

- Time-dependent processes (4-D) requires in-situ monitoring
  - e.g., the granular physics of landscape evolution (L&S)
  - e.g., the physics of partial melt migration (MDE)
- Requires taking equipment to a beamline
  - engineering support for physical infrastructure
- Beamline technician support



Beamline experiment from RISD website

3 Pronged Community Effort

No Single Laboratory or Apparatus can answer the questions and provide the quantity of data. 3 efforts that would be most effective with a community approach:

3. Distributed model of long-term experiments

- **Stress state**, **extent of seismogenic zone**, **mode of slip**, **healing** likely controlled by:
  - pressure solution creep
  - deformation of phyllosilicate-rich rocks

- **Long-term experiments** at in-situ conditions
  - Pool of identical rigs
  - Rely on well-established firm to develop professionally-designed standard rig
  - Leverage existing infrastructure

Dead load creep apparatus at the University of Minnesota