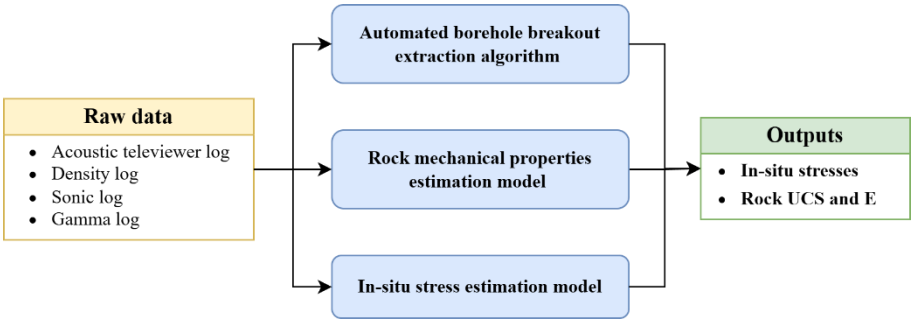
BBSET User Guide

BBSET (Borehole Breakout Stress Estimation Tool) is a web-based software application designed to estimate in-situ horizontal stresses using borehole breakout data.

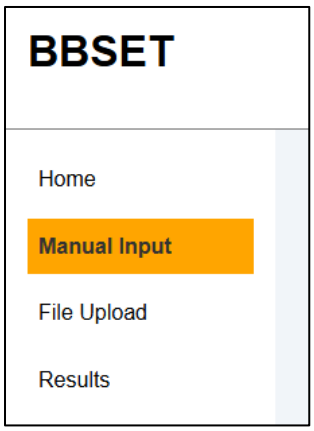
BBSET incorporates two built-in machine learning models:

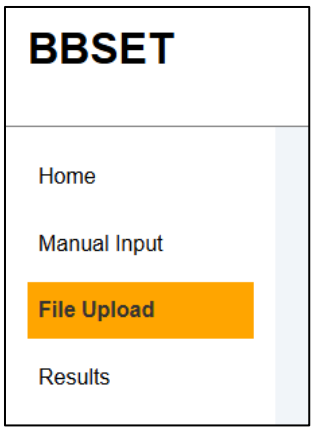
- **Rock mechanical properties estimation model**: This model estimates the uniaxial compressive strength (UCS) and Young's modulus (E) of rocks based on borehole geophysical logs, including depth, sonic log, density log, and gamma log.
- **In-situ stress estimation model**: This model utilises borehole breakout (breakout width and normalised breakout depth), UCS, and vertical stress (σ_v) to estimate both maximum horizontal (σ_H) and minimum horizontal (σ_h) stresses.



The software offers the following two operational modes, which can be assessed from the side menu.

- **Manual Input** – for direct, single data-point analysis
- **File Upload** – for automated data processing from raw borehole geophysical logs





Manual Input

The Manual input mode allows the user to estimate horizontal stresses from an individual set of breakout parameters. The estimation process will require two input categories: **Breakout Information** and **Rock Mechanical Properties**, which will be explained below.

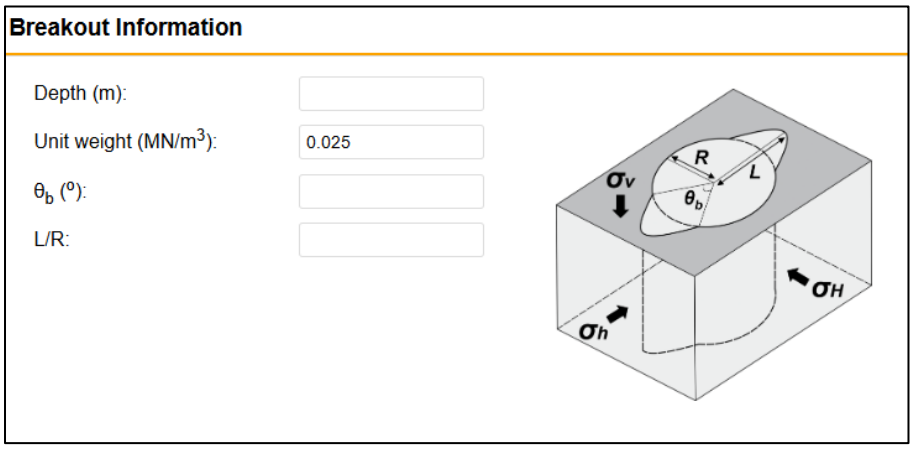
Breakout Information

The section requires four parameters, depth, unit weight, breakout width (θ_b), and normalised breakout depth (L/R).

- Depth (m): The depth where the breakout is observed. The value must be greater than 0.
- Unit weight (MN/m^3): The unit weight of the rock at the breakout location, which can be calculated based on rock density. The default value is 0.025 MN/m^3.

$$Unit\ weight\ (MN/m^3) = density\ (g/cm^3) * 9.81/1000$$

- θ_b (degrees): The width (angular span) of the breakout.
- L/R: The ratio of the breakout depth (L) to the borehole radius (R).



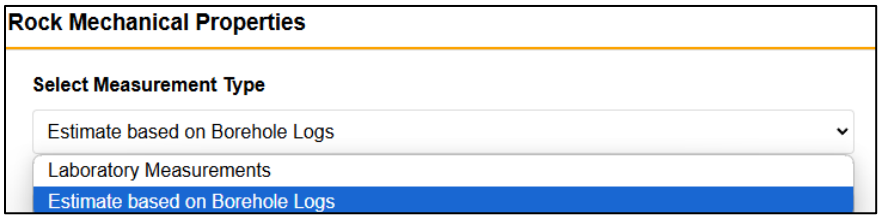
Rock Mechanical Properties

The Rock Mechanical Properties section requires two parameters: UCS and E. BBSET offers two options for providing these values:

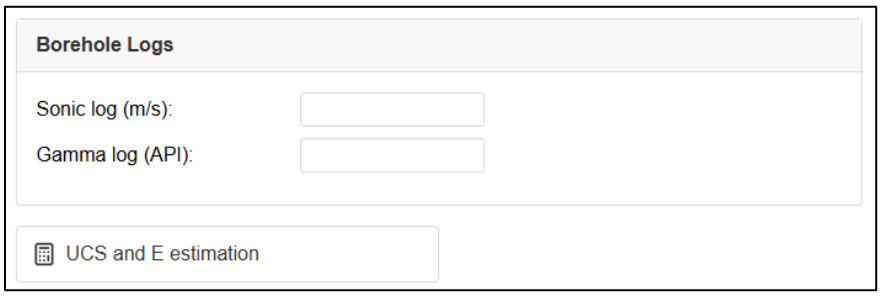
Direct input using Laboratory Measurements: If laboratory measurements are available, the UCS and E can be directly inputted by selecting Laboratory Measurements from the Select Measurement Type dropdown menu. Once both values are manually inputted, the user can click the in-situ stress estimation button and proceed to the Manual input results interpretation section.

Estimation using borehole logs: If laboratory measurements are unavailable, UCS and E can be estimated using the built-in Rock Mechanical Properties Estimation Model:

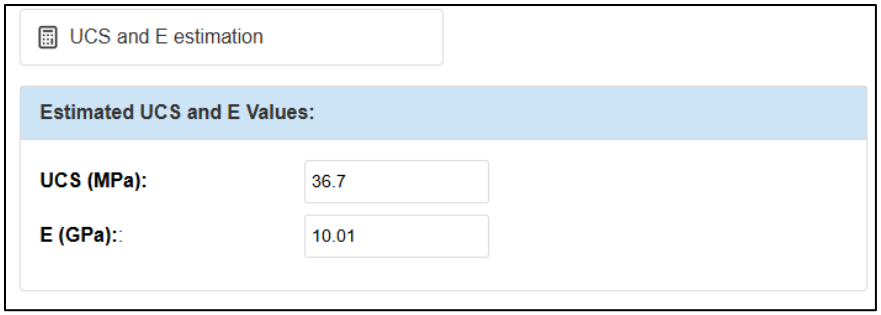
- Select Estimate Based on Borehole Logs from the Select Measurement Type dropdown menu.



- Input the following parameters:
    - Sonic log (m/s): Sonic logs measure the travel time of an elastic wave through the formation around the borehole wall. The short-spaced sonic log (i.e., VL2F) should be used here.
    - Gamma log (API): Gamma logs indicate the extent of the natural radiation in borehole walls. The gamma ray recorded from the density probe (e.g., GRDE) should be used here.
    - Depth **and** Unit Weight: These values are sourced from the Breakout Information section



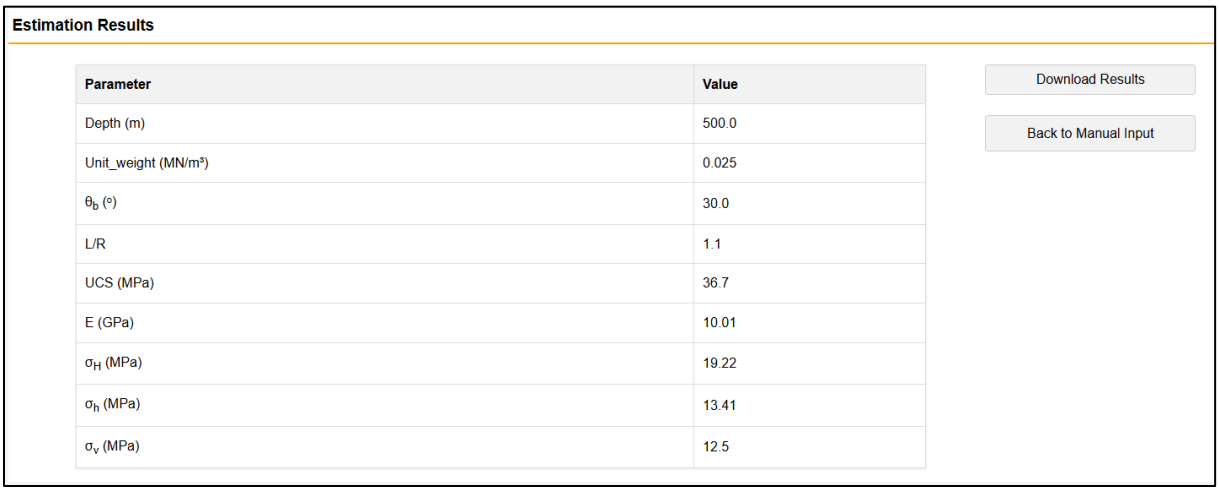
- Click the UCS and E Estimation button. The results will appear below the button.



- Once the UCS and E values are estimated, click the In-situ Stress Estimation button to proceed to the Manual Input Results Interpretation section.

Manual Input Results

After all inputs are correctly provided and the In-situ Stress Estimation button is clicked, the user will be redirected to the Estimation Results page. The input parameters and estimation results are displayed in a table on the left side of the page. Results can be downloaded via the Download Results.



File Upload

The File Upload mode automates the process of extracting breakouts, deriving rock mechanical properties, and estimating in-situ stresses from raw borehole geophysical logging data.

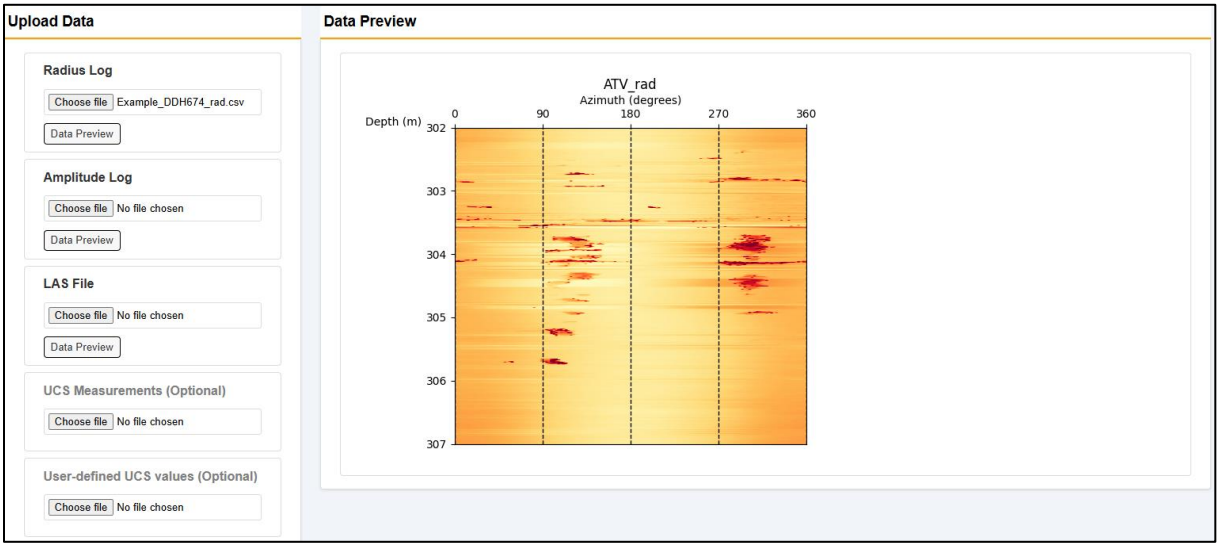
To estimate in-situ stresses, the following files are required:

1. Radius log (required)
2. Amplitude log (required)
3. Log ASCII Standard (LAS) File (required)

4. UCS measurements and user-defined UCS values (optional)

Radius and Amplitude Logs

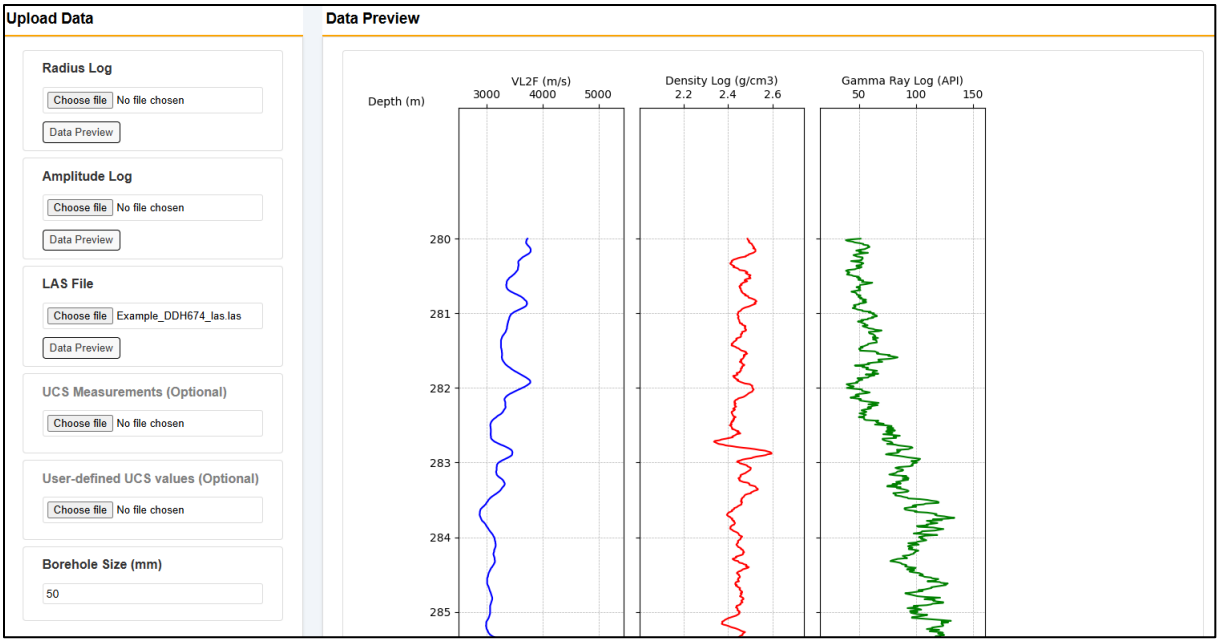
Both radius and amplitude logs are obtained from acoustic televiewers and will be used to extract breakout information (file format: .csv). Depth must align between the radius and amplitude logs. After uploading, the logs can be visualised and reviewed using the Data Preview button.



LAS and Optional UCS Files

Log ASCII Standard (LAS) is a standard file format that stores well log information, which can contain a wide range of borehole geophysical logs. The uploaded LAS file will be used to calculate rock UCS and E based on the **Rock Mechanical Properties Estimation Model** and must contain the following logs:

- Depth
- Density
- Sonic (VL2F)
- Gamma (GRDE)

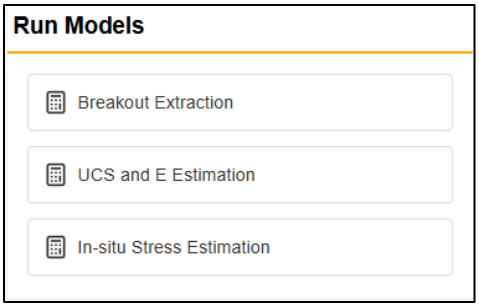


Users also have the option to upload UCS measurements and user-defined UCS values for in-situ stress estimation. UCS measurements are obtained from laboratory experiments on core samples, and the user-defined UCS values can be either derived from empirical equations (e.g., sonic velocity-UCS equations) or based on operational experience. Both files should be in .csv format, with column 1: Depth values, and column 2: UCS values.

	A	B
1	Depth (m)	UCS (MPa)
2	303.8	25
3	304.4	40
4	315	60
5	320	18
6		

Run Models

After uploading all required files, the user can proceed to the Run Model section. The section consists of three steps: Breakout Extraction, UCS and E estimation, and In-situ Stress Estimation, which need to be executed in order.



Breakout Extraction:

The Breakout Extraction function utilises a built-in algorithm to extract breakout information based on the radius and amplitude logs.

The Borehole Radius input in the Upload Data section would also affect the extraction accuracy, therefore, it is important to ensure the correct borehole radius is entered.

Click the Breakout Extraction button to start the process. A progress bar will appear below the button, indicating the status. For large log files, the extraction process may take 10–15 minutes. When the process is complete, the progress bar will turn green.

UCS and E Estimation:

The UCS and E Estimation function calculates rock UCS and E values for the entire logging depth using the LAS file and the Rock Mechanical Properties Estimation Model.

Click the UCS and E Estimation button to start the process. A progress bar will appear below the button, indicating the status. When the process is complete, the progress bar will turn green.

In-situ Stress Estimation:

The In-situ Stress Estimation function combines the results from the Breakout Extraction and UCS and E Estimation steps to estimate in-situ stresses.

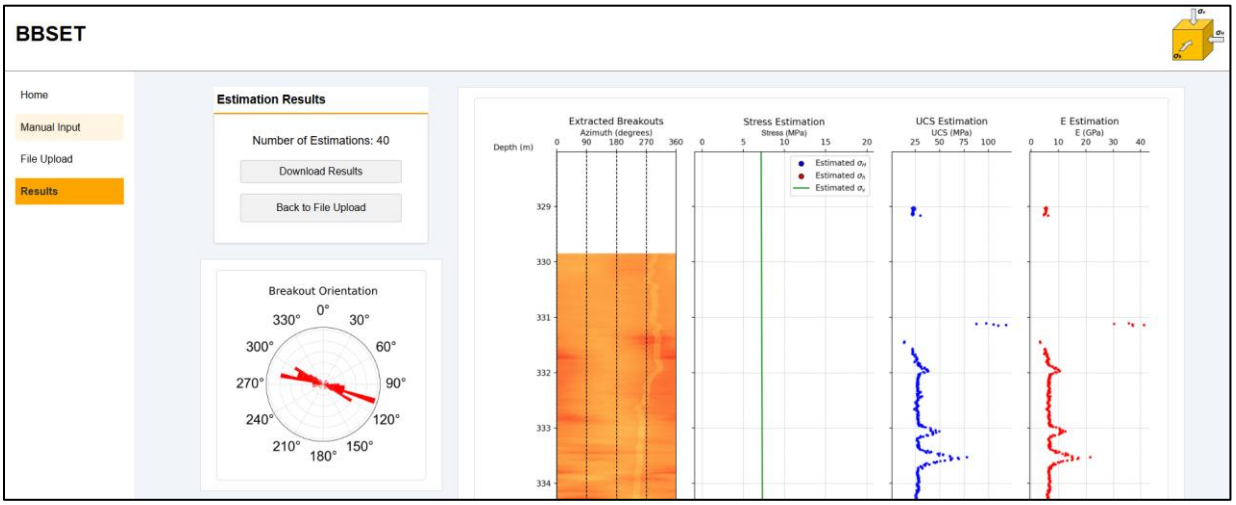
The software prioritises data sources for UCS in the following order:

1. UCS Measurements: Used if depths match the breakout locations
2. User-defined UCS Values: Used if no UCS measurements are available for the matching depths.
3. UCS and E Estimation Model results: Used if neither UCS measurements nor user-defined UCS values match.

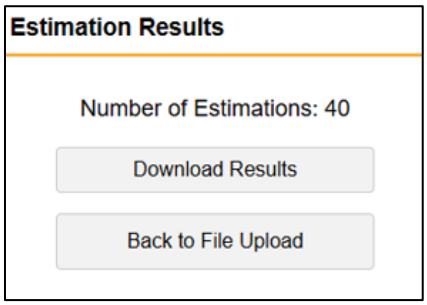
Once the estimation process is complete, the user will be redirected to the Estimation Results page.

File Upload Results

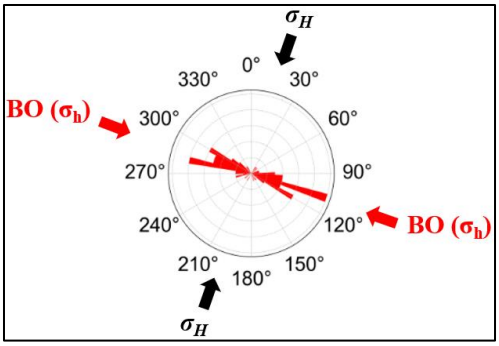
An example of the estimation results is presented below.



The total number of extracted breakouts is displayed at the top left of the page, and the results can be downloaded through the Download Results page.

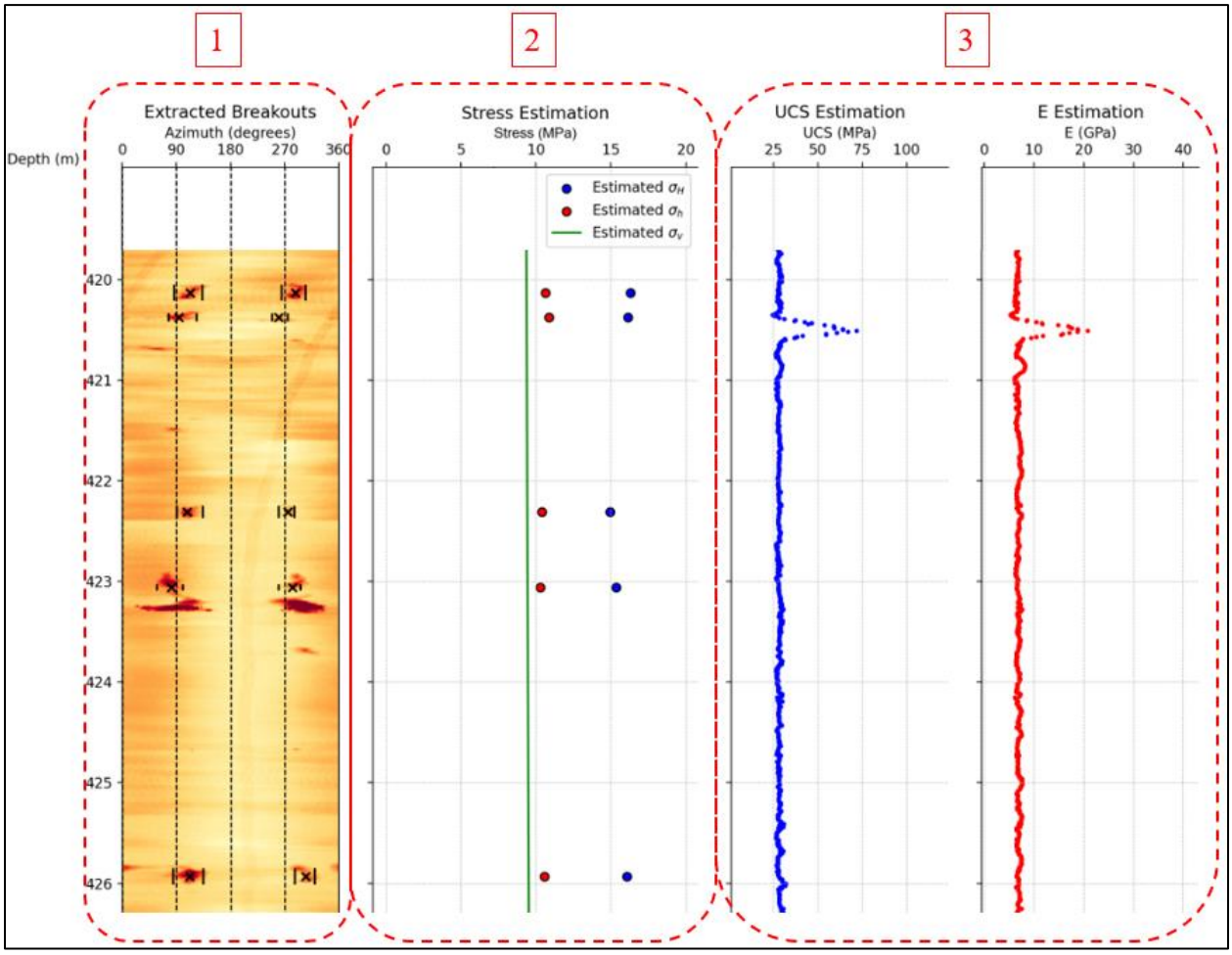


The orientation of the extracted breakouts is visualised in the rose diagram at the bottom left of the page, which can be interpreted as the σ_h direction, and the σ_H orientation is assumed to be 90 degrees from the breakout orientation.



The figure on the right side of the page displays the estimation results across the logging depth., presented in multiple figures:

1. Radius Log (first figure): The locations and extent of the extracted breakouts are marked as |×|.
2. Stress Plot (second figure): Estimated σ_H (blue points), σ_h (red points), and σ_v (green line).
3. UCS and E (third figure): The estimated UCS and E by the rock mechanical properties estimation model.



Assumptions and Limitations

To ensure accurate and reliable results, users should be aware of the following assumptions and limitations inherent in the software:

- There are two reliability indicators associated with the stress estimation results: 1 and 2. A reliability indicator of 2 is assigned to breakouts exhibiting one or more of the following features, making the results less reliable:
    - Asymmetrical
    - Tilted
    - Noisy
    - Near washout or crushed zone
    - Not clear in amplitude log
- Due to the limitation of the training data for the **Rock Mechanical Properties Estimation Model**, the model currently can only estimate the UCS and E values with the following parameter ranges:
    - Depth: 135 – 585 m
    - Sonic log: 1900 – 5000 m/s
    - Density log: 1.93 – 2.95 g/cm^3
    - Gamma log: 41 – 251 API
- Averaged errors for the estimation results on the model development dataset:
    - σ_H: ~ 8%
    - σ_H: ~ 19%
    - UCS: ~ 18%
    - E: ~ 22%

Contact and Support

For further assistance, bug reporting, or suggestions, please contact: **joung.oh@unsw.edu.au**