# STRABOEXPERIMENTAL

This manual describes the basic functionality and features of StraboExperimental. It is based on the prototype version as published and initially presented at AGU 2023. The manual will be continuously updated to accommodate future changes in the site repository.

LAPS/StraboExperimental is a project partly funded by NSF (Award# 1948453) and is supported by the Experimental Geophysics Community.

## INTRODUCTION

StraboExperimental is a digital database for experimental geophysical data, particularly for rock deformation tests. In its envisioned, final form, StraboExperimental is going to be an essential part of the Strabo System. Projects entered via StraboExperimental can be linked to other data stored in the Strabo database, including data from the StraboMicro application for microstructure-related images and data as well as geologic field data imported through StraboMobile. Its aim is to provide experimentalists with a comprehensive and easy-to-use tool to manage, store and share experimental results.

Some of the major benefits of StraboExperimental are:

- Capability to add all relevant data to an experiment, including apparatus, operating procedures, sensor, sample information etc.
- Public Apparatus Repository
- User has complete access control over his datasets.
- Search and Presentation Features
- Import and Export all Metadata as JSON
- Use of reusable Templates for quick data entry
- Public Rest API
- Publicly funded.

# THE STRABOEXPERIMENTAL PHILOSOPHIE

The goal of this project is to create a practical standard to describe experimental geophysical data, to implement the findings in an online digital repository and to provide tools for researchers to utilize these standards in the laboratory.

## A Metadata Standard for Experimental Data

Experimental data are not per se self-evident and explanatory. As experiments and models are increasingly intricate and complex, contextual information, or metadata, gains proportionally in importance to describe the results in detail.

A comprehensive set of metadata is useful in many respects. It may be used to estimate the quality and reliability of experiments or its relevance to a theoretical model. It also may provide explanations for unexpected results and is essential to be able to find, reproduce and compile other researchers' discoveries. Direct public access to data and metadata allows to compare results between different laboratories improving data quality. It also creates accountability and facilitates further data processing and long-term storage.

Unfortunately, up to now, in experimental geophysics, no standards exist for the ways data and metadata are to be stored. Most laboratories have their own proprietary workflows and means of data gathering and storage. During publication, it is the researcher's responsibility to provide experimental data and metadata in arbitrary digital form in a publicly accessible repository. Without a structured approach, this is a frequently a tedious and difficult task.

During the last years The Strabo Team compiled the most important aspects of various experimental workflows and parameters and created a general schema to formulize data entry and storage. We particularly focused on aspects of 'ease of use' and compatibility with existing public repositories to draw on experiences and the needs of the experimental community.

## The StraboExperimental Prototype

The underlying schema of the StraboExperimental database is based on a perceived workflow for a single experimental test. Following a strict protocol from choice of equipment, sample selection and preparation to experimental procedure, StraboExperimental will make sure that most relevant experimental parameters are recorded and stored in an organized way. While only a small fraction of metadata fields is mandatory, the user is presented with the option to add as much information as possible.

It might appear cumbersome and repetitive to use an extensive form to enter information for each experiment, but the underlying premise is that metadata and data needs to be stored and archived together to ensure the usefulness for future users as well as for machine learning applications. Adding all metadata information to a dataset does not add significant storage load (<1MB) compared to most other experimental data (e.g., images or data files).

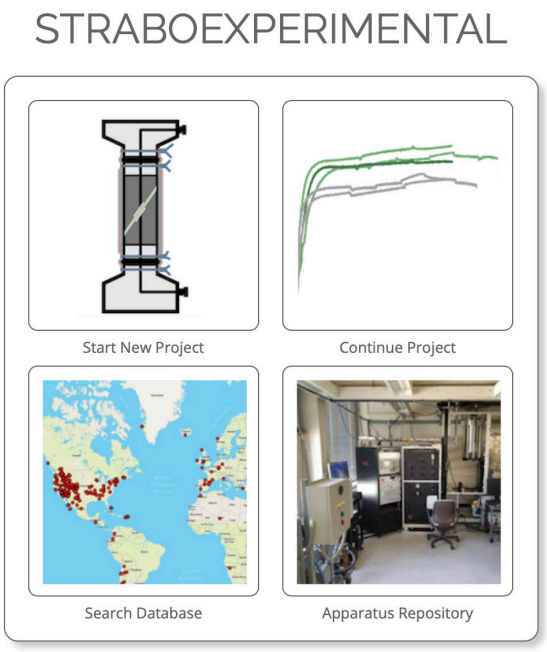
Recognizing that within a project, a series of experiments often use similar or identical conditions and settings, the web application makes extensive use of templates as well as the possibility to import and export information from previous datasets. We hope that this approach saves significant time for data entry. By being able to import readable JSON files, lab managers can also incorporate the metadata structure into existing workflows. It is also possible to share these templates with different laboratories.

# THE LANDING PAGE

StraboExperimental is accessible at [https://strabospot.org/experimental/](https://strabospot.org/experimental/). Before being able to use StraboExperimental, you will have to sign up with your name, address and affiliation. Please contact the Strabo site administrator for more information. After login with your user credentials, you get to the main Projects landing page.

The Landing Page consists of four sections:

- *Start a New Project*
- *Continue Project*
- *Search database (in process)*
- *Apparatus Repository*

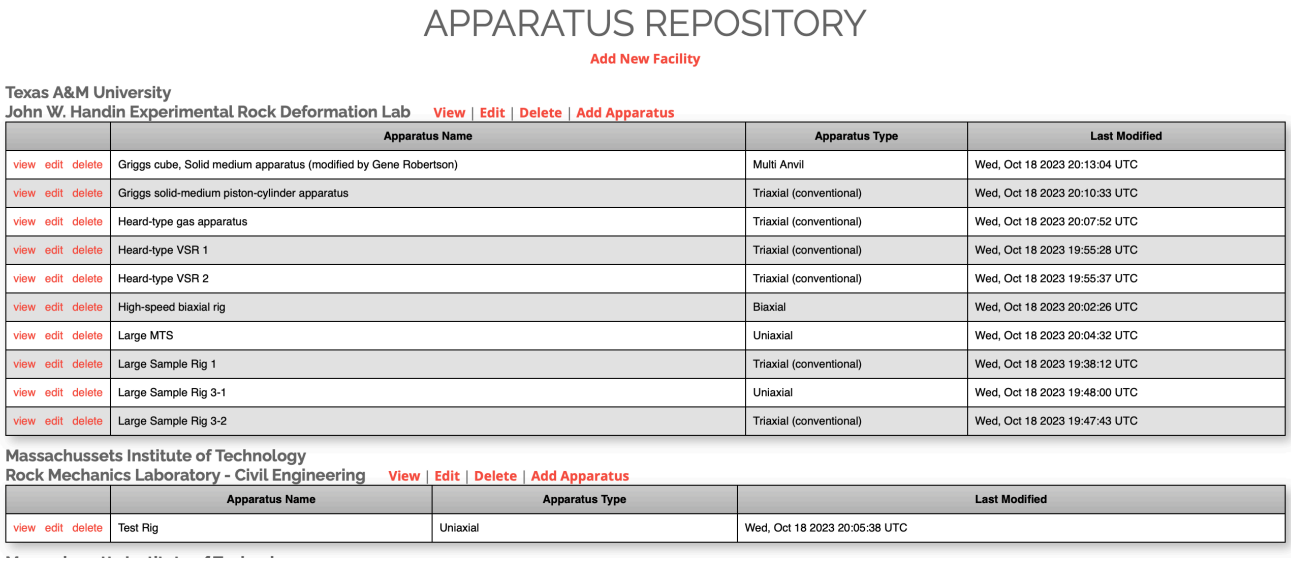


# APPARATUS REPOSITORY

The Apparatus repository contains a **publicly** accessible list of Equipment used in Experimental Rock Physics. It is maintained and updated by the community and **facilities** and laboratory managers can add to and edit their respective equipment at any time.

Today, many laboratories are also service centers available to external users. Researchers without access to experimental facilities can use this repository to find and utilize appropriate equipment to conduct their experiments. This will benefit the laboratories as well as widen the scope for potential research. More detailed apparatus information might also serve as a valuable source of information when designing new equipment.

For convenience, the list of **apparatuses** is grouped by **facility** and shows name and type of the apparatus. Lab Managers may add, edit and delete apparatuses at any time. Users can only view and browse the directory for specific equipment. Search functionality based on apparatus specifics will be added at a later stage.



APPARATUS REPOSITORY

Add New Facility

Texas A&M University
John W. Handin Experimental Rock Deformation Lab View | Edit | Delete | Add Apparatus

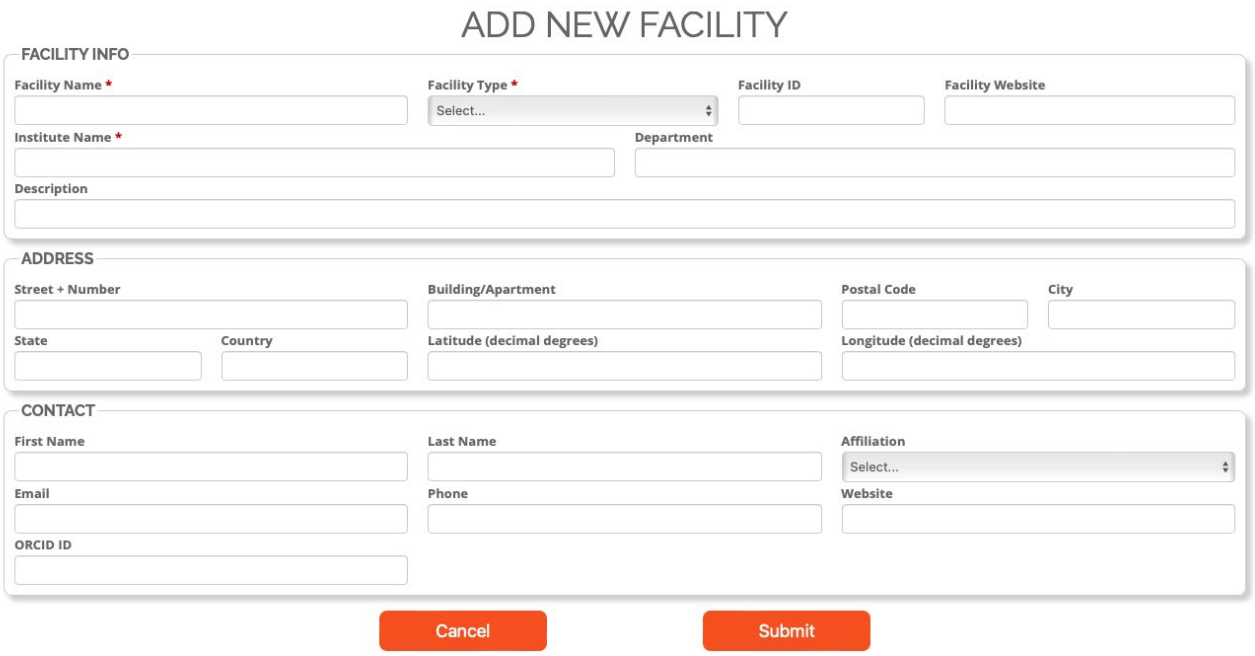
| | Apparatus Name | Apparatus Type | Last Modified |
|---|---|---|---|
| view edit delete | Griggs cube, Solid medium apparatus (modified by Gene Robertson) | Multi Anvil | Wed, Oct 18 2023 20:13:04 UTC |
| view edit delete | Griggs solid-medium piston-cylinder apparatus | Triaxial (conventional) | Wed, Oct 18 2023 20:10:33 UTC |
| view edit delete | Heard-type gas apparatus | Triaxial (conventional) | Wed, Oct 18 2023 20:07:52 UTC |
| view edit delete | Heard-type VSR 1 | Triaxial (conventional) | Wed, Oct 18 2023 19:55:28 UTC |
| view edit delete | Heard-type VSR 2 | Triaxial (conventional) | Wed, Oct 18 2023 19:55:37 UTC |
| view edit delete | High-speed biaxial rig | Biaxial | Wed, Oct 18 2023 20:02:26 UTC |
| view edit delete | Large MTS | Uniaxial | Wed, Oct 18 2023 20:04:32 UTC |
| view edit delete | Large Sample Rig 1 | Triaxial (conventional) | Wed, Oct 18 2023 19:38:12 UTC |
| view edit delete | Large Sample Rig 3-1 | Uniaxial | Wed, Oct 18 2023 19:48:00 UTC |
| view edit delete | Large Sample Rig 3-2 | Triaxial (conventional) | Wed, Oct 18 2023 19:47:43 UTC |

Massachussets Institute of Technology
Rock Mechanics Laboratory - Civil Engineering View | Edit | Delete | Add Apparatus

| | Apparatus Name | Apparatus Type | Last Modified |
|---|---|---|---|
| view edit delete | Test Rig | Uniaxial | Wed, Oct 18 2023 20:05:38 UTC |

## Facility

To get started, you need to add a **Facility Name**, i.e., the name of your lab or group. Also required entries are Facility **Type** and the name of your **Institution** (e.g., University). All other entries are voluntary, but we do recommend adding at least a contact name and email.



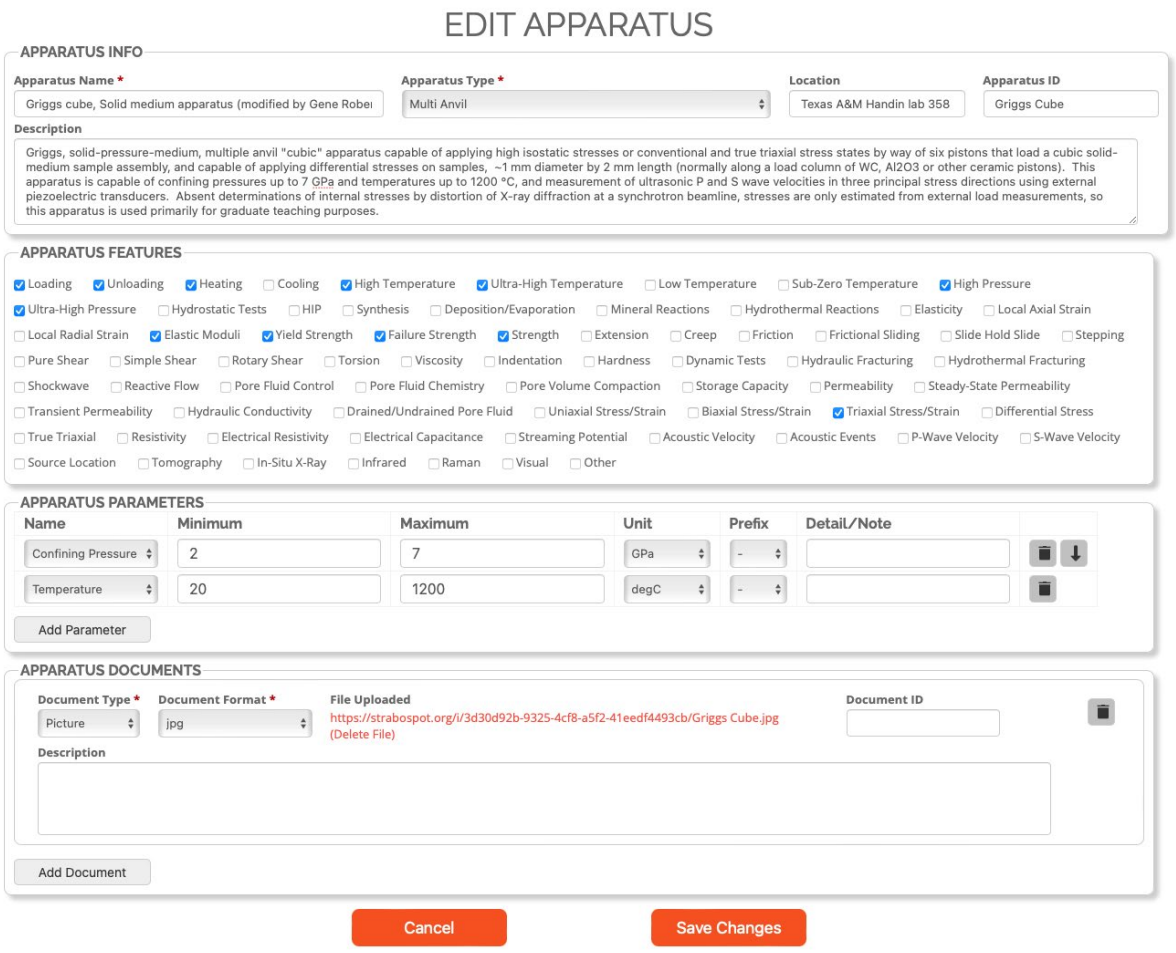

## Apparatus

Each Facility contains a list of **Apparatuses** the Lab manager or responsible party is willing to share with the community. Equipment details should be concise and not contain proprietary information. To add new equipment, click on '**Add Apparatus'** in the Facility section of the Repository.

Required information are **Name***, **Type*** of the Apparatus. Additional fields are shown to add specific details about the apparatus and its capabilities. Frequently, generic equipment is being modified over the years to add new **features** and capabilities. Such changes may be outlined to reflect the most recent upgrades.

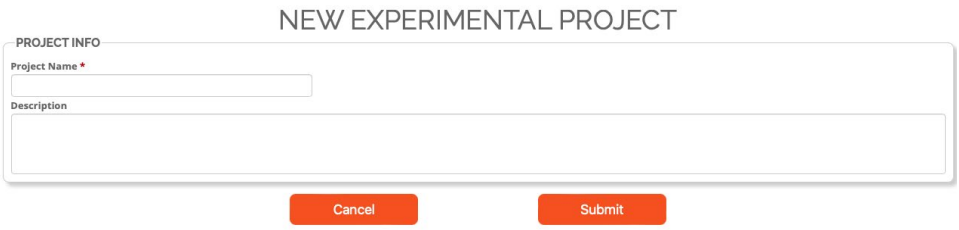
The **Parameters** section lists machine limits with respect to Pressure, Temperature, Stress, Load, Dimensions, etc. capabilities. They are included to help users find equipment that covers a certain range of experimental conditions.

Supporting **documents** such as manuals, diagram, photos or schematics may be uploaded as desired. If in public domain, specific design drawings may be included.



# EXPERIMENTAL PROJECTS

The basic workflow for StraboExperimental users starts by creating an **experimental project**. This term is used to group individual experimental datasets. A new project may be started from the initial landing page or by adding a new project from within the **Project Management** page.




The simple form requires only a project name. Once you save a project it will be added to the project list. You can add as many projects as needed.

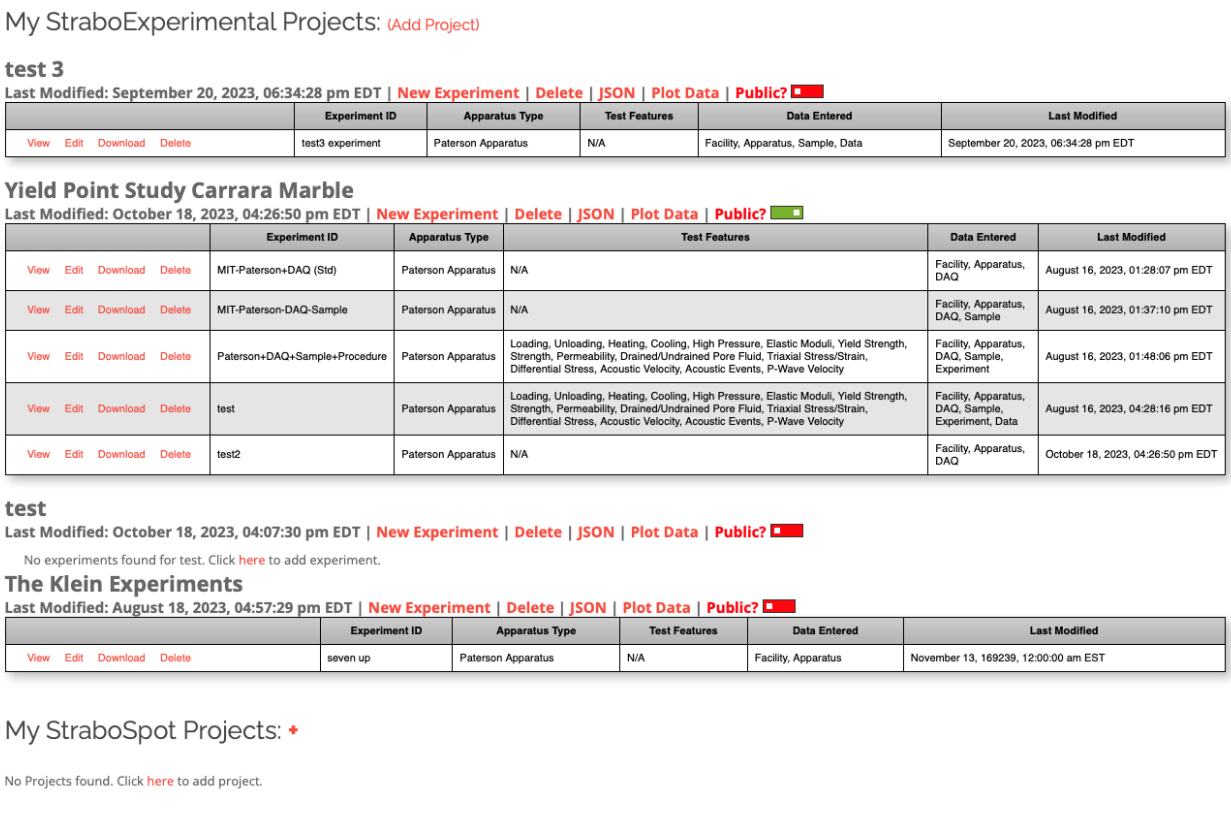
# PROJECT MANAGEMENT (CONTINUE PROJECT)

This page contains all experiments grouped by experimental projects. Differing from the Public Apparatus repository this information is only accessible by the registered user unless the Public option is selected. For ease of use a new project may be added directly from this page. The list of experiments contains the Experiment Id, Apparatus Type and Test Features. In addition, data entered, shows the sections of the workflow that are already completed.

Options for each Project are:

- **New Experiment** – creates a new experiment with experimental data and metadata
- **Delete** – deletes the current Project **including** all Experiments contained in it.
- **JSON** – View/Save JSON file of entire Project
- **Plot Data** – Filter and Plot Time Series Data
- **Public** – Toggle Switch for Private and Public view

Once a Project contains an experiment, the information can be Viewed, Edited, Deleted or Downloaded to your device.  Please not that if you choose to download an experiment currently only the metadata will be saved to your computer. Any documents uploaded to the repository will be referenced by its server id. The functionality to download all information including data files will be added at a later stage.



My StraboExperimental Projects: (Add Project)

**test 3**

Last Modified: September 20, 2023, 06:34:28 pm EDT | New Experiment | Delete | JSON | Plot Data | Public?

| | Experiment ID | Apparatus Type | Test Features | Data Entered | Last Modified |
|---|---|---|---|---|---|
| View Edit Download Delete | test3 experiment | Paterson Apparatus | N/A | Facility, Apparatus, Sample, Data | September 20, 2023, 06:34:28 pm EDT |

**Yield Point Study Carrara Marble**

Last Modified: October 18, 2023, 04:26:50 pm EDT | New Experiment | Delete | JSON | Plot Data | Public?

| | Experiment ID | Apparatus Type | Test Features | Data Entered | Last Modified |
|---|---|---|---|---|---|
| View Edit Download Delete | MIT-Paterson+DAQ (Std) | Paterson Apparatus | N/A | Facility, Apparatus, DAQ | August 16, 2023, 01:28:07 pm EDT |
| View Edit Download Delete | MIT-Paterson-DAQ-Sample | Paterson Apparatus | N/A | Facility, Apparatus, DAQ, Sample | August 16, 2023, 01:37:10 pm EDT |
| View Edit Download Delete | Paterson+DAQ+Sample+Procedure | Paterson Apparatus | Loading, Unloading, Heating, Cooling, High Pressure, Elastic Moduli, Yield Strength, Strength, Permeability, Drained/Undrained Pore Fluid, Triaxial Stress/Strain, Differential Stress, Acoustic Velocity, Acoustic Events, P-Wave Velocity | Facility, Apparatus, DAQ, Sample, Experiment | August 16, 2023, 01:48:06 pm EDT |
| View Edit Download Delete | test | Paterson Apparatus | Loading, Unloading, Heating, Cooling, High Pressure, Elastic Moduli, Yield Strength, Strength, Permeability, Drained/Undrained Pore Fluid, Triaxial Stress/Strain, Differential Stress, Acoustic Velocity, Acoustic Events, P-Wave Velocity | Facility, Apparatus, DAQ, Sample, Experiment, Data | August 16, 2023, 04:28:16 pm EDT |
| View Edit Download Delete | test2 | Paterson Apparatus | N/A | Facility, Apparatus, DAQ | October 18, 2023, 04:26:50 pm EDT |

**test**

Last Modified: October 18, 2023, 04:07:30 pm EDT | New Experiment | Delete | JSON | Plot Data | Public?

No experiments found for test. Click here to add experiment.

**The Klein Experiments**

Last Modified: August 18, 2023, 04:57:29 pm EDT | New Experiment | Delete | JSON | Plot Data | Public?

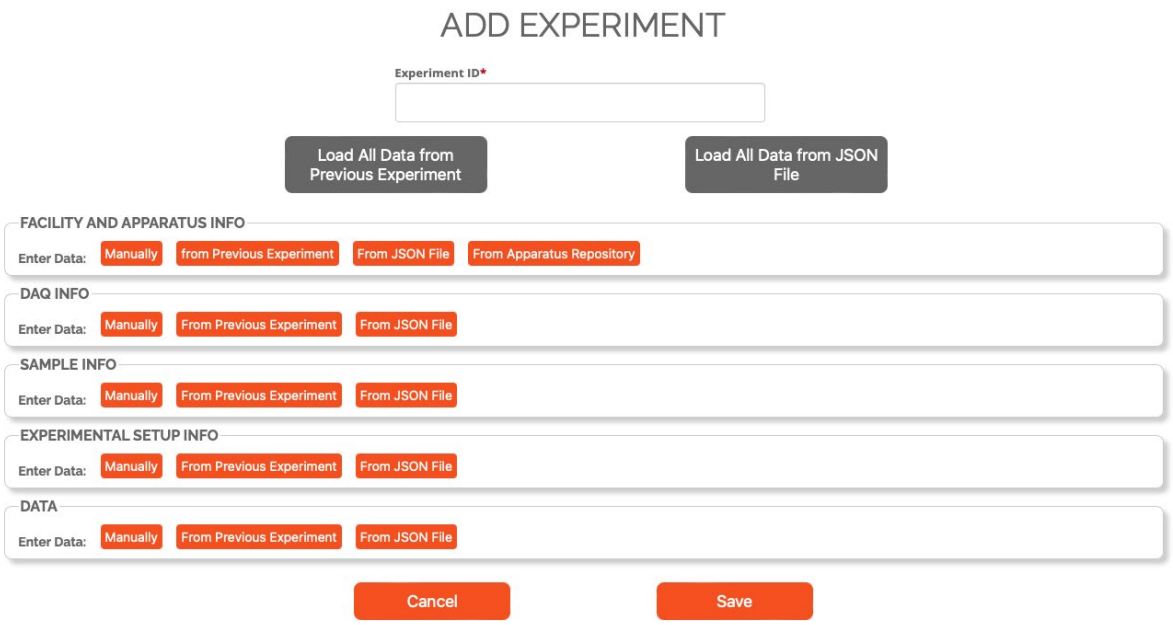
| | Experiment ID | Apparatus Type | Test Features | Data Entered | Last Modified |
|---|---|---|---|---|---|
| View Edit Download Delete | seven up | Paterson Apparatus | N/A | Facility, Apparatus | November 13, 169239, 12:00:00 am EST |

My StraboSpot Projects: +

No Projects found. Click here to add project.

## Experiment

The second step in the StraboExperimental Workflow is to Add an Experiment to a Project.




This page contains the main functionality and information for a specific experiment. The user has several options to enter the required data:

**Load All Data from Previous Experiment:** It is the fastest way to replicate a dataset for quick entry. Selecting this option opens a list of all projects and Experiments in the User database and will create a copy of the selected data and metadata under the current project. Please note that the data section contains a reference to the original data files. Make sure you update these accordingly.

**Load All Data from JSON File:** Recognizing that users would like more control over the type of metadata templates, you can choose to upload data from a JSON file on your computer. If you edit the JSON file to accommodate your needs, make sure you adhere to the original metadata structure outlined in the schema. If unsure, you can download an existing dataset as a template and modify it.

This feature will only upload the metadata and not the actual data files. Please note that if your template contains references to existing files on the server, these links will only work if you have

permission to view these. It is possible, and intended, to exchange templates between different laboratories, but existing data references in the JSON files will have to be updated.

The StraboExperimental metadata is organized into the following sections:

- Facility Information
- Apparatus Information
- DAQ (Digital Data Acquisition)
- Sample Information
- Experimental Setup and Procedure
- Data

Individual sections (e.g., Sample Info) may be populated **Manually**, from **Previous Experiment** or **From a JSON File**. The **Facility and Apparatus** section also allows the selection of equipment from the public **Apparatus Repository** as described previously. The added Apparatus will contain references to all files uploaded to the original repository. All registered users have permission to view these documents. If there are any changes to the Apparatus for a specific experiment (e.g., newly added capabilities), you can add them here. Any modifications made here will not update the information in the Apparatus Repository.

Please note that you can populate each section from its corresponding part from a **Previous Experiment** in your **Project Page**. For example, you can choose to load the **Sample Information** from one of the previous experiments and the **Apparatus** from another experiment. This gives you full flexibility in prepopulating StraboExperimental **within** the application. The **JSON Import/Export** capability will allow you to manipulate experimental metadata on your local computer as well.

## DAQ

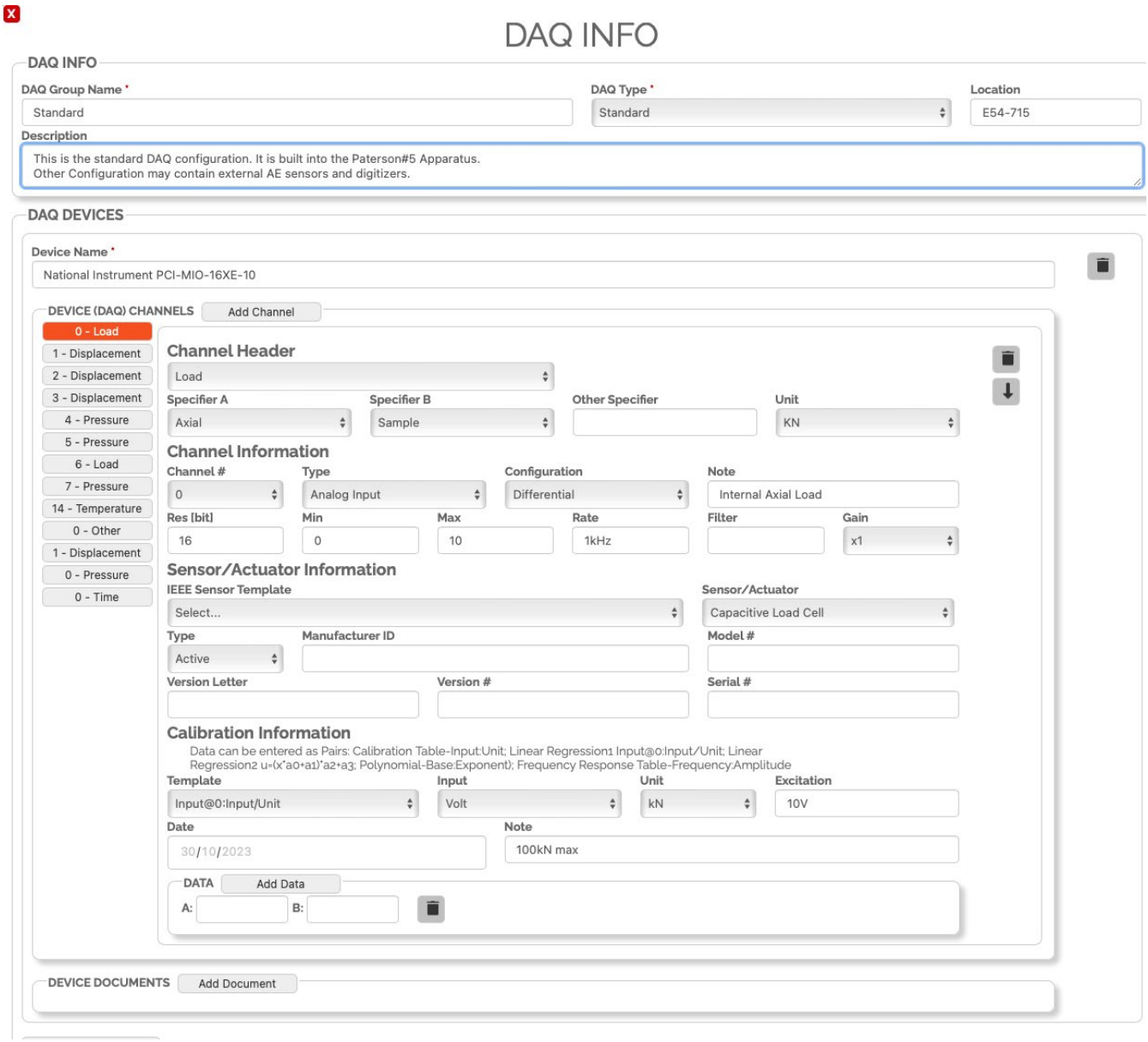
The Digital data Acquisition Part is specifically designed for Laboratory Managers and users who would like to know more about the system details and how the data was acquired. Adding information into this section is not required.

For most cases, DAQ is an integral part of the apparatus, but some tests use additional measurement devices or configurations. In addition, sensors and sensor calibrations might change from experiment to experiment. It is therefore important to have a means to add this information.

We chose the terminology of a **DAQ Group** that describes the complete set of physical measurements, sensors and actuators. If you choose to enter DAQ information, a **DAQ Group Name** and the **DAQ type** is mandatory.

A **DAQ Group** might consist of one or more **DAQ Devices** (required). Each device consists of an array of sensors and possibly actuators for measuring and controlling a range of physical properties and parameters (**Channels**).

You may select from a large selection of physical measurements (**Channel Header**) and a set of property dependent **Specifiers**. Please note that the list of options offered is a compromise for structuring the information. It therefore may not be exhaustive and is a work in progress. The **Header** section also contains fields for **Units** and additional information the user can add (**Other Specifiers**).




Channel Information lists general parameters for the chosen property to measure, such as **index**, and details for the type of electrical connection, **range**, **frequency**, sample **resolution** and amplifier settings (**filter**, **gain**). Options not listed can be added in the Notes field.

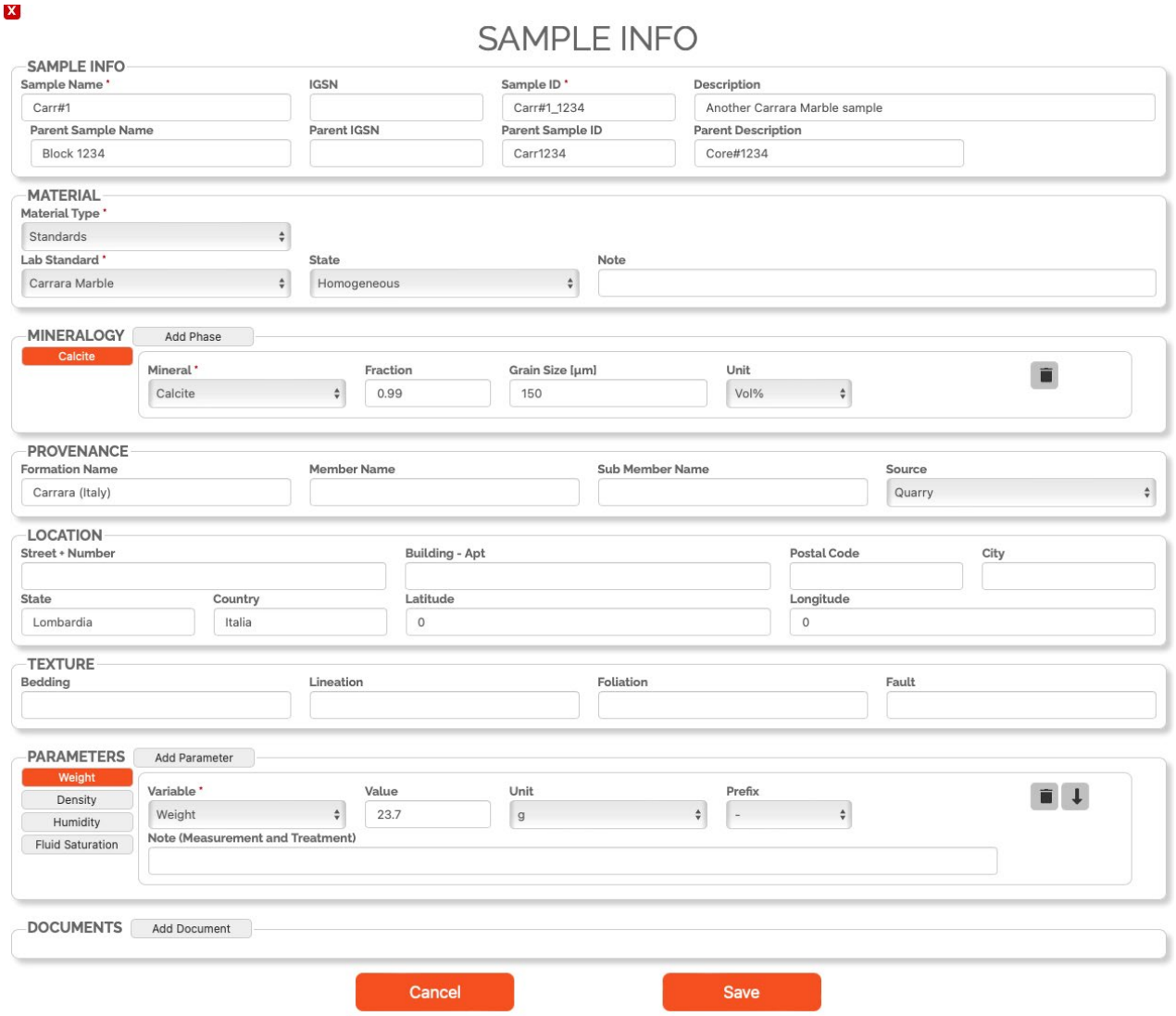
For Sensor and Actuator Information, we follow a shortened IEEE template but also added commonly used Sensors for Geophysical laboratory tests, recognizing the fluidity of the field.

A Calibration Section allows users to store sensor calibrations in a variety of ways. After choosing a suitable calibration template and units, a table of input/output values may be used to the calibration data with the current calibration date.

Each DAQ device also allows the upload of documents describing its function and configuration in more details.

## Sample

All sample related properties may be added in the Sample Form. Combination of **Sample Name***, **IGSN#, ID***, and **Description** should be unique for each dataset. We also provide the option to add **parent sample** ids to allow for experiments on successive samples.




The Material Section entails all Sample material information, except for geometry and specific preparation for the test. This is covered in the Experimental form.

The material section is currently still the development stage. Common Material Types (e.g., Rock Types, Minerals or Commodities) are added for convenience but the list is not comprehensive. A menu lists different **material types** such as common minerals and rock types. In the prototype

version the selections are unique. In subsequent versions we plan to link the choices to standard mineral and rock databases as well as to the Strabo rock repository. Material **state** depicts the general condition of the sample (e.g., solid, powder, composite) together with a note field for more details. Description of more complex materials will have to be added as a separate document.

**Mineralogy** lets you add the sample mineralogy or the composition of a powder, mixed sample or gauge layer. Adding **phases** to the mineralogy allows to add the **Mineral** name, the **Fractional** Composition and **Grain Size** if needed.

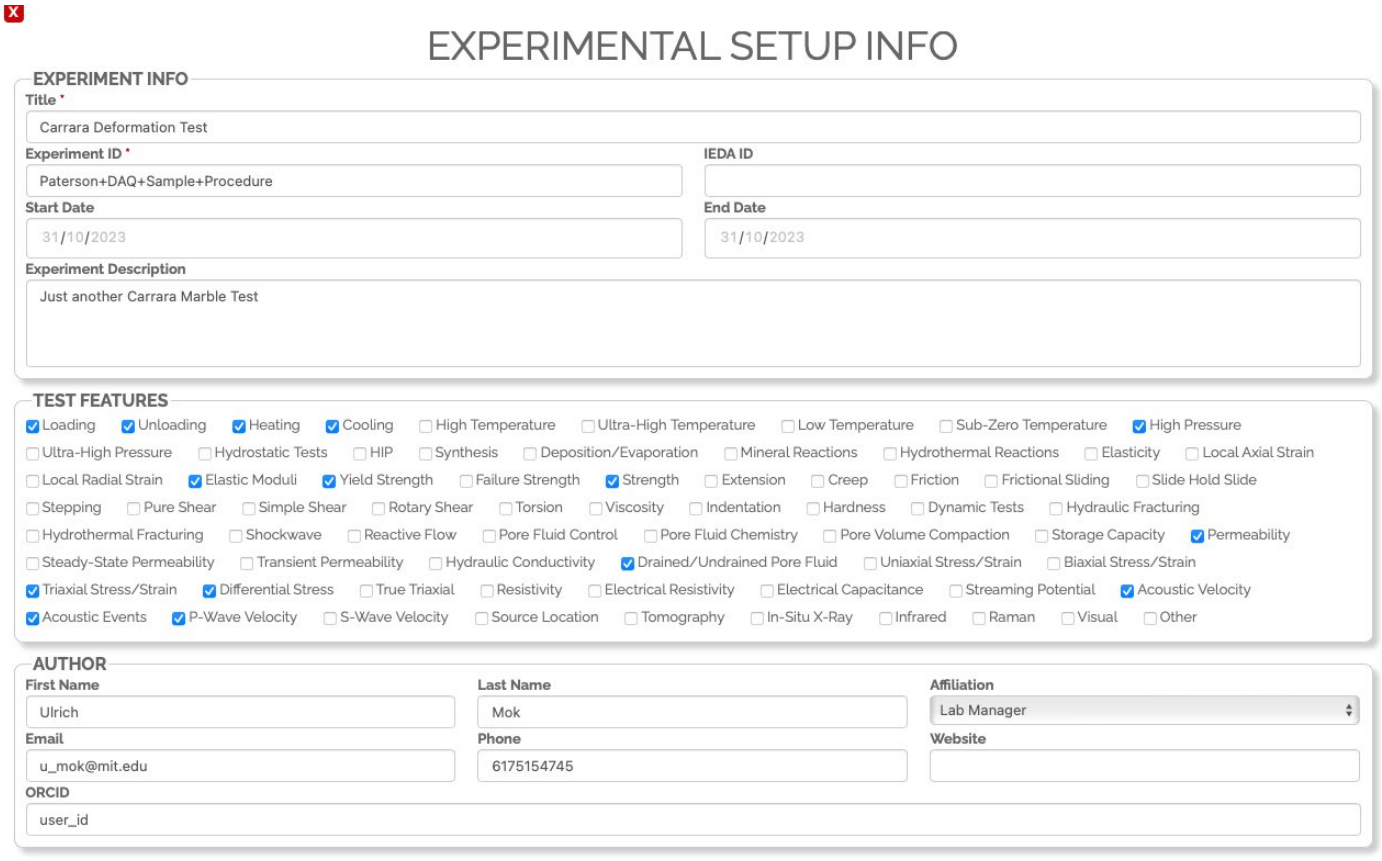
**Provenance** describes the general **source** and **location** of natural samples and rocks as well as their geological **formation** and **member** names.

**Texture** adds optional fields to describe macroscopic features, such as **bedding**, **lineation**, **foliation** and **faults**. For detailed descriptions and information, it is recommended to upload supporting documents (e.g., pictures and/or data).

**Sample Parameters** lists sample **weight** as well material specific properties, such as **density**, **permeability**, **porosity** and/or **prestress** conditions, as well as specific sample treatment (e.g., humidity, fluid saturation, etc.). This is not a comprehensive list, and it may be extended added in future. Sample and assembly geometry will be covered in the experimental section.

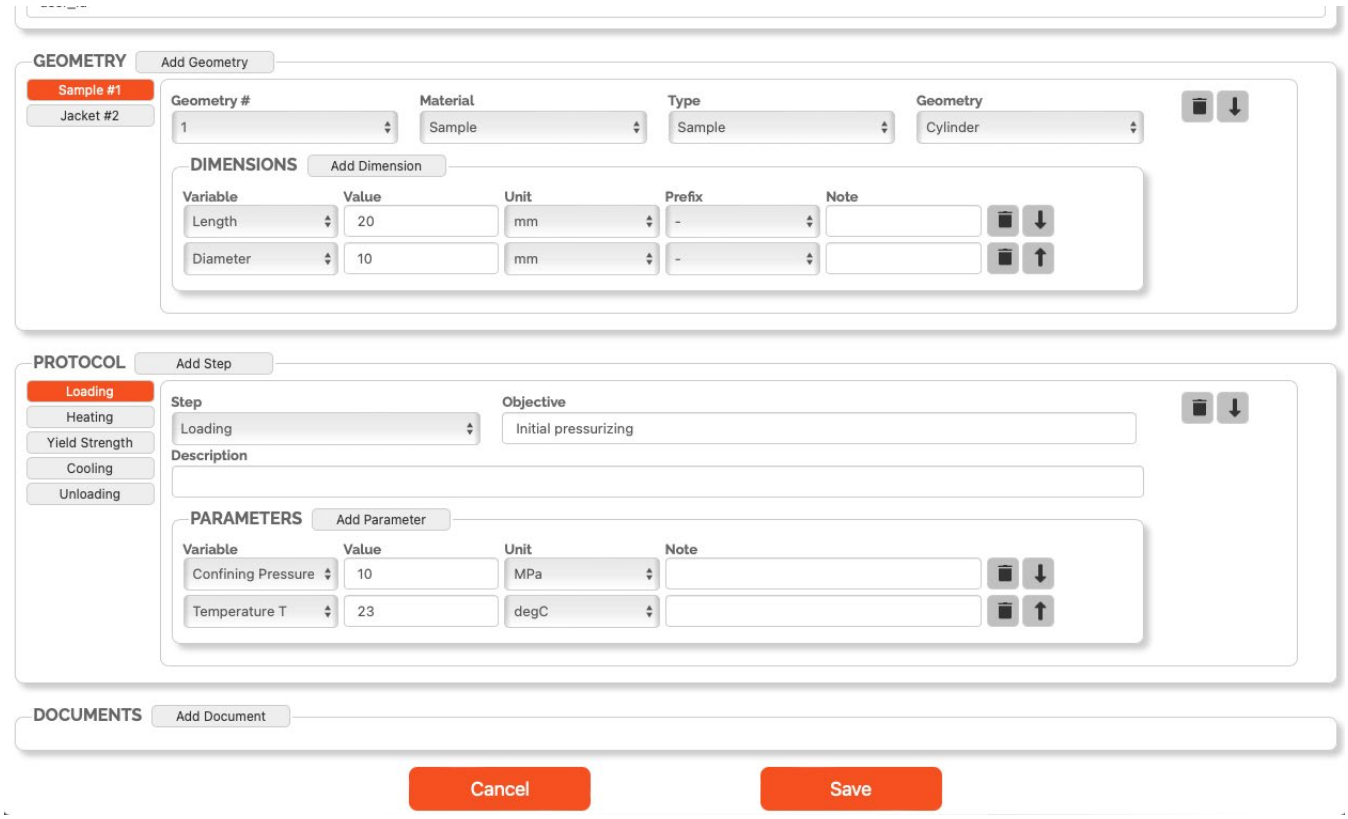
## Experimental Setup/Protocol

Experimental **title**, **ID**, **start** and **end date** as well as a basic **description** are entered in the infomation section. The api also contains the **Project Name**.




**Test Features** allow to add commonly applied test procedures. They are distinct from Apparatus features because they will indicate the purpose of the test and the applied methods. Make sure that all procedures are checked.

**Author** is the experimentalist who is responsible for running the test. At least a **name** and **email** address is recommended to ensure the proper authorship of the experimental results.




**Geometry** is for sample as well as assembly geometry. You can add as many assembly elements as you like, including **sample**, **jacket**, **spacer** and **forcing blocks**. It allows for most used geometries for rock physics and petrology (e.g., cylindrical, rectangular, dog bone). Even complex assemblies can be described using the indexed order of geometries.

**Protocol** lets the users add a step-by-step procedure for a test. Listed **steps** are all features checked under **Test Features** (e.g., Heating, Loading, Permeability, etc). Each step contains a field for Objective and description as well as Step Parameters. **Parameters** are **values** for specific test variables, such as Pressure, Temperature and Load.

The protocol order can be rearranged according to the test sequence.

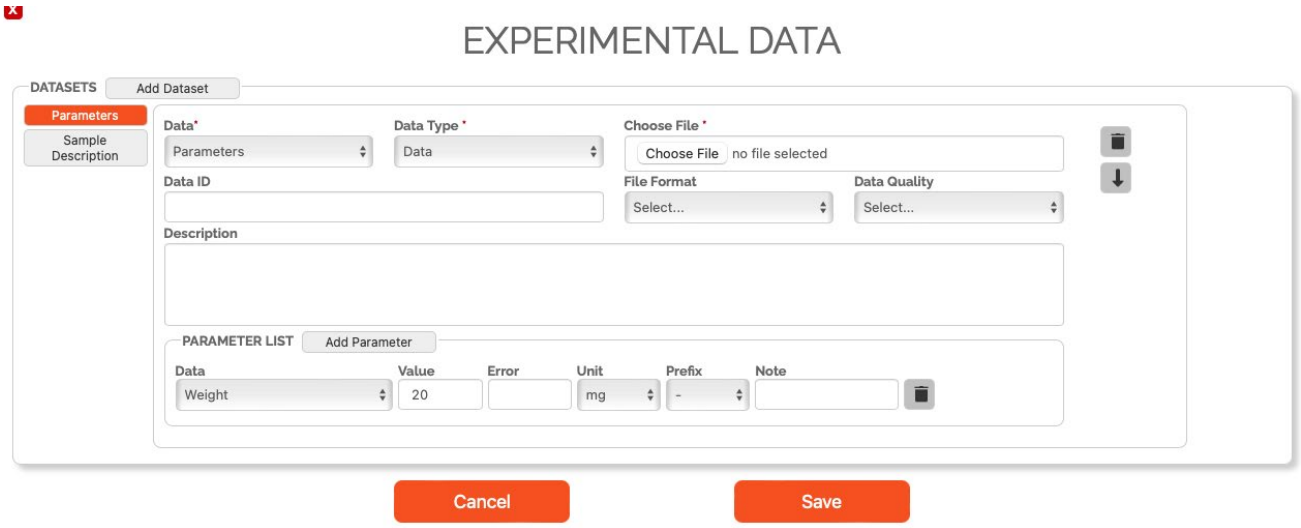
**Documents:** supporting information to the test protocol and objective.

## Experimental Data

This section is to upload pre- and post-experimental results and data, such as **Pictures**, **SEM**, **micrographs**, **Data files**, **software**, etc. We recommend organizing the data into **datasets**. Each dataset contains a specific type of data **type** (shown via pulldown menu are a list of common types for experimental results.)

Most **data** types are unstructured images, videos or experimental results and require a Data **Type**, **ID**, **File Format**, **Description** and an estimate of the **Data Quality**. A file **upload** option is available for each data type. Please refer to the API for the upload of a series of images or pictures.

However, there are some exceptions where data may be entered in a more structured way. Please note that this is an attempt make the data more useful for external users and the public.




***Specific structured Data Types:***

**Parameters**: Here the user can manually add a list of pre- and post-experimental measurements. They can include sample **length** or **diameter** or any other single measurement (e.g., **permeability**) that applies to the test.

**Pore Fluid**: Users can add multiple pore fluid **phases** with their respective **fraction/fugacity** or **activity** values. For each **phase** the pore fluid **chemistry** can be added with the most common **anion/cation** composition.

**Time Series:** Most commonly, a deformation experiment will contain some form of time dependent measurement (**time series).** These are mostly used to analyze elastic and inelastic rock properties and may contain **time**, **stress**, **strain**, **pressure**, **load**, **temperature** or any other low frequency measurements. High frequency data such as **acoustic emissions** will be treated separately.

The **time series dataset** should contain details about **file** content and **format**. The data **header** section is an attempt to allow digestion of the data files in a more structured way. Like the Headers in the **DAQ** section, they contain additional descriptors to make each header unique.

It is assumed that the data is contained in a text file and a tabular format with individual measurements listed as columns. Only the number and standardized names of data **headers** entered with their respective format are considered. Additional headers or columns contained in the data file will be ignored.

*Nomenclature of Data Headers*

The main **Header** categorizes the type of measurement taken. These include common basic and derived Variables such as: **Time, Temperature, Pressure, Load, Stress, Displacement, etc.**

Secondary Header Information (**Specifier A**) depend on the initial header choice. For example, if **Temperature** is chosen as main header, there are the following options available: **Room, Sample, Furnace, Vessel, Pore, Fluid.**

Lastly, **Specifier B** depicts more detailed information about measurement location **(e.g., Sample Top, Average, Bottom, Internal, External, etc). An** additional descriptor field is added for more measurement details but is not mandatory.

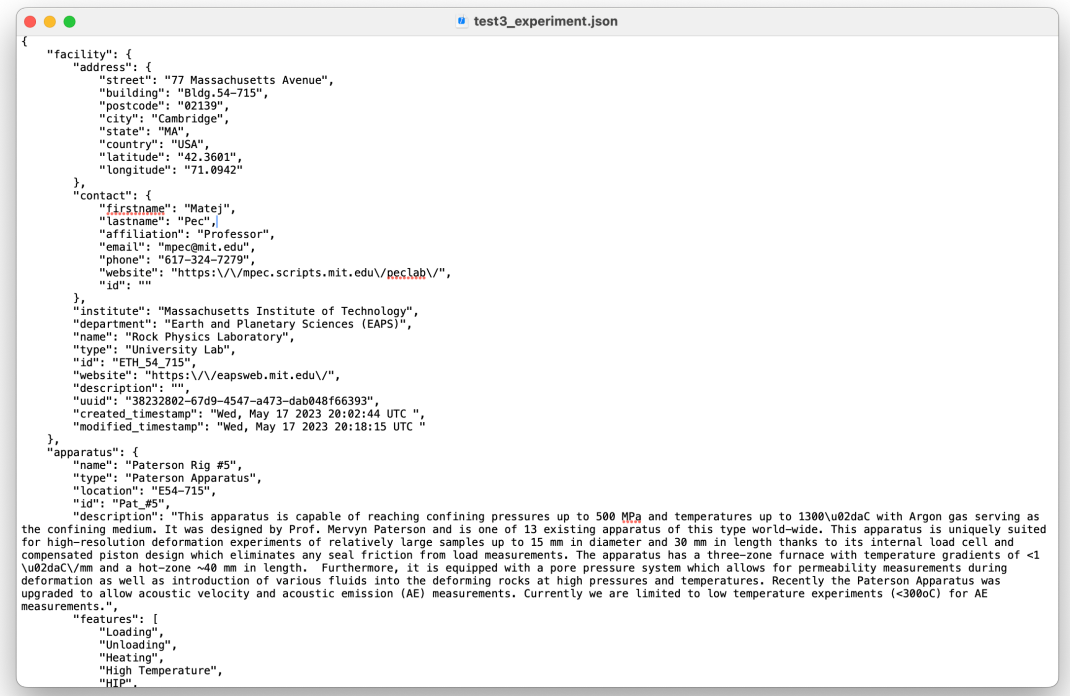
For non-conventional data headers, a list of SI and derived units is available as well.

# JSON IMPORT/EXPORT

This section describes the (optional) capabilities for using readable JSON files as experimental templates. They are using the same schema as the API but are more easily accessible for the end users. We briefly summarize the various options to make use of the Import/Export capabilities of StraboExperimental.

The exported JSON file lists all data entered in the web form (values) as well as their corresponding properties in a hierarchical structure that follow a predefined schema. Only files that adhere to this schema and are valid JSON may be used as templates and can be later uploaded to StrabExperimental. If you follow the schema guidelines, you are free to modify the files in a text editor. We will also offer offline editing tools with LAPS later.

**Option 1:** In your Project Page, choose an Experiment and select Download. This will download your entire experiment. You can download a JSON file at various stages in your workflow and save them as backup or template containing a combination of Apparatus, DAQ, Sample and Testing Information. For a series of experiments using similar settings, you may simply upload the template and modify experiment specifics (i.e., Sample Name or Specific Sensor Calibrations). This will speed up your data entry significantly.



**Option 2:** In the Project Page, choose an experiment and click View. The download button for *Download Project JSON* on the top right corner of the page will let you download or copy the JSON data for the experiment.